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The Many Factors of Growth:

How Innovation Plays a Part

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Innovation, growth, GDP, educational attainment

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Abstract

Innovation has increased dramatically since the advent of the 1765 steam machine. Today, we possess technology that can process millions of instructions in a matter of seconds. Endogenous growth theory has stressed the importance of technological change and education as a source of economic growth. Thanks to technological innovation and the related economic growth, many people are better off today than before. However, computers cannot mimic human capacity in creativity and the ability to envision new solutions to existing problems. The rate at which workers use these unique capabilities is industry related. Therefore, in this study I relate the proportion of workers in each industry to known industry level innovation rates to predict economic growth rates at the local level. This study is especially important, as it guides policy makers as to what incentives they might use to attract new industries to bolster their future economic well being. Specifically, this study analyzes how innovation and other factors impact growth in the United States through the years 2005-2015 at the Metropolitan Statistical Area (MSA) using a lagged first-difference quantitative statistical model. This model is well matched to the structure of the data in revealing causality between the independent variables and the dependent. Results indicate no significant relationship between innovation, as measured by localized Multifactor Productivity (MFP), and growth. However, results do indicate a strong relationship between educational attainment and economic growth. Quantitative analysis reveals that a 1% increase in average years of education within an MSA will, on average, cause an increase in localized GDP the following year by 2.33%. Future research is encouraged to better understand the matter and to determine policies that can aid educational attainment and thus, boost economic growth.

Undergraduate Research Journal
University of California, Merced

Introduction

Developed and developing countries alike could benefit from a betterment in economic health. Specifically developing counties with a low standard of living and high inequality. According to data from the World Bank India had a GDP per capita of $1,709 in 2016. Comparing this number to the GDP per capita of $57,638 within the United States that same year, this number is miniscule (The World Bank, 2016). However, this does not indicate that all citizens of the United States are well off economically. According to the Survey of Household Economics and Decision Making, also known as SHED, 70% of Americans report that they are either doing okay or living comfortably compared to 62% in 2013 (Board of Governors of the Federal Reserve System, 2017). The results do reflect a continuation of the positive trend since 2013, when the survey first began. However, despite 70% of Americans reporting financial sustainability, there still remains the 30% or approximately 73 million of adults that report financial difficulty (Board of Governors of the Federal Reserve System, 2017). These statistics put forward for consideration further research in order to decrease the percentage of people who face financial difficulty and for an economically superior world. Proceeding on this track, the thesis of this study is to determine if there is a causal relationship between innovation and economic growth in order to help policy makers better understand this matter and set forth policies to help boost future economic growth and living standards.

Literature Review

Many expansions have been made since Solow's (1956) neoclassical growth model, which treats productivity, capital accumulation, and population growth as the main sources of

Undergraduate Research Journal
University of California, Merced

economic growth. There are many theories that support the view that one of the key drivers for economic growth in global economies is innovation. Paul Romer's endogenous growth theory is of those theories. The endogenous growth theory distinguishes itself from the neoclassical growth theory by making a point that economic growth is an endogenous outcome of an economic system (Romer, 1994). In other words, economic growth is not the result of forces that impact from the outside. Furthermore, the endogenous growth theory states that human capital, innovation, and knowledge are important contributors to economic growth (Romer, 1994).

Innovation itself can be defined as the implementation of new ideas to products or processes that lead to an increase in value of a firm. The innovation process has a number of stages that can be compiled into three main stages, research and development, commercialization, and diffusion (Greenhalgn & Rogers, 2010). At each stage of the process there are sub stages requiring inputs of knowledge, human capital, and specialized equipment**.** Again, relating back to the endogenous growth theory that states that human capital and knowledge are important contributors to growth. It is important to take into consideration that it is not until diffusion has taken place that the benefits of innovation to the economy and its citizens are fully realized. Therefore, a workforce knowledgeable in new technologies is critical in the diffusion process.

Behind innovation and productivity is another factor important to growth, educational attainment. Literature emphasizes mechanisms through which education may affect economic growth. Mankiw et al. (1992) theorized that education can increase the human capital within the labor force, which increases labor productivity and therefore, leads toward a higher level of

Undergraduate Research Journal
University of California, Merced

output. An additional mechanism puts forth the idea that education can increase the innovative capacity of the economy by utilizing new knowledge on new technologies, products, and processes and in such way promote growth (Romer, 1990). Lastly, a mechanism theorized by Nelson and Phelps (1996) states that education can ease the diffusion and transmission of knowledge in order to successfully implement new technologies, which therefore lead to growth.

Data Sources

Multiple sources were utilized in the compilation of the dataset. Innovation in this study was measured by Multifactor Productivity (MFP). Multifactor productivity is a measure of economic performance that compares the amount of output produced such as goods and services to the amount of all combined inputs used to produce such goods and services. Inputs include factors such as labor, capital, raw materials, and energy. The MFP data for the manufacturing industry was retrieved from the Bureau of Labor Statistics. Gross Domestic Product (GDP) was used as a measure of economic growth. GDP is calculated on an annual basis as well as quarterly basis and represents the monetary value of all the finished goods and services produced within a country. For this study, GDP per capita was utilized, which is total GDP over the population expressed in local currently, which in this case is the U.S. dollar. GDP per capita is an important indicator of economic performance and a useful measure for making cross-country comparisons of average living standards and economic wellbeing. Annual GDP per capita data was retrieved from the Bureau of Economic Analysis. Data on total employment and population was retrieved from the United States Census Bureau. Additionally, nationwide demographic data was collected and retrieved from the American Community Surveys (ACS) through the Integrated Public Use

Undergraduate Research Journal
University of California, Merced

Microdata Series (IPUMS).

All sources obtained were in terms of year, industry, and geographic location. The unit of observation present in this study is the Metropolitan Statistical Area (MSA). Within the United States, a MSA is a geographical area that has a highly dense populated area at its core and is an area with a strong economic system. Once all data sets were properly filtered, they were merged by industry, year, and MSA for the 2005-20015 time period. Upon merging, the number of observations dropped drastically from the hundred thousands to the thousands. This is due to the fact that only the manufacturing industry had data on MFP. This presents a limitation in the study and, therefore may have an impact on the statistical significance of the results.

Model

In order to study the relationship between innovation and economic growth, this paper utilizes a time series regression model in lagged first-differences. This relates a change in an independent variable in a past year with the changes in the dependent variable between the two most recent years. By doing so, we are able to describe relationships and make predictions from the given data. Furthermore, the regression model is able to relate current growth in GDP based on innovative history. Given the workforce data within the manufacturing industry we can determine the innovative potential within each MSA and use this to determine if growth rates are responding as expected given previous literature. Specifically, the time series regression model I employ in order to investigate the causal factors is as follows:

$$\Delta \, \mathrm{GDP}_{t,\,MSA} = \lambda + \Delta \, \beta_1 \, \mathrm{Mfpweight}_{\,t\text{-}i,} + \Delta \, \beta_2 \mathrm{yearseduc}_{t\text{-}i} + \Delta \, \beta_3 \mathrm{Citizen4}_{t\text{-}i}$$

Undergraduate Research Journal
University of California, Merced

Where $GDP_{t, MSA}$ indicates the mean Gross Domestic Product per capita for a given Metropolitan Statistical Area—M*SA*, in a given year – *t*. Mfpweight is the weighted average Multifactor Productivity for *t–i*, *i* representing the number of years that are shifted backwards. Yearseduc indicates average educational attainment as measured by maximum years of education completed for *t–i*. Citizen4 indicates the average number of individuals who are born abroad of American parents for *t –i*.[1] To further investigate the potential factors that influence GDP, in the analysis I compute a five lag time series, shifting the time base back by five years. Furthermore, the delta— Δ —denotes the change in the given variable. Specifically, the change in the primary treatment variable in relation to the change in GDP. I am therefore able to make a causal inference from analyzing the response of the effect variable.

Results

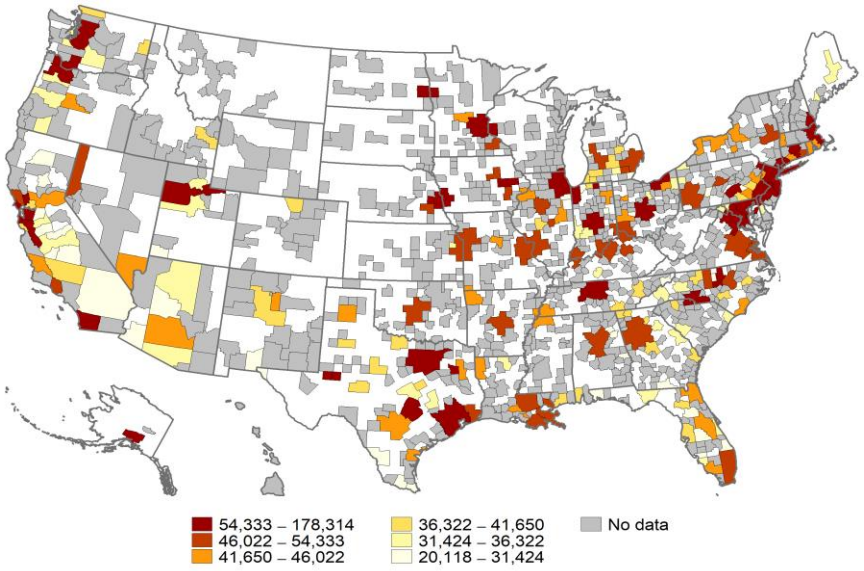

Figure 1: GDP per capita for the year 2015 by MSA

[1] Other factors such as employment status, year of immigration, and race were investigated, however they did not show a statistical significance.

Undergraduate Research Journal
University of California, Merced

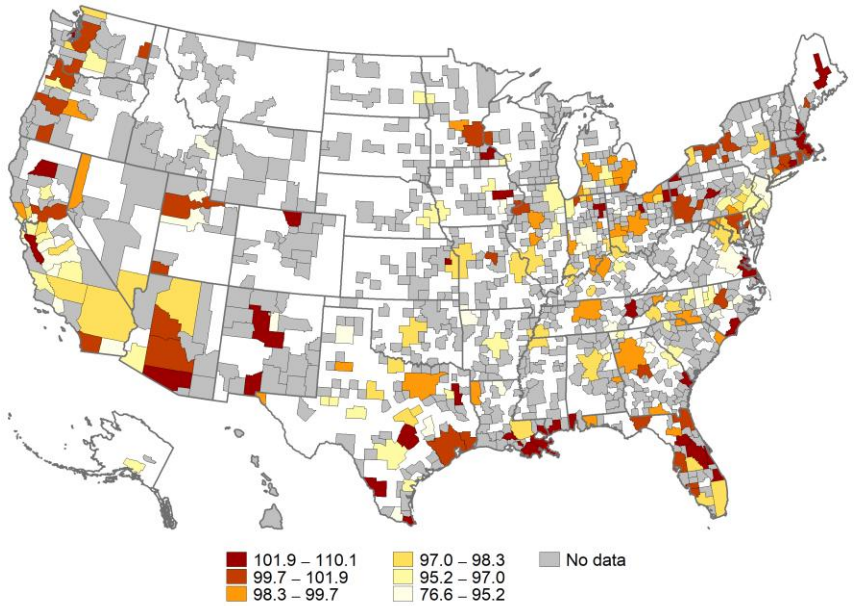

Figure 2: MFP for the year 2014 by MSA

Figure1 and Figure 2 provide a visual illustration demonstrating that innovation as measured has no obvious causal effect on future GDP. Those MSAs with high rates of MFP are not necessarily those that have high GDP when looking at the related 2014 and 2015 rates respectively. Evidently, when comparing GDP per capita for 2015 to MFP the year before we can see a dissociation within the regions. For example, the Midwest and Northeast regions of the United States in Figure 1 are high in per capita GDP output. However, as can be seen by Figure 2, these same regions are rather low on Multifactor Productivity.

Furthermore, when running the regression there was little to no statistical significance between MFP and GDP. Within a one year lag, MFP showed a slight negative relationship at the 90% significant level with a -34.31* contribution to GDP. The remaining results showed to be statistically insignificant. These results are quite surprising given the work of previous literature, which brings forth the question of measuring productivity through other mechanisms.

Undergraduate Research Journal
University of California, Merced

Although innovation as measured through MFP showed no significant correlation, years of education did prove to have a statistically significant effect on GDP. The average years of education were found to have a positive statistically significant correlation with growth in GDP at the 99% significance level starting at the second lag. An increase in years of education in 2013 results in a 216.05*** increase in GDP per capita in 2015. Additionally, results indicated an increase of 251.11*** and 220.89***to GDP per capita due to an increase in average years of education for the years 2011 and 2012, respectively.

Additionally, as can be seen in Table 1 below, Citizen2, the average number of people born abroad of American parents, results to have a statistically significant effect on GDP. The reasoning for this is difficult to determine, and further investigation is needed to explore the nature of the existence of such causal relationship.

Variable Results on GDP				
Mfpweight $_{t-1}$	-34.31*			-41.39**
Mfpweight $_{t-2}$	-16.84			-24.77
Mfpweight $_{t-3}$	-19.40			-30.35*
Mfpweight $_{t-4}$	1.05			4.71
Yearseduc $_{t-1}$		71.28		88.86
Yearseduc $_{t-2}$		216.05***		248.63***
Yearseduc $_{t-3}$		251.11***		273.14***
Yearseduc $_{t-4}$		220.89***		231.61***
Citizen2 $_{t-1}$			2412.70**	2262.99*
Citizen2 $_{t-2}$			4076.34***	4072.79***
Citizen2 $_{t-3}$			5198.69***	5013.58***
Citizen2 $_{t-4}$			2547.28	2449.31
R-Squared	0.0041	0.0171	0.0082	0.0317
N	1099	1097	1099	1097
*P<0.10, **p<0.05, ***p<0.01				

Table 1: Regression outputs; each column is a separate time series regression. The outcome is the effect on GDP. The primary treatment variable is indicated in the left column.

Undergraduate Research Journal
University of California, Merced

Conclusion

The findings of this study demonstrate that innovation as measured by MFP has little to no effect on future economic growth. This surprising result encourages further research in order to better understand innovation and all its influencing factors. Despite so, there is enough evidence that supports the endogenous growth theory, specifically with respect to educational attainment. Results indicate an increase in years of education will help boost economic growth in the future. That being said, despite the ongoing controversy of the American educational system, this paper provides evidence that the current U.S. educational system is not only functional, but also a key factor for future economic growth. As most U.S. residents have attained a high-school degree, increases that influence GDP are achieved by increasing college attendance. Therefore, policies are encouraged to promote post-secondary education within the United States. Moreover, this conclusion can be further expanded onto developing countries in order to boost their economic well-being. Collectively, we must focus our resources and seek policies that maintain and better the quality of education in order to ensure future economic growth.

Undergraduate Research Journal
University of California, Merced

Appendix

Variable Code	Definition
Cbsa	The core-based statistical area is an area code used to define a MSA.
Mfpweight	Weighted average Multifactor Productivity for the manufacturing industry by MSA.
GDP	Average Gross Domestic Product per capita by MSA.
incwage	Average income by MSA.
Yearseduc	Average years of education for a given year.
Race1	Average white by MSA.
Race2	Average black by MSA.
Race3	Average American Indian or Alaskan Native by MSA.
Race4	Average Chinese byMSA.
Citizen1	Average Citizen by MSA.
Citizen2	Average board abroad of American parents by MSA.
Citizen3	Average naturalized citizen by MSA.
Citizen4	Average noncitizen by MSA.
Empstat1	Average employment status not available by MSA.
Empstat2	Average employed by MSA.
Empstat3	Average unemployed by MSA.
Empstat4	Average not in labor force by MSA.

Table 2: Variable codes included in the data set.

Undergraduate Research Journal
University of California, Merced

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Undergraduate Research Journal
University of California, Merced

Mariela was born and raised in the city of Merced. After completing high school she enlisted in the Army Reserves. Mariela served for five years while also continuing her college education. She is Merced Junior College Alumni and transferred to UC Merced with a major in Management and Business Economics. While at UC Merced she has served as Director of Community Engagement within Alpha Kappa Psi, a professional business fraternity, in which she coordinated events such as raising money for disaster relief fund, creating care packages for the homeless, and visiting the elderly all for the goal of enriching the relationship between the Merced community and the University's students. She is currently the Supervisor at the UC Merced Campus Store, where she supervises the day-to-day operations and all 40 student staff members. Mariela is projected to graduate this upcoming May with high honors. Upon graduation, she will assume employment in Arizona with multi-trillion-investment company, Vanguard.