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ABSTRACT

An analysis of the history of the evolution of education and its impact on economic development establishes the context and motivation for my primary research. The research inquiry is to determine if there is a measurable relationship between the three variables of training expenditures, private education spending, and academic publications with the dependent variable of GDP for various countries and globally. The analysis is followed by a discussion of future policy implications from the research, in order to create greater government investment in public education.

The history of education demonstrated the random development of human learning from prehistoric times through the middle ages, culminating with the advent of public education in the late 1700s. Public education moved literacy from 12% in the world in 1820 to 86% of the world population by 2016 (Roser & Ortiz-Ospina, 2018). Buckminster Fuller (1981) in his book *Critical Path* estimated the growth in human knowledge. In the common era (CE) one unit of information took 1500 years to double. It is doubling every 13 months now (Miller, 2019). In addition, economic outcomes have gained tremendously. The world was at $1,102 per capita GDP in 1820 and was at $14,944 in 2017, an increase of over 13-fold (Roser, n.d.). Denison's research (Kerr, 1994) concludes that 20% of economic growth is contributed by education and 40% is contributed by advances in human knowledge. There is every reason to believe the growth in this trend will continue.

The primary research inquiry focused on three variables. Denison's measurements were formal education, private education spending, and corporate on-the-job training (Kerr, 1994). Measures of knowledge were growth in academic publications, research and development, and patents. The literature review shows relationships between educational attainment and

expenditures , R&D, and patents with economic outcomes. As far as could be ascertained, there is insufficient research on training, private education spending, publications, and its relationship to GDP. This is the focus of the research and analysis conducted.

The discussion of the results of the research inquiry leads to policy arguments for funding education. The government in the United States has been characterized as divided in partisan politics. However, in 2021, a bipartisan Congress passed a $1 trillion dollar Infrastructure Bill to invest in the economic future of the country (World Economic Forum, 2021). When logical economic investment rationales are used to persuade both Democrats and Republicans of the importance of investing in the future competitiveness of the nation’s economy, then these arguments are shown to be the one approach that has been successful in getting unified support.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

I. INTRODUCTION

The present study will examine the relationships between the invention of public education, followed by the explosive growth in human knowledge, and the expansive economic outcomes that occurred in the same time periods, having significantly changed humanity's social conditions.

The purpose of the dissertation is built on the following. Particular emphasis will be placed on the research of Edward Denison and his books, *Why Growth Rates Differ* (Denison & Poullier, 1967) and *Trends in American Economic Growth* (1985). Although somewhat dated, these seminal works comprehensively define the independent variables of education and human knowledge. Also, most research in this area has been using advances in statistical methods to validate Denison's work. In the literature review, it will be demonstrated that Denison's findings have led researchers to identify four independent variables for education: educational attainment, educational expenditures, private spending on education (primarily by families), and corporate spending on educational training and development. Three additional independent variables have been identified as determinants of the massive increases in human knowledge, another key economic driver. They are academic journal publications adding to human knowledge, research and development into these discoveries, and patents that commercialize new products and technologies. Three of these seven independent variables have not been researched for their impact on the growth of a country's GDP, as far as I can ascertain, and this studies research will examine the relationship between these variables. These independent variables are private spending on education, training expenditures, and the growth in academic journals as it relates to changes in GDP. In order to establish the context for these complex relationships, The study proceeds as follows.

The research will start with a brief historical perspective to establish the importance of the independent variables that drive the growth in public education and the massive increase in human knowledge. Next, examination will define the economic dependent variables and their theories and measurements, also providing some historical perspective on the corresponding expansion of economic growth that occurred in the same historic timeframes. The study will then review the extensive research that has been done on this research problem, sharing these studies and the corresponding statistical results. Afterward, the investigation will conduct research based on the specific independent variables of education and human knowledge not completely researched, as previously defined, in order to add to the scholarly inquiries already established. Let us turn now to a brief historical perspective of education and human knowledge.

Education And Human Knowledge

Free public universal education is one of the most important recent innovations in the history of humanity. Since the late 1700s, civilization has moved from general ignorance into the light of wisdom and understanding. Humanity has reached a point where our title of *homo sapiens*, translated as the wise human, has finally been achieved for the majority of humankind. Although *homo sapiens* appeared around 300,000 before the common era (BCE) in Africa (Smithsonian, n.d.), civilization did not see the invention of agriculture until about 12,000 years ago (National Geographic Society, n.d.). The invention of the use of metallurgy is dated to around 6,500 years in the past (Britannica, n.d.), and the invention of the wheel dates back to about 5,000 BCE (English, 2021). The process of formal learning is usually linked to the advent of cuneiform, and consequently, writing began in roughly 3,500 BCE with the Sumerians (Baro, 2015). Shortly after, the first formal schools were believed to develop in Egypt and Mesopotamia around 3,000 BCE (Britannica, n.d.).

However, Egyptian schools reached perhaps one-half to one percent of their population, and only these Egyptians achieved the skill of literacy in the three thousand year period before the birth of Christ (Baines, 1983). Some studies indicate that China started schools in 2,400 BCE, and by 1,600 BCE, during the Shang dynasty, government schools were providing education to the aristocrats' children, a very limited number of people (Jing, 1993). In ancient Greece, the Greek philosopher Socrates created the Socratic method of questioning, and this became one of the principal teaching methods to develop human reasoning (Farnsworth, 2021). Socrates writes in his *Apology of Socrates* that the only true wisdom is in knowing you know nothing, and that education is the kindling of a flame, not the filling of a vessel (Goodreads, n.d.). The Greeks famously had many schools starting at about 400 BCE, but these were private institutions, and most of the population was uneducated (Coulson, 1999). The Romans started schools around the same time period and by about 200 BCE one to two percent of their population were literate. The schools were never free and only those who could pay attended. The peak of literacy rates throughout the Greco-Roman world was only occasionally above 20%, and for the rest of the Roman empire, literacy rarely averaged about 10% of the population, while literacy rates were much lower around the globe (Harris, 1989). These citations represent the elite nature of education throughout most of the history of human civilization. For example, in the Americas, the Incas of the 15th and 16th centuries had limited education for only their nobility. They learned some oral history, military training, religion, government, and moral norms (Davies, 1995). This was the best achievement in education for the New World. The vast majority of typical human beings from 5,000 BCE until the late 1700s could not read or write, knew very little math, and practically no science, history, or geography (Harris, 1989). How then could we claim to be wise humans? Were people really that much smarter than all other living things? No wonder animal and astronomical worship lasted for so long, and the average person believed very strongly in legends, mysteries, and myths (Britannica, n.d.).

Public Education And The Learning Revolution

When did universal public education start to take hold? Perhaps the most important change came in 1450 when Gutenberg invented the printing press (History.com, 2019). It is believed that Gutenberg attended the university of Erfurt (Bellis, 2020). Actually, the printing press was invented in China much earlier. However, learning to read and write Chinese requires knowing 3,500 essential characters, and many graduating from school know 5,000 to 6,000 (Cahill, 2022). Because of this difficulty with reading and writing Chinese, there was not an explosion of education in China after the printing press was created. Books replaced scrolls by the 1100s, but they were limited to the ruling class and a book was a status symbol of wealth (History.com, 2019). Nonetheless, books were made by hand before the printing press, and this slowed down the production of books while making them costly items. As books were created in greater numbers at reduced cost in Europe, demand grew for education, in part to create more readers in the world (History.com, 2019). Gutenberg's printing press may have happened at the start of the Renaissance, but it did take some time to begin the process of universal education. By the 1700s things started to change. Johann Julius Hector was a German teacher and pastor whose parents were educators. In 1735, Frederic William I, king of Prussia, appointed him to a government post, and later to be the first pastor of the new Trinity Church in Berlin. He won the king over to the idea of educating his subjects, and he was also an influence on the King's son, Frederic II. Frederic established the German system of state supported primary schools with an edict in 1763. Around this time, we begin to see the initial forms of public education in Europe. The Prussian educational system later became a model for Europe and the Americas (Schindler, 1969).

Of course, new ideas about education were emerging elsewhere in Europe during this period. Jean-Jacques Rousseau had written *Emile* in 1762, an educational philosophy that was revolutionary at the time. He proposed that education should encourage and promote creativity in children, and his works were well-read by the people of the 18th century (Rebore, 2014). In the Americas, Thomas Jefferson put forth a bill in the late 1770s for the more general diffusion of knowledge. Jefferson saw public education as the greatest prevention of attacks against democracy by tyranny. This legislation proposed general public primary education, but it did not pass. With the help of James Madison, a revised bill was finally passed into law in 1796 (Burkes, 2009). With public education taking hold, by 1820 about 12% of the world could read and write. This revolution in learning from the late 1700s continued, and by 2016, literacy had reached 86% of the world population (Roser & Ortiz-Ospina, 2018).

This is a remarkable and massive social change. Not only had literacy grown by over sevenfold in less than 200 years, but this was achieved while the human population was exploding worldwide. The human population in 1820 was perhaps, at most, 1.2 billion people, and by 2016 the world population was over 7.4 billion, an increase of over 600% (Worldometer, n.d.). Humanity had moved from education for only the elite to universal public education for the vast majority. This took place in about 250 years while population growth exploded.

Given the challenge of educating billions of people, the changes to the extent of public education were also phenomenal. According to the International Association of Universities, there are 18,000 tertiary institutions in 180 countries today, and in 2014 they estimated the number of university graduates had reached 137 million worldwide. The Association also projects we will reach 300 million graduates by 2030 (ICEF Monitor, n.d.). As of 2019, UNESCO estimates that 76% of youths attend secondary educational schools (The World Bank, 2021). All of these students are gaining a broader education than was ever offered in universities worldwide before the 1700s.

Science education was practically non-existent from 5,000 BCE until the 1700s, even in the best universities worldwide. The oldest university in the world is the Al-Karaouine in Fez, Morocco. It started in 859, but it did not teach mathematics, physics, chemistry, or offer foreign languages until 1957 (College Stats.org, n.d.). The University of Bologna in Italy started in 1088. However, prior to the modern revolution in learning they limited their teaching to religion, the law, and the arts (Lines, 2017). The Sorbonne, or University of Paris, started in 1096, and they too focused on theology, law, medicine, and the arts (College Stat.org, n.d.). Oxford University also started in 1096 and its curriculum focused primarily on religion. In the 1800s reforms started to expand Oxford's educational offerings (Walpole, 1903).

Of course, the curriculum was slow to expand because human knowledge had not started to explode until public education started. Public education's impact may seem obvious, but it is not always the case that additions to human knowledge come exclusively from formal education. Let us look at some historical examples of formal education impacting human knowledge. Newton gave us calculus and explained the law of gravity in the late 17th century. Sir Isaac Newton attended King's School, Cambridge, and Trinity College. Adam Smith introduced economic theory with *The Wealth of Nations* in 1776 (O'Rourke, 2005). Smith attended the University of Glasgow and then Oxford University (Britannica, n.d.). In 1784 Captain Cook gave us the first map of the world with any sort of true accuracy (Printsellers.com, 2020). James Cook was admitted to the merchant navy's apprenticeship and studied algebra, geometry, trigonometry, navigation, and astronomy. He passed the master's exam in 1757 (Williams, 2011). Michael Faraday explained electricity in the 1800s, and Darwin introduced the theory of evolution. Faraday was self-taught and had extraordinarily little formal education, but Charles Darwin studied medicine at Edinburgh University and graduated from Christ College, Cambridge (Ashworth, 1935). In the 1900s Freud introduced us to concepts of the subconscious mind (Internet Public Library.org, n.d.). Sigmund Freud earned an M.D. from the University of Vienna (Sulloway, 1992). We also saw the discovery by Einstein of the theory of relativity, and Watson and Frick discovered the double helix structure of DNA in 1953 (leslistes.net, 2018). Albert Einstein completed his Ph.D. in 1905 at the University of Zurich (Mehra, 2001) and James Watson earned his Doctorate at Indiana University, while Francis Crick earned a BA in physics from the University of London (Science History Institute, n.d.). These anecdotal examples suggest a strong relationship between public education expansion and the exponential development of human knowledge over the last 250 years. I will share more evidence of this relationship in the literature review. The complete list of discoveries and additions to the subject matter in schools globally, accumulated from the 1700s until today, is vast and daunting. Students today learn more about all subjects and have more subjects available than was ever available before the 1700s. More of us are educated now, and we know far more than the brightest humans prior to the 1700s ever knew.

Given the explosion of universal education, even with the population swelling and human knowledge accelerating through its expansion, this has led to the conclusion that the age of public universal education has been perhaps the single most important social change in the history of human civilization. The scope and magnitude of this change for human beings make this conclusion seem self-evident. However, scholarly analysis demands further research and evidence, rather than acceptance. But how have we analyzed the impact of education on society, and by inquiry, gained a more specific, detailed, and comprehensive understanding of the importance of public education's impact worldwide? Before exploring this question further in the literature review, let us first examine the dependent variables by reviewing economic theory and outcomes. Afterward, the study will present research on the relationship between these variables over time.

Economic Theory And Measurements

Although research has focused on many factors that are impacted by education, primarily political, economic, and social, I will focus my analysis on economic outcomes. Economic prosperity has grown at incredible rates over the same modern historical era from the 1700s to today. If we analyze all output of products and services for a country in terms of its ratio to the population, then we are measuring Gross Domestic Product (GDP) per Capita. These numbers have been deflated, in order to adjust for inflation, referred to as real GDP. Keep in mind, historic data is less and less accurate as we go back in time, just as fewer and fewer people were educated, and their grasp of scientific methods was not well understood or practiced. Given these limits, we still have several important examples. The United States has grown from a real GDP per capita of $2,635 annually in 1802 to $54,006 in 2017 (Roser, n.d.). This is an explosive growth of over 20 times its value, without the increase being distorted by population growth or inflation. For Great Britain, their real GDP per capita has grown from $3,360 in 1802 to $37,783 in 2017. For China, the growth has been from $901 in 1810 to $12,734 in 2017. For France, the growth was $1,875 in 1822 to $37,895 in 2017. India has seen growth from $901 in 1850 to

$6,449 in 2017. Finally, the world was at $1,102 per capita GDP in 1820 and is at $14,944 in 2017, an increase of well over 13-fold (Roser, n.d.). This data is displayed below (Table 1.1).

Table 1.1: GDP per Capita adjusted for inflation (Roser, n.d.)

Countries	1800s	2017	% Increase
United States	$2,635	$54,006	2000%
Great Britain	$3,360	$37,783	1100%
China	$901	$12,734	1400%
France	$1,875	$37,895	2000%
India	$901	$6,449	716%
World	$1,102	$14,944	1350%

This level of economic prosperity means that billions of people now enjoy more travel, better diets, new clothing choices, superior housing, incredible medical care, and a host of technology enhancements that every human being living prior to the market revolution, including the elite, could not even dream of experiencing in their lifetimes. Of course, we need to understand how much of this expansion in economic prosperity is attributable to a similar explosion in education. And as the data shows, the positive accelerated trends are similar for both education and economic growth, but they vary when compared to individual countries. What economic theories explain this variance in economic outcomes?

In economics, Adam Smith defined the theory of absolute advantage (Corporate Financial Institute, 2021). Absolute advantage occurs from a country's ability to produce more of a commodity than its global competitors. This advantage may come from natural resources, as is seen in the oil and gas markets, where certain countries have these mineral rights in abundance. However, many times a country can create a comparative advantage. David Ricardo was a

British economist who defined this economic theory in 1817 (Market Business News, n.d.). Comparative advantage occurs when a country can produce a good or service at a lower opportunity cost than other nations (Corporate Financial Institute, 2021). Opportunity cost is the loss of potential gain from other alternatives when the less attractive alternative is chosen. For example, Ricardo recommended a nation like Great Britain not block trade to protect its business sectors that faced a disadvantage, but rather the better opportunity is that they focus the nation's resources on expanding industries where England had a comparative advantage over other nations. Research shows this specialization occurring today where certain agrarian countries produce food stocks and export them to industrialized countries, while the industrialized countries may then use more resources to produce cars, jets, and medications, as Great Britain does, and export them around the world (Corporate Financial Institute, 2021). These theories promoted international trade and globalization, and international trade as a percentage of world GDP has grown from 6.3% in 1831 to 57% by 2018 (Ortiz-Ospina & Beltekian, 2018). But the advantages defined in mineral resources or industrialization specialties can also apply to the working people of a nation, and consequently, their productivity is increased through education.

These historical themes provide the context for the research inquiry. It is time now to transition to the problem statement, research questions, hypotheses and their rationale, and the strengths and weaknesses of the study. Keep in mind, a glossary of terms can be utilized at the end of the paper to assist with unique economic and statistical terminology.

The Problem

In our world today, are our leaders aware of the relationship between education, human knowledge, and the economic growth and prosperity of the nation? Do policymakers fund education based on this understanding, realizing that without investment in education, a nation's future international competitiveness will be in jeopardy? Are our leaders aware of the historical growth in human knowledge, and that without funding the education and research and development functions new technological solutions will not be forthcoming, leaving our serious future economic, social, and political problems without new and innovative solutions. Do our leaders know where to invest and do they understand which investments will yield what levels of return on the nation's investment? Or do policymakers cut funding for education, eliminate favorable tax systems enticing R&D expenditures, and make systems changes that limit the growth in educational outcomes, leading to lost opportunities for creative solutions, and the future stagnation of our economic system. These potential problems are in the future, and their existence is based on the investment decisions we make in the present. My research questions and hypotheses are aligned with clarifying these relationships and focusing the nation's policymakers on the investments that need to be made.

Another problem addressed by this study is to help educational leaders develop a host of policy arguments, leading to increased investment in education and human knowledge. The National Education Association argues for more funding for students and schools by calling legislatures "greedy politicians" (NEA, n.d.). The Association goes on to say politicians use the reduced educational funding to pay for tax breaks for their corporate donors. This is not the type of persuasive argument educators should use to encourage investment in education. An article by Eric Hanushek (2004) identifies another key issue as to why the government is reducing funding for education. The movement to hold schools accountable for performance with standardized tests has led to budget cuts in education. Testing has grown in the US, at significant cost to the system, and schools not meeting performance mandated outcomes are losing funds. Hanushek explains that educators are arguing that obviously more money is needed to improve outcomes. This has also not been an effective approach to encourage policymakers to increase educational funding. Given these problems, research questions were developed to create data addressing these concerns, with the hope that educational policy arguments can be positively affected.

The Research Questions

Since education has exploded around the globe, while economic growth has also expanded rapidly, the study now explores the following. What are the relationships between education and human knowledge investments and economic growth? Economic growth is the rate of increase in GDP over time and human productivity is the rate of output of products and services per worker, usually growing from investments in capital or people. Can educational and human knowledge investments lead to a positive comparative economic advantage for a nation? Do these countries' decisions on educational expenditures, primarily by the size of the investment or by making larger investments in a level of education, such as tertiary education, indicate what educational investments are most effective in creating a comparative advantage in our global, international markets? Tertiary education is all post-secondary education beyond K-12, and this includes universities, trade schools, and colleges.

These are broad research topics and much of this has been explored in detail, as shown in the literature review. In the literature review process, research explores seven independent variables driving economic outcomes. The literature will examine educational attainment, public educational expenditures, private spending on education, and business expenditures on training to see what their impact is on individual income, national income, GDP growth, and productivity, for the United States, other countries, and the world. The other three independent variables are the growth in academic journal articles, research and development expenditures, and patents. These three independent variables measuring the growth in human knowledge will be analyzed in the literature review for their impact on economic growth and productivity. The research will also examine the impact on returns for individual firms and industries. Data will be examined for the United States as well as many other countries. Where the research is lacking, quantitative analysis will be conducted with the purpose of augmenting and strengthening the scholarly arguments for improved investments in education and human knowledge. The three variables shown to be lacking in the literature review are training expenditures and private spending on education for the education independent variable, and the growth in academic journal articles for the human knowledge independent variable. These are the three variables in the title that are the primary focus of the research.

The study examined the relationship between these three independent variables and the dependent economic variable measured by National GDP over time. GDP is the most consistent and reliable economic variable used, having been accepted since WWII by all nations. GDP measures all goods and services for a country, year by year. Economic growth is captured in the changes in GDP over time, and GDP per capita is standardizing GDP as a ratio to the population. Productivity, at a national level, measures the GDP output as a ratio of labor inputs. Improvements in productivity mean labor is producing more output per worker, and this is captured in positive increases in GDP at the national level. In selecting one dependent economic variable for analysis, GDP is the best choice.

The Hypotheses And Rationale

The three hypotheses based on these research questions are as follows (Statistical Matrix in Appendix A). Training expenditures as the independent variable is positively related and a determinant for the dependent variables of national and global GDP. The rationale for this hypothesis, in the literature review, is based on the research already conducted measuring the statistically significant relationship between training expenditures and the individual firm. Denison (Kerr, 1994) defined a key variable for economic growth to be training expenditures. These expenditures are made by corporations and are in addition to public education. Denison examined the relationship using residual data and his growth accounting methodologies; however, I could find no research using aggregate training expenditures and national economic outcomes. It is reasonable to assume the growth in individual firms taken as a whole will positively impact a nation’s economic growth. However, growth in training expenditures may or may not lead to growth in GDP in the aggregate. GDP growth may or may not be positively related to gross training expenditures as a determinant. The results may suggest the need for national policies to consider the importance of increasing investments in training expenditures to influence the GDP growth of the country.

For the second research question, the hypothesis states that private spending on education as the independent variable is positively related and a determinant for the dependent variables of national GDP data by country. The rationale for this hypothesis is based on research already conducted on the relationship between private education spending and economic outcomes. Private spending on education is generally comes from the families of students. Again, the research by Denison in the literature review specifically refers to the positive relationship between private spending on education and economic growth. The technique used took data from the residuals, and this must be accepted as valid and reliable in order to accept these conclusions. Private spending on education has been researched and it shows a positive impact on individual incomes in several studies. These findings could support the hypothesis that total private spending on education by country will be a determinant of positive national GDP results. These results might then suggest that national policies that choose to stimulate these investments may be a positive influence on economic outcomes.

For the third research question, the hypothesis states that the growth in academic journal articles as the independent variable is positively related and a determinant for the dependent variables of national GDP data by country and globally. The rationale for this hypothesis is based on the research in the literature review. Like the education variables previously mentioned, Denison found a statistically significant relationship between the growth in human knowledge and economic growth. As previously stated, this relationship is based on a derived variable from residual data. In the literature review research and development expenditures as well as patent growth have been shown in cited studies to influence economic outcomes. One study demonstrated the relationship between academic journal articles and patents. Another study showed that academic journal articles, along with patents, acted as a determinant in the formation of a knowledge-based economy. The growth in academic journal articles may or may not be a determinant of the positive growth in GDP outcomes. These results might lead government policy to increase the support of universities that yields increases in academic article publications, particularly doctoral-granting universities doing high to very high research and development activities, with the intent to improve GDP outcomes. Since these three variables have seen growth over time and this corresponds to positive economic growth over the same period, while other education and human knowledge variables have shown significant relationships with economic outcomes, these rationales support the hypotheses to be researched.

Strengths And Limitations Of The Study

Education has been studied as a predictor of effective democratic practices, perhaps as the greatest defense against tyranny, as described by Jefferson (Burke, 2009). Social changes are seen as likely outcomes of educational initiatives. As an example, in *The Economics of Education* (Lochner, 2020) studies cited found increases in educational attainment significantly reduced violent and property crime. Research in health outcomes has been studied as being influenced by our educational system. For instance, a paper by Cutler and Lleras-Muney (2006) concludes there is a large and persistent association between education and improvements in health outcomes. Cultural enhancements in the arts, the growth of museums, symphonies, and the growth of literature could all be examined as outcomes of the growth in education and human knowledge. Boylan (2000) finds that there are more university museums and galleries in the world today than at any time in history, and some have the most important collections in the world. However, the limitations of this study will only focus on the relationship between education, human knowledge, and economic outcomes. Although a limited analysis, it still remains an expansive topic.

These limitations do not reduce the importance of this analysis for developing educational investment. In the literature review, the historical explosions in education and human knowledge show the relationship with the expansive growth in a host of economic outcomes. This study could help educators and policy leaders create another two centuries of a continuation on the growth curve for education, human knowledge, and GDP. The strength of this research would then have significant relevance, if only as a partial catalyst for positive change.

Summary

This issue is vital for our future. In 2017 education expenditures were 13.9% of the total U.S. budget, while education expenditures dropped the next year to 13.1% of the 2018 budget (Macrotrends, n.d.). For 2022, education expenditures dropped by -7.7% compared to the higher level of 2021 spending (U.S. Spending, n.d.). More than 30 million adults in the United States cannot read, write, or do basic math above a third-grade level (Resilient Educator, n.d.). The high school dropout rate rose to 5.8% in 2020 (USA Facts, n.d.). College enrollment dropped in 2019, and then it dropped another 2.5% in 2020. That same year community college enrollment dropped 10% (Smith, 2021). These very recent statistics demonstrate a change in our investment levels in education and human knowledge, a downward trend and a reversal of the previous growth in funding. The statistics addressing educational gaps also identify the additional work that needs to be done to grow the education and knowledge capabilities of our people. The literature review shows the positive economic impact of investing in education, and this gives educators persuasive arguments to encourage continued growth in educational funding. Let us examine the review of literature on the economic impact created by education.

II. LITERATURE REVIEW

There have been many landmark works dedicated to understanding the relationships between education and economic outcomes over the nineteenth and twentieth centuries, and into the new millennium. The review begins with Robert Barro and Jong-Wha Lee's (1993) book, *Education Matters: Global Schooling Gains from the 19th to the 21st Century*. This is perhaps the most broad and comprehensive time series analysis on the subject, and therefore, a good starting point. The authors described a reconstruction effort to provide data dating back to the 19th century for 89 countries, and they provide projections for educational attainment up to the year 2040 for 146 countries. The data reconstruction effort gives us transparency as to the validity and reliability of the dataset. They go on to use growth accounting and panel data regressions, a statistical model, to provide empirical evidence in the form of education as a determinant of economic development. Growth accounting examines the impact of labor, capital, and technology on total GDP growth. Barro and Lee (1993) focused on international student test scores, adult literacy surveys, and educational attainment levels. Their source data is considered to be more comprehensive for reconstruction and projection analysis by most researchers. They were also more detailed and transparent in their technical challenges in developing the data. The results suggest that increases in education levels since the 19th century are estimated to account for between one-fifth to one-third of economic growth in the United States (McGivney & Winthrop, 2016). However, with data over the stretch of two centuries and the challenge of validating accuracy, questions surrounding data quality are a legitimate concern for statisticians.

In 1964, Nobel Laureate Gary Becker published his book, *Human Capital* (Becker, 1964). He focused in part on the impact education had on economic growth. Analyzing individual families, he noted the negative impact dropping out of school has on an individual in the labor market. Unemployment is higher for those without education. Becker relates this to the relationship between poor families and their children's higher dropout rates. Also, data showed that the relationship between parents' earnings and the earnings of children was not strong, but more strongly related when the parents are poorer. He attributed this difference to the ability of wealthier families to invest in their children's education. This led Becker to promote the concept of government loans for higher education, with the premise that these students would pay higher taxes from higher lifetime earnings, resulting from these investments in education, and therefore create more wealth for the nation.

Additionally, Becker sees the reduction in the size of the family as another indicator of social change. Becker examined the theory of Thomas Robert Malthus, put forth in his book, *Principles of Population*, written in 1798. Malthus hypothesized that people marry earlier, and birth rates rise when incomes increase. Malthus saw industrialization as raising incomes, and this would lead to overpopulation and cause severe negative economic conditions to follow, such as worldwide starvation. However, Becker argues that larger families were seen as a buffer for economic difficulties, with more family members contributing to the food stocks in an agrarian economy. Rather than attend school, children could go to work at an early age. Also, before the education revolution, coming from the tremendous growth in public education started in the late 1700s, and improvements in medicine led to disease elimination and rapidly rising longevity rates, infant death was high in agrarian cultures of the 1800s. Malthus' theory has played out in some areas of the world, specifically in Africa (Ose, 2021). However, Becker found that as we have industrialized and incomes rose, family size has shrunk, and with it, the parents have been more willing to invest in their fewer offspring by contributing more to their education. This outcome was not seen by Malthus, and his theory has only applied to underdeveloped countries in overpopulated poorer nations. Instead, Becker gives examples of Taiwan's 50% reduction in the birth rate between 1960 to 1975, while high school graduation rates doubled, along with their remarkable economic growth during this period. Mexico's birth rate dropped by more than one-third starting in 1975 and school enrollments expanded rapidly. Mexico's GDP per capita was $1,476 in 1975 and had grown to $10,929 by 2014, an improvement of sevenfold in 39 years (Macrotrends, n.d.). Poverty still exists in Mexico but drops in birth rates and growth in GDP per capita is improving economic conditions. As investments in education increase, related to drops in population, economic growth is positively improving. Becker further argues that the increased taxes gained from higher lifetime earnings, resulting from higher education levels, also helps pay for the government programs supporting retirement plans. These programs reflect the move away from parents relying on a large number of offspring to care for them in their old age.

Furthermore, Becker (1964) hypothesized that a nation's income growth is limited by the reliance on the limits of available land and physical capital per worker. Physical capital is the investment in plant and equipment that has driven industrialization. These limitations of land and capital are seen as the cause of the long historical lack of growth in income per person. But why has there been a huge expansion of per capita GDP, and consequently incomes, in the modern era? The modern era I refer to is from the late 1700s until today. Becker postulates that the growth in income we have had in recent history could be due to the growth of scientific knowledge and the development of technology, due to the increased levels of education. He notes that all countries that have consistent growth in incomes have also had large increases in the education and training of their people. An example he gives is the case of Japan. The Japanese imported nearly all of their sources of energy, and yet they grew their economy rapidly after World War II, utilizing the strength of an educated workforce. He also explains the impact education and new discoveries have had on agriculture. Farmers were usually the least educated in society, but today, farmers must deal with hybrids, new breeding methods, fertilizers, complicated new farming equipment, and complex future markets for their commodities. Their education and new technologies have reduced the demand for physical farm laborers while increasing the productivity of their output, leading to more migration off the farm and into industrial work. Becker concludes that we are now in the era of nations expanding their human capital through education, in order to create economic prosperity. For scientific evidence, Becker refers the reader to the data collected on the subject by Denison (1985).

Predictive Empirical Evidence

In Edward Denison's (1985) book *Trends in American Economic Growth,* he took what he called growth accounting methodology, a process he pioneered, and used it to track changes in the trend of per capita income from 1929 through 1982. This is based on the premise that national income growth is driven by increases in physical capital, increases in the size of the labor force, and all other residual factors. Residual is a statistical term for the unknown variables not specified in the analysis, and as such, they cannot be named because they are unknown. Denison focused explicitly on accounting for education in the residual measure. He used fluctuations in business cycles to compute potential output and compare it to actual output, thereby allowing him to break down some of the specific components in the residual. Output is a term in economics, and as mentioned earlier, it is all products and services. He developed tables that allowed him to isolate inputs, like education, and identify output per unit of input. He found that the increases in educational growth were responsible for 16% of total potential output and 30% of the growth of the productivity of the people employed in the private sector. Productivity gains come primarily in manufacturing and new industry creation, not in the service sector or government sector. It is interesting that correlation analysis was not applied directly to the per capita income gains to measure the impact of education, instead relying on the analysis of the residual. However, the growth in physical capital contributes less predictive significance than the total residual value does. Therefore, identifying education in the residual was seen as of greater value in explaining the relationship to the growth in per capita income.

Clark Kerr (1994) references Denison's per capita income study (1929 to 1982) in his book, *Troubled Times for American Higher Education*. Clark shares the conclusions made from Denison's research on what drives advances in real wages, improvements in the standard of living, and thus, in the base from which per capita taxes are paid. To achieve these numbers, negative contributions are taken out, such as fewer hours worked per employed person, in order to derive the results. Denison concludes that 20% is contributed from education per worker and 40% is contributed from advances in knowledge. This means the majority of gains come primarily from education, outweighing the contributions of the economic variables of capital per worker, improved resource allocation, and economies of scale combined. Some key concerns in this form of measurement are attributed to the combining of education as formal school completion by the number of years, private spending for education, and corporate on-the-job training. Private spending includes spending by households and all other private entities. Also, the analysis is focused on residual data and assumes education's contributions can be identified in the residual, rather than measuring education directly. Additionally, the analysis is focused on income rather than GDP, and further exploration of the relationship between education and GDP growth would be interesting. Rather than assuming income growth leads to GDP growth, and also assuming the residual analysis of the value of education is correct, we should ask what is the relationship between education expenditures and GDP growth. Research reviewed later will address this research question.

Denison (1967) in his book, *Why Growth Rates Differ*, began to analyze the impact of education on a nation's economic growth by doing a comparative analysis. He took data from 1950 until 1962 in the United States and Western Europe. Specifically, he analyzed data from the United States and Belgium, France, the United Kingdom, Norway, the Netherlands, Denmark, Italy, and Germany. He analyzed the amounts of education received by adding quality classifications, rather than merely relying on the growth in the number of years of schooling completed. Denison's quality classifications focused on the number of days in a school year and attendance records, which vary between countries. This was used to examine outcomes in earnings by country, and the growth in earnings is equated to the country's economic growth. The specific conclusions were as follows.

First, in the period from 1950 until 1962, the amount of schooling increased in all the countries examined. Next, the total amount of increased education in the United States was greater than in any of the European countries. Thirdly, Denison found that incremental increases in education in Europe raised the quality of labor more than in America, and this incremental increase contributed proportionately more to the countries' growth rate. If you are at a lower level of quality, incremental gains tend to be larger than in a country at a more mature level, and the mature countries' incremental gains are not as great. Nevertheless, he also found that the growth in the quality of labor overall was greater in the United States, and this contributed more to the American total growth rate. Finally, there were significant variances in the amount by which the quality of labor was increased by education among the European nations. Italy was significantly below the United States in the educational quality of the workforce. These results suggest that the growth in education is driving growth in incomes, and with it, economic growth. However, Denison's unique growth accounting methodology and his quality of education classifications must be accepted as valid and reliable in order to accept his conclusions. When you make changes to your data, it is fair to ask whether or not the results are valid. Further research will examine more directly what education variables can be related to economic outcomes.

Many studies have been conducted to demonstrate a direct impact on an individual's salary level and lifetime earnings from their investment in education. Without any leakages, typically savings and taxes, GDP is equal to national income in national income accounting, just as assets equal liabilities for a company's balance sheet in corporate accounting. The accounting process forces them to balance, and if they do not, offsets are inserted. Therefore, based on this principle, I will examine some of these more comprehensive studies on the educational impact to individual earnings, understanding that these increases in income cumulatively drive up national income, and with it, GDP growth per capita.

Educational Impact On Individual Income

Denison (1967) shared some data for males in 1959 based on their educational achievement levels. The first group did not progress past 10 years of schooling. The second group completed 11 to 13 years of schooling and earned 20% (median earnings) to 30% more income (mean earnings). The third group completed 14+ years of schooling and earned 47% (median earnings) to 74% (mean earnings) more than the second group. I prefer the median wage since income is positively skewed due to a few high incomes, however, Denison provides both and we can see the impact of a few high-end earnings on the mean in comparison to the median.

Regardless of the selection, these results imply that education has a significant impact on an individual's earnings. However, perhaps this relationship is quite different today than it was in 1959. Let us analyze a more comprehensive longitudinal study.

A study cited by the Social Security Administration (n.d.) was entitled, *Education and Lifetime Earnings in the United States* (Tamborini et al., 2015), and it found significantly more lifetime earnings at each educational attainment level. The study used social security data over a 50-year period. The difference in incomes between an education of less than high school completion and a graduate school degree was a 270% difference in lifetime earnings. The biggest gain from level to level was between some college and a college degree, where the graduate saw a 38% greater amount of lifetime earnings for completing the degree. The smallest gain was between some college and a high school diploma, where some college education created an increase of 11% in lifetime earnings. However, in absolute terms, this amounted to $170,000 dollars. Those individuals who never completed high school compared to individuals with graduate degrees earned an average of $1,920,000 less over their lifetime. It appears that education has a significant economic impact on the individuals' economic prosperity.

The United States Census Bureau (2011) added to this analysis with a news release of its own. They drew the same conclusions but clarified that education's impact on lifetime earnings was five times more than other demographic factors. Many factors, like race and origin, gender, citizenship, English speaking ability, and geographic location impact lifetime earnings, but none of these factors had anywhere near the impact of education. The study concluded that there is a clear and well-defined relationship between education and earnings and that higher education levels lead to better jobs with higher levels of pay.

Is this relationship still valid since 2011? A study from the U.S. Bureau of Labor Statistics (Torpey, 2021) used a stratified sample of 84,805 participants. A stratified sample is a sample taken by education level, thereby guaranteeing a suitable sample size for every educational level attained. The author found those with no high school diploma had a median income of $20,028 annually. High school graduates make 62% more. Vocational associate graduates earned 38% more than high school graduates. College graduates had salaries that are about 35% higher than associate graduates. Master's degree holders are making 28% more than college graduates, and this amounts to a salary that is 388% higher than high school dropouts. This relationship is significant and enduring. These three studies span over 70 years, and there is every reason to believe there will be no change in this positive predictor of income for the foreseeable future.

However, these income gains by educational attainment are not limited to the United States. China shows income by education level in 2011 (Statista, 2012) to be positively related as they are in the United States. Elementary school education yields an average annual income that is over 41% less than a high school graduate. High school graduates make 243% less than those attaining some college degree, including a junior college equivalent or higher. In Japan (Salary Explorer, n.d.) the difference between a high school graduate and a college degree is 24% in additional earnings, while the Master's degree raises income by another 29%. Furthermore, these comparisons are for individuals in the same job with the same experience level. For Germany, a Master's degree gains an average of 14% over the Bachelor's degree. Also, those with college degrees in Germany make over 17% more than vocational workers (Housing Everywhere, n.d.). In India (Dhanaraj, 2021) data is scarcer, but analysis shows that earnings grow over time with experience. In addition to the value of experience, between the age of 55-59, degreed Indian workers earn 2.3 times the income of workers with lower education. These five examples, China, Japan, Germany, India, and the USA, represent $47 trillion of the world's GDP, about 56% of the worldwide total (World Bank, 2020). Finally, for the global averages, the world economic forum finds university graduates are more likely to be employed and they earn 56% more than those without a degree (Gray, 2017).

A side note of significant importance is the recent concern over the net benefit of higher education. These numbers are averages, and variance plays a key role for the individual. The net impact is always with consideration for lost wages while attending school and the personal cost of education. In the USA, college debt has reached $1.75 trillion (Hahn & Tarver, 2022). There are three key factors driving these enormous debts from education. The first is the variance in cost for the specific institution. Public four-year college average cost is $10,740 a year and private nonprofit institutions average $38,070 per year in the United States (Hahn & Tarver, 2022). Lower costs can be achieved by first attending community college, but the difference in cost between these types of schools is $109,320 over four years. The next factor is the cost of interest. Federal student loan rates varied over the last 17 years but typically have fallen between 3.73% to 7.27% interest. Based on the time frame to pay off the debt, some students pay more in interest than the principal amount of the loans (Kirkham, 2021). The average student loan debt is $28,950 per borrower, and 55% of public college students and 57% of private college students take on debt (Hahn & Tarver, 2022). Finally, career choice is critical. Careers in medicine pay the most, with annual salaries for some doctors reaching above $250,000 a year. Pilots make over $160,000 a year, on average. IT Managers and Petroleum Engineers earn in the range of $150,000 annually, and Attorneys and Business Managers exceed the average of $140,000 per year (Mcintyre, 2022). Other majors do not fare as well. Ministry, Counseling, Journalism, and

Teaching typically have starting wages below $40,000 per year (Guina, 2020). Is it still true that education leads to higher incomes, and with it, greater economic growth? Yes, gross incomes are higher on average, but net income gains may not indicate that education is the best investment for achieving higher lifetime wages, depending on their earnings and the total cost to the individual. However, Denison's research shows that economic growth appears to be an outcome of the growth in education, and with it, the improvements in human knowledge (Kerr, 1994).

Educational Influence On Cognitive Ability

From the beginning of these studies on the impact of education and human knowledge, many have challenged this premise of investing in the development of human capital. Rather than challenging the cost/benefit return on investing in education for the individual's lifetime income, the original challenges came from the assumption that education was responsible for improvements in capability. Becker (1964) cited a summary of these challenges when he first defined the idea of investing in human knowledge in his landmark work. Critics have argued that the true rate of return on lifetime earnings is exaggerated in the extreme because individuals differing in education are also different in other characteristics, and these characteristics cause their income to differ systematically. Perseverance, or grit, is one of the characteristics mentioned (Becker, 1964). Contacts and social connections are another variable driving educational outcomes, and therefore, income gains. Race and gender should also be considered. Individuals living in a rural environment are another factor (Becker, 1964). However, probably the most persistent argument is over the correlation between education and innate ability. The argument is that the underlying variable creating income growth is the intelligence certain individuals are born with and not the intervening variable of education. According to some, our life outcomes are determined by breeding and genetics. The measure used to identify these variations in innate ability is the IQ test (Becker, 1964).

The intelligence quotient, or IQ test, was developed in 1904 by French psychologist Alfred Binet (Cherry, 2022). The premise of the test design was to set average intelligence at 100 with the standard deviation set at 15 to 16 points. Psychologists assumed that innate intelligence distributions would not change, because you are born with intellectual potential, and nothing can change your innate intelligence. When psychologists worked to revise the test, they had a sample test group take the test and they discovered these test takers scored much higher on the old test. Test score increases have been continuous and linear for decades now. Someone scoring an average of 100 points in 2015 would have scored 130 points in 1915, an increase of two standard deviations (Bailey, 2015). The test is continually revised to force the average back down to 100 points. This was discovered by James Flynn, and it has come to be known as the Flynn effect (Baker et al, 2015).

Several explanations have been given for this effect. Why are the vast number of human beings across the globe getting smarter decade by decade? Are we just developing better test-taking skills? Is it due to the modern technologies we are using? Is it from better nutrition and medicine eliminating infectious diseases? Or is it a reduction in lead in our gasoline? Another factor could be the expansion of public education (Pietchnig et al, 2015).

Richie and Tucker-Drob (2018) published a meta-analysis of studies exploring the effect education has on intelligence. They examined 142 effect sizes from 42 data sets with over 600,000 participants. Some of these studies explored education's effects on intelligence after controlling for earlier intelligence. Other studies used compulsory schooling policy changes as instrumental variables, and the last group used regression-discontinuity designs on school entry age cutoffs. A regression-discontinuity design is a quasi-experimental pretest-posttest design that aims to determine the causal effects of interventions. The authors did not find a greater propensity for intelligence leading to more education. Instead, they found consistent evidence of the beneficial effects of education on intelligence. Gains of one to five IQ points were observed for every additional year of education. Analysis indicated the effects persisted across the individual's lifespan and were present in all broad categories of cognitive ability studied. Education appears to be the most consistent, robust, and durable method to be identified for raising intelligence. Potential at birth is not as important as educational opportunities. Regardless, not all changes to the educational process have yielded a better educated workforce with greater knowledge. Depending on changes to the educational system, negative educational outcomes can drive down educational achievement and the growth in human knowledge, and with it, economic results.

Education And Negative Economic Outcomes

All of the data reviewed to this point has focused on the increases in economic growth related to the increases in education. However, in a six-year period from 1974 through 1979 U.S. gross domestic product growth per worker fell to an annual rate of 0.0% (Kerr, 1994). The drop in GDP growth per worker followed a business downturn, and this downward business cycle was related to the oil embargo and the hyperinflation the world was experiencing, but it also caused some to focus on the relationship between economic growth and education. One distinguishing factor in the analysis showed the comparison of the USA to other countries around the globe. Over the same six-year period Japan and West Germany posted annual GDP per worker growth rates of 2.9%, France had 2.7%, Italy was at 1.7%, and Canada and Great Britain had 1.3%

yearly growth. The oil embargo and hyperinflation were affecting the world, but there was something distinctive about the collapse in GDP growth for the United States, and this caused an analysis of educational metrics.

One analysis discovered a decline in SAT scores starting in 1963 and ending in 1977 (Kerr, 1994). This registered a 5% to 10% decline in math and verbal scores respectively. The drop in test scores was followed by a 2 to 4 year lag of declining productivity measures. There was also a drop in scores for college graduates taking the Graduate Record Examination. The decline in the GRE for verbal scores starts in 1965 and reaches the bottom in 1982, while math scores started down at the same time and bottom out in 1975. GDP growth per worker recovered to 0.8% per year in the 1980 to 1987 time frame. The recovery of test scores also started in the 1980s. This analysis led to the assertion that declining test scores indicated declines in the quality of education, and the drop in educational attainment drove down productivity results for the country.

Kerr (1994) defends education and hypothesizes that many other factors could be blamed for the falling GDP per worker. He argues that only about 5% of the workforce were those taking the SAT and GRE in this time frame, and therefore, they could not have impacted GDP growth at this level. However, the decline was only from a 1.9% GDP per worker growth rate in 1961 to 1973, dropping down to a low of 0.0% in 1974. Also, the decline in test scores preceding it had continued for over a decade. This level of reduction in productivity does not require the entire workforce to fail in education quality, and the test scores could be representative of an overall decline in the educational system, impacting many more workers. But we need to accept Kerr's 5% estimates of workforce participation in order to question the impact of the test scores on educational performance. In addition, Kerr blames three other reasons for the decline:

government policies, the quality of management, and the 1960s counterculture and its effect on values. Suggesting government policy decisions were the cause needs to be supported with specific evidence, of which Kerr provides none. The same is true of the accusation that business management was failing. What changed in management in 1974, as compared to business management from 1970 to 1973? No explanation is offered beyond conjecture. Finally, to suggest the counterculture of the 1960s led to workers not working hard suffers from the same lack of analysis. Why did the counterculture enter the workforce throughout the 1960s and work hard through 1973, only to ease up starting in 1974? Fundamentally, it is contradictory to praise education for the gains in economic growth reported throughout the century but then refuse to take responsibility for declines when they occur in the 1970s. If we agree with Denison that 60% of economic growth is related to education growth and the growth of human knowledge, then the decline in test scores relating to the decline in GDP per worker should be acknowledged as a reasonable analysis. Were there any other indicators of issues with education during this period?

The report *A Nation at Risk* came out in 1983. It found the same issue, that SAT scores had dropped between 40 to 50 points for Math and English respectively from 1963 to 1980. Also, the report referenced comparative tests with other nations in the 1970s, showing that out of 17 tests American students finished last seven times. The commission called for many changes to our educational system, and this remains a controversial report to this day. The report characterized education as a rising tide of mediocrity, and they saw this as a threat to our nation's future, while even going so far as to surmise that education was failing to meet our need for a competitive workforce. Many analysts acknowledged the link between falling test scores and reduced economic growth, and this relationship between SAT test scores and economic outcomes corresponds with the other relationships already identified. The outcome suggests a connection, but do test results predict economic outcomes?

Four scholars, including the lead researcher, Hanushek from Stanford University, conducted a study to determine the connection between international test results and their economic impact on their respective countries (Hanushek et al., 2008). Their study reviewed 12 international test results in math and science over various grade levels for 50 countries. The tests were begun in 1964 and this study covered the entire period until the year 2000. They concluded that the concerns of *A Nation at Risk* were valid, in that the level of cognitive skills development of a country's students has a large effect on the economic growth rate of the nation. The average number of years of schooling does not offer the same precision of understanding of the cognitive gains, since a year of schooling in Japan is considered the same as a year of schooling in Papua New Guinea. Their findings also found that the more open the economy is, participating in international trade, the more important human capital development is for economic growth.

The researchers developed a norm and constructed an index of cognitive skills levels to get comparable scores for each test. The USA testing process used by the National Assessment of Educational Progress was selected as the norm. Of the nations in the analysis, 30 of the 50 nations are free market economies and are members of the Organization for Economic Cooperation and Development (OECD). The other 20 countries are at lower levels of economic development (Hanushek et al., 2008).

Their first level of analysis compared growth in average school attainment to the economic growth rate. Across the 50 countries, they found that each additional year of schooling increased the 40-year growth rate for GDP by about 0.37%. This amounts to a minimum of a 12% increase in a country's normal economic growth rate. Education, on average, augments economic growth. Next, the analysis was conducted by comparing average test score performance to economic growth rates. If a country's test scores were higher by a 0.5 standard deviation above the average test score, then the country's annual growth rate was, on average, 1% higher than the comparable country over the 40-year period. The idea of understanding differences in GDP growth rates for individual countries is greater with the test score analysis. When comparing differences between nations, years of educational attainment could only explain one-quarter of the difference. When comparing differences in test scores between nations, almost three-quarters of the differences in growth rates could be attributed to this variable. Their analysis went on to review other variables like the fertility rate of a country, and this did not impact economic growth. Their overall conclusion was that a highly skilled workforce can raise economic growth by about two-thirds of a percentage point every year. Over the time frame studied, Japan and Finland moved to top performers, the United States and Germany settled as average performers, and the Philippines and Albania remained low performers (Hanushek et al., 2008). Education excellence, as defined by top test scores, determines which countries will thrive in our global economy. Also, falling test scores indicate setbacks for a nation's economic growth. Another study conducted by Barro (2001) confirms these findings. Scores on internationally comparable examinations, particularly in science, have a strong positive relationship with economic growth. They also found gains from changes in the average years of educational attainment, but the quality measure of test scores is much more important in predicting economic growth.

There are other indicators of educational setbacks for education and the world economy. The United Nations (2021) recently published their assessment of the impact the COVID-19 pandemic has had on the future economy globally. They identified countries such as Brazil, Pakistan, India, South Africa, and Mexico who were suffering substantial losses in math and reading skills, sometimes proportional to the length of school closures. These difficulties are exacerbated by economic inequalities around the world. Those separated by the digital divide have fallen behind in their education, and it has been particularly hard for primary school children. The peak of the pandemic saw school shutdowns impacting 1.6 billion students. Less than 3% of all government stimulus packages worldwide are being spent on education, and therefore, it does not appear that much is being done for learning recovery programs. Given the educational impact, the UN estimates that children living in learning poverty (not having access to the digital world) could jump from 53% to 70% in low and middle-income countries. To quantify the economic impact, they calculated a present value loss of roughly 14% of the current gross domestic product. Students of the pandemic are facing a $17 trillion loss in lifetime earnings, and this income loss will cascade throughout the demand for products and services worldwide for years to come.

These problems also impact higher level income economies. In the United States, *Education Week* (Herold, 2020) found that 84% of teachers were concerned with the level of absenteeism of low-income students. These students lacked internet access, computer equipment, and internet training, and yes, the digital divide in America is the main cause of attendance issues (Herold, 2020). In the Fall of 2020, Herold notes that Stanford researchers estimated students lose between one-third of a year to a full year of learning in reading, and about three-quarters of a year to one year in mathematics. In response, the Biden administration in March of 2021 established $122 billion in funding to help learning recovery efforts (U.S. Department of Education, 2021).

Educational changes impact the world economy positively or negatively. The data, however, strongly suggests that economic outcomes, be it personal income, national income, GDP growth, GDP growth per capita, national productivity, or any of these economic outcomes internationally, in poor, middle, or higher-level nations, are strongly related to the development and performance of the predictor variable of education, and with it, the growth in human knowledge. The citations include Tamborini (2015), Denison (1985), Kerr (1994), Herold (2020), Hanushek (2008), Gray (2017), and the United Nations (2021). I have discussed how most of human history has been without much public education, fundamentally up to the late 1700s. The world economy during this time has been described as an agrarian economy with some merchant exchange that was a marginal portion of all business activity. As public education started to spread the world economy transformed into an industrial economy with far more international trade. Where are we today?

The Knowledge Economy

In 1968 Peter Drucker published his book *The Age of Discontinuity*. In it he developed the idea of significant changes that were transforming economics, politics, and society. Drucker defined four major areas of discontinuity. First, he saw technology transforming all of our activities. Next, he predicted an evolution from international trade to a global economy where economic practice would extend beyond national policies and institutions. Thirdly, from this would come pluralistic institutions, like global corporations and international financial institutions that would present major social challenges. Lastly, the new universe of knowledge, based on mass education, would have significant implications for work, leisure, and leadership.

Drucker described the economic future as the knowledge economy, and he defined this as an economy where workers are the integral element.

Over fifty years later, have these predictions come to fruition? As of 2021, the global technology sector has a value of $5 trillion worldwide (Eria, 2022). Most of us cannot imagine working or living without technology. Second, Forbes lists the Forbes 2000, the top 2000 multinationals worldwide, as having a market capitalization of $74.5 trillion (Contreras & Murphy, 2022). Next, the third important change Drucker identified is the challenges these organizations present and the major difficulties they are creating (Connect Us, 2019). Job opportunities are lost as corporations shift jobs offshore to lower-cost areas. They can create monopolies in markets, consumer choices drop, and they can threaten the environment with their business practices. Now the examination turns to the prediction of the development of a knowledge economy.

The analysis starts with the United States economy. As of 2020, 44% of the economy was in the government sector (Trading Economics, 2022). The service sector of the private economy is now at 76.89% (Statista, 2021). Since the private economy is 56% of the total economy, the service sector represents about 43% of the total economy. These two sectors, government and services, represent over 87% of our economy. Neither of these economic activities requires much in the way of capital investment. Capital is primarily for manufacturing, thereby creating productivity gains, and with it, economic growth. Manufacturing is shrinking as a portion of total economic activity, and without capital growth, productivity growth must come primarily from educational growth in our human capital. Without new discoveries, innovations, and knowledge growth, our economic growth will disappear. It is fair to say we are a knowledge economy now.

What is the transformation to a knowledge economy like for the rest of the world? Let us analyze the leading economies. In 2020, China's government expenditures were 37% of the total GDP (Knoema, 2020). For the private sector, China's service sector represents 54% of the GDP (Mullen, 2021). This means the government and the service sector represent close to 71% of the Chinese economy. In 2019, Japan's government expenditures were 38.7% of the GDP (Trading Economics, 2019). In 2019, in their private sector, 69.3% is in the service sector (Statista, 2019). This represents approximately 81% of the Japanese economy. In Germany, government spending reached 51.1% of the GDP in 2020 (Trading Economics, 2020). The service sector is 69.8% of the private sector in 2021 (Statista, 2021). This is about 85.9% of their total GDP. Great Britain's government expenditures were 52% of GDP in 2020 (Trading Economics, 2020). Their service sector in the private economy was 72.8% of the 2020 GDP (Statista, 2020), and this represents roughly 86.9% of the total GDP. Finally, for 2021, India's government expenditures were only 17.6% of the GDP (Trading Economics, 2020). Their service sector in 2020 was 48.89% of private enterprise (Statista, 2020), which means this represents about 58% of the total GDP. Including the USA, these are the top six economies in the world. With India, the analysis shows that as we move toward less highly developed countries the transformation to a knowledge economy is not as prevalent. However, these six economies represent over 59% of the total worldwide GDP, and in the global economy, in 2018, agriculture represented only 4% of the total GDP (World Bank, 2022). Manufacturing data is less available, but in 2011 it represented 16% of the world economy (McKinsey, 2012). This data is summarized below (Table 2.1)

Table 2.1 Percentage of Economy in Government and Service Sectors

Countries	Government Sector	Service Sector	Govt. and Services
United States	44%	43%	87%
China	37%	34%	71%
Japan	38%	43%	81%
Germany	51%	35%	86%
United Kingdom	52%	35%	87%
India	18%	40%	58%

The agriculture and manufacturing sectors will not disappear, but the majority of the world has transformed into a knowledge economy, and a knowledge economy is dependent on continued investments in education.

Global Investments In Education

According to the research reviewed so far, education and knowledge are predictors of economic growth. Denison (Kerr, 1994) suggests up to 60% of economic growth is predicted by these two variables. Since economic growth drives income growth, and this is essential for growth in GDP per capita, then all of civilizations' aspirations for the elimination of poverty, human illness, and the creation of greater social equity and justice may be in peril without more educational investment. What is the pattern of educational investment in the world today?

The World Economic Forum (Charlton, 2019) published OECD data from 2016 on the educational expenditure levels of their member countries. Luxembourg was number one, but they are considered an outlier because of its size. The United States was number two for the highest expenditures per full-time student. When the data is examined more closely, the US is reaching higher levels because of the much higher investments in tertiary education. Sweden, the United

Kingdom, and Canada round out the top five countries. Australia and New Zealand are average for the group, with about half the amount invested at the level of the top five countries, and Mexico and Columbia are at the lower level. Keep in mind, the OECD is comprised of the leading democratic free market countries in the world, so they do not represent all countries. Their 38 members, however, account for over 62% of the global GDP (International Monetary Fund, 2022). Of course, there are other ways to examine public investment levels in education. The author used additional data from the OECD and also examined education expenditures as a percentage of all government spending. In this analysis, the top five countries are Chile, Mexico, Brazil, New Zealand, and Switzerland. These countries are dedicating 13% to 17% of their government spending to this critical future investment. The United States is around the average level with about 11% of their total government spending dedicated to education. In order to become the world leader, using this metric, the United States would need to increase its investment in education by over 50% above present levels (Charlton, 2019).

However, historically the United States has been increasing its level of investment in education. Public education expenditures were 2.33% of GDP in 1950, and by 2015 this had grown to 5.47% of GDP, an increase of almost 235% (Our World in Data, n.d.). By 2015, the American economy had grown over 62 times its size compared to GDP in 1950, but public education expenditures have grown 145 times over. The United States has been doubling its investments in education. Has this been a better investment for GDP growth? And how does the United States compare with educational investments by other nations today?

Predictor Elements Of Education

A study was undertaken to see if there was a connection between public investment in education and economic growth in the US (Cullison, 1993). The author used the Granger-Causality tests and the Ireland-Otrok VAR model. VAR is the vector autoregressive model. Starting with the causality tests, the analysis used 22 government variables, including economic development, income support, and transportation, all of which can be viewed as potential investments for economic growth. Total government expenditures were also examined. Only two variables had significant *T* test results, and those were education and labor training. The adjusted R^2 results were 0.10 and 0.14, respectively. This means that 10% and 14% of the economic growth is explained by education and labor training. Since education and labor training have statistically significant impacts on private economic growth, the VAR model was used to examine those variables. The VAR model was estimated for the period of 1953 to 1991. The analysis used one, two, and three-year lags. An increase in educational expenditures may yield results over multiple years, and the lag measures capture this data. Real GDP is deflated, eliminating the impact of inflation. The results found that education and labor training might be expected to result in a cumulative increase in the level of real private GDP. Education and labor training have statistically significant and numerically significant effects on future economic growth, although the impact of labor training was only significant below the 0.05 level in the first-year lag analysis. This could be inferred to represent the shorter time period required for labor training and its more immediate effect versus the longer-term impact of education. The author recommends education and labor training expenditures as likely sources worthy of further examination to drive economic growth. This methodology now starts to examine the direct relationship between education funding and economic outcomes. The researchers are not examining residuals as Denison did or inferring increases in personal income creates greater national income, and with it, greater GDP per capita. They are describing the direct relationship between the predictor variable education funding and the outcome variable economic growth.

The one exception to take with the statements in the study presented is our persistent labeling of education as expenditures. In economics, expenses are costs that can unnecessarily drive up the overhead costs of an economic activity, and therefore, should always be managed to the lowest possible cost level. Cost is considered a necessary evil. An investment, however, is different. Investments are additional costs deployed to create a higher return. An investment returns revenues that repay the cost of the investment, and these increased revenues go further and create a rate of return above the initial cost. Educational investments generate higher incomes with higher tax rates, and these new future tax revenues, over time, are greater than the costs of educating our people, creating a positive return on investment. Last year, the U.S. invested heavily in infrastructure, viewing this investment as necessary to renew economic growth in the country. However, this study suggests education and labor training of our workforce may be a better investment than investing in transportation enhancements. There are further studies of this nature to discuss.

A study was conducted to examine internationally the impact of education expenditures on economic growth (Idrees & Siddiqi, 2013). This study used panel data for the 17-year period from 1990 to 2006. The cross sections used data from the G7 countries: United Kingdom, United States, Canada, Germany, France, Italy, and Japan. Seven developing countries were also used, and they included Pakistan, India, China, Turkey, Poland, Russia, and South Africa. The results concluded that there were long-run relationships between the variables of education and economic growth. Again, economic results from education are spread over multiple years, and so the focus is on long-term relationships. The authors also found that education expenditures are an important determinant of economic growth, implying that one dollar of increase in education expenditures brings about $20.85 dollars in increased Gross Domestic Product. Public education expenditures are an investment in labor that raises the productivity of labor, resulting in economic growth by increased output levels. By examining the differences between the G7 countries and developing countries, the authors also found empirical evidence of the catching-up effect. The impact of education is greater in developing countries than in developed countries. This effect comes from developing countries having a greater marginal productivity rate in human capital formation. A one dollar increase in education expenditures in developed G7 countries was a $21.85 dollars increase in GDP. Comparatively, a one dollar increase in education expenditures was a $27.29 dollar increase in GDP for developing countries. It is believed that this difference for developing countries is because they are able to replicate the methodologies of developed countries in the most cost effective way. The authors also point out that education not only increases the productivity of human capital, but it also ensures the implementation of modern technologies by lowering the costs of time and skills development, allowing people to adapt to new technologies quickly. Clearly, these two studies suggest that education is an excellent investment for growing the economy. The next study summarizes the results from education expenditures on economic growth in one meta-analysis.

Churchill, Ugur, and Lew (2015) completed a study examining the relationship between government expenditures on education and economic growth by conducting a meta-analysis. They used a sample of 237 estimates drawn from 29 primary studies. They conducted a hierarchical meta-regression analysis that examined the associations between economic growth and government expenditures on education. This gives us a good summary of this type of analysis. They concluded that the effect of education expenditures on growth is positive for developed countries. Interestingly, despite the work of Idrees and Siddiqi (2013), this meta-analysis could not find a significant association for less developed countries. This perhaps indicates that less developed countries, these being different from developing countries, have not reached the point of greater marginal productivity that has been achieved by developing and developed countries. The authors were careful to examine heterogeneity in empirical results. They found that factors like econometric specifications, publication characteristics, and data characteristics explain the heterogeneity in the literature. Heterogeneity is a non-normal distribution in your sample of studies for your meta-analysis. Publication characteristics, along with the other factors mentioned, can cause this outcome. Heterogeneity makes your results suspect of bias. They found no evidence of publication selectivity. Given all of these studies, we can conclude that education expenditures have a significant relationship with economic outcomes.

This analysis of public education that we have cited has been extensive and illuminating in multiple scholarly research reports . Now the analysis turns its attention to the two other elements identified by Denison (Kerr, 1994). First there is private spending on education, and secondly, there is on-the-job training derived from investments by individual firms in the private sector or labor training programs provided by the government. Corporations spend significantly to develop employee skills through their learning programs, and so the review begins here.

Corporate Educational Investments

Corporate learning and development programs are rather distinctive. The outcomes are focused on improving the economic results for the individual firms. The time commitments are much briefer, and the outcomes range from technical training skills development, interpersonal skills development, business skills training, and management and leadership development. Also, the investment is tied to corporate objectives, not to general economic outcomes. The data collected is usually managed by private business associations, and its data organization tends to be driven by these different purposes. In the United States, over the last 10 years total training expenditures have grown from $55.8 billion in 2012 to $92.3 billion in 2021, an increase of 65% in a decade (Statista, 2022). To compare, in 2020 the U.S. government spent $860 billion for the 2019-2020 school year, close to a 10 times greater investment in education than corporate training's investment in their employees (U.S. Department of Education, 2021). However, this is still a substantial sum being spent by private firms to create a comparative advantage in their market sector of the knowledge economy. The data for workplace training worldwide shows a value of $302 billion in 2007 with growth to $370 billion in 2019, just prior to the pandemic. This represents an increase of 22.5% in this fourteen-year period (Statista, n.d.). The lower growth rate might indicate a greater concentration of business training activity focused in the more developed countries' markets. What are the results of the research on training expenditures?

The Association of Talent Development (formerly ASTD) completed a study in 2000 to determine if training is a sound investment for corporations, or if it should be treated as an expense instead (Essex, 2000). The outcome was defined as the change in the value of the stock and its dividends, the true value to a shareholder. They found that companies that spent $680 more on training per person than the average firm increased their shareholder value by six percent the following year. These top companies for employee development had a 37% increase in share value, while those firms below the average investment in training had an average return of 20%, and the Standard and Poor's 500 indexes saw a 26% return. To control for confounding variables, they used a multiple regression approach with a sophisticated statistical model, and they found that when employee training was added to the investment model they were able to improve the model's ability to predict growth in stockholder value by 50 percent. Additionally, an externality saw improvement since employee retention improved in the companies with significant training efforts.

To move from a focus on the United States to a more thorough global view of private firms and their learning and development investments, the examination now turns to the results of a meta-analysis of training and organizational performance (Lai et al., 2020). The authors used systems theory and a moderated meta-analysis of this training and organizational performance relationship from 119 primary studies. The studies' results found that training was directly and positively related to organizational performance. They reported a correlation of 0.25 in the overall relationship between training and organizational performance. Their effect size was significantly greater than other studies. They also examined other factors. The authors found a lack of significant difference between the quantity and quality of training and organizational performance. Frankly, they found this to be surprising, and the authors believe future studies need to more accurately measure training quality and use longitudinal research designs, in order to more accurately assess the impact on performance. Quality is a difficult measure for training, often relying on human assessment. One significant and unique result was that the strength of the relationship between training and organizational performance has increased year on year over the past three decades, and this suggests organizations are developing a competitive advantage through training. According to the adaptation principle of systems theory, training must adapt to changing environmental conditions in order to achieve organizational performance, and this is happening over time (Lai et al, 2020).

There is also the idea of congruence in systems theory because training is designed to fit the context of the organization. Lower labor cost countries benefit more from training than higher labor cost countries, and the marginal returns are higher in these contexts. This could suggest that training yields a higher rate of return than education in lower cost countries, since we had earlier findings that suggest more education is not as effective in less developed countries (Churchill et al., 2015), and training may be more effective in these nations. Lower labor cost countries do not have government investments in more education, and training is a better investment for the firm since the skills developed repay the firm on the job. However, these studies link training and development to the results of individual firms, and not to economic outcomes for nations and the global economy. This might be an area for further research.

Now the analysis turns its attention to government provided workplace training. We have already seen that the Cullison study (1993) showed labor training had a significant impact with an adjusted R^2 of 0.14, and this was a positive outcome for real private GDP in the United States. However, these results were only significant at the .05 level with the one-year lag and not the longer periods. Outside of the United States, a meta-analysis was conducted for European labor market programs (Kluve, 2010), and this study will give us an understanding of these labor training programs in a host of other countries. The study examined 137 programs from 96 academic studies in 19 different countries. The meta regression model did find that traditional training programs had a modest likelihood of generating a significant positive impact on post-program employment rates. Private sector incentive programs and government service and sanctions programs had a 30% to 50% higher probability of achieving positive outcomes. Service and sanctions training provides skills in identifying and managing government sanctions against specific foreign countries. These skills make the worker more employable. Programs targeting youth are less likely to be successful. There was no connection made, however, with any impact on GDP.

Government labor training, however, does not seem to have the national investment interest of other variables like education or company training and development. OECD data (2019) shows that from 2000 to 2018 for 28 OECD countries the funding for labor training was minor. As an example, The United States spent 0.06% of its GDP in 2000, an amount of a little over $6 billion dollars. By 2019, the United States was spending 0.03% of GDP, an amount of a little less than $6.3 billion dollars. This is less than 10% of what is spent on training in-house by private United States firms, which was $92.3 billion in 2021. It is also over 50 times less than what is spent on public education, which was 5.47% of the GDP in 2015. Nor do labor training expenditures show any growth rate over the last 20 years. The most spending for labor training takes place in Germany. However, they were only spending 0.59% of GDP in 2003, and by 2019 it had dropped to 0.18% of GDP. Given this is a flat to a downward trend in labor training expenditures I doubt any analysis would find a relationship between labor training and changes in national economic outcomes. All economic variables have long-term positive growth trends.

Private Educational Investments

Having examined company training and development and labor training, the analysis now turns its attention to private family spending on education. Private spending is spending by households and all other private entities. The global student tutoring market was $92.6 billion in 2020 (Fortune Business Insights, n.d.). The worldwide education software market is over $11 billion for 2022 (Statista, 2022). The data is less available, but the U.S. textbook market was $11.1 billion in 2016 (Statista, 2020). These are only a few examples of monies spent by families on their children's education. The OECD (2019) shows private educational spending data for 38 countries as a percent of GDP in the 2017-2018 school year. The OECD reports direct private spending on educational institutions, and this excludes funds spent on textbooks, tutoring, software or student living expenses. The percentage of GDP is from a low of 0.02% for Norway to a high of 1.2% for Chile. These funds are for K-12 expenditures. For higher education, the low is Luxemburg at 0.02% of GDP to a high of 1.6% of GDP for the United States. The average for all 38 countries is 0.03% of GDP for K-12 and 0.44% of GDP for private higher education expenditures. There have been studies of education expenditures with analysis of their impact on economic measures, and these studies will be explored next.

The World Bank published information on some of the specifics of personal spending on education expenses and their variances between nations worldwide (Huebler and McGee, 2019). Data from 2017 was examined and revealed that families in many developing countries pay more for their children's general education. When examining the expenditures as a percent of GDP, parents in developing countries spend 20-25% of the average GDP per person spent on education, whereas in high-income countries the families share does not exceed 5% of GDP per capita. The examples of less developed countries selected by the authors include Chad, Guiana, and Niger. The data also reveals that almost 25% of education expenditures are provided by families in Vietnam, 50% in Nepal, and more than 50% in Uganda. We have a long way to go to have universal public education at the primary and secondary levels worldwide without relying on private family donations.

In terms of developed countries, there is another type of specific finding to review (Huber et al, 2020). Huber and his colleagues' study analyzed and explored the impact of private education on inequality in the knowledge economy. High levels of private education spending increase both wage dispersion and create an educational premium. These data represent 13 different countries, and the effect of the impact of private education is, in part, to create economic value through differential skills acquisition. Therefore, since these skills have economic value, private educational investments help create income inequality in the developed nations of the world. The authors argue their results further demonstrate that public expenditure instead of private funding would reduce the differential in skills acquisition and increase the general capabilities of the nation's human capital, creating more positive economic results from educational investment. These two cited studies on the impact of private spending on education expenditures are focused on the size of the private spending investments to create wage dispersion and the different impacts in terms of cost burden in underdeveloped countries, leading to the individual economic advantages created. There is also a need to examine the OCED data to see what relationship exists between broad private educational investments and the economic outcomes by country.

Human Knowledge

This concludes our review of the elements of education, both public and private, and for corporate training, as defined by Denison's research (Kerr, 1994). If you recall, his data suggests that human knowledge, created by mass education, is a larger predictor of economic outcomes than the education predictors, estimated at twice the contribution to economic growth. Let me turn our attention to the research and evaluation of the independent variable of human knowledge and the economic impact it has had.

The expression, "knowledge is power" is often attributed to Sir Francis Bacon, from his *Meditationes Sacrae* in 1597 (The Jefferson Monticello, n.d.). Thomas Jefferson is known to have used the phrase in his correspondence on four occasions. An examination of the power of knowledge will be specifically related to economic power, but our first examination will be of the definition and measurement of human knowledge. George Berkley, an empiricist philosopher, describes human knowledge in his book *Principles of Human Knowledge* (1710), as ideas from the human mind about the outside world. He also saw logic and regularity as key principles of the development of human knowledge. The scientific method was developed starting with Aristotle (Science Buddies, n.d.), and it relies on defining questions, making predictions, investigating, observing, collecting data, analyzing data, and drawing conclusions in a rigorous fashion. Although the scientific method is important in developing human knowledge, any facts, data, and information that can be learned or known is human knowledge. As to measurement, Buckminster Fuller (1981) in his book *Critical Path* took a closer look at the development of human knowledge. He estimated that if we took all knowledge that humanity had accumulated and transmitted in the year one of the common era (CE) and equated it to one unit of information, it probably took until the 16^{th} century, about 1500 years, for that amount of knowledge to double. The next doubling of knowledge, from two to four units, took place in only 250 years, probably by 1750 CE. Fuller estimates that by 1900, only 150 years later, knowledge had doubled again to eight units. The speed at which information doubled is getting faster and faster. Fuller's knowledge doubling curve doubled again by the end of World War II (Lundell, 2014). By the 1990s, President Bill Clinton is quoted as saying "The store of human knowledge doubles every five years" (Newsfan, 2007). Some are estimating it is doubling every 13 months now, and IBM theorizes someday it could become every 12 hours (Miller, 2019).

How do researchers define and measure all human knowledge? One example talks about the differences based on diverse types of knowledge as to the rate of knowledge growth. The knowledge of nanotechnology is doubling every two years and clinical knowledge is doubling every 18 months. So, there is an attempt to accurately measure knowledge. Technology is having an impact on measuring the knowledge doubling curve, and on our ability to store and report the creation of new human knowledge. However, could we reach a limit on human knowledge? Jeff Lichtman, a Harvard University neuroscientist, is attempting to map the human brain, and he has calculated that several billion petabytes of data storage would be needed to index the entire human brain. The Internet in 2013 is estimated to have reached five million terabytes. Petabytes and terabytes are measures of data storage, where a byte is 8 binary digits or bits. A terabyte is one trillion bytes, and a petabyte is 1,000 terabytes. The Internet would need to grow over 400,000 times its estimated size in 2013 to equal the data storage of one human brain. So, it appears as if the human brain has tremendous potential for more growth, perhaps unlimited growth, in human knowledge (Schilling, 2013).

But how is the United States investing in the creation of new human knowledge? According to the Carnegie Foundation summary, the United States has 279 Doctoral Universities, 7.1% of our total four-year institutions, doing high to very high research activity. These are defined as awarding at least 20 research and scholarship doctoral degrees and also, the institution had at least $5 million in total research expenditures annually (Carnegie Summary Tables, n.d.). The National Science Foundation reports federal research outlays of over $173 billion in science and engineering for 2021. This is an increase in funding of about 35% since

2019 (NCS Summary Data, n.d.). Keep in mind this figure vastly surpasses the $92 billion spent by corporations on all learning and development expenditures in the same year. However, the private sector is leading the way with 75% of the funding of basic scientific research, while higher education is contributing 15% and the federal government is funding only 10% (Streamlyne, n.d.). The private sector prefers applied research, and they do not coordinate their research efforts, but welcome competitive endeavors. Historically, U.S. research funding has increased 13 times over from 1955 through 2019 (Congressional Research Service, 2021). This is measured in constant dollars, adjusted for inflation. Federal funding peaked in 1964 as the main source of research funding, but it has declined since then with private businesses dominating the process. However, researchers are overwhelmingly university educated in order for them to be prepared to work in the research environment, and therefore, tertiary education is essential to this process.

To examine the international approach to funding research and development (R&D) let us examine comparative data for countries (Royal Society, n.d..). The U.S. led the world in 2010 with its R&D expenditures. The top five countries include China, Japan, India, and Germany. However, South Korea is ahead of the United States with expenditures on R&D per capita. Singapore, Taiwan, and Israel round out the top five on this metric. Finally, by R&D as a percent of GDP, the leading countries are Israel, South Korea, Taiwan, and Sweden. The United States ranks 8th in this analysis, with 3.1% of GDP dedicated to R&D. This makes the U.S. tied with Denmark. The top two, Israel and South Korea, are spending 4.9% and 4.6% respectively. America would need to increase expenditures by 58% to match the commitment of Israel to leading in knowledge investment. Despite this overview of human knowledge, we still need to understand the impact investments in human knowledge are having on economic growth.

Predictor Elements Of Human Knowledge

The analysis of economic outcomes starts with the private returns to research and development. The paper, *Measuring the Returns of Research and Development* (2009) completes an extensive review of the measurement methodologies deployed, be it theoretical frameworks, measurement, or econometric models (Hall et al, 2009). The authors summarize the major results that have been obtained from over 50 studies of individual firms and industry analysis. The general results show private returns on R&D are strongly positive and somewhat higher than those for ordinary capital.

Given these measures of private investment in research and development, are these expenditures impacting economic growth? Freimane & Bolina (2016) examined the relationship between R&D expenditures and economic growth using a panel data analysis for the European Union. She divided the countries into two groups, old and new member nations such as France and Germany versus Poland and Slovakia. The old members are more developed economies than the new members. Data was used from 2000 to 2013 with projections for 2020 for all 27 countries. Fifteen countries have old members, and twelve countries are new members. The results obtained were consistent with previous studies, both theoretically and empirically. There was a statistically significant impact of R&D expenditures on growth in real GDP per person employed in the EU countries. The same was true for the new member nations. For low investment levels, less than 1% of GDP, research activities are even more important and necessary for GDP growth. Finally, these findings maintain that in order to ensure sustainable growth performance, it is necessary to allocate more resources to R&D activities.

Another study examined the impact of research and development on economic growth and productivity in the United States (Blano et al., 2013). The authors used data from 1963 to

2007 and they focused on the outcomes at the state level. The authors found results over the long run between 83% and 213%. There were also spillover effects, with 77% of total returns impacting other states beyond the impact for the originating state. Finally, Robert Wieser (2005) did an expansive survey of the body of empirical literature examining the relationship between research expenditures and the productivity of individual firms. The studies represent primarily the United States, Japan, France, Belgium, the Netherlands, The United Kingdom, and total world data. Firms were in the chemical industries, metals, electrical, motor vehicles, aircraft, scientific, and a host of others. The results show a clear, strong, positive relationship between R&D expenditures and the growth of output and productivity. Rates of return ranged from 7% to 69%. The studies confirmed spillover effects, averaging twice the private rates of return.

The connection between education levels and income is strongly similar to the relationship between research and development and economic outcomes. Both show positive outcomes at the individual level, be it for the individual's income based on investments in education or the individual firm's return on investments from research and development. Both show positive relationships for national outcomes, be it economic growth or productivity gains, and both show consistently positive results for a host of different countries around the globe. But human knowledge is vast and complex, so the review now turns to other types of development of new information, leading to the rapid doubling of human knowledge.

Academic Papers As Predictor

Publication output from academic work has a strong tie to research and development. In 2018, there were 2.6 million published, peer-reviewed articles, with high-income economies like the United States, Germany, and Japan producing 56% of all scientific and engineering papers (National Science Foundation, n.d.). Upper-middle-income countries like China, Russia, and Brazil produced 34%, and lower-middle-income economies like India, Indonesia, and Pakistan produced 9% of the total. Actually, China now leads in publications with 20.67% of the world's total. They dominate the upper middle-income category of countries. The United States is second with 16.54%. India, Germany, and Japan round out the top five, but all with single-digit shares. The growth rate of scientific publications has been studied since 1907, and there has been an ongoing increase in articles published, although, in the new millennium, papers are moving away from the traditional scientific publishing arena and into new channels for conferences and homepages (Larsen & Von Ines, 2010). The authors conclude that accurate reporting is becoming a problem and the lines are being blurred as to what constitutes a scientific paper. The growth is greatest now in the computer and engineering sciences. Also, they speculate about the end of the growth curve, but they have no indicators of when this might be. The Microsoft Academic Graph (MAG) dataset shows an exponential explosion of academic papers starting in the 1940s, with the exponential growth rate ending in the early 2000s. However, MAG's decline in the new millennium is attributed to publications' movement away from their dataset (Fire & Guestrin, 2019). They also note that citation numbering and the impact factor have remained constant. Additionally, there are large growth rates in the energy and medical fields. In terms of size, in 2015 the academic research publishing industry had an annual income of $25.2 billion

(Brandon Gaille, 2018). This industry used to be dominated by non-profit publishing houses and now about 50% of global academic journals are part of commercial, for-profit publishing houses.

It can be argued that publish or perish policies for professors at universities are driving the continued growth in academic publications and not simply the intellectual curiosity of scholars. However, research grants in the U.S. for scientific and health research totaled over $30 billion in 2020 (Statista, 2023), and outside of the hard sciences, a research grant award is a career enhancement for a professor in any field of study. However, the scientific, health, and engineering fields are driving this process, since monetizing new discoveries in these fields is creating an economic impact. Given this rather large and important process for new ideas and scientific innovation, what relationships are being predicted by the body of peer-reviewed articles in their relationship to economic outcomes?

No studies were found that were conducted to analyze the link between the increases in academic publications and the change in economic outcomes. Also, very little research has been done to determine if there is a relationship between article output and changes in research and development expenditures. The only reference found was a paper by Wong and Goh (2012) that reviewed the impact of academic papers and patents on the transformation of emerging Asian economies towards a knowledge-based economy. Using the number of published papers and patents as proxies, bi-logistic growth functions were fitted to examine the prolongation ability of science and technology, and the time at which each functionality development emerges. Growth functions measure the richness of a set family. It is especially used in the context of statistical learning theory, where it measures the complexity of a hypothesis class. The Bi-logistic growth function is effective in modeling systems that contain two logistic growth pulses, such as this study with publications and patents. For a more complete understanding of bi-logistic growth functions, I refer you to a textbook by Steinbach and Posthoff (2022). Returning to the specific analysis, the changes in the newly industrialized economies of South Korea, Taiwan, and Singapore suggest a significant transformation of their innovation systems, leading to a higher degree of functionality. The results suggest that these countries have succeeded in developing new economic growth trajectories that are beneficial for their transformation towards a knowledge-based economy.

Further analysis of the links between scientific articles and the production of patents is studied by Branstetter and Ogura (2005). This research examines the growth in patents citing academic scientific papers, and these knowledge spillovers were helping drive innovation in the United States in the 1990s, the period under review. The authors found specific applications in the life sciences, where academic researchers have generated new technological opportunities, and these firms are experiencing inventive productivity with their R&D spending and their patenting. Regardless, these two studies suggest there are links between scientific publications and research and development, as well as patent growth, all of which have a potential impact on economic growth. Clearly, more research is needed on publications. We have seen the predictor of research and development and the outcome of economic growth, and we have examined the limited studies on the links between scientific papers and their economic impact, but let us pause here and divert our attention now to the independent variable of patents and their influence on economic growth worldwide.

Patents As Predictor

The first documented historical case for patents was in England in 1331. The sovereign issued a letter patent to inventors who petitioned the monarch and were approved. John Kempe and his company were given a royal grant to a monopoly to produce a particular good or provide particular services (Hulme, 1896). Kempe was a Flemish weaver who could exclusively develop and sell his woolen cloths in England. Since that time, patents have grown around the world, modeling the growth in economic prosperity, education, and human knowledge. For the United States, patents have grown on a yearly basis from 45,679 in 1963 to 352,049 in 2020 (U.S. Patent and Trademark Office, n.d.). This is an increase of well over sevenfold in the last 57 years. The number of patents granted with foreign origin has grown substantially too. It was 18.6% of the total in 1963 and is at 53.2% in 2020. In terms of growth internationally, by 2015, the US had granted 3,030, 080 patents, whereas Japan had issued 1,069,394 and Germany granted 365,627 (U.S. Patent and Trademark Office, 2015). At numbers four and five, South Korea had issued 166,353 and Taiwan had granted 162,732 patents. The total for the world was 5,739,851. So, the US holds over 50% of all patents and the top five countries hold over 83% of all patents.

Patents have changed industries and the world with their revolutionary impact. A few notable ones include the light bulb, the internal combustion engine, the telephone, the computer, (Intellectual Property Talent Search Examination, n.d.) the apple phone, global positioning systems, gene editing, solar panels, virtual reality, and a multitude of others (Bennett, 2022). The top companies now start with IBM, which was awarded 9,262 patents in 2019 (Bajpai, 2020). They include patents in blockchain, cloud computing, quantum computing, and security. Samsung, the Korean firm, was second with 6,469, but they lead IBM with 76,638 active patent families, which is more than double the number held by IBM. Coming in third, Canon, the Japanese firm, set a record in 2019, becoming the only firm to rank in the top 5 companies for patent awards for 34 years running. The list goes on and on, but it is clear, at least anecdotally, that patents have a great economic impact. The top 100 universities in the world received 6,833 patents in 2018 (Share America, 2019). This is a considerable number, but not nearly as many as IBM was granted in 2019. If patents are driving economic growth, what do the studies show?

In 1975, France held a meeting with the United States, Germany, Italy, the United Kingdom, and Japan to discuss the oil crisis and the stock market crash. This became an annual meeting and Canada was invited to join, thus forming the G7. Josheski and Koteski (2011) used quarterly data for this group to analyze the relationship between patent growth and GDP growth. The data is from quarter one of 1963 through quarter four of 1993. They used an ARDL model, the autoregressive distributed lag model, to analyze the long and short-term effects on coefficients. To better understand ARDL Models, I refer you to Tabachnick and Fidell's textbook, *Using Multivariate Statistics* (2019). The studies' authors found that there is a positive long-term relationship that is statistically significant between the quarterly growth of patents and GDP. They also found a negative short-term effect where lagged growth for patents had a two-year lag effect for GDP. This finding was also statistically significant. The error correction term, measuring the speed of adjustment, suggests that 20.6% of the adjustment back to the positive long-term trend is corrected after one year. Diagnostic tests also pass the overall validity of the model.

Another paper by Hu and Png (2013) examined the impact patent rights have had on economic growth. The authors examined data from 72 countries for 54 manufacturing industries between 1981 and 2000. Stronger patent rights were associated with faster growth in more patent intensive industries. The Stronger Patent Rights Act establishes key legal processes, and it is explained by Alex Moss in his article in The Electronic Frontier Foundation (2019). The effect was also larger in higher-income countries. Patent rights were associated with faster growth through both factor accumulation and raised productivity. In the legal terminology of patent law, factor accumulation is capital accumulation. Their results were robust to alternative measures, such as patent rights and patent intensity.

A research study from 2015 examined the impact patent rights have had on the economic growth of middle-income countries (Rehman et al, 2015). The data was for the time period 1993 through 2012, and data was drawn from the World Bank, the World Intellectual Property Organization (WIPO), and UNESCO. Unfortunately, the authors do not mention the number of countries, which nations were included in the study, or how they define middle-income countries. However, their results mirror the conclusions already stated. The results showed that domestic patents affect GDP positively only in the short run for the pooled mean group. Additionally, the mean group estimator reveals insignificant outcomes both in the short and long run. The mean group estimator provides consistent estimates of the mean of the long-run coefficients, though these will be inefficient if slope homogeneity holds. There appears to be a division of impact on GDP growth between countries trying to develop their nation as a knowledge economy and those high-income established knowledge economies that are gaining the economic growth advantage. R&D levels are also a key element in the analysis.

Maskus and McDaniel (1999) studied the impact the patent system of Japan had on productivity growth. The author's paper provided econometric evidence that the technology diffused through the patent system had a significant and positive impact on Japan's technical progress. Japan's system was uniquely designed to promote technological catch-up and diffusion through incremental innovation.

Finally, an article entitled *Innovation, Patents, and Economic Growth* makes an impassioned plea for Europe to institutionalize innovation and intellectual property (IP) generation and reward investments in IP (Atun et al, 2007). The authors describe the United

States as approaching IP generation strategically by creating IP infrastructure, while Japan and China are developing IP systems with the goal of becoming IP nations. The Lisbon Agenda explicitly identified the EU's objective to become the world's leading knowledge-based economy. They admit, however, that the EU is playing catch-up to regain a competitive advantage.

Summary

This concludes the review of the relevant literature on the economic importance of education and human knowledge. Keep in mind education has been influential in many other arenas, including the political and the social. However, I believe the economic prosperity related to the expansion of mass education and the subsequent exponential growth in human knowledge and its economic impact are perhaps the most vital roles public education has played since its inception.

We have observed many relationships in this review. Education attainment has had a significant impact on the rise in personal incomes, and collectively, on national incomes and global incomes. Furthermore, a strong relationship has been demonstrated between educational attainment and educational expenditures as significant determinants of economic growth and productivity gains, both within countries and worldwide. Further studies would be repeating what these studies have already thoroughly researched.

For the importance of the growth in human knowledge created by research and development, the researchers have demonstrated statistical significance for individual firms, industries, countries, and the world. Equally, patents have shown strong relationships with revenue growth for individual firms, many industry expansions, determinants for country conversion to knowledge economies, and national GDP growth. These two variables have been sufficiently researched, and the conclusions are considered important for influencing future investment in these two independent variables.

Research in this study will focus on the opportunities to add to this analysis. The first research question is as follows. What is the relationship between training expenditures and national GDP data by country? Various countries' data from the United States and internationally is used for roughly the 1990s to 2020 in this study. Cited references have demonstrated a strong relationship with growth values for training expenditures and individual firms, but no research examining training expenditures as a predictor of economic growth for nations appears to have been conducted. Next, the second research question is the following. What is the relationship between private spending on education and national GDP data by country? The plan was to utilize data panel analysis by pooled nations to analyze OECD data from approximately 1998 to 2018. Random data panel analysis was deemed more appropriate. In education, although the variable of private spending on education has revealed anecdotally positive relationships with economic outcomes, I have found no study examining the relationships between private educational investments and economic growth. Lastly, the third research question is as follows. What is the relationship between academic journal articles and national GDP data by country? Academic journal articles have been shown to play a role in new patents of intellectual property, and they were also utilized, along with patents, in the research of the national conversion of Asian economies to knowledge-based economies. However, I found no research examining the relationship between the growth in academic journal publications and the economic growth of nations. For the last research question, data was utilized from 2000 through 2019. To proceed, the research process will now review the proposed research design and methods.

III. RESEARCH DESIGN AND METHODS

The successful and comprehensive examination of four independent variables in the research literature was accomplished using quantitative analysis, and so, this study's research also used quantitative analysis as the methodology. The first two successful independent variables for public education were educational attainment and public education expenditures, and they were analyzed with positive results in different studies with the dependent variables of individual income, national income, productivity growth, income growth, GDP growth, and GDP per capita growth. The next comprehensively tested independent variable for human knowledge was research and development expenditures, and it was strongly examined in various studies with the dependent variables of revenue growth for individual organizations, and national economic growth rates. The last successful independent variable for human knowledge was patent growth rates, and it was successfully analyzed in various studies with the dependent variables of returns for individual firms, returns within industries, and the country's economic growth rates. The research questions for inquiry have focus on other variables that, as far as I have found, have not been researched as thoroughly.

My research questions for the independent variables of training expenditures, private educational spending, and academic publications are similar in their design and their statistical methodological analysis to the methodologies deployed for the successful studies cited in the literature review. The statistical methodologies deployed for this research have also taken the successful studies approach. The three research questions are necessary due to variances in the data available. As stated, they are the growth in company training expenditures, the growth in private educational spending, and the growth in academic journal publications. The study includes the variable public education expenditures as a covariate and statistical control for all three analyses. This variable will function as a statistical adjuster. Training expenditures and private spending on education have been studied for their impact at the individual person or individual firm level, and these studies have found significance in these relationships. Journal articles have been studied for their relationship with R&D and patents. All three independent variables have not been examined for their relationship to the dependent variable of national GDP, as far as my research has been able to ascertain, and the analysis will therefore focus on these relationships. The methods applied in all of the cited literature is utilizing the methodology of statistical analysis, examining correlations, regression values, and whether the values are statistically significant, determinant, and therefore the basis for recommending further investment in the independent variable. Let us now review the research questions, the hypotheses, the rationale for the hypotheses, the data to be analyzed, and the purposed statistic, and level of significance.

The Hypotheses And Research Design

The hypotheses and research design are based on the research questions. To restate, the first research question is the following. What is the relationship between training expenditures and national GDP data by country and globally? This study will be using training data from North America, specifically the combination of the United States and Canada, and it will also use global spending data for training and development. The data is from 2013 to 2019 for this study, and this data comes from the Training Industry Association, provided by Statista (2022). Cited references have demonstrated a strong relationship between training expenditures and growth values for individual firms, but I have found no research examining training expenditures as a predictor of positive GDP growth for nations. The equation for this model is:

$$\log Y_{1it} = B_0 + B_1 \log X_{1it} + B_2 \log X_{2it} + B_3 \log X_{3it}$$

Where Y_{1it} is GDP, X_{1it} is training expenditures, X_{2it} is R&D spending, and X_{3it} is public education expenditures. The variables have i and t subscripts for i = 1, 2, …, N cross sections of data and t = 1, 2, …, t time periods. The parameter B_0 is the intercept term, and B_1, B_2, and B_3 are the slope coefficients with the expected positive signs.

The second research question is as follows. What is the relationship between private educational investments and national GDP data by country? For the statistical model, the plan is to utilize random data panel analysis to analyze OECD data from 2003 to 2019 (OECD database, n.d.). In education, although the variable of private spending on education has revealed anecdotally positive relationships with economic outcomes, no study was found examining the relationships between total private educational investments and GDP growth. The equation for this model is:

$$\log Y_{2it} = B_0 + B_1 \log X_{21it} + B_2 \log X_{22it}$$

Where Y_{2it} is GDP, X_{21it} is private education spending, and X_{22it} is public education expenditures. The variables have i and t subscripts for i = 1, 2, …, N cross sections of data and t = 1, 2, …, t time periods. The parameter B_0 is the intercept term, and B_1 and B_2 are the slope coefficients with the expected positive signs.

The third research question is the following. What is the relationship between the growth in academic journal articles and national GDP data by country and globally? Academic journals have been shown to play a role in new patents of intellectual property, and they were also utilized, along with patents, in the research of the national conversion of Asian economies to knowledge based economies. However, no research was found examining the relationship of the growth in academic journal publications and GDP growth for nations. For the last research question, data will be utilized from 2000 through 2019 provided by the National Research Foundation (NSF, n.d.). The equation for this model is:

$$\log Y_{3it} = B_0 + B_1 \log X_{31it} + B_2 \log X_{32it}$$

Where Y_{3it} is GDP, X_{31it} is academic journal publications, and X_{32it} is public education expenditures. The variables have i and t subscripts for i = 1, 2, …, N cross sections of data and t = 1, 2, … t time periods. The parameter B_0 is the intercept term, and B_1 and B_2 are the slope coefficients with the expected positive signs.

The design maintains three research questions due to the use of several different databases and the inequalities in the time series available. A better approach might be to analyze all seven variables in one research equation, the four variables already demonstrated as significant and the three that have not been thoroughly researched. The results would demonstrate the relative importance of each independent variable based on the strength of their relationship to the dependent variable GDP. However, this research would require significant funding to acquire all of the necessary data and should probably be conducted by a research team over a significant period of time. The necessary resources are not available. Nevertheless, some of the analysis in the first equation for training data may yield these relative valuations. Included in this analysis is R&D spending and public education expenditures in the model, giving us these major proven variables for economic outcomes. The selection of the dependent variable of GDP by country and the independent variable of education expenditures provides more consistency in the metrics for all three equations. Dollar values are used for most of the variables. GDP as the dependent variable also inherently demonstrates economic growth in the positive changes in GDP over time. Now let us examine the accompanying research hypotheses, rationales, and the proposed statistic and level of significance.

For the first research question, the hypothesis states that training expenditures as the independent variable is positively related and a determinant for the dependent variables of national and global GDP. The rationale for this hypothesis is based on research which demonstrates at a general level the statistically significant relationship between education and economic outcomes. Denison (Kerr, 1994) specifically refers to the positive relationship between training expenditures and economic growth based on his derivation of the variable from residual data, utilizing his growth accounting methodologies. Other studies cited demonstrate a determinant relationship between training expenditures and the growth in revenues for the individual firm. The studies of education and personal income levels were followed by the studies of the relationship between education and national incomes, and these were both positively determinant. This could suggest that the growth in revenues for individual firms based on training expenditures could lead to growth in GDP in the aggregate. GDP growth may or may not be positively related to gross training expenditures as a determinant. The results may suggest the need for national policies to consider the importance of increasing investments in training expenditures to influence the GDP growth of the country. The statistic for this analysis is the adjusted R^2 and the level of significance is 0.05. This is the standard statistic for measuring the relationship between independent and dependent variables, and the customarily accepted level of significance is 0.05.

For the second research question, the hypothesis states that private spending on education as the independent variable is positively related and a determinant for the dependent variables of national GDP data by country. The rationale for this hypothesis is based on research which demonstrates at a general level the statistically significant relationship between education and economic outcomes. Again, the research by Denison specifically refers to the positive relationship between private spending on education and economic growth. The techniques used to extract the variable from the residuals must be accepted as valid and reliable in order to accept these conclusions. Private spending on education is demonstrated to positively impact individual incomes in several studies. One proposal for this finding could support results where total private spending on education by country will be a determinant of positive national GDP results. These results might then suggest that national policies that choose to stimulate these investments may be a positive influence on economic outcomes. The statistic for this analysis is the adjusted R^2 and the level of significance is 0.05.

For the third research question, the hypothesis states that the growth in academic journals as the independent variable is positively related and a determinant for the dependent variables of national GDP data by country and globally. The rationale for this hypothesis is based on research which demonstrates at a general level the statistically significant relationship between the growth in human knowledge and economic outcomes. Like the education variables previously mentioned, Denison found a statistically significant relationship between the growth in human knowledge and economic growth. As previously stated, this relationship is based on a derived variable from residual data. Research and development expenditures as well as patent growth have been shown in cited studies to influence economic outcomes. One study demonstrated the relationship between academic journals and patents. Another study showed that academic journals, along with patents, acted as a determinant in the formation of a knowledge-based economy. The growth in academic journals may or may not be a determinant of the positive growth in GDP outcomes. These results might lead government policy to increase the support of universities that yields increases in academic publications, particularly doctoral-granting universities doing high to very high research and development activities, with the intent to improve GDP outcomes. The statistic for this analysis is the adjusted R^2 and the level of significance is 0.05. A statistical matrix is in Appendix A.

With the research questions, the hypotheses and their rationale, and the statistic and level of significance defined, it is time to delve deeper into statistical methodologies.

Data Sources and Analysis

The type of data collected was subject to many statistical methodologies, Therefore, the data was reviewed to ascertain what types of analysis would be applied. Data is archival and longitudinal in the public domain, and inquiries were completed to access internationally recognized sources and gain access to their databases. The first hypothesis on training expenditures cites data from the Training Industry Association. Some of their data was published by Statista (2022) from 2007 through 2019, and this data should be sufficient to complete the data panel analysis. I have contracted with Statista to access this data. The study should be able to analyze the training data available since data panel analysis is not as sensitive to issues of the size of the database. Five studies cited in the literature review, Idress & Siddiqi (2013), Freimane & Balina (2016), Branstetter & Ogura (2005), Hu & Png (2013), and Rehman (2015), successfully used time series from 14 to 20 years in completing their data panel analysis. Some of the Statista (2022) training data was cited in the literature review. The global training data for all nations will provide us with a comparative analysis of the training investments made in North America. The matching data for R&D spending should demonstrate some of the relative added predictive or determinant levels of training expenditures relative to another determinant, as well as the comparison to public education expenditures. The OECD database is the source for public education data (OECD database, n.d.), while research and development data is sourced from

UNESCO (World Bank, 2022), and GDP data is sourced from Macrotrends (n.d.). One exception is world education expenditures. OECD does not represent all 196 countries in the world, and the world's public education data was obtained from UNESCO (World Bank, 2022). These comparisons of two additional independent variables will be a unique analysis for this research hypothesis.

For the second hypothesis, the OECD has published a chart comparing private education spending to country GDP for the 2017-2018 academic year, and some data has been accessed to begin a time series study from their online sources (OECD database, n.d.). The time series data accessed is from 2003 to 2019 for seven OECD countries. The countries are the United States, Japan, Germany, the United Kingdom, France, Spain, and Sweden. All seven countries are in the top 25 economies in the world, and they represent over 43% of the world's GDP (Worldometer, n.d.). These countries were selected from the 40 countries in the OECD database given the issue of missing data for other member countries. Comparisons were made with public education expenditures by country, and this data is also from the OECD (OECD Database, n.d.). GDP data is from Macrotrends (n.d.).

For the third hypothesis, the data for academic publications comes from the National Science Foundation (NSF, n.d.). This data from the National Science Foundation is for 2000 through 2019 for four nations and the world. These countries are the United States, Germany, the United Kingdom, and Japan. In addition, data has been acquired for public education expenditures from the OECD from 2000 to 2019 (OECD database). The world public education data is from UNESCO (World Bank, 2022). The dependent variable GDP data is for the respective countries in this study and global data, and this data was acquired from Macrotrends (n.d.).

Additionally, there are a few unique aspects of economic data to review. Most of the data is in U.S. dollars except for academic publications. This variable is measured in the hundreds of thousands and the low millions, ranging from the low hundreds of thousands to the low single digit millions. The dollar values of the other independent variables for their respective countries range from hundreds of millions of dollars to billions of dollars and reaches trillions of dollars. GDP data tends to range from billions of dollars to trillions of dollars. These magnitude of differences are why the equations will utilize logarithmic scales.

The conversion of data from local currencies to U.S. dollars required two adjustments. Exchange rates were deployed to convert all currency to dollars. However, besides the price of the U.S. currency vis a vis other currencies, the price variances of goods and services between countries must be accounted for too. This is why U.S. currency values are subject to purchasing price parity. To equate price variances between currencies the purchase price of a basket of goods and services was compared between the countries. For example, rent, car prices, food prices, clothing costs, etc. were compared between the United States and Spain. The variance was converted to an index, and in 2019 this index value for Spain was 0.633. The index values are from the OECD. This means that private education spending in Spain that year was 11,936,000,000 Euros. After conversion to U.S. PPP values, the value was $18,851,000,000 dollars. Purchasing price parity allows us to equate economic monetary values between countries. The following table summarizes the overall key aspects of the datasets.

3.1 Summary of the Datasets

Variables	**Training Dataset**	**Publications Dataset**	**Private Ed Spending Dataset**

Countries	2 country variables	5 country variables	7 country variables
Years	14 years	20 years	17 years
Statistical Adjusters	R&D and Ed Exp	Ed Exp	Ed Exp
Dependent Variable	GDP	GDP	GDP
Observations	104 Observations	300 Observations	357 Observations
World Data	Global Data Included	Global Data Included	No Global Data

Now let us turn to the statistical methods to be used in the analysis of the data.

Statistical Methodologies

The analysis proceeds by reviewing all of the design options and methodology issues for analyzing the data and proving the hypotheses, and then, concludes with the decision of the best possible design chosen using the most appropriate methodologies for the studies. Next is an examination of the practical issues of time series analysis.

Practical Issues

Referenced is the statistical methodologies text, *Using Multivariate Statistics* by Barbara Tabachnick and Linda Fidell (2019). Their guidance on time series analysis was examined and considered. There are assumptions in time series analysis and practical issues to be reviewed. For example, after a statistical model is developed, the authors recommend testing the data for the normality of distributions of residuals. Statistical models typically can include autoregressive, integrated, moving average (ARIMA) models, multiple regression models, and data panel analysis models. The three common data panel models include fixed, random, and ordinary least square (OLS) pool models. Returning to our first practical issue of the normality of the distribution of residuals, the normality of the residuals is an assumption of running a linear model. So, if residuals are normal, it means that the assumption is valid and model inference (confidence intervals, model predictions) should also be valid. If residuals are non-normal, then one consideration is transforming the data by eliminating outliers. Another is using a log transformation, and another option is to substitute parametric tests with non-parametric tests. However, given business cycles are impacting the data, it was fair to assume the data would be nonlinear, and therefore, multiple regression analysis was not used. Also, after the statistical model was developed, the authors recommend examining plots of standardized residuals versus predicted values to assess the homogeneity of variance over time. The Shapiro-Wilk test was used to make the determination. If the width of the plot varies over the predicted values, the transformation of the data for the dependent variable is an option. Time series data inherently violates the assumptions of independence of residuals because of autocorrelations over time. Autocorrelation is often used with the autoregressive-moving-average model (ARMA) and autoregressive-integrated-moving-average model (ARIMA). A moving average takes a grouping of data, three years as an example, averages the number, subtracts the first datapoint, adds the next datapoint, computes the next average, and proceeds by producing averages as it moves through the data in the time series. The analysis of autocorrelation helps to find repeating periodic patterns, which can be used as a tool for analysis, especially for cross sectional variables over time. An investment such as training expenditures may have their outcomes spread over multiple years, and we saw this result in the cited articles that demonstrated statistical significance for the individual firms (Lai et al., 2020). The plot of the dependent variable was examined over time before and after adjusting for autocorrelation to identify obvious outliers.

The sample size and missing data have to be evaluated too. Sometimes data is missing, as in the data from the OECD where certain member countries were missing data. The most common option is to transform data by using means to substitute for missing data. The size of the dataset improves the robustness of the analysis, and so efforts were made to acquire the most comprehensive time series for each independent and dependent variable to be analyzed. Given that missing data is an issue for the analysis, countries without missing data were selected for the time series being used.

The pattern of autocorrelation is modeled in the time series. As we have seen in many of the citations in the literature review, the relationships tend to be time-lagged. Again, the impact of the independent variable is not in one year but is usually spread over several time periods. Therefore, how quickly do autocorrelations diminish and run out over time? Are the trends linear or quadratic? As has been mentioned, business cycles are common in economic analysis, and we have seen other studies that anticipated these nonlinear events in the datasets. Autoregressive and moving average components were examined to reveal cycles. Decisions regarding forecasting was decided against as the statistical model was developing.

The Preferred Statistical Model

Given that multiple countries' data was used, the relationships between different countries' time series was examined by using cross-correlation functions. For example, in the second hypothesis for private spending, each time period for multiple countries was used with public education expenditures and GDP as cross-sections for that particular year. The feature of fixed or random data panel analysis eliminates issues of heterogeneity. Random data panel analysis has been selected for use since the country selection was random based on data availability. At this point, analyzing covariates within the three analyses will not be examined. For example, if OLS pooled variables for private spending were to be analyzed then combining nations by income levels as covariates would be necessary, but this method will probably have heterogeneity issues since pooled OLS data panel analysis does not eliminate the heterogeneity issue. Also, the limited countries under review will not allow grouping by income level. Private spending on education as the determinant variable was examined as the main independent variable under analysis, using educational expenditures as a statistical control.

The most effective model for these three analyses is data panel analysis. Data panel analysis is two-dimensional (typically cross-sectional and longitudinal) panel data. The data are usually collected over time and for the same countries and then a regression is run over these dimensions using cross-sections by country within the given year. As already indicated, problems with homogeneity, known as heterogeneity, commonly occur with autocorrelations over time. The advantage of data panel analysis is that we can control heterogeneity in our regression model by acknowledging heterogeneity as random. Multiple regression is a more general approach, and therefore needs larger sample sizes and is more susceptible to heterogeneity issues, making data panel analysis the better choice.

Freimane and Balina (2016) analyzed research and development expenditures in the European Union as it impacted economic growth, and the authors used a data panel analysis that placed countries into pooled groups based on the length of membership in the European Union. This model is the Ordinary Least Squares (OLS) pooled data panel analysis, and it gives us a quasi-experimental design, where the most developed countries can be compared to a control group of developing countries. A quasi-experimental design is where group assignment is not random. Idrees and Siddiqi, (2013) completed a study using data panel analysis for the 17-year period from 1990 to 2006. The cross sections used data from the G7 countries and seven developing countries, also a case of pooled OLS data analysis. Two of the three research questions are intended to be comparisons of multiple countries over time periods, as I stated earlier. The analysis was of the independent variable and its relationship to the dependent variable. The two research questions for private spending on education and academic publications should also fit with the approach of pooled groups of nations to do a data panel analysis. However, OLS pooled data panel analysis can suffer from heterogeneity issues. This did not appear to be the issue in several cited articles, but if it does occur, it would be necessary to either transform the data using the methods explained earlier or accept that my results may be biased. Therefore, the OLS pooled data model will not be used for the research proposed. After review of all of the design and methodology issues, the conclusion is that random data panel analysis is the design method to be used for all three hypotheses, and pooled results will not be deployed since as already mentioned, random data panel analysis overcomes the heterogeneity problem.

Statistical Tools for Panel Data Analysis

Another issue of concern is endogeneity. An uncontrolled confounding variable like capital investment, a variable that is correlated with the independent variable and with the error term, can make the findings for the model biased. The confounding variable may be influencing the outcome without our controlling for it. To test for this issue, it is recommended that the Hausman test is applied. Since SPSS does not offer this option, it is recommended that a Wald test is run for the joint significance of the individual means. It can be shown that the Wald test is algebraically equivalent to the Hausman test, and you do not run into negative covariance problems. If you want to examine the algebra, Wooldridge (2010) derives the Wald test comparison in his cross-sectional and panel textbook.

To run a data panel analysis in SPSS, IBM recommends using the mixed procedure. Mixed models allow for the analysis of data in which the measurements were made at random (varying) time points. Analysis of Longitudinal Data with Missing Response Data: Problems caused by missing data in repeated measures and cross-over trials are eliminated. A mixed model handles panel data maximum likelihood or restricted or residual maximum likelihood estimation. IBM provides an example for SPSS with a technical note demonstrating pooled cross-sectional time series data. The IBM technote was requested from UTEP's IT support group, and it recommended the mixed procedure. Another option offered is the generalized linear mixed models. SPSS does not have a data panel analysis option, and since this is IBM's recommendation to do the equivalent of data panel analysis using SPSS, the choice for a statistical model is the mixed model approach (IBM, n.d.). Efforts were also made to acquire access to STATA software, since STATA has the option to run data panel analysis. As this was successful, then the proximity process of generalized mixed models will only be utilized as a cross-check instrument.

The proposal defense was successfully completed, and the design and methodology plan was submitted to the institutional review board (IRB) for approval.

Summary

The expectation was that the results of these studies will help demonstrate the importance for the world economy of these three additional independent variables, given what the literature review has already shown us with its evidence of the importance of the independent variables of education and human knowledge. Countries should be strategically making further educational investments to enhance their nations' economic growth and prosperity. This analysis should help clarify what educational and human knowledge investments could mean for the United States' economic competitiveness in the future. As cited by Roser and Ortiz-Ospina (2018), about 14% of the world's population is still illiterate. This amounts to over 1.2 billion people. UNESCO and the World Bank (n.d.) tell us that 24% of youths do not attend secondary school. The International Association of Universities is only projecting 300 million university graduates by 2030 (ICEF Monitor, n.d.). This is less than 4% of the world population. There are significant opportunities to grow education and human knowledge in front of us, and given what the literature review and what history have shown public educators are capable of accomplishing throughout the learning revolution, there is a strong belief investments in education and human knowledge will continue to yield remarkable results.

The modern political landscape in the United States has been characterized as a strongly divided partisan political environment. However, in 2021, a bipartisan Congress passed a $1 trillion dollar Infrastructure Bill to invest in the economic future of the country (World Economic Forum, 2021). In 2022 a bipartisan Congress passed Semiconductor Legislation to invest $280 billion in semiconductor manufacturing in the United States (The Council of State Governments, 2022). When logical economic investment rationales are used to persuade both Democrats and Republicans of the importance of investing in the future competitiveness of the nation's economy, then these arguments are shown to be the one approach that has been successful in getting results.

Pleading for funds to improve educational performance on standardized tests or accusing politicians of using funds to further their political fundraising are not effective methods to motivate decision makers to increase educational expenditures. Demonstrating that economic growth, higher incomes, and international competitiveness are determined by investments in education is an effective argument to motivate public opinion to support investing more in our public education system, and to grow our collective human knowledge at the national level.

IV. DATA ANALYSIS AND RESULTS

The starting point was to contact the internal review board (IRB) at UTEP and get approval to conduct the statistical research. The plan was approved by the board. As indicated in the methodology and design chapter, the data analysis began with the practical issues concerning the viability of the datasets. The Pearson product correlation coefficients were computed for all three datasets in STATA Software, which was acquired from the university. This was to see if there was an issue with linearity. The data was logarithmic in scale because of the variable interaction. Logarithmic scale is not needed in the model because of a lack of exponential distributions of the variables; however, the magnitude differences between the variables necessitates using logarithmic transformation when variables interact. The first table is for the training dataset variables.

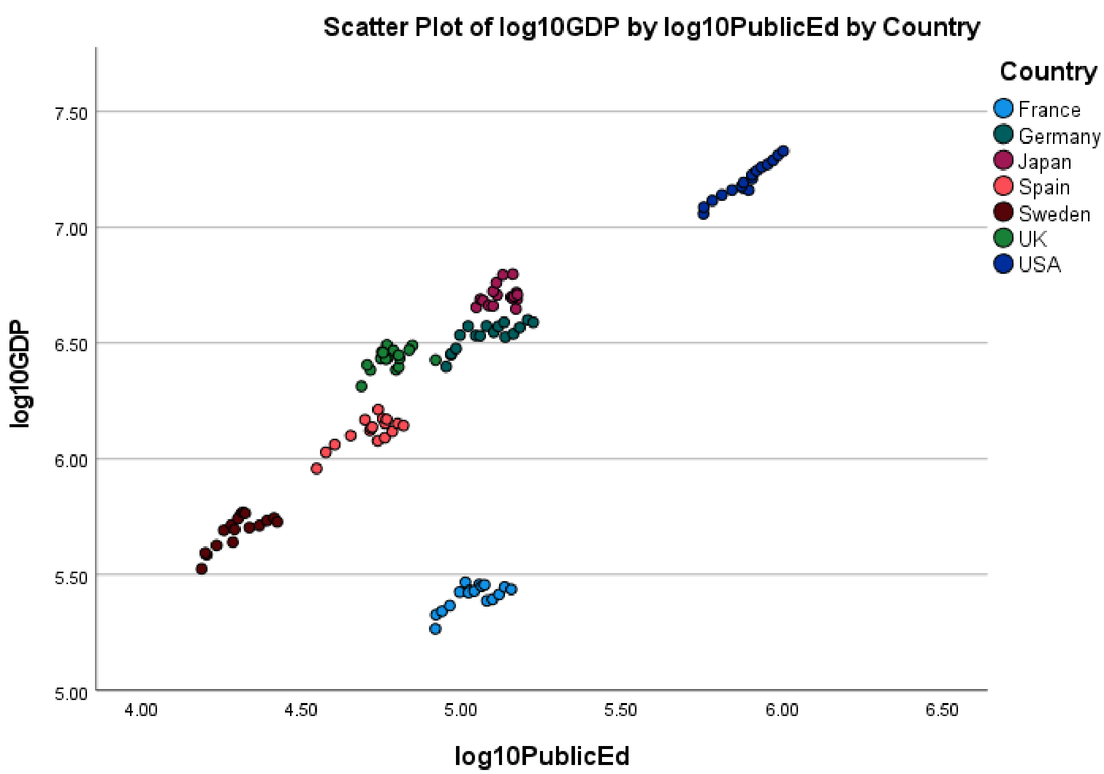
Table 4.1 Pearson product correlation coefficients for the Training Expenditures dataset

Variables	Log_Training	Log_RD	Log_PublicEd	Log_GDP
Log_Training	1.000			
Log_RD	0.984	1.000		
Log_PublicEd	0.977	0.991	1.000	
Log_GDP	0.981	0.993	0.997	1.000

The coefficients are very high, showing almost a one-to-one correlation for all six relationships. Moving on to the private education spending dataset, the coefficients are again high, with the lowest correlation between public education spending and GDP, and yet this correlation is still at 0.716. The last dataset is for academic journal publications, and these correlations are also very high, with all three variables over 0.97+ in value. The corresponding tables for these two datasets is in Appendix C.

All of the plotted points are close to the line of best fit. Nevertheless, as an example, the scatter plot of educational expenditures correlated with GDP in the private education spending dataset demonstrates a clear linearity in the variables. Below is a posting of the graph. All of the other scatterplots are similar in their visual conclusion, and they are found in Appendix C.

Figure 4.1 Scatterplot of Correlation from Private Education Spending Dataset



The linearity in all three datasets does not correspond to the assumption in the design model presented in chapter III. Although there are business cycles during all the time series observed, particularly from the recession of 2007 through 2009, these cyclical movements were not relatively strong enough to generate a nonlinear relationship. Instead, a linear relationship of least squares best fit in the scatter plots corresponds to the data and provides us with samples that meet the linearity assumption. Another interesting point, the outlier in the graph is France. Remember the Pearson coefficient was the lowest of all the variables for these two variables, public education and GDP in the private spending dataset. The 0.716 value is pulled down by France, which has a Pearson coefficient value of 0.259. France has a much weaker alignment between their decisions concerning funding public education and their economic outcomes.

The next analysis was conducted running an SK Test of the independent variables in STATA software. The SK Test is a test of normality using skewness, kurtosis, and an overall test statistic of an adjusted Chi-square value. Logarithmic data was not used since the analysis examines the variable data independently. The results for the training expenditures dataset, for all three independent variables was below 0.05 and therefore indicates issues with normality. The data is displayed in Appendix C.

For the private education spending dataset, the Chi-square significance for both independent variables indicates issues with normality. Lastly, for the academic journal dataset, both independent variables have problems with normality too. The output is fully disclosed in Appendix C and this practice will be followed for the summaries presented in the data analysis and results.

Attention is now turned to exploring the condition of the datasets for issues with multicollinearity. Due to the interaction of the independent variables, logarithmic data was used. For all of the datasets, the VIF coefficients and their 1/VIF values were tested in the STATA software. In the training dataset, the three independent variables of training expenditures, research and development, and public education expenditures all had coefficients above 10 and with probability below the 0.05 level, making multicollinearity a significant issue. Again, the detailed data is in Appendix C.

The results of the test for the private education expenditures dataset suggests that multicollinearity is not an issue because it remains below the threshold of 10 with a probability above 0.05, and therefore, the multicollinearity issues are manageable for both independent variables. The third and final dataset for academic journals had the following test results. The independent variables are academic publications and public education expenditures, and they are just slightly above the 0.05 significance level at 0.051, but with values well above the 10 threshold at 19.54. The academic journal publications variables are marginally passable, but would be a concern for multiple regression analysis due to multicollinearity, and are therefore a potential issue for this analysis. Appendix C displays the data.

To complete this review of practical issues with the data, the STATA heteroskedasticity test was administered to all three datasets. STATA uses the Breusch–Pagan/Cook–Weisberg test for heteroskedasticity and the assumption is that error terms are normal. Logarithmic data was used. For the training expenditures dataset, the results suggest an issue with heteroskedasticity. The private education spending dataset has a result where heteroskedasticity is not an issue. Lastly, the academic journal data shows heteroskedasticity was an issue. The output is in Appendix C.

Additionally, all three datasets are smaller than the preferred sample set. The largest dataset is the private education spending data. It would be a more robust sample, even for data panel analysis, if it had more than seven countries, more than 17 years of data, and more than only two independent variables. After addressing practical issues for the data, the analysis suggests that sample size, very high correlations of variables, problems with normality, multicollinearity, and issues of heteroskedasticity supports the design and methodology plan to rely on random data panel analysis. Two datasets would make the results biased for multiple regression analysis, and the private spending data might have issues for its variables due to normality issues. But first, given lag effects that may be present in the relationships, analysis of the ARIMA model was appropriate.

ARIMA Analysis of the Data

The autoregressive, integrated, moving average (ARIMA) is a model used to compute auto regressions and partial regressions in order to determine lag effects for the independent variables in the analysis. The expectation is that education and human knowledge changes do not predict or determine changes in economic outcomes in only the immediate period following a change in these variables. This analysis will measure the lag effects in our three datasets.

Starting with the training dataset, there are three independent variables to examine: training expenditures, research & development, and public education expenditures. Logarithmic data was not used since each variable was analyzed independently. The first step was to select a model. The model (1,0,0) was selected from the model (p, d, q) where p is the autoregressive function, d is the difference, and q is the moving average. This means the model has one autoregressive component with zero difference and zero moving averages. The autocorrelation for this model is shown on the next page.

Table 4.2 Autocorrelations for Training Expenditures

Autocorrelations

Series: Training Expenditures PPP $

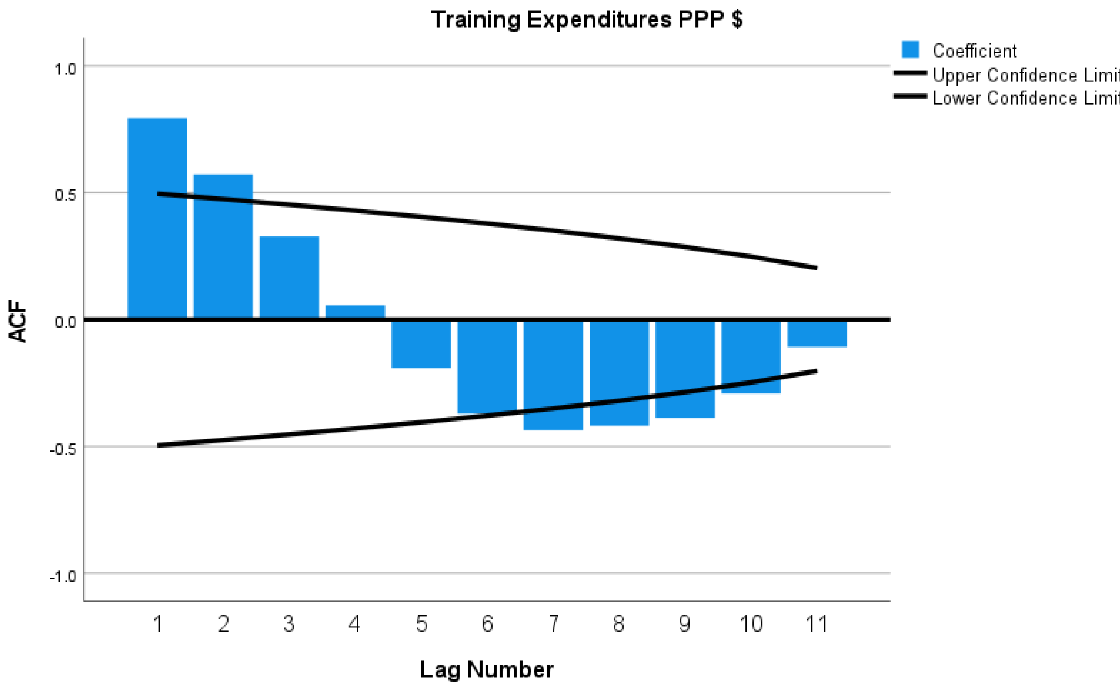
Lag	Autocorrelation	Std. Error[a]	Box-Ljung Statistic Value	df	Sig.[b]
1	.795	.248	10.262	1	.001
2	.572	.238	16.062	2	.000
3	.328	.226	18.162	3	.000
4	.057	.215	18.231	4	.001
5	-.191	.203	19.119	5	.002
6	-.371	.189	22.958	6	.001
7	-.437	.175	29.164	7	.000
8	-.418	.160	35.984	8	.000
9	-.388	.143	43.312	9	.000
10	-.292	.124	48.838	10	.000
11	-.108	.101	49.966	11	.000

a. The underlying process assumed is independence (white noise).

b. Based on the asymptotic chi-square approximation.

The length of the lag covers only 11 periods, given the restrictions of the size of the sample. All eleven periods show significance, and the value increases almost fivefold. However, a correlogram is typically used to determine the significant length of the lag for the dataset, as shown on the next page.

Figure 4.2 Correlogram of the Autocorrelation for Training Expenditures



This graph shows the first two periods above the upper 95% confidence level, and so this is the lag period for the variable. Keep in mind, training typically is measured in hours while education is measured in years. Hence the shorter two year lag effect for training is the result. For example, a software training course would need to be presented again for all new software purchased by the firm, and the cycle appears to be from two years for the maximum training impact to six years when the negative lag crosses the 95% confidence level. In comparison, years of developing writing skills in school can be utilized over much of a lifetime.

To confirm the model is a fit, the residuals of the dependent variable GDP were generated and analyzed in the next table. (see the following page)

Table 4.3 Autocorrelation of Residuals for Training

Autocorrelations

Series: Error for GDPPPP$ from ARIMA, MOD_2, CON

Lag	Autocorrelation	Std. Error[a]	Box-Ljung Statistic Value	df	Sig.[b]
1	.107	.277	.187	1	.665
2	.218	.281	1.028	2	.598
3	-.009	.293	1.030	3	.794
4	-.002	.293	1.030	4	.905
5	-.043	.293	1.075	5	.956
6	-.041	.294	1.122	6	.981
7	-.071	.294	1.286	7	.989
8	-.083	.296	1.554	8	.992
9	-.077	.297	1.846	9	.994
10	-.156	.299	3.423	10	.970
11	-.193	.305	7.060	11	.794

a. The underlying process assumed is MA with the order equal to the lag number minus one. The Bartlett approximation is used.

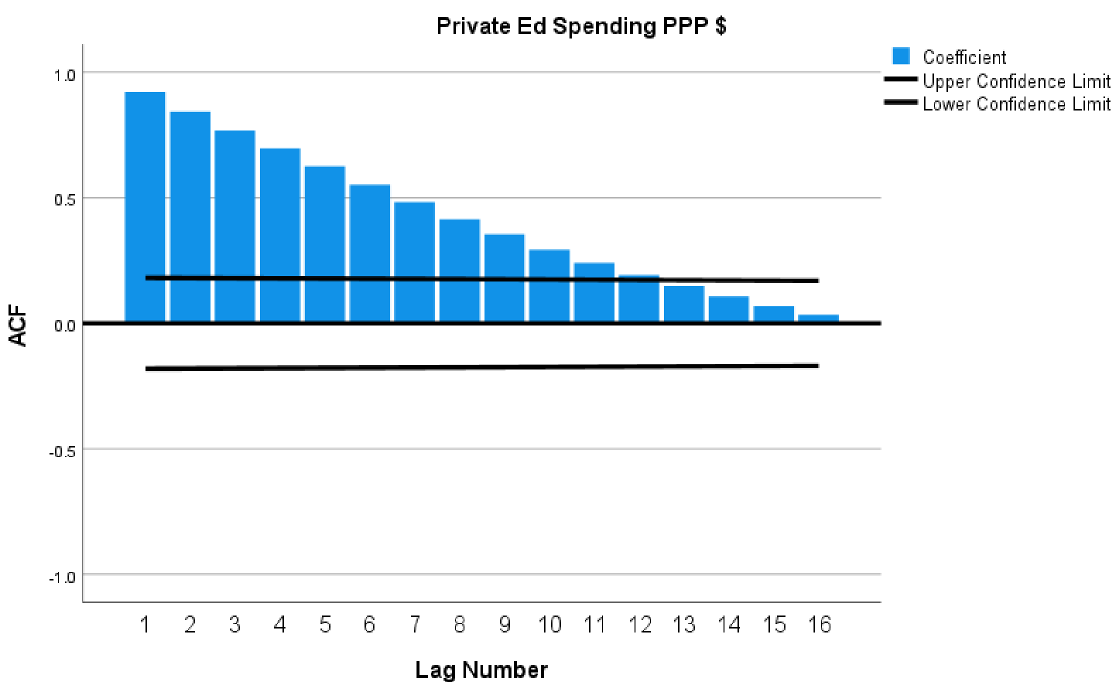
b. Based on the asymptotic chi-square approximation.

Using the McClain and McCleary rule, the absolute value of *t* for autocorrelation at each of the first three lags should be less than 1.25, and for the remaining lags less than 1.60. All of the autocorrelation values are less than the standard error, and therefore, the *t* value which is computed by dividing the autocorrelation value by the standard error, is less than one for every value in the series, making the model a fit.

The correlation tables and correlograms were generated for both R&D and Public Education Expenditures. The results also showed significance for all 11 periods with increases in the autocorrelation values, and the correlograms showed a 2-period lag effect. This model was the same for all three independent variables and was also a fit based on the residual evaluation. These tables and graphs are in Appendix D.

The dataset for private education expenditures was analyzed next, with the two independent variables of private education spending and public education spending. The same model (1,0,0) was applied. The autocorrelation matrix showed a five-fold increase in value for 16 periods and the tables can be found in Appendix D. The correlogram is below.

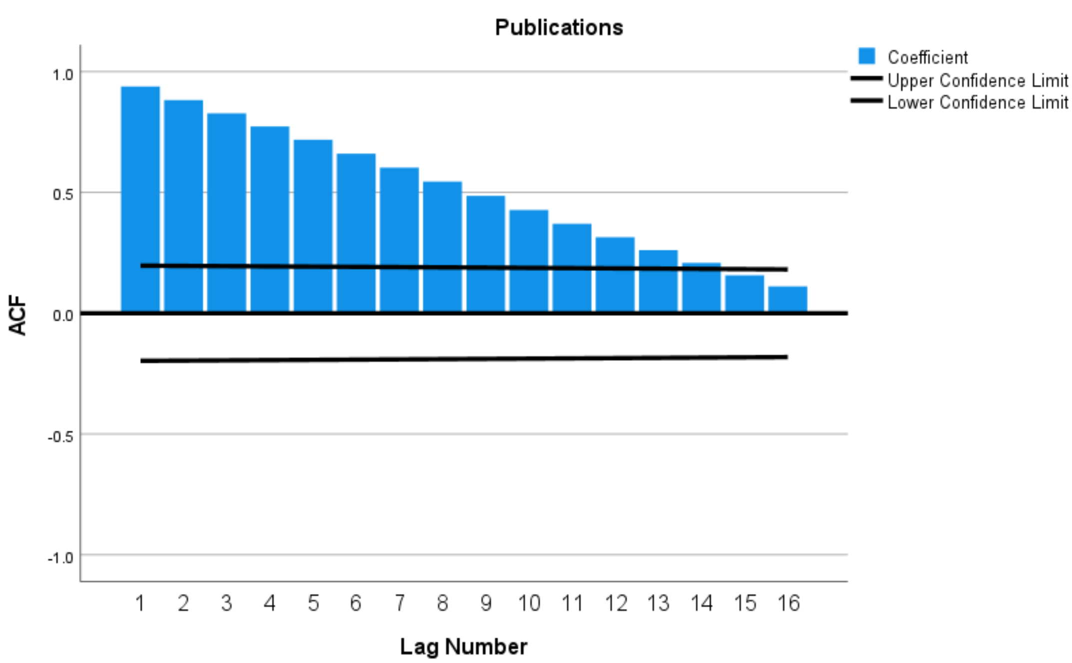
Figure 4.3 Correlogram for Private Education Spending



There are 12 periods where the autocorrelations exceed the upper 95% confidence level. The effect of formal education is spread over a much longer time frame than business training, and given the years of study compared to the hours of training, this finding is understandable. The testing of the dependent variable residuals in order to determine model fit is displayed in Appendix D. The autocorrelation values for the residuals are well below the paired standard error values, and so all *t* values are less than one in absolute terms. The model is a fit. The last dataset to analyze is the academic publications.

The publications of academic journals dataset has two independent variables. The first is academic journal publications and the second is our statistical adjuster, public education expenditures. For this last ARIMA analysis, the model is once again (1,0,0). The autocorrelation data is in Appendix D. The data is significant for all 16 periods with an increase of nearly sixfold for the values. As indicated in the correlogram below, the significant lag period above the upper 95% confidence interval is for 14 periods. This can be attributed to journal article ideas building on other journal publications, and thereby increasing the lag effect. For instance, with a nuclear fusion article there are huge numbers of other articles written by researchers studying the original, and citation rates continue for years. For journal research articles, citation numbering and the impact factor have remained constant. Consider the graph presented.

Figure 4.4 Correlogram of Publications

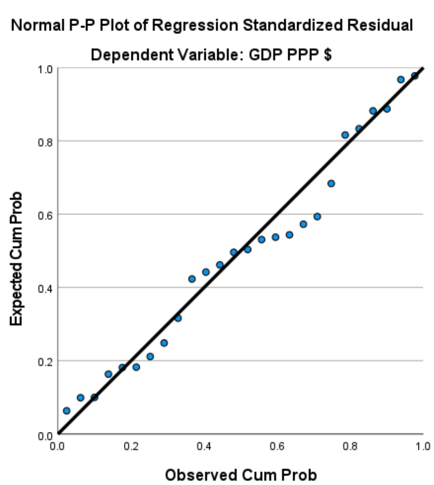


All 16 of the autocorrelation values are less than the paired standard error, making the *t* values less than one, and therefore confirming the model is a fit. The education expenditures variable was also significant for all 16 periods with increasing valuations, and the correlogram indicated a 14-period lag effect for this variable too. The evaluation of the residuals demonstrates the model is a fit. This data is in Appendix D. The next section will continue the evaluation of the data before analyzing the generalized mixed models.

Normality of Residuals and Endogeneity

The independence of residuals is often questioned with data that exhibits autocorrelation over time. If there is an issue with normality of the residuals then other adjustments to the model may be necessary. To test for normality of residuals requires the dataset residuals be plotted and the Shapiro-Wilk test be applied. Logarithmic data was not used. The first dataset to be tested is the training dataset, with predicted and random residuals from the three independent variables of training expenditures, R&D expenditures, and public education expenditures The plot is below.

Figure 4.5 The P-P Plot of Standardized Residuals



The P-P plot appears to exhibit normality with a relative closeness of points to the best fit line. However, we will examine the Shapiro-Wilk values to confirm.

Table 4.4 Test of Normality for Residuals of the Training Dataset

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Unstandardized Residual	.131	26	.200*	.961	26	.413
Standardized Residual	.131	26	.200*	.961	26	.413

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

The Shapiro-Wilk is not significant at the .05 level, and therefore both standardized and unstandardized residuals are exhibiting normality. The two tests for the private education spending dataset are next. The two independent variables are private education spending and public education spending. The P-P plot appears to have a close fit of points to the best fit line, with one notable exception. However, the Shapiro-Wilt test is significant below the .05 level at .002, and therefore, there is an issue with the lack of normality for the residuals. Our last dataset is academic publications, and it has two independent variables of publications and education expenditures. The graph and test of normality are in Appendix E.

The test of normality for the academic journal publications data was also .002 for the residuals, just as was demonstrated for private education spending. In fact, this is a rare practical issue for the private spending dataset in its data analysis. The plot and test of normality are in Appendix E. Our next concern is evaluating endogeneity.

Endogeneity occurs when a confounding variable biases the results of the model, and this issue is evaluated by using the Wald test. The test was run using the STATA software, and the results for the training dataset were a Chi-squared value. The results cause us to accept the null hypothesis, where the value of the confounding variable is zero, and therefore, no issue with endogeneity is observed. The values for the training dataset, private spending dataset and the academic publications dataset are at a significance level of 0.000. Endogeneity is not a problem for the datasets. The data for the normality of residuals and endogeneity are found in Appendix E. The summary of the practical issues is presented in the table below.

4.7 Summary of Practical Issues

	Training Data	**Private Spending Data**	**Publication Data**
Linearity	Linearity is demonstrated	Linearity is demonstrated	Linearity is demonstrated
Normality	***Normality issues***	***Normality issues***	***Normality issues***
Multicollinearity	***This is an issue***	It is Not an issue	Marginally passable
Heteroskedasticity	***This is an issue***	It is Not an issue	***This is an issue***
ARIMA Lag Effect	2 Period Lag	12 Period Lag	14 Period Lag
Normality of Residuals	No issues for this test	***This is an issue***	***This is an issue***
Endogeneity	No issues observed	No issues observed	No issues observed

Having evaluated all of the practical issues and determined the lag effects for each dataset, next in the analysis is the examination of the relationships between the independent variables and the dependent variable of GDP. The data analysis of the results of the generalized mixed model in SPSS was considered in addressing these questions.

Generalized Mixed Model Analysis

The SPSS statistical package offers generalized mixed models analysis. The scale response was set for gamma with log link. This approach favors positive data relationships and manages logarithmic data. Estimations were set for the hybrid method and maximum likelihood estimates. The hybrid method uses both scoring methods to improve estimation. The model effects analysis type was set at type III. The Wald test was also selected.

The first analysis was for the training dataset. The results are shown in the table.

Table 4.8 Test of Model Effects for Training Dataset

Tests of Model Effects

	Type III		
Source	Wald Chi-Square	df	Sig.
(Intercept)	9.933	1	.002
Country	.123	1	.726
Year	38.263	12	.000
log10Training	3.533	1	.060
log10RD	37.909	1	.000
log10PublicEd	2.763	1	.096

Dependent Variable: log10GDP

Model: (Intercept), Country, Year, log10Training, log10RD, log10PublicEd

The test of model effects shows that only the independent variable R&D is significant. The training data is the smallest dataset of those we are examining. This data was logarithmic in scale. Also, there are problems with multicollinearity, and with only two country variables, one of which is world data, the replication of North America data is over one-third of the world data.

The next dataset to be tested was the private education spending dataset. The results of the generalized mixed model are as follows.

Table 4.9 The Test of Model Effects Private Education

Tests of Model Effects

Source	Type III Wald Chi-Square	df	Sig.
(Intercept)	212.799	1	.000
Country	18521.938	6	.000
Year	96.662	16	.000
log10PrivateEd	15.398	1	.000
log10PublicEd	23.814	1	.000

Dependent Variable: log10GDP

Model: (Intercept), Country, Year, log10PrivateEd, log10PublicEd

In this case, both variables are shown to be significant in the test of model effects. The private spending dataset was the largest, had the most countries, and had a longer lag effect than training. The last dataset to be examined is the academic journal publications data. The Test of Model Effects table is on the next page.

Table 4.10 The Test of Model Effects for Publications

Tests of Model Effects

Source	Type III Wald Chi-Square	df	Sig.
(Intercept)	393.311	1	.000
Country	288.259	4	.000
Year	41.046	19	.002
log10Pub	28.730	1	.000
log10EdEx	3.224	1	.073

Dependent Variable: log10GDP

Model: (Intercept), Country, Year, log10Pub, log10EdEx

The results of the test of model effects shows publications are significant in relationship to GDP. However, the education expenditures variable is not significant. This is because we included the world data, and the observations are reflective and duplicated. Over 36% of the world data is captured in the other four reported countries. Consequently, the world data was blocked, and the following results were obtained.

Table 4.11 Test of Model Effects for Publications without World

Tests of Model Effects

Source	Type III Wald Chi-Square	df	Sig.
(Intercept)	32167.950	1	.000
LogPubs	43.778	1	.000
LogEdExp	109.783	1	.000

Dependent Variable: LogGDP

Model: (Intercept), LogPubs, LogEdExp

Now both variables are significant. The difference is shown in the next two graphs.

Figure 4.7 Graphs of GDP by Country with World Data

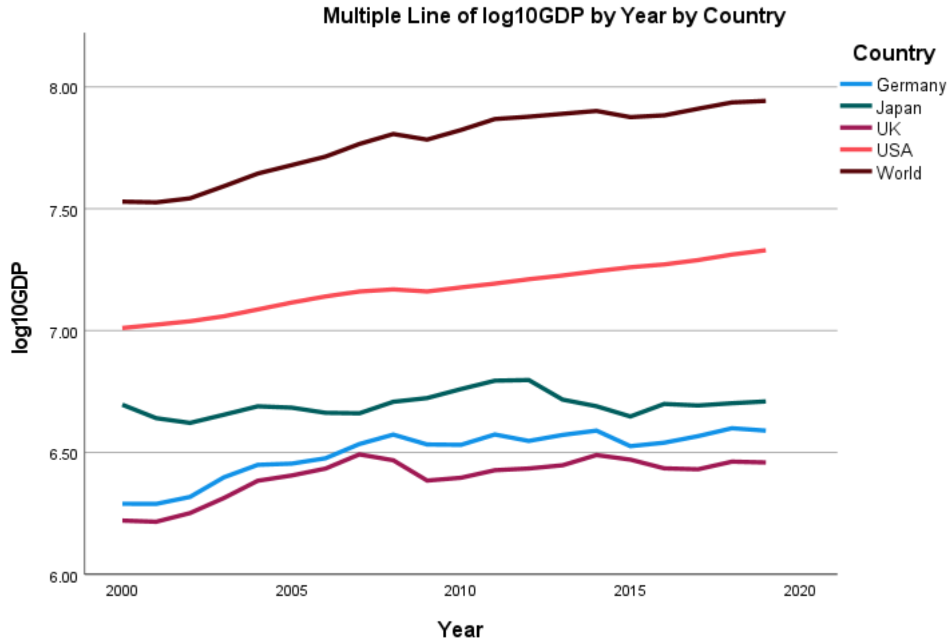
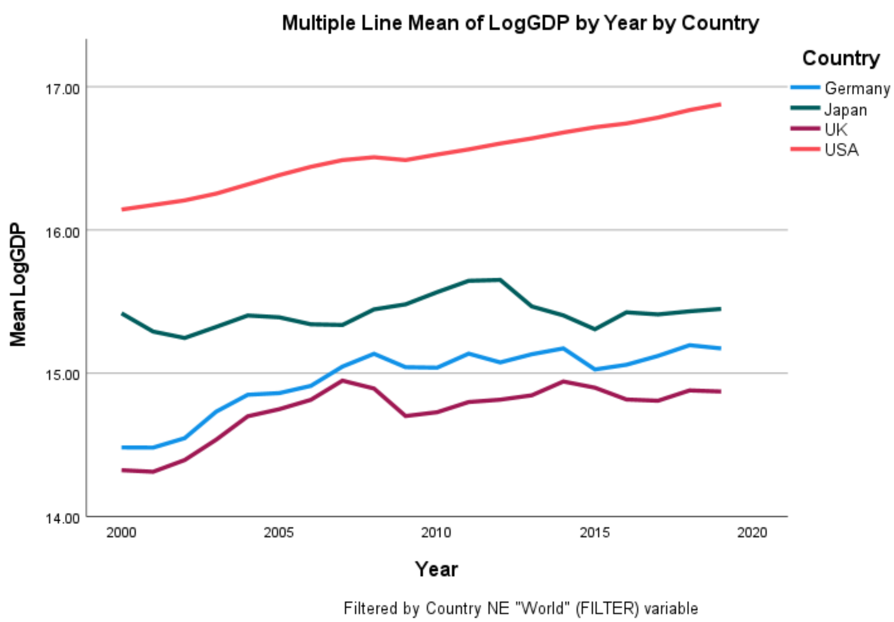


Figure 4.8 Graph of GDP by Country without World Data



Without the world data, the education variable moved to significance. The data for the rest of the world does not have as strong of a relationship between education and GDP, as we have seen in the literature review. There are stark differences between developed, developing, and underdeveloped nations. Developed and developing nations spend more on education, are more of a knowledge economy, and have higher education outcomes.

Noticeably, the results of GMM in SPSS do not post an R value. IBM support has posted an explanation (IBM Support, n.d.). IBM states that the generalized mix model analysis does not post an R value. They go on to argue that other statistical packages do not provide this statistic for GMM either. Only STATA provides a pseudo R value by fitting a negative binomial, and only with a log link function. Since my planned methodology was to provide the R coefficient, other solutions were examined. The university provided the statistical package STATA as we have seen. This software offers a data panel analysis option, and this produces the R value from the analysis, so running the datasets using this approach was a viable option.

Data Panel Analysis

The data panel analysis in STATA offers several options. Since my datasets were produced based on selecting countries having no missing data in available public domain data, I chose to focus these shared results from the random data panel analysis approach. The logarithmic scale was used. The results for the training dataset are the first, and they are on the next page.

Table 4.12 Random Data Panel Analysis for the Training Dataset

Variables	Coefficient	Std Error	Z Score	P>Z	95% Conf Intvl	
Log Training	0.197	0.132	1.50	0.135	-0.061	.455

Log RD	0.169	0.155	1.09	0.278	-.136	.473
Log Public Ed	0.902	0.120	7.52	0.000	667	1.137

Overall R square = 0.996; Wald Chi-square (5648.6) with p< 0.001

The results show significance for only the public education variable. The Wald statistic is significant, and the overall R-squared value is 0.996. This suggests that nearly all the variance in GDP is determined by this model. This is the only model to include the third variable of research and development. I elected to run the data panel analysis with only the training and public education variables. The results are below.

Table 4.13 Random Data Panel Analysis for Training and Public Education

Variables	Coefficient	Std Error	Z Score	P>Z	95% Conf Intvl	
Log Training	0.276	0.110	2.50	0.012	.059	.492
Log Public Ed	1.005	0.074	13.6	0.000	.860	1.15

Overall R Square – 0.996; Wald Chi-square (5603.9) with p < 0.001

The results now show both variables, training and public education, as significant. The Wald test is significant, and the overall R-squared value is 0.996. This R-square value appears to be highly inflated, perhaps indicative of a bias effect. The next dataset for data panel analysis is the private education spending data. Next are their results.

Table 4.14 Random Data Panel Analysis for Private Education

Variables	Coefficient	Std Error	Z Score	P>Z	95% Conf Intvl

Log Private Ed	0.116	0.039	2.98	0.003	.039 .192
Log Public Ed	0.487	0.070	6.99	0.000	.350 .623

Overall R Square = 0.565; Wald Chi-square (149.4) with p< 0.001

Both variables, private and public education, are significant. The Wald test is significant, and the overall R-square value is 0.565. This R-square value is more realistic, and the private spending dataset is the largest. Lastly, we will examine the data panel analysis for the academic journal dataset. The output is below.

Table 4.15 Data Panel Analysis for Publications Data

Variables	Coefficient	Std Error	Z Score	P>Z	95% Conf Intvl
Log Publications	0.626	0.110	5.69	0.000	.411 .842
Log Public Ed	0.429	0.081	5.29	0.000	.270 .588

Overall R Square = 0.985; Wald Chi-square (787.7) with p< 0.001

The variables for publications and education expenditures are both significant. The Wald test is significant, and the R-square value is 0.985. This R-square value appears to be inflated too. What could be causing these inflated R-square values?

Professor Nawaz (n.d.) states that the R-squared values tend to be lower with cross section data compared to time series analysis. He attributes this to the heterogeneity of cross sections. However, if the data is more time dominant, the R-square value can be inflated to higher levels (ResearchGate, n.d.). This corresponds to the literature review results, where their analysis had as many as 10 to 30 countries for cross section analysis. Their datasets would be described as cross section dominant. All of these public domain research datasets are limited in the number of countries available to analyze cross sections.

In order to assess the value of our one lower R-square value found in the private spending dataset, an analysis can be run as a standard multiple regression analysis.

Multiple Regression Analysis

The private education dataset has 357 observations over a 17-year period for seven countries. There are no problems with linearity, multicollinearity, and heterogeneity. Additionally, the normality test showed issues for both the private and public education spending variables, and the normality test of residuals had problems. The time series focuses on time and not the cross section analysis of the countries. However, the research hypothesis calls for an R square measure that is reliable, and this analysis can perhaps serve as validation for the data panel R square results. Next are the results of the analysis, and logarithmic data was used.

Table 4.16 Multiple Regression of Private Education Spending

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.790[a]	.623	.617	.35427	.180

a. Predictors: (Constant), log10PublicEd, log10PrivateEd

b. Dependent Variable: log10GDP

The adjusted R-square is 0.617, above the 0.565 overall R-square showing for the random data panel analysis. Also, the significance coefficients were different, as shown in the table.

Table 4.17 Coefficients for Private Education Data

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.348	.368		6.377	.000
	log10PrivateEd	.643	.110	.635	5.826	.000
	log10PublicEd	.220	.136	.175	1.610	.110

a. Dependent Variable: log10GDP

The coefficient for public education was not significant for the multiple regression analysis. This was not the case with the data panel analysis output, but it was the case with the generalized mixed model analysis. However, the multiple regression data may be biased due to issues with normality and normality of residuals.

This completes the data analysis and the results of the research. There is an interesting mix of results for these statistical models. The following discussion and conclusions will attempt to place all of the data into perspective.

V. DISCUSSION AND CONCLUSIONS

The discussion will begin with examination of the primary research inquiry. Denison suggested forms of measurement that are attributed to the combining of education as formal school completion by the number of years, private spending for education, and corporate on-the-job training (Kerr, 1994). Other measures of human knowledge are attributable to the growth in academic journal publications, research and development expenditures, and the growth in patents. The research inquiry focused on three of these variables. Significant research was reviewed in the literature showing the determinant relationships between the independent variables of educational attainment and educational expenditures, research and development, and the growth in patents. As far as could be ascertained, there is insufficient research on the three independent variables of training, private education spending, and publications and its relationship to the economic outcome of GDP.

The data analysis attempted to demonstrate a statistically significant relationship between all three of these variables and GDP. Also, the research was to state a determinant value for these relationships. The discussion of the results will focus on these salient points.

Starting with the training expenditures hypotheses, this variable was not shown to be statistically significant in either the generalized mixed model or the random data panel analysis. There were issues with normality, multicollinearity, and heterogeneity. Regardless of these concerns, the variable failed to demonstrate significance in data panel analysis where these issues were not as relevant. The dataset for the training variable was limited given what data I could obtain in the public domain. I was unable to acquire data by country, only having data for North America and the world. Also, with one-third of the world data duplicating the North America data, the concerns over multicollinearity are strengthened. As explained by Professor Nawaz (n.d.), the R-squared values tend to be lower with more cross section data compared to time periods. He attributes this to the heterogeneity of cross sections. A wide dataset has numerous cross sections relative to the time periods. This was demonstrated in the literature review where countries were so numerous that they were divided into OLS groups of countries. Contrary to wide datasets, a long dataset is where the cross sections are limited, like our training data with only two country variables, and this is small relative to a longer set of time periods. If the data is more time dominant, the R-square value can be inflated to higher levels (ResearchGate, n.d.). All of the public domain research datasets used in this research are limited in the number of countries, and to a lesser degree, the time periods available. The dataset only covered the period from 2007 to 2019. The sources of data were private industry organizations, and their focus is on the impact of training for the individual firm. This has limited the type of data compiled. The obtained overall R-square value from data panel analysis only applied to the education expenditures variable, the only variable that was statistically significant. Also, the overall R-square value was inflated. In generalized mixed model analysis, the R&D variable was the only variable achieving statistical significance.

To correct these issues, a researcher in the future will need to acquire a larger dataset. In addition, the dataset must be more cross-sectional, with data from many countries. This could reveal potential results where there is statistical significance, and additionally, the overall R-square value might not be inflated. However, perhaps the much lower lag effect of training in comparison to the other two variables of private education spending and academic publications may limit the training variable, and consequently not ever show it to be significantly related to or a determinant of economic outcomes. In conclusion, without showing statistical significance and with an inflated R square value, the findings suggest training expenditures do not positively relate to or determine economic outcomes. From the literature review, we only know that training expenditures positively impact the individual and the firm.

Next, the academic journal publications variable was found to be statistically significant for both the generalized mixed model and data panel analysis. However, the R-square value was inflated, even though the dataset represented four different countries and the world. This dataset also had issues of normality, multicollinearity, and heterogeneity. Additionally, the normality of residuals was not met. Given its data limitations from a long form dataset, the R-square values must be considered inflated and possibly biased. Also, a large portion of the world data replicated the data from the four countries, strengthening the concern with multicollinearity. Future research should be expanded to potentially cover a larger dataset, and the number of countries should be expanded to include at least 10 nations out of the top 25 countries, ideally in the range of 20 nations. This level of research will require funding to purchase data, since I do not believe this data is in the public domain. However, the significance of the relationships should warrant further investigation. In conclusion, this analysis could be the first demonstration of academic journals publications showing a statistically significant relationship to economic outcomes. Future research should analyze publications with research and development and patents. This will give us deeper insight into the relative value each variable contributes to the R square value, and thereby identify the relative importance of these determinants to economic growth.

Lastly, private education expenditures were found to be statistically significant for both the generalized mixed model and data panel analysis. The overall R-square value from data panel analysis of 0.565 is worth consideration. The dataset was the strongest with seven countries for cross-section analysis. Also, the multiple regression finding of an adjusted R square at 0.617 was relatively similar to the R square of 0.565 in data panel analysis. The dataset did have normality issues for both the tests of normality and the normality of residuals. Given these issues, this analysis would also benefit from funded research. Again, an increase from the seven countries used in the private spending dataset to a cross section of more than 10 countries from the top 25 nations would increase the validity of the overall R-square value. Also, an analysis needs to be conducted to determine the relevant contributions of each of the two variables, R&D and public education, to the determinant value. Assumptions in the research suggested that private education expenditures should contribute less determinant value than public education spending. There is a magnitude difference between their expenditure levels. I believe the future studies' data should attempt to include spending on software, books, and tutors by country, in addition to the data obtained by the OECD. Given its significance, further funded research is appropriate. In conclusion, this could be the first demonstration of the statistically significant relationship between private education spending and economic outcomes. This completes the discussion and conclusions from the specific statistical research of the primary inquiry.

Policy Implications

Attention will now be returned to the historical context and motivation of the revolution of learning and its relationship to economic expansion. Alongside the inquiry, the historical context significantly contributes to the expansion of the implications for the future of educational policy.

The review of the history of education demonstrated the slow and random development of human learning from prehistoric times through ancient and medieval history, culminating in the modern era with the advent of public education. Public education moved us from about 12%

literacy in the world in 1820 to 86% of the world population by 2016 (Roser & Ortiz-Ospina, 2018). The human population in 1820 was perhaps, at most, 1.2 billion people, and by 2016 the world population was over 7.4 billion, an increase of over 600% (Worldometer, n.d.). The growth in the human knowledge of biology and medicine are key contributors to health improvements, leading to tremendous population growth (Murphy & Topel, 2003). Buckminster Fuller (1981) in his book *Critical Path* estimated that if we took all knowledge that humanity had accumulated and transmitted in the year one of the common era (CE) and equated it to one unit of information, it probably took about 1500 years for that amount of knowledge to double. With public education beginning in the 1700s, knowledge had accelerated the doubling effect. Some are estimating it is doubling every 13 months now, and IBM theorizes someday it could become every 12 hours (Miller, 2019). IQ test scores have also demonstrated gains in human learning (Bailey, 2015). Someone scoring an average of 100 points in 2015 would have scored 130 points in 1915, an increase of two standard deviations in only 100 years (Bailey, 2015). To clarify, the tests were changed periodically to force the average back to 100. Had the test not been changed from the original used in 1915, taking that same test in 2015 would move the average score to 130 instead of 100.

Additionally, according to the International Association of Universities, there are 18,000 tertiary institutions in 180 countries today, and in 2014 they estimated the number of university graduates had reached 137 million worldwide. The Association also projects we will reach 300 million graduates by 2030 (ICEF Monitor, n.d.). Universities are currently working to demonstrate the relationship between education and research with economic outcomes. As an example, the University of Texas at El Paso has set strategic goals of focusing on workforce productivity in their region and creating clear connections between the classroom and real-life situations. In five years, they have grown enrollment 6.3% and grown degrees awarded 17%. In research, as an R1 institution, they have seen 1,315 scholarly publications, 18 patents, and 15.6% growth in R&D expenditures (2030 UTEP Strategic Plan and Annual Report, 2022). But to continue, universities worldwide will need more funding.

In summary, literacy improved sevenfold while population was growing sixfold and human knowledge had grown by over 32 fold. The average IQ also improved two standard deviations. Alongside the learning revolution, economic outcomes were improving tremendously too.

The world was at $1,102 per capita GDP in 1820 and was at $14,944 in 2017, an increase of well over 13-fold (Roser, n.d.). International trade had grown from 6.3% in 1831 to 57% in 2018, an increase of ninefold (Ortiz-Ospina & Beltekiam, 2018). What was driving the economic expansion? Robert Barro and Jong-Wha Lee’s (1993) book showed the relationship between this economic growth and education. Their results suggest that increases in education levels since the 19th century are estimated to account for between one-fifth to one-third of economic growth in the United States over approximately 150 years (McGivney & Winthrop, 2016). Denison's research concluded that 20% of economic growth is contributed from education per worker and 40% is contributed from advances in human knowledge. This means the majority of economic gains come primarily from education, outweighing the contributions of the economic variables of capital per worker, improved resource allocation, and economies of scale combined (Kerr, 1994). There is every reason to believe these trends will continue and grow.

In 2018, agriculture represented only 4% of the total world GDP (World Bank, 2022). Manufacturing data showed in 2011 it represented 16% of the world economy (McKinsey, 2012). These trends are one reason education and human knowledge are continuing to overtake capital investments as the driver of the world's economic outcomes. In a current issue of *The Economist* (n.d., 2023), data was presented showing US manufacturing dropping from 25% in 1970 to well under 10% in 2020. The drop in agriculture and the manufacturing sectors has continued since Denison's determinant estimates (Kerr, 1994), making education and human knowledge even more important for economic growth in the knowledge economy.

What persuasive arguments from these historic trends can educators use to encourage continued growth in educational funding? The National Education Association posts arguments for more funding for students and schools by calling legislatures "greedy politicians" (NEA, n.d.). The NEA goes on to say politicians use the reduced educational funding to pay for tax breaks for their corporate donors. This argument by educators does not encourage lawmakers to invest in education. An article by Eric Hanushek (2004) identifies why the government is reducing funding for education. The movement to hold schools accountable for performance with standardized tests has led to budget cuts in education. Testing has grown in the US, and schools not meeting performance mandated outcomes are losing funds. Hanushek explains that educators are arguing that more money is needed to improve outcomes. This has also not been an effective approach to encourage policymakers to increase educational funding. Given these problems, research should create data demonstrating the economic impact of investing in education, and with it, the hope that educational policy can be positively affected.

A recent article by The World Bank (Patrinos, 2016) argues that education sets the foundation for sustained economic growth. Hanushek (2020) continues to research the economic outcomes from education in his latest book, *The Economics of Education*. He concludes growth simulations reveal that the long run rewards from education are large but require patience. And finally, the Proceedings of the National Academy of Sciences published an article (Lutz et.al.,

2019) for 165 countries from 1980 through 2015 showing a clear dominance of improving education giving evidence of both a health and general resilience and a human capital dividend. But more research, communication, and awareness needs to be built from a concerted effort of this obligation to change our universal understanding of the role of education.

In the last 60 years since Becker's book, *Human Capital* (1964), perhaps 100's of millions of students have learned that the industrial revolution created an economic revolution, and this revolution was driven by the engine of capital investment. This is history now. Curriculum needs to change, and 100's of millions of students now need to learn that we live in a knowledge economy where the engine of economic growth is education, not capital. This could have the single largest impact on education funding and policy.

Policy Considerations

We have also seen data from 2017 demonstrating US education expenditures were 13.9% of the total U.S. budget, but then education expenditures dropped to 13.1% of the 2018 budget (Macrotrends, n.d.). For 2022, education expenditures dropped again by -7.7% (U.S. Spending, n.d.). As to human knowledge development, in 2022 the Tax Cuts and Jobs Act (TCJA) required companies to amortize their R&D costs over five years. Companies had been deducting R&D costs immediately each year. This change will raise the cost of R&D investment, reducing the future level of R&D funding, and with it, lead to reductions in the level of economic output (Bellafiore, 2019).

What three policy areas should the United States focus on today? First, more than 30 million adults in the United States cannot read, write, or do basic math above a third-grade level (Resilient Educator, n.d.). In the United States, we should be funding Comprehensive Literacy

State Development (CLSD) grants (Diallo, 2020). The funding for this process has sadly been reduced. Second, the high school dropout rate rose to 5.8% in 2020 (USA Facts, n.d.). The funding approach in the U.S. has been the School Dropout Prevention Program (US Dept. of Education, n.d.). More investment is needed in this critical area now. Lastly, college enrollment dropped in 2019, and then it dropped another 2.5% in 2020.. The Gates Scholarship Program USA provides full scholarships including room and board for candidates based on merit. A federal program following this approach would find the graduation rate of their recipients is much higher than the partial funding approach taken by most federal programs (Scholarship Agency.com, n.d.). Gates has spent 1.6 billion on 20,000 Gates scholars while gaining a six-year graduation rate of nearly 90% versus the average of 58% for all college students (GMSP, n.d.).

These very recent statistics demonstrate a change in our investment levels in education, and this downward trend is a reversal of the previous growth in funding. The statistics of educational gaps identify the work that needs to be done to grow the education and knowledge capabilities in the United States. Is the government responding?

Proposed Policy Changes

The government in the United States has been characterized as a strongly divided partisan political environment. However, in 2021, a bipartisan Congress passed a $1 trillion dollar Infrastructure Bill to invest in the economic future of the country (World Economic Forum, 2021). In 2022 a bipartisan Congress passed Semiconductor Legislation to invest $280 billion in semiconductor manufacturing in the United States (The Council of State Governments, 2022). When logical economic investment rationales are used to persuade both Democrats and Republicans of the importance of investing in the future competitiveness of the nation’s economy, then these arguments are shown to be the one approach that has been successful in getting results. Can these arguments apply to education?

First, those separated by the digital divide have fallen behind in their education. The peak of the pandemic saw school shutdowns impacting 1.6 billion students worldwide (United Nations, 2021). President Biden's political platform was to provide universal preschool for three and four-year-olds, address the national teacher shortage, upgrade and build new public schools, invest $20 billion in Title I schools, spend $2.6 billion to support special education, and improve broadband infrastructure for unserved and underserved communities (The White House Factsheet, 2021). These proposals need to be funded. Second, community college enrollment also dropped by 10% in 2020 (Smith, 2021). President Biden introduced a plan to spend $109 billion to make two-year community college tuition-free (McGurran, 2021). This proposal needs congressional support. Thirdly, in the USA, college debt has reached $1.75 trillion (Hahn & Tarver, 2022). Perhaps the most publicized plan from the President has been Biden's plan to forgive student loan debt. Borrowers who receive Pell Grants could see up to $20,000 in debt cancellation and all those with incomes below $125,000 could receive up to $10,000 in loan forgiveness (White House Fact Sheet, 2022). This issue is before the Supreme Court now. Lastly, the Harvard Gazette (O'Rourke, 2021) published data from the Bureau of Labor Statistics showing the growth of STEM jobs has been 79% in the last three decades. One answer for the Biden administration has been to allow immigrants to fill the gap. In 2022, the State department announced a STEM research initiative to attract international STEM scholars, students, researchers and experts by removing barriers to legal immigration (White House Fact Sheet, 2022). And this makes sense because we are falling behind. If the United States cannot produce enough educated employees to fill our research and development needs, what might our trading partners worldwide do to attract the best talent away from us? Competition means we have to improve our performance, and this means we have to double our efforts in building our human capital through education.

Conclusion

This gives us an idea of the level of support for funding education from the progressive left of the political continuum. After Biden's State of the Union Address, the Republican response came from Sarah Huckabee, Governor of Arkansas. Huckabee's platform for the state of Arkansas focuses on education. She plans improved access to reading coaches for at-risk children at the pre-K level, reward good teachers with incentives and higher pay, expand high-speed internet, and prioritize school safety (sarahforgoverner, n.d.). Although a Trump ally and a representative of the far right, Huckabee demonstrates that from both sides of the aisle there could be general support for better funding of education in the future.

Making standardized tests the debate point or accusing politicians of using funds to further their political fundraising are not effective strategies to motivate political policymakers to increase educational expenditures. Demonstrating that economic growth, higher incomes, and international competitiveness are determined by investments in education is the effective argument. Public opinion could shift to support investing more in our public education system, and to the growth of our collective human knowledge at the national level. The economic prosperity of the country is an issue we can all unite behind, particularly when we understand the importance education plays in determining future economic success for the country, and yes, for all of humanity.

As cited by Roser and Ortiz-Ospina (2018), about 14% of the world’s population is illiterate. This is over 1.2 billion people. UNESCO and The World Bank (n.d.) tell us that 24% of youths do not attend secondary school. Data from 2020 estimates that 34% of adults had not completed secondary education (Statista, 2022). The International Association of Universities is only projecting 300 million university graduates by 2030 (ICEF Monitor, n.d.). This is less than 4% of the world population. Opportunities to grow education and human knowledge are abundant, both in the United States and globally. Given what the literature review and what history has shown public educators are capable of accomplishing throughout the learning revolution, the investments in education and human knowledge need to continue to increase over time. If we do not grow education investments, future economic outcomes will fail. We need to invest in education and human knowledge with the commitment shown to capital investment during the industrial revolution. Without this investment, the knowledge economy cannot grow, and the revolution in learning will be over.

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Glossary

Absolute Advantage - This advantage occurs from a country's ability to produce more of a commodity than its global competitors. This may come from natural resources, as we see in the oil and gas markets, where certain countries have these mineral rights in abundance.

ARDL Model -Autoregressive distributed lag model, where the dependent variable is a function of its own past lagged values as well as current and past values of other explanatory variables.

ARIMA Model – A method to use a historical time series to predict future outcomes. The data is auto regressed and integrated, sometimes based on differences and/or a moving average.

Autocorrelation – A mathematical representation of the degree of similarity between a time series and a lagged version of itself over successive time intervals.

Bi-logic Growth Functions - Growth functions measure the richness of a set family. They are especially used in the context of statistical learning theory, where it measures the complexity of a hypothesis class. The Bi-logistic growth function is effective in modeling systems that contain two logistic growth pulses.

Comparative Advantage - This advantage occurs when a country can produce a good or service at a lower opportunity cost than other nations.

Cross Sections – A statistical method where data is collected at a single point in time on a statistical unit, such as a cross section of a countries economic metrics at one time period.

Data Panel Analysis – This is a statistical method, widely used in social science and econometrics to analyze two-dimensional (typically cross sectional and longitudinal) panel data.

Determinants – A statistical term that describes when the results in the data are not explainable by chance alone. It typically is an R square value that indicates how strong the relationship is between the determinant and the independent variable.

Economic Growth - This is the rate of increase in GDP over time.

Economies of Scale – This is when a cost advantage is gained by increases in output. The greater the quantity produced, the lower the fixed cost, since capital cost are fixed, and more is produced at no additional cost. Also, average variable costs fall due to operational efficiencies.

Endogeneity – In economics, endogeneity broadly refers to situations in which an explanatory variable is correlated with the error term.

Gross Domestic Product (GDP) - All output of products and services for a country.

Growth Accounting – The examination of the impact of labor, capital, and technology on total GDP growth.

Heterogeneity - means that your populations, samples or results are different. It is the opposite of homogeneity. A heterogeneous population or sample is one where every member has a different value for the characteristic you're interested in.

Homogeneity – This relates to the validity of the often convenient assumption that the statistical properties of any one part of an overall dataset are the same as any other part.

Human Capital – Physical capital is all investments in plant and equipment yielding output improvements in the productivity of the enterprise. Productivity improvements yielding output improvements from investments in the education of labor is the creation of human capital.

Human Knowledge - Ideas from the human mind about the outside world. Logic and regularity are key principles. The scientific method is a rigorous approach to acquiring knowledge. Any facts, data, and information that can be learned or known is human knowledge.

Human (or labor) Productivity – This is the rate of output of products and services per worker, usually growing from investments in capital or people.

Hypothesis – A proposed explanation made on the basis of limited evidence as a starting point for further investigation.

Inflation - A general increase in prices and fall in the purchasing value of money.

Knowledge Economy – This is defined as an economy where workers are the integral element based on their knowledge.

Kurtosis – A statistical measure to determine how much data resides in the ends of the distribution curve. Distribution curves with kurtosis have more data in the ends of the curve than found in a normal curve.

Learning Revolution – This refers to the historic period from the beginning of free public education in the late 1700s and continuing through today.

Logarithmic Model – A method to take the inverse of data that is growing exponentially, or to reduce the magnitude of the data variances being measured.

Maximum Likelihood – A method of estimating the parameters of an assumed probability distribution, given the observed data.

Mean – The statistical term for an average. The total sample is computed and divided by the population of the sample to compute the average or mean.

Median – The midpoint of a sample. All sample data is rank ordered, divided in half, and the middle value is the median.

Moving Average – This methodology takes a grouping of data, three years as an example, averages the number, subtracts the first datapoint, adds the next datapoint, computes the next average, and proceeds by producing averages as it moves through the data in the time series.

National Income Accounting – This is the government bookkeeping system that measures the health of the economy, projected growth, economic activity, and development during a specific time period.

Opportunity Cost – This is the loss of potential gain from other alternatives when the less attractive alternative is chosen.

Output – This is an economic term used to describe all the product or services produced, either by the individual firm, an industry, a nation, or output globally for the world.

Per Capita – Relating or applied to each person.

Purchasing Price Parity – Currency conversion rates that try to equalize purchasing power by eliminating the differences in price levels.

Physical Capital – This is the investment in plant and equipment that has driven industrialization.

Predictor – This is a statistical term that describes when the results in the data are not explainable by chance alone. It typically is an R square value that indicates how strong the relationship is between the predictor and the dependent variable.

Productivity – The effectiveness of industrial effort, as measured in terms of the rate of output per unit of input. This is typically measured in terms of labor inputs or capital inputs.

Quasi Experimental Design – This design aims to identify the causal relationship between the independent and dependent variables. This design utilizes nonrandom criteria in assigning groups.

Real Terms - The change in a financial number after correcting for the effect of inflation.

Regression-Discontinuity Design - is a quasi-experimental pretest-posttest design that aims to determine the causal effects of interventions.

Residual – This is a statistical term for the unknown variables not specified in the analysis. As determinants or predictors explain part of the variance in the relationship between the independent variables and the dependent variables, the remaining variance is the residual.

Service and Sanctions Training – This training provides skills in identifying and managing government sanctions against specific foreign countries.

Skewness – A measure of the asymmetry of a distribution. The left and right side of the distribution curve are not mirror images.

Standard Deviation – A measure of how dispersed data is in relation to the mean or average. A high standard deviation means values are generally far from the mean. 99.7% of data observed in a normal distribution lies within three standard deviations of the mean.

Stratified Sample – This is a sample drawn from a number of levels or strata of the population, rather than at random, in order to be more representative.

Tertiary Education - This is all post-secondary education beyond K-12, and this includes universities, trade schools, and colleges.

Time Series – A series of quantity values at successive time periods, typically with equal intervals. This data is available for time series analysis.

Variables – In statistics, these refer to measurable attributes that typically vary over time or between individuals.

Vector Autoregression Model (VAR) – This is a multivariate time series model that relates current observations of a variable with past observations of itself and past observations of other variables in the system. VAR models differ from univariate autoregressive models because they allow feedback to occur between the variables in the model.

Appendix A

Statistical Matrix

Research Questions	Research Hypotheses	Rationale for Hypotheses	Data to be Analyzed	Proposed Statistics	Level of Significance
1. What is the relationship between training expenditures and national GDP by country and globally?	The hypothesis is that training expenditures as the independent variable is positively related and a determinant for the dependent variable of national GDP by country and globally.	The rationale is based on research which demonstrates at a general level the statistically significant relationship between education and economic outcomes. Denison specifically refers to the positive relationship between training expenditures and economic growth based on his derivation of the variable from residual data, utilizing his growth accounting methodologies. Other studies demonstrate a determinant relationship between training expenditures and the growth in revenues for the individual firm. This suggests that growth in revenues for individual firms based on training expenditures could lead to growth in the national GDP, and this may or may not be positively related to	The Training Industry Association data for North America and International data from the 2007 to 2019, along with national and global data for public education, R&D spending, and GDP.	The statistic for this analysis is the adjusted R^2	0.05 level.

		gross training expenditures as a determinant. Findings may suggest the need for national policies to consider the importance of increasing investments in training expenditures to influence the national GDP of the country.			
2. What is the relationship of private educational investments and national GDP by country?	The hypothesis is that growth in private educational investments as the independent variable is positively related and a determinant for the dependent variable of national GDP by country	The rationale is based on research which demonstrates at a general level the statistically significant relationship between education and economic outcomes. Again, Denison specifically refers to the positive relationship between private spending on education and economic growth. The variable from the residuals must be accepted as valid and reliable in order to accept the conclusions. Private spending on education is demonstrated to positively impact individual incomes in several studies. It may be suggested	OECD data from 2003 through 2019 by country and education data and national GDP data.	The statistic for this analysis is the adjusted R^2	0.05 level.

		that this finding could support results where total private spending on education by country will be a determinant of positive national GDP results. These results might then suggest that national policies choose to stimulate these investments as a positive influence on economic outcomes			
3. What is the relationship of the growth in academic journals and national GDP by country and globally?	The hypothesis is that the growth in academic journals as the independent variable is positively related and a determinant for the dependent variable of national GDP data by country and globally.	The rationale is based on research from Denison that found a statistically significant relationship between the growth in human knowledge and economic growth. One study demonstrated the relationship between academic journals and patents. Also, academic journals and patents were found to act as a determinant in the formation of a knowledge based economy. The growth in academic journals may or may not be a determinant of the positive growth in national GDP.	Academic Journal publication growth data from 2000 through early 2019 and education expenditures and GDP data, both nationally and globally.	The statistic for this analysis is the adjusted R^2	0.05 level.

		These results might lead government policy to increase the support of universities that yields increases in academic publications, with the intent to improve economic outcomes.			

Appendix B

Mail from OECD

OECD Data

Greetings:

This is my second attempt to reach the right party at the OECD to see if I can utilize your data.

I am a Doctorate student in Education at the University of Texas at El Paso. I have seen your chart on private spending (2017-2018) by country. I am interested in researching this topic and I would like access to all of the data over time that you have on the subject. The reference is:

OECD (2022), Private spending on education (indicator). doi: 10.1787/6e70bede-en (Accessed on 30 July 2022)

I am thanking you in advance for your help, and I look forward to hearing from you at your earliest convenience.

Best wishes,
Lex Stapp

Sent to: eco.contact@oecd.org.

Dear Lex,

Sorry for the delay to answer your data request below.

To access our data please visit OECD Statistics. You'll be able to access education finance data by opening the following menus: Education and Training->Education at a Glance->Financial resources invested in education

I hope this will prove useful for your research.

Best regards,

Simon

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https://trainingindustry.com/

I am a Doctorate student in Education at the University of Texas at El Paso, and I am using training data from Statista that quotes you as the reference. The data is total training expenditures in the United States and the market size of the global workplace training industry. The data is from 2007 to 2020.

I am hoping you have more historic data going back to the 1990s and that your global workplace data breaks down by country.

I am thanking you in advance for your assistance.

Best,

William Lex Stapp

Appendix C

Table 4.1 Pearson product correlation coefficients for the Training Expenditures dataset

Variables	Log_Training	Log_RD	Log_PublicEd	Log_GDP
Log_Training	1.000			
Log_RD	0.984	1.000		
Log_PublicEd	0.977	0.991	1.000	
Log_GDP	0.981	0.993	0.997	1.000

Table 4.2 Pearson correlation coefficients for Private Education Spending dataset

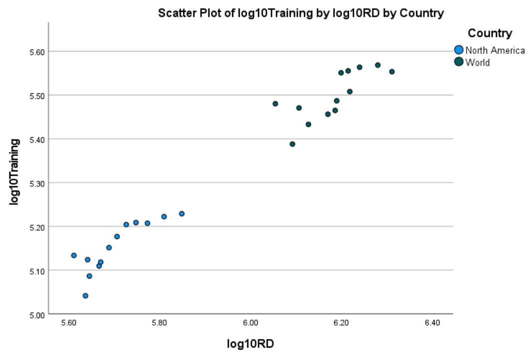
Variables	Log Private Ed	Log Public Ed	Log GDP
Log Private Ed	1.000		
Log Public Ed	0.852	1.000	
Log GDP	0.784	0.716	1.000

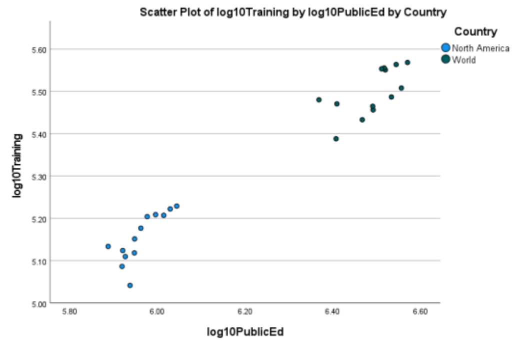
Table 4.3 Pearson product correlation coefficients for Academic Journals dataset

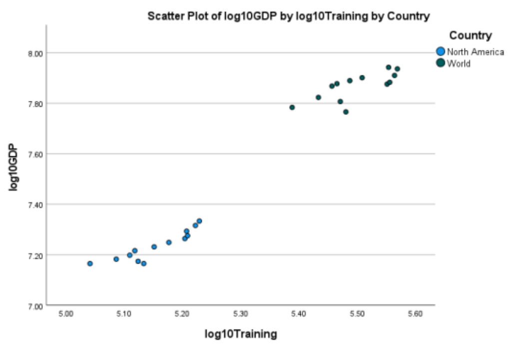
Variables	Log Publications	Log Ed Expenditures	Log GDP
Log Publications	1.000		
Log Ed Expenditures	0.974	1.000	
Log GDP	0.985	0.986	1.000

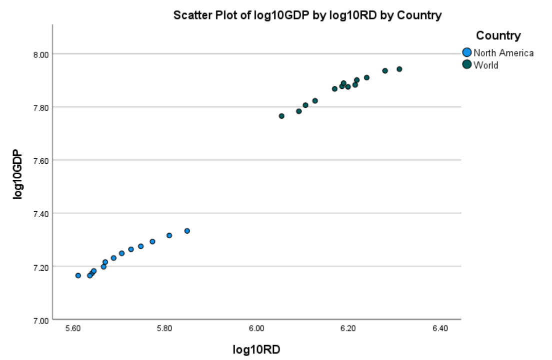
Scatter Graphs for all three Datasets

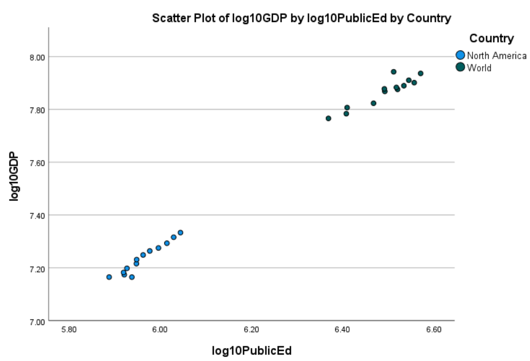
Training Scatter Graphs (next page)

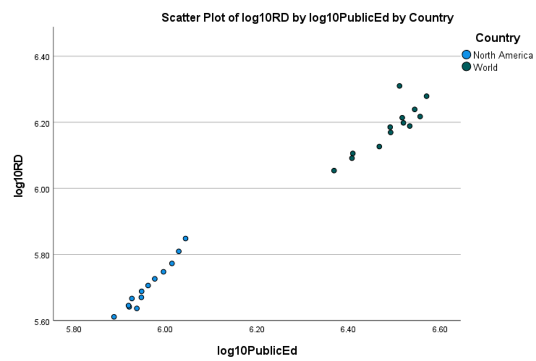




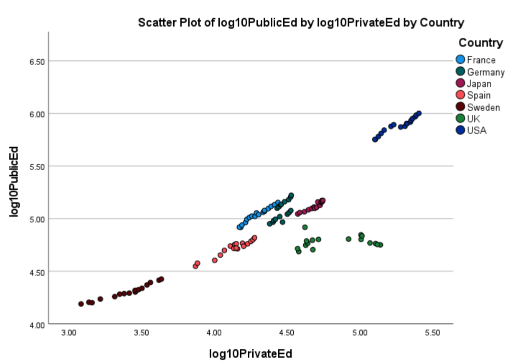


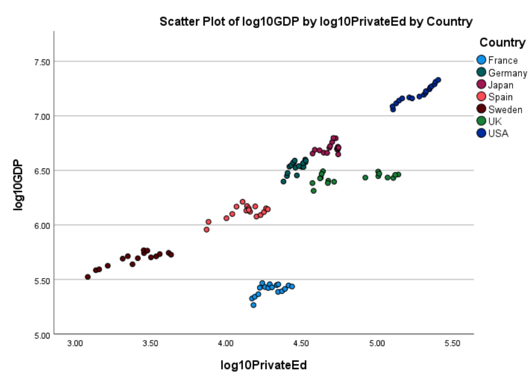


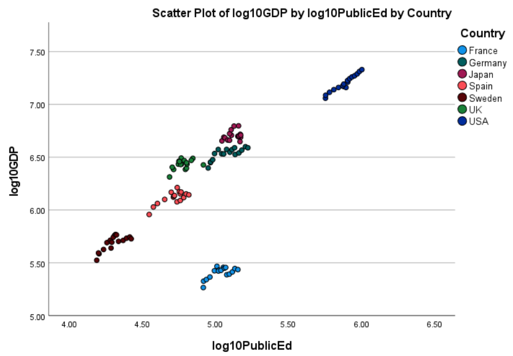




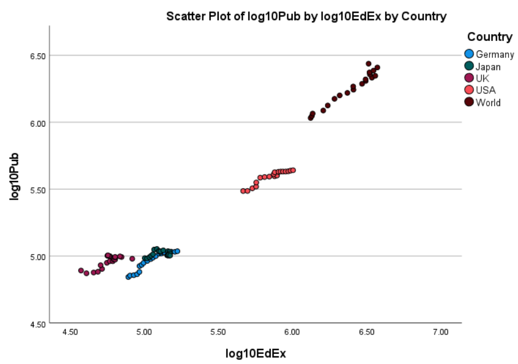
Private Spending Scatter Graphs

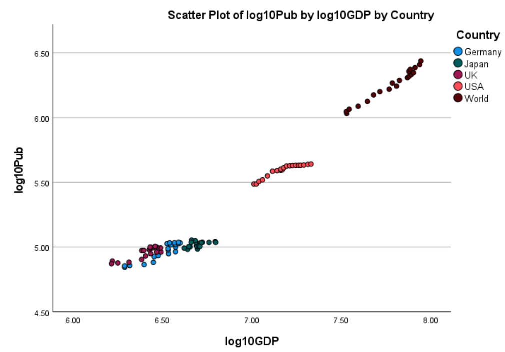


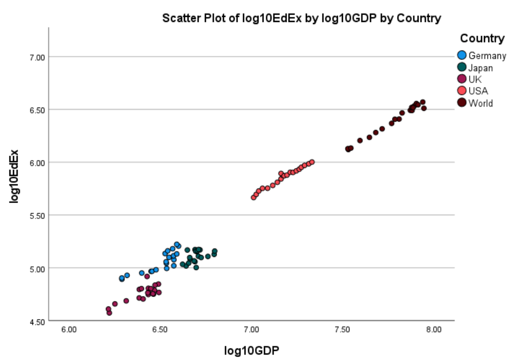




Academic Journals Scatter Graphs







SK Tests for All Datasets (next page)

SK Test Training RD Public Ed

Skewness and Kurtosis tests for Normality

Variable	Obs	Pr(skewness)	Pr(kurtosis)	Adj chi2(2)	Prob>chi2
			----- Joint test -----		
Training	26	0.629	0.000	14.15	0.000
RD	26	0.502	0.000	10.77	0.005
Public Ed	26	0.687	0.000	25.82	0.000

Private Spending SK Test Priv Ed Pub Ed

SK Test Priv Ed Pub Ed

Skewness and Kurtosis tests for Normality

Variable	Obs	Pr(skewness)	Pr(kurtosis)	Adj chi2(2)	Prob>chi2
			----- Joint test -----		
Priv Ed	119	0.000	0.004	32.01	0.000
Pub Ed	119	0.000	0.000	41.74	0.000

Academic Journals SK Test Pub Ed Ex

SK Test Pub Ed Ex

Skewness and Kurtosis tests for Normality

Variable	Obs	Pr(skewness)	Pr(kurtosis)	Adj chi2(2)	Prob>chi2
			----- Joint test -----		
Pub	100	0.000	0.012	27.75	0.000
Ed Ex	100	0.000	0.015	26.58	0.000

VIF Tests for Multicollinearity (next page)

Training VIF

Variable	VIF	1/VIF
log_RD	82.56	0.012
log_Public Ed	57.77	0.017
log_Training	31.26	0.032
Mean VIF	57.20	

Private Spending VIF

Variable	VIF	1/VIF
log_Priv Ed	3.66	0.275
log_Pub Ed	3.66	0.275
Mean VIF	3.66	

Academic Journals VIF

Variable	VIF	1/VIF
Log Ed Ex	19.54	0.051
log_Pub	19.54	0.051
Mean VIF	19.54	

Heteroskedasticity Test for All Datasets

Training Het Test
Breusch–Pagan/Cook–Weisberg test for heteroskedasticity
Assumption: Normal error terms
Variable: Fitted values of log GDP

H0: Constant variance

chi2(1) = 4.96
Prob > chi2 = 0.0260

Private Spending Het Test
Breusch–Pagan/Cook–Weisberg test for heteroskedasticity
Assumption: Normal error terms
Variable: Fitted values of log GDP

H0: Constant variance

chi2(1) = 0.70
Prob > chi2 = 0.402

Academic Journals Het Test
Breusch–Pagan/Cook–Weisberg test for heteroskedasticity
Assumption: Normal error terms
Variable: Fitted values of log GDP

H0: Constant variance

chi2(1) = 13.70
Prob > chi2 = 0.000

Appendix D

ARIMA for Training Dataset

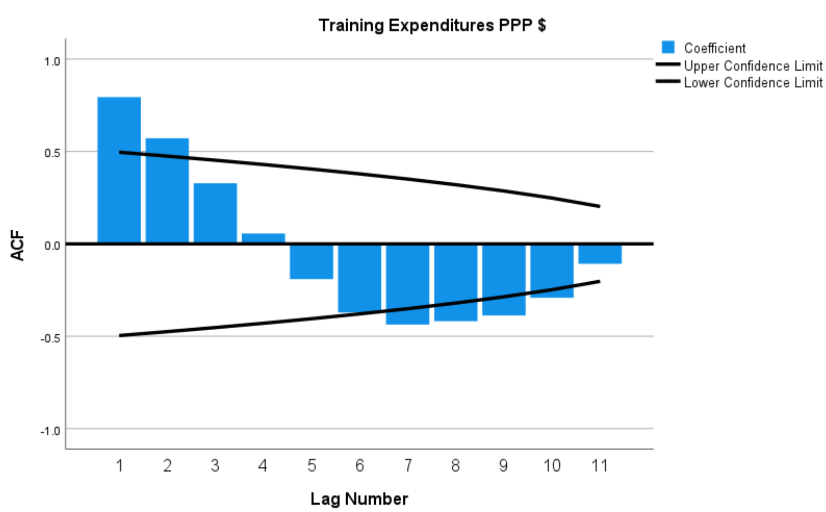
Autocorrelations

Series: Training Expenditures PPP $

Lag	Autocorrelation	Std. Error[a]	Box-Ljung Statistic Value	df	Sig.[b]
1	.795	.248	10.262	1	.001
2	.572	.238	16.062	2	.000
3	.328	.226	18.162	3	.000
4	.057	.215	18.231	4	.001
5	-.191	.203	19.119	5	.002
6	-.371	.189	22.958	6	.001
7	-.437	.175	29.164	7	.000
8	-.418	.160	35.984	8	.000
9	-.388	.143	43.312	9	.000
10	-.292	.124	48.838	10	.000
11	-.108	.101	49.966	11	.000

a. The underlying process assumed is independence (white noise).

b. Based on the asymptotic chi-square approximation.



Autocorrelations

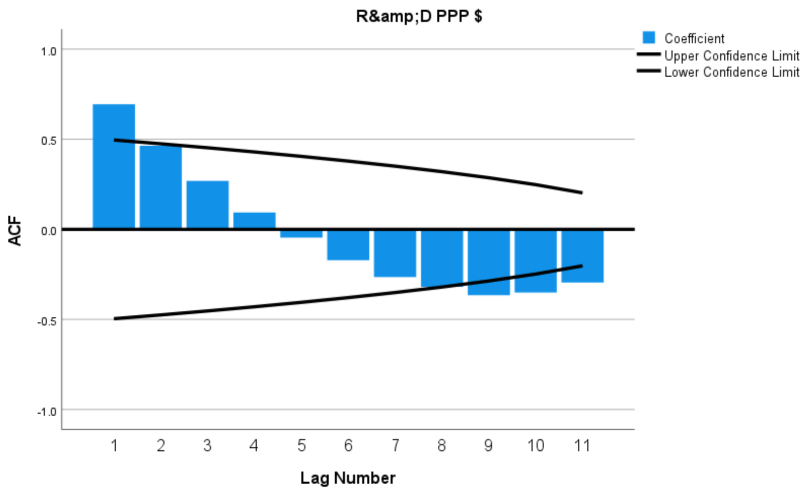
Series: R&D PPP $

Lag	Autocorrelation	Std. Error[a]	Box-Ljung Statistic Value	df	Sig.[b]
1	.695	.248	7.844	1	.005

2	.464	.238	11.658	2	.003
3	.269	.226	13.069	3	.004
4	.094	.215	13.259	4	.010
5	-.046	.203	13.310	5	.021
6	-.171	.189	14.128	6	.028
7	-.265	.175	16.403	7	.022
8	-.319	.160	20.379	8	.009
9	-.365	.143	26.881	9	.001
10	-.351	.124	34.871	10	.000
11	-.295	.101	43.342	11	.000

a. The underlying process assumed is independence (white noise).

b. Based on the asymptotic chi-square approximation.



Autocorrelations

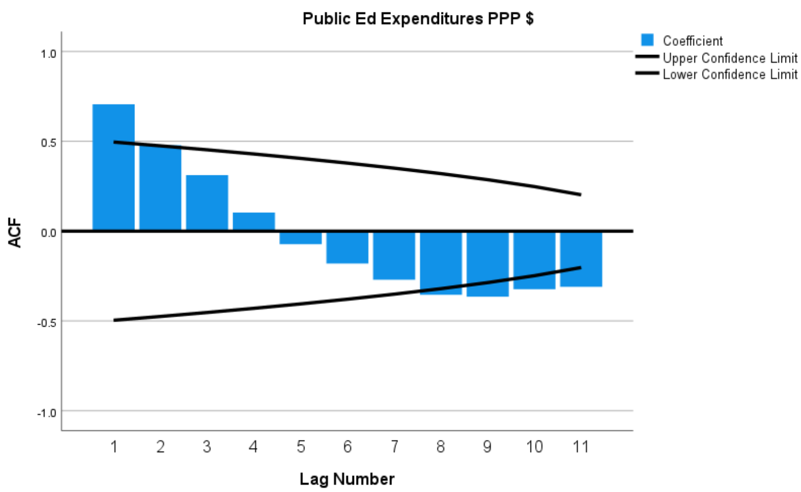
Series: Public Ed Expenditures PPP $

Lag	Autocorrelation	Std. Error[a]	Box-Ljung Statistic Value	df	Sig.[b]
1	.706	.248	8.110	1	.004
2	.478	.238	12.164	2	.002
3	.312	.226	14.063	3	.003
4	.103	.215	14.295	4	.006
5	-.073	.203	14.424	5	.013
6	-.180	.189	15.330	6	.018
7	-.271	.175	17.710	7	.013
8	-.354	.160	22.606	8	.004

9	-.365	.143	29.105	9	.001
10	-.323	.124	35.906	10	.000
11	-.310	.101	45.284	11	.000

a. The underlying process assumed is independence (white noise).

b. Based on the asymptotic chi-square approximation.



Autocorrelations

Series: Error for GDPPPP$ from ARIMA, MOD_2, CON

Lag	Autocorrelation	Std. Error[a]	Box-Ljung Statistic Value	df	Sig.[b]
1	.107	.277	.187	1	.665
2	.218	.281	1.028	2	.598
3	-.009	.293	1.030	3	.794
4	-.002	.293	1.030	4	.905
5	-.043	.293	1.075	5	.956
6	-.041	.294	1.122	6	.981
7	-.071	.294	1.286	7	.989
8	-.083	.296	1.554	8	.992
9	-.077	.297	1.846	9	.994
10	-.156	.299	3.423	10	.970
11	-.193	.305	7.060	11	.794

a. The underlying process assumed is MA with the order equal to the lag number minus one. The Bartlett approximation is used.

b. Based on the asymptotic chi-square approximation.

ARIMA for Private Spending Dataset

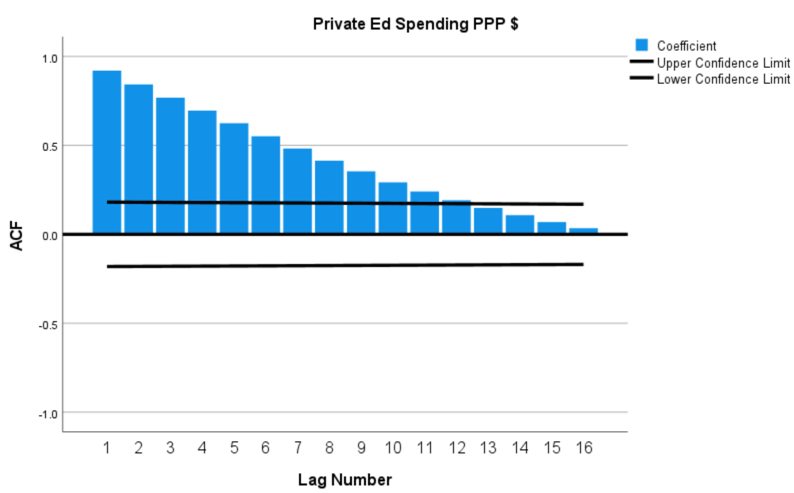
Autocorrelations

Series: Private Ed Spending PPP $

Lag	Autocorrelation	Std. Error[a]	Box-Ljung Statistic Value	df	Sig.[b]
1	.921	.091	103.449	1	.000
2	.843	.090	190.940	2	.000
3	.769	.090	264.259	3	.000
4	.696	.089	324.879	4	.000
5	.625	.089	374.189	5	.000
6	.551	.089	412.909	6	.000
7	.482	.088	442.835	7	.000
8	.414	.088	465.106	8	.000
9	.354	.087	481.509	9	.000
10	.292	.087	492.783	10	.000
11	.241	.087	500.524	11	.000
12	.191	.086	505.446	12	.000
13	.148	.086	508.432	13	.000
14	.108	.085	510.030	14	.000
15	.069	.085	510.683	15	.000
16	.035	.085	510.853	16	.000

a. The underlying process assumed is independence (white noise).

b. Based on the asymptotic chi-square approximation.



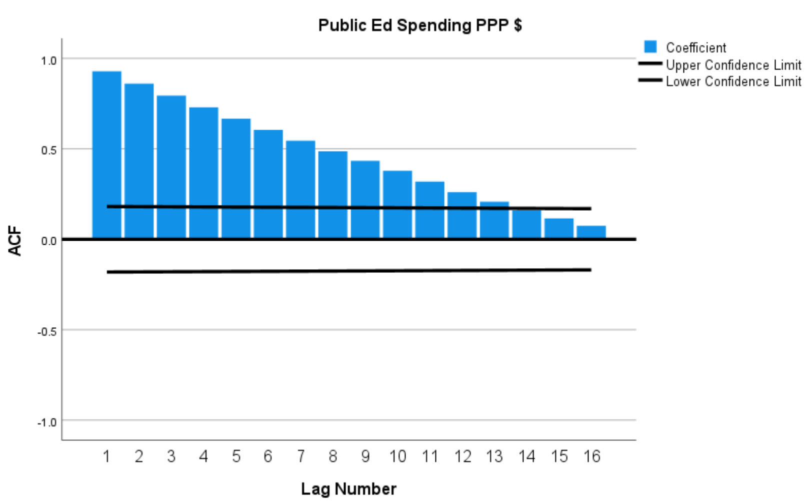
Autocorrelations

Series: Public Ed Spending PPP $

Lag	Autocorrelation	Std. Error[a]	Box-Ljung Statistic Value	df	Sig.[b]
1	.929	.091	105.241	1	.000
2	.861	.090	196.456	2	.000
3	.794	.090	274.793	3	.000
4	.730	.089	341.493	4	.000
5	.667	.089	397.705	5	.000
6	.605	.089	444.381	6	.000
7	.545	.088	482.601	7	.000
8	.487	.088	513.310	8	.000
9	.434	.087	537.910	9	.000
10	.379	.087	556.865	10	.000
11	.319	.087	570.423	11	.000
12	.261	.086	579.581	12	.000
13	.208	.086	585.462	13	.000
14	.160	.085	588.968	14	.000
15	.116	.085	590.817	15	.000
16	.075	.085	591.604	16	.000

a. The underlying process assumed is independence (white noise).

b. Based on the asymptotic chi-square approximation.



Autocorrelations

Series: Error for GDPPPP$ from ARIMA, MOD_1, CON

Lag	Autocorrelation	Std. Error[a]	Box-Ljung Statistic Value	df	Sig.[b]

1	.004	.092	.002	1	.964
2	-.001	.092	.002	2	.999
3	.002	.092	.003	3	1.000
4	-.008	.092	.012	4	1.000
5	-.001	.092	.012	5	1.000
6	.015	.092	.042	6	1.000
7	.024	.092	.117	7	1.000
8	-.010	.092	.130	8	1.000
9	.008	.092	.137	9	1.000
10	-.014	.092	.163	10	1.000
11	.029	.092	.272	11	1.000
12	.024	.092	.348	12	1.000
13	-.010	.092	.361	13	1.000
14	-.016	.092	.395	14	1.000
15	-.024	.092	.472	15	1.000
16	-.016	.092	.506	16	1.000

a. The underlying process assumed is MA with the order equal to the lag number minus one. The Bartlett approximation is used.

b. Based on the asymptotic chi-square approximation.

ARIMA for Academic Journals Dataset

Autocorrelations

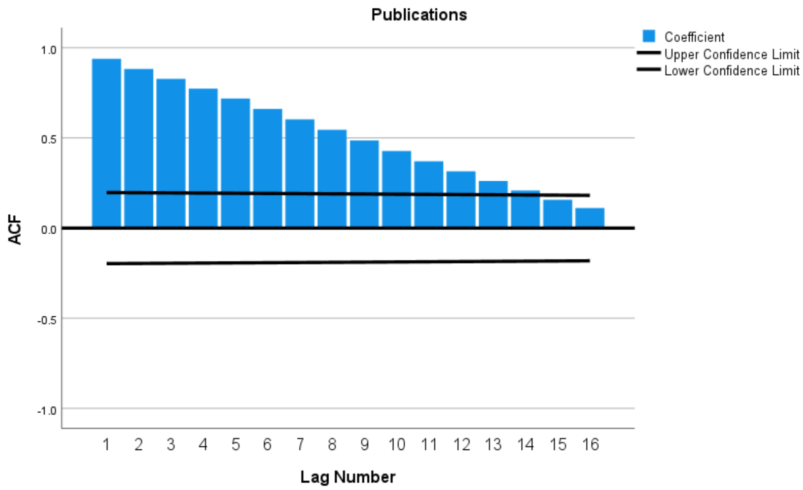
Series: Publications

Lag	Autocorrelation	Std. Error[a]	Box-Ljung Statistic Value	df	Sig.[b]
1	.939	.099	90.869	1	.000
2	.882	.098	171.877	2	.000
3	.828	.098	243.948	3	.000
4	.773	.097	307.500	4	.000
5	.718	.097	362.914	5	.000
6	.661	.096	410.304	6	.000
7	.603	.095	450.178	7	.000
8	.545	.095	483.087	8	.000
9	.486	.094	509.532	9	.000
10	.428	.094	530.259	10	.000
11	.371	.093	545.992	11	.000
12	.315	.093	557.473	12	.000

13	.261	.092	565.461	13	.000
14	.208	.092	570.600	14	.000
15	.157	.091	573.553	15	.000
16	.111	.091	575.051	16	.000

a. The underlying process assumed is independence (white noise).

b. Based on the asymptotic chi-square approximation.



Autocorrelations

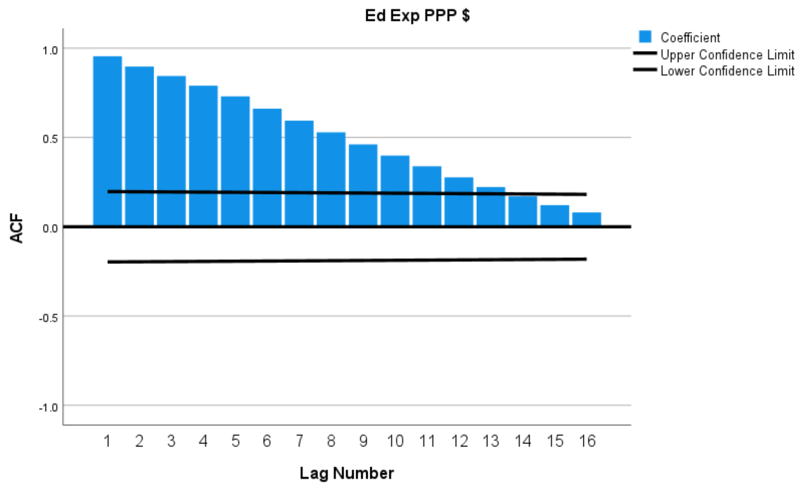
Series: Ed Exp PPP $

Lag	Autocorrelation	Std. Error[a]	Box-Ljung Statistic Value	df	Sig.[b]
1	.955	.099	93.979	1	.000
2	.897	.098	177.765	2	.000
3	.844	.098	252.718	3	.000
4	.790	.097	319.086	4	.000
5	.731	.097	376.411	5	.000
6	.662	.096	423.895	6	.000
7	.594	.095	462.628	7	.000
8	.529	.095	493.675	8	.000
9	.461	.094	517.532	9	.000
10	.399	.094	535.547	10	.000
11	.339	.093	548.698	11	.000
12	.277	.093	557.592	12	.000
13	.222	.092	563.385	13	.000
14	.171	.092	566.842	14	.000
15	.121	.091	568.611	15	.000

16	.080	.091	569.389	16	.000

a. The underlying process assumed is independence (white noise).

b. Based on the asymptotic chi-square approximation.



Autocorrelations

Series: Error for GDPPPP$ from ARIMA, MOD_1, CON

Lag	Autocorrelation	Std. Error[a]	Box-Ljung Statistic Value	df	Sig.[b]
1	.050	.100	.261	1	.610
2	.033	.100	.371	2	.831
3	.083	.100	1.095	3	.778
4	.087	.101	1.907	4	.753
5	.050	.102	2.178	5	.824
6	.079	.102	2.849	6	.828
7	.088	.103	3.695	7	.814
8	.075	.103	4.321	8	.827
9	-.015	.104	4.345	9	.887
10	.078	.104	5.035	10	.889
11	.090	.105	5.969	11	.875
12	.027	.105	6.051	12	.914
13	.023	.105	6.113	13	.942
14	.024	.105	6.180	14	.962
15	-.047	.105	6.451	15	.971
16	.012	.106	6.468	16	.982

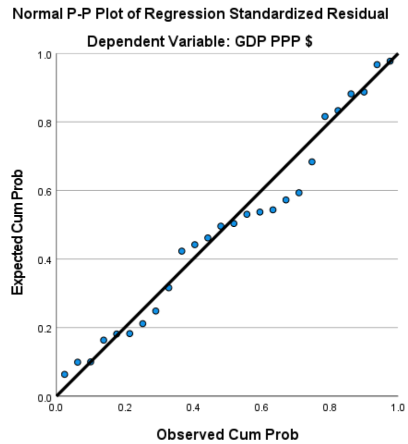
a. The underlying process assumed is MA with the order equal to the lag number minus one. The Bartlett approximation is used.

b. Based on the asymptotic chi-square approximation.

Appendix E

Normality of Residuals for All Datasets

Training Normality of Residuals



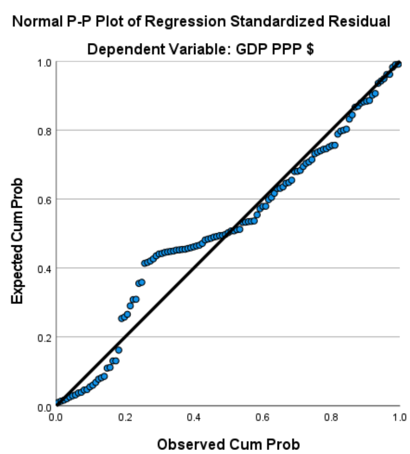
Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Unstandardized Residual	.131	26	.200*	.961	26	.413
Standardized Residual	.131	26	.200*	.961	26	.413

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Private Spending Normality of Residuals



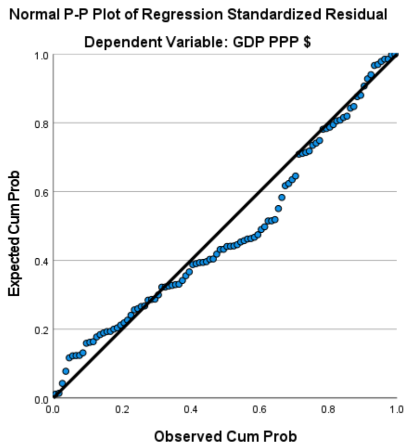
Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		

	Statistic	df	Sig.	Statistic	df	Sig.
Unstandardized Residual	.161	119	.000	.963	119	.002
Standardized Residual	.161	119	.000	.963	119	.002

a. Lilliefors Significance Correction

Academic Journals Normality of Residuals



Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Unstandardized Residual	.131	100	.000	.956	100	.002
Standardized Residual	.131	100	.000	.956	100	.002

a. Lilliefors Significance Correction

Wald Test for Training Data

Wald chi2(3) = 3659.0
corr(u_i, X) = 0 (assumed) Prob > chi2 = 0.000

Wald Test for Private Spending

Wald chi2(2) = 1035.62
corr(u_i, X) = 0 (assumed) Prob > chi2 = 0.000

Wald Test for Academic Journals

Wald chi2(2) = 1035.62

corr(u_i, X) = 0 (assumed)   Prob > chi2 = 0.000

CURRICULUM VITA

William Lex Stapp has over thirty-five years' experience providing premier human resource solutions that foster a dynamic company culture. Much of his professional work was focused on corporate learning and development, including managing university reimbursement benefits with career planning, designing curriculum, facilitating and instructing, and evaluating and measuring learning results for skills development and financial impact from the training. He is skilled in developing and delivering successful training outcomes, organizational development initiatives, and managing learning and development organizations at six major corporations in his career. Some examples of his work include delivering sales training globally while integrating Salesforce.com and strategic selling techniques at Powerwave Technologies. He led a site-wide TQM change effort, implementing concurrent engineering teams at Honeywell. He further led an organizational change team that resulted in the company winning the Malcolm Baldrige U.S. National Quality award at ST Microelectronics. He also instituted a Fab Supervisory Development Program which drove improved organizational results at ST Microelectronics. He delivered supervisory training for the manufacturing teams which resulted in a 20% productivity gain at Honeywell. And he conducted technical skills analysis for an engineering team which resulted in a 50% documented gain at Honeywell. Some of his instructor development includes the Problem Solving/Decision Making Instructor program from Kepner-Tregoe Inc., Princeton, NJ and he was Qualified in the Myers-Briggs Type Indicator from the Association for Psychological Type in Gainesville, FL. Lastly, he was certified in the Criterion Referenced Instruction program from Magor Associates in Carefree, AZ. Mr. Stapp holds a Bachelor of Arts and a Master of Arts in Economics from San Francisco State University. His contact email is lexstapp2001@yahoo.com.