Measuring the Impact of the Finance Industry on States' Economic Growth

Ayo Aladesanmi & Haigh Angell

November 20, 2018

ECON 3161: Econometric Analysis

Dr. Shatakshee Dhongde

Abstract: This paper analyzes how per capita GDP has grown in the 50 states within the U.S. between the years 2006 and 2016, and how different economic indicators have affected economic growth. Particularly, we examine the link between per capita GDP growth and the growth of state-level financial industries. By studying the links between these two variables, we were able to determine a statistically significant connection between the the growth of U.S. states' finance industries and state-level per capita GDP growth over the course of the given time period.

## I. Introduction

The study of economics tells us that GDP growth can be influenced by many different economic factors. Whether those factors are associated with private sector activity, public sector spending, or national and international economic forces, it is well accepted that all of these pushes and pulls can have strong effects on an economy's gross domestic product. This paper focuses on analyzing how per capita GDP has grown in the 50 states within the U.S. between the years 2006 and 2016, and how different economic indicators have affected this economic growth, especially growth in the state-level finance industry.

The bulk of historical evidence suggest that financial development affects economic growth in a positive, monotonic way, yet lacks evidence of such a relationship at a state-level. Moreover, the proliferation of state-level datasets has enabled this scope to be explored, particularly during times of rapid economic growth and decay. During the last 30 years, the finance industry has grown tremendously, apparent by its current share of GDP, impact on the economy, and utilization to fund everyday business operations. Though the relationship between the growth of per capita GDP and output of the finance industry has previously been tracked in economic literature at the country level, no litterature exists pointing towards a similar relationship at the state-level within the US.

The units of observation for our project are the 50 states of the U.S., while our dependent variable is state-level per capita GDP growth between 2006 and 2016. Our seven different independent variables are also growth rates over the years of 2006 through 2016: output of the state finance, insurance, and real estate industries, output of government services and enterprises, output of state level manufacturing, states employment rates, appropriations to public post-secondary institutions, high school educational attainment rates, and bachelor's degree attainment rates. We chose to study these particular independent variables because they each represent characteristics that are the backbone of American economies and modern societies. Educational investment, financial innovation, public goods and infrastructure, and robust job growth provide the backbone of economic stability and growth, and according to existing literature, it is possible that these characteristics can all affect levels of GDP per capita according to different magnitudes.

Another reason we decided to study a diverse set of economic indicator variables is because of the time period that we chose for our project. From 2006 to 2016 is entirely inclusive of the United States financial crisis that occurred toward the end of the 2000s, and during a period of time characterized by risk and uncertainty, we wanted to use our project to determine if GDP growth over this period of time could be best predicted by educational spending, public sector output, output of the financial industry, or state-level job growth.

Understanding the impact the financial sector has on economic activity is of first-order importance when determining factors that stimulate policy-relevant economic development initiatives, especially at the state level. For this paper, our hypothesis is that there will be a statistically significant relationship between the state-level GDP growth of the financial industry and per capita GDP growth in the United States for the decade between 2006 and 2016. Even though at that point in time, national governments, state governments, and multinational firms were in economic disarray, after considering the literature surrounding the factors affecting GDP growth, we have come to believe that our hypothesis will be supported by the data.

## II. Literature Review

Since Raymond W. Goldsmith documented the relationship between financial and economic development over 50 years ago, the topic area has made important progress. This paper explores the theoretical framework that illuminates many of the channels through which the emergence of financial markets and institutions affect— and are affected by— economic development. Although Levine (1997) states conclusions hesitantly and with ample qualifications, the preponderance of theoretical reasoning and empirical evidence suggest a positive relationship between financial development and economic growth. Financial systems are a fundamental feature of the process of economic development where a greater understanding of economic development requires a satisfactory understanding of financial systems. This paper specifically focuses on how particular market frictions motivate the emergence of financial markets and intermediaries that provide the five functions that are enumerated in Figure 1, and it serves to explains how they affect economic growth.

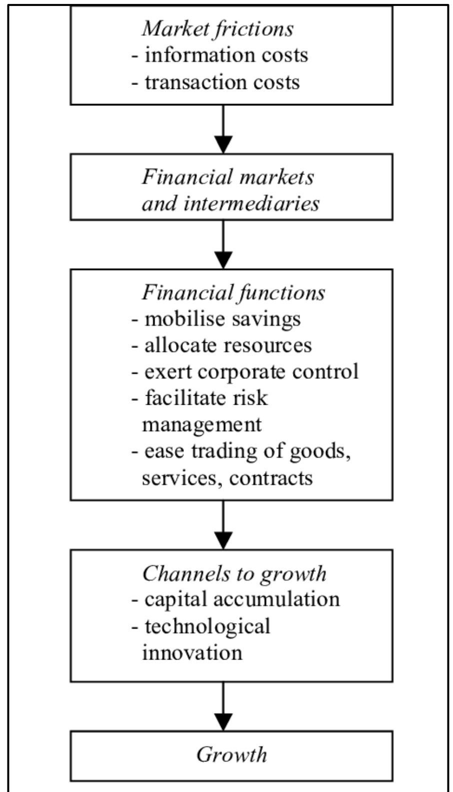



Figure 1: Levine's Theoretical Approach to Finance and Growth

Our specific contribution to this literature adds a different level of empirical analysis, including state level job growth, GDP per capita, and financial and government output. By studying the links between these variables we were able to demonstrate a strong positive link between the the growth of the financial system and GDP per capita growth within a state. As more levels of analysis are included in the determinants and implications of financial systems, we will move closer to a comprehensive view of financial development and economic growth.

Furthermore, Alexander Popov's work found in "Evidence on Finance and Economic Growth" reviews and appraises the body of empirical research on the association between financial markets and economic growth that has accumulated over the past quarter-century. Popov (2017) suggests that the early body of empirical analyses based on cross-country regressions strongly suggested that there is a significant positive association between how deep financial markets are and the rates of economic growth. More recent microeconomic analysis, taking advantage of well-defined proxies for financing constraints at the firm and household level, has taken this theoretical argument a step further by illuminating specific theoretical mechanisms for how access to finance should affect economic growth. By and large, Popov found that evidence suggests that both financial intermediaries and markets matter for growth, in a wide range of countries and during a wide range of periods.

Our research could further develop Popov's contribution to economic literature by looking further into the U.S. financial crisis and how these events affect growth. Digging deeper into the mechanisms through which this effect takes place and juxtaposing the relative importance on educational attainment, job growth, and government spending—in particular using state-level datasets—would give this paper a more robust and thorough lense of study.

And lastly, the more theoretical work of Ross Levine that explores the roles of finance and economic growth, found in chapter 12 of the "Handbook of Economic Growth", reviews and critiques theoretical and empirical research on the connections between the operations of the financial system and economic growth. A preponderance of evidence suggests that both financial intermediaries and markets matter for growth and that reverse causality alone is not driving this relationship. Furthermore, evidence implies that better developed financial systems ease external financing constraints facing firms, which highlights one mechanism through which financial development influences economic growth. The remainder of the paper discusses broad areas needing additional research, such as the need for further modeling of the dynamic interactions between the evolution of the financial system and economic growth. The broad spectrum of work suggest that political, legal, cultural, and even geographical factors influence the financial system and that much more work is required to better understand the role of financial factors in the process of economic growth.

In terms of empirical work, our paper evaluates how different state level indicators not only affect GDP, but finance as well. When regressed, there is an evident positive relationship the growth GDP per capita and the financial industry. Though this is not a novel observed relationship in itself, it shows that this relationship also exists at the state level and not just between countries.

## **III. Data**

In selecting our project's variables, for both statistical accuracy and the usefulness of our project, a diverse set of variables were chosen in order to provide a comprehensive look into economic growth over the ten year period in question. And from studying the literature surrounding the role that financial operations and the financial services industry play in the world's developed economies, it is very apparent that for wealthier economies with robust institutional and financial infrastructure, tracking the output of the financial services industry within a particular economy should yield strong results. Especially in the United States, where it is common for each of the individual 50 states to have differing economic and financial landscapes, it becomes very important to consider how each state has responded to the nationwide growth of the financial industry.

GDP per capita: The dependent variable we use in our study is state-level GDP per capita, which is measured as a growth rate between 2006 and 2016 for each state in the U.S. Each observation reflects the average percentage change of per capita GDP across the ten year period, not adjusted for increases or decreases in price inflation over time. In this study, state-level per capita GDP is the dependent variable, and in designing the regression models, this measure was chosen because of its means as a measure of economic output. However, because measures of per capita GDP are simply averages of the level of productivity across the size of the population, it is sometimes incapable of capturing the more nuanced effects of economic growth, such as measures of inequality or purchasing power. But despite the drawbacks that per capita GDP has as a measure of comprehensive economic health, it is very often used as a measure of the general vitality or strength of an economy, and that is what we seek to study in terms of the four independent variables that we also chose.

Finance Industry GDP: The working definition of the financial services industry has also evolved considerably over time, and for the purposes of this project, the definition provided by the U.S. Bureau of Economic Analysis is the definition that is used for this project. According to BEA, the "financial services industry" includes finance and insurance, (Federal Reserve bank activity, credit intermediation, securities, commodity contracts, investments, trusts, funds, insurance carriers, other financial vehicles, and related activities) and real estate and leasing (housing, rental services, leasing services, lessors of intangible assets, and other forms of real estate). In the end, considering not only the rapid growth of the financial services industry, but also its incredibly broad definition, it became imperative to study the growth of the financial services industry over time in order to obtain a useful cross-section of the activity surrounding U.S. states' economies.

Government Services & Enterprises GDP: In a similar vein, it is generally true that wealthy economies also benefit from robust "government output", which refers to the establishing of public infrastructure at the various levels of government that will provide the public services necessary for market economies to function efficiently. In the case of the United States, national and state governments often fulfill this responsibility by increasing government spending as well as increasing the output of state-run government enterprises, and these changes manifest as increases or decreases of GDP at the various levels of government. According to BEA, "government output" is comprised of federal spending (general government administration, national defense spending, non-defense spending, national government enterprises) and state and local spending (general government administration, state and local government enterprises). For this project - measuring from 2006 to 2016 - the contributions of state governments to their respective state economies is captured, which is also especially useful considering that generally, it is the risk-averse financial activity of public spending that steadies national and state economies during times of disarray, such as during the years of the U.S. financial crisis.

Manufacturing Industry GDP: In order to track an industry that could serve as an interesting counterpart to the financial services industry and provide insight into a different sector of the U.S. economy, we also chose to monitor growth in U.S. states' manufacturing industries. While the financial services industry does play a huge role in allowing U.S. companies to plan for future levels of production, and invest in capital expenditures that will help capital-intensive businesses to grow, the two industries also require vastly different skill sets and input goods, which makes the two industries interesting economic complements. In choosing to add the growth in states' manufacturing industry GDP to our model, the underlying rationale is that widespread economic trends will have different effects on the financial services industry than they do on the manufacturing industry, and we sought to see if our model reflected this. BEA defines the "manufacturing industry" as consisting of the production of durable goods (wood products, nonmetallic mineral products, primary metals, fabricated metal products, machinery, computer and electronic products, electrical equipment and appliances, motor vehicle bodies and trailers, other transportation equipment, furniture and related products, and miscellaneous manufacturing) as well as nondurable goods (food, beverages, tobacco products, textile mills, apparel and leather products, paper products, printing and related support activities, petroleum and coal products, chemical products, and plastic and rubber products). Like the other industry-related variables, we measure the growth rate of states' manufacturing industries by observing the average percentage change in the manufacturing industry's GDP for the years between 2006 and 2016.

Job Growth: As one of the economic indicators that we chose to track, our job growth variable tells us the average percentage change of state's employed workforces from year to year from 2006 until 2016. In tracking the growth of employment rates across states, we aimed to condition our regression model in order to see if increases or decreases in a state's workforce affected the growth rate of the state's GDP.

Post-Secondary Education Appropriations: For our model, we also sought to include some kind of measure as to how states invest their educational systems, and in particular, their post-secondary educational systems. At first, we tried to capture the effect of education investments by measuring the per pupil annual spending for state's primary and secondary educational systems, but we found that typically in economic literature surrounding questions of economic growth, especially at the state level, it is usually investments in postsecondary education that yield more useful and definitive results. This variable, collected from the National Center for Education Statistics tracks the average percent change in the appropriations from state governments to their public degree-granting postsecondary institutions. In measuring these values, NCES also acknowledges the difference between "degree-granting institutions" and "institutions of higher education", a definition that they decided to stop using back in 1991. In defining degree-granting institutions, NCES says that "[d]egree-granting institutions grant associate's or higher degrees and participate in Title IV federal financial aid programs. The degree-granting classification is very similar to the earlier higher education classification, but it includes more 2-year colleges and excludes a few higher education institutions that did not grant degrees." Unfortunately, though, because of limitations in the data, the observations for this variable do not include all ten years between 2006 and 2016 like all of our other variables; instead, there was only available data for 2010, 2013, 2014, and 2015.

High School & College Educational Attainment: Also, in attempting to capture the effects of education on states' GDP growth, we decided to measure both the high school and college educational attainment rates of each state. We collected these variables for a couple of reasons. In terms of high school educational attainment, one reason was to somehow capture the relationship between secondary education on the GDP growth of states. In the context of college educational attainment, the main reason was to combine a variable measuring of post-secondary educational spending with a measure of post-secondary educational attainment. In measuring educational attainment alone in order to gauge effects on GDP growth, a criticism that we found in the literature is that it is possible that there would be a reverse causality effect between the two variables. Since wealthier states are often comprised of people who can afford to send students to a 4-year college, it is possible that GDP growth is a driver of college educational attainment, instead of educational attainment driving GDP growth. Also, college educational attainment is often something that is predetermined, so having a variable to gauge how much states finance their post-secondary educational systems allows us to see which aspect of education - spending or attainment - actually effects states' GDP growth.

Population Growth: A measure of population growth - observed over the course of the 16 year period from 2002 until 2016 - was included in the first version of the predictive model in order to observe how changes in population can affect per capita GDP. For each state, population growth was measured by calculating the average percentage change in population between 2002 and 2016. In most economic literature, it is found that population growth over time will lead to eventual increases in GDP per capita, and in terms of the 50 states that were studied over this 16 year period, this project sought to determine whether or not that trend would hold true. However, in the end, we decided to remove this population growth measure in order to avoid any potential problems of multicollinearity; specifically, having our dependent variable - state-level GDP per capita - denominated in a measure of population, while also tracking growth in population via one of the models independent variables.

Annual Per Pupil Spending: And lastly, from the first version of our predictive model, we measured the average percentage change in per pupil annual spending of each state between 2006 and 2016. This measure represents state governments' own investments into their educational systems, and in particular, reflects the spending on primary and secondary school education by state governments. Not only is education an all-important public investment for economies across the United States, but in terms of the time frame of the project, it is a useful variable for the project's predictive model. Ideally, state investments into primary and secondary education that are made in 2006, would begin to take effect and begin to show benefits to states' economies by 2016. And considering that we are looking at a time period characterized by economically-stressed state governments, this variable shows an interesting perspective into the time period we selected for our project, providing somewhat of a proxy method for determining the effectiveness of state-level educational investments by evaluating them alongside state-level per capita GDP growth.

For the first version of our predictive model, the independent variables we used were state population growth, states' annual per pupil spending, GDP of the state-level finance industry, and states' government spending and output. However, ultimately, when designing our refined regression model, we decided to remove population growth due to concerns of collinearity with per capita GDP growth, and we removed annual per pupil spending in favor of measuring postsecondary educational appropriations instead of primary and secondary schooling.

**Data Sources**

The data for this project was acquired mainly from the United States' Bureau of Economic Analysis, along with the U.S. Census Bureau, American Community Survey, and National Center for Education Statistics. State-level per capita GDP measures of government services and enterprises, the financial services industry, and the manufacturing industry were all collected from BEA. The American Community Survey provided data on high school and college educational attainment, and the National Center for Education Statistics sourced the data regarding public post-secondary institution appropriations. From the first model that was crafted, the U.S. Census Bureau provided data for states' population growth as well as states' per pupil annual education spending.

**Descriptive Statistics**

As we can see from the table in Table 1, the summary statistics, which are comprised of mean, standard deviation, minimum value, and maximum value, are displayed for each of our variables and all reflect observations made in the ten years between 2006 and 2016 . In analyzing our findings from the project, each set of statistics provides interesting insights about the in-depth details of each variable in the predictive model.

GDP per Capita: In looking at the growth rate of states' per capita GDP, we see that the mean is 3.2%, the standard deviation is 9.78, the minimum value is -19.44% (Nevada) and the maximum value is 50.27% (North Dakota). Something particularly interesting about the summary statistics for states' per capita GDP is that the mean, 3.2%, reflects what is generally considered to be a "healthy" growth rate in economics. In this case, the fact that the economically healthy growth rate, which is generally considered to be around 2-3% per year, reflects state GDP's average growth rate might insinuate that between 2006 and 2016, on average, U.S. states experienced a normal rate of growth. The years 2006 to 2016, however, include the years that the American economy suffered from the national financial crisis, which is generally considered to have lasted from 2008 until 2011. This could either mean that the way we configured our model is not quite capturing the state-level economic effects of the U.S. financial crisis, or, on average, states across the U.S. still experienced healthy economic growth during a period characterized by by a chaotic economic landscape.

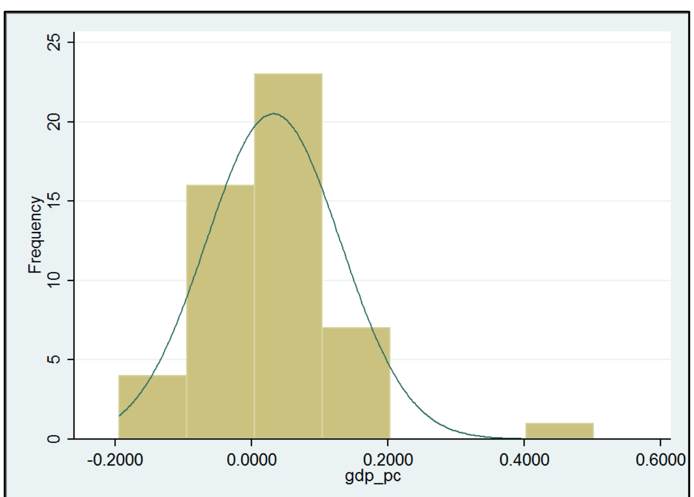
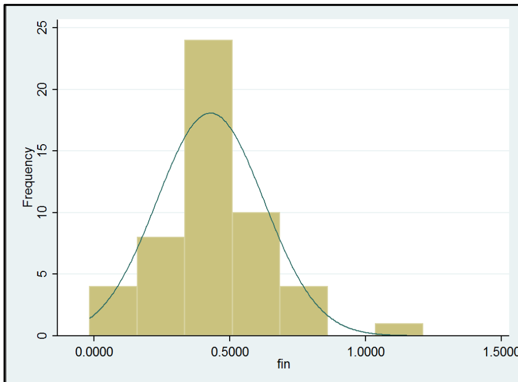



Figure 2: State-level per capita GDP growth rate

Figure 2 shows the relatively normal distribution of states' per capita GDP growth rates, save for one outlier, which is the per capita GDP growth rate of North Dakota. With a per capita GDP growth rate of 50.27%, the fact that North Dakota is such a positive outlier could reflect the fact that North Dakota's state government and economy might have been shielded from some of the nationwide economic trends during the decade between 2006 and 2016.



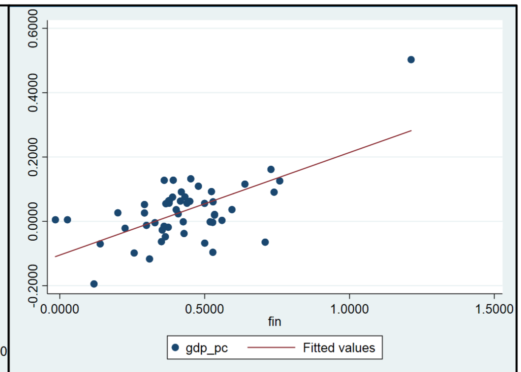




Figure 4: State level financial

Finance Industry GDP: In looking at the growth rate of states' finance industries over the ten year period, the mean growth rate is 42.89%, the standard deviation is 19.53, the minimum rate is -1.53% (Alaska), and the maximum rate is 121.28% (North Dakota). The histogram and scatter plot in Figure 3 and Figure 4 show that the growth rates of states' finance industries also follows a very normal distribution, and just like per capita GDP growth, illustrates North Dakota as a positive outlier again. Especially for this particular ten year period, a 121% growth rate in a state's finance industry is definitely of particular interest, meaning that there is a good chance that the state government or finance industry in North Dakota is following unique measures in order to have such a productive and quickly-growing financial industry.

Government Services & Enterprises GDP: For the growth rate of states' government services output from 2006 to 2016, the mean is 29.95%, the standard deviation is 9.21, the minimum rate is 10.25% (Iowa), and the maximum rate is 53.5% (Wyoming). The trends in these statistics show that across states, government spending and the output of government enterprises is increasing at relatively robust rate. And while the observation reflecting Wyoming's government output between the years of 2006 and 2016 isn't an outlier, it is definitely quite close to being three standard deviations higher than the mean. This could mean that over the course of this ten year period, Wyoming's state government was spending a lot, or that its state enterprises were particularly productive.

Manufacturing Industry GDP: For the GDP growth rates of states' manufacturing industries, the summary statistics show a mean of 2.4%, a standard deviation of 18.7, a minimum value of -5.5%, and a maximum value of 5.8%. These statistics reflect that nationwide, states' manufacturing industries are growing at a slow pace.

Job growth: In considering the summary statistics for job growth in states, we see a mean of 2.5%, a standard deviation of 3, a minimum value of -2.5% (Michigan), and a maximum value of 14.1% (North Dakota). Once again, we see that North Dakota is leading the country's other states in terms another major economic indicator, which corroborates the notion that something about North Dakota's economic landscape or state policy making is very effective in terms of increasing employment in the state.

Post-Secondary Education Appropriations: The summary statistics for post-secondary education appropriations shows a mean of 2.5%, a standard deviation of 5.2, a minimum value of -21.2% (Illinois), and a maximum value of 14.7% (Oregon). Out of all the variables, appropriations to post-secondary education is actually the only one with a negative outlier, which in this case is Illinois. Effectively, this means that from 2006 to 2016, it is possible that the state of Illinois might have been facing unique budgetary challenges that forced the state government to take away more and more funding from its state colleges and degree-granting institutions.

High School Educational Attainment: For rates of high school educational attainment, there is a mean of 88.6%, a standard deviation of 2.9, a minimum value of 82.1% (Texas) and a maximum value of 92.9% (Nebraska).

College Educational Attainment Attainment: For rates of college educational attainment, there is a mean of 30%, a standard deviation of 6.1, a minimum value of 19.6% (West Virginia) and a maximum value of 55.4% (District of Columbia), meaning that for this variable, the college educational attainment rate of the District of Columbia is an outlier observation.

Population Growth: For the growth rate of states' populations from 2006 to 2016, the mean is 8.19%, the standard deviation is 5.69, the minimum rate is -0.73% (Michigan) and the maximum rate is 20.76% (Utah), showing that on average, states across the U.S. are growing at a modest rate every year, while there are some states experiencing larger-than-average influxes of new residents

Annual Per Pupil Spending: And lastly, for the growth rate in public schools' annual per pupil spending from 2006 to 2016, the mean is 29.74%, the standard deviation is 12.17, the minimum rate is 11.13% (Idaho) and the maximum rate is 55.46% (North Dakota). These statistics illustrate that across the country, states are appropriating an increasing amount to primary and secondary school education, and even though the maximum observation is not an outlier, it is worth mentioning that North Dakota, again, leads U.S. states in another indicator of economic growth and method of investing in a state's population.

| Table 1: Summary Statistics | | | | | |
|---|---|---|---|---|---|
| **Variable** | **Observations** | **Mean** | **Std. Dev.** | **Min** | **Max** |
| **gdp_pc** | 51 | 3.2% | 9.8 | -19.4% | 50.3% |
| **fin** | 51 | 42.9% | 19.5 | 1.5% | 120.3% |
| **manu** | 51 | 2.4% | 18.7 | -5.5% | 5.8% |
| **gov** | 51 | 30% | 9.2 | 10.2% | 53.5% |
| **jobgrowth** | 51 | 2.5% | 3.0 | -2.5% | 14.1% |
| **publicuni** | 51 | 2.5% | 5.6 | -21.2% | 14.7% |
| **educhs** | 51 | 88.6% | 2.9 | 82.1% | 92.9% |
| **educuni** | 51 | 30.0% | 6.1 | 19.6% | 55.4% |

**Gauss-Markov Assumptions**

1. MLR.1 Linear in Parameters: There is linearity in parameters α and β; the dependent variable is a linear function of independent variables and a random error component. The equation

$$Y = \beta_0 + \beta_1 x_1 + \ldots + \beta_k x_k + u$$

holds, thus our model meets MLR assumption one.

2. MLR.2 Random Sampling from the Population: For each variable, the data was collected at regular time intervals (annually) and was collected for each of the 50 U.S. states and the District of Columbia. All of the data was collected irrespective of time or geographic region in the United States, so our model meets MLR assumption two.
3. MLR.3 No Perfect Collinearity: In the sample, none of the independent variables are constant, and there are no exact linear relationships among the independent variables. However, because our all of our independent variables serve as major economic indicators and can all be influenced by state policymaking or widespread economic conditions, it is possible that they will show some degree of correlation. *See Appendix:Output 1 for correlation coefficients between the independent variables.*
4. MLR.4 Zero Conditional Mean: The error term u has an expected value of zero given any values of the independent variables.

5. MLR.5 Homoskedasticity: The variance around the regression line is similar for all values of the predictor variable, where the OLS estimators are mostly unbiased estimators of the population parameters. *See Appendix: Figure 1 for scatter plot and trend line illustrating the variances of observations.*

**IV. Results**

Simple Regression Model 1:

Equation: $\widehat{gdp\_pc} = \widehat{\beta_0} + \text{fin}(\widehat{\beta_1}) + \hat{u}$

Regression Model: $\widehat{gdp\_pc}$ = -0.105 + fin(0.319)

N = 51, $R^2$ = 0.405

| Table 2: Estimation Results - Simple Regression Model 1 | | | | |
|---|---|---|---|---|
| **Variable** | **Coefficient (Std. Error)** | **T-value** | **P > \|t\|** | $H_0 : B_j = 0$<br>$H_1 : B_j \neq 0$ |
| fin | .319***<br>(.055) | 5.83 | 0.000 | Reject at 1% |
| constant | -.105***<br>(.026) | -4.07 | 0.000 | Reject at 1% |

*Statistically Significant at 10%, **Statistically Significant at 5%, ***Statistically Significant at 1%

Multiple Linear Regression Model 1:

Equation: $\widehat{gdp\_pc} = \widehat{\beta_0} + \text{fin}(\widehat{\beta_1}) + \text{gov}(\widehat{\beta_2}) - \text{popg}(\widehat{\beta_3}) + \text{ppa}(\widehat{\beta_4}) + \hat{u}$

Regression Model: $\widehat{gdp\_pc}$ = -0.161 + fin(0.302) + gov(0.243) - popg(0.492) + ppa(0.107)

N = 51, $R^2$ = 0.504

| Table 3: Estimation Results - Multiple Regression Model 1 | | | | |
|---|---|---|---|---|
| **Variable** | **Coefficient (Std. Error)** | **T-value** | **P > \|t\|** | $H_0 : B_j = 0$<br>$H_1 : B_j \neq 0$ |
| fin | 0.302***<br>(0.054) | 5.57 | 0.000 | Reject at 1% |
| gov | 0.243*<br>(1.72) | .092 | -0.041 | Reject at 10% |
| popg | -0.492**<br>(0.222) | -2.21 | 0.032 | Reject 5% |

| | | | | |
|---|---|---|---|---|
| ppa | 0.107 (0.089) | 1.21 | 0.232 | Fail to reject at 10% |
| constant | -0.161 (0.041) | -3.98 | 0.00 | Reject at 1% |

*Statistically Significant at 10%, **Statistically Significant at 5%, ***Statistically Significant at 1%

Multiple Regression Model 2:

Equation: $\widehat{gdp\_pc} = \widehat{\beta_0}$ + fin($\widehat{\beta_1}$) + manu($\widehat{\beta_2}$) + gov($\widehat{\beta_3}$) + jobgrowth($\widehat{\beta_4}$) + publicuni($\widehat{\beta_5}$) + educhs($\widehat{\beta_6}$) + educuni($\widehat{\beta_7}$) + $\hat{u}$

Regression Model: $\widehat{gdp\_pc}$ = -0.714 + fin(0.249) + manu(0.449) - gov(0.090 ) + jobgrowth(0.734) + publicuni(0.127) + educhs(0.784) - educuni(0.714 )

N = 51, $R^2$ = 0.506

**Table 4: Estimation Results - Multiple Regression Model 2**

| **Variable** | **Coefficient (Std. Error)** | **T-value** | **P > \|t\|** | **$H_0 : B_j=0$ $H_1 : B_j \neq 0$** |
|---|---|---|---|---|
| fin | 0.249*** (0.064) | 3.86 | 0.000 | Reject at 1% |
| manu | 0.449 (0.675) | 0.67 | 0.506 | Fail to reject at 10% |
| gov | -0.090 (0.155) | -0.63 | 0.534 | Fail to reject at 10% |
| jobgrowth | 0.734 (0.501) | 1.46 | 0.152 | Fail to reject at 10% |
| publicuni | 0.127 (0.205) | 0.62 | 0.540 | Fail to reject at 10% |
| educhs | 0.784* (0.425) | 1.82 | 0.076 | Reject at 10% |

| | | | | |
|---|---|---|---|---|
| educuni | -0.194<br>(0.206) | 0.93 | 0.357 | Fail to reject at 10% |
| constant | -0.714*<br>(0.352) | -2.0 | 0.051 | Reject at 10% |

*Statistically Significant at 10%, **Statistically Significant at 5%, ***Statistically Significant at 1%

**Interpretation**

In all of the above regression models we conducted a two-tailed hypothesis test in order to determine the significance of the relationships. In a majority of the cases, the relationships with per capita GDP were not significant when considered in the final multiple regression. The only significant relationships that were found were finance industry output and high school educational attainment.

The output from the Simple Regression Model 1 proves that finance and per capita GDP are highly correlated, showing a significance level of 1%. It produced a high $R^2$ value of 0.405, meaning 40.5% of the variation in per capita GDP could be explained by finance as a whole. The evidence for the statistical significance of finance industry variable is likely due to the fact that financial operations are the underpinning of business in the U.S. economy. This was evident in the 2008 Financial Market Crisis when large banks such Merrill Lynch, AIG, HBOS, among many others, went bankrupt and effectively crashed world economic markets.

Following these attempts, we expanded upon the original simple regression model and formed our first multiple regression model, which included growth at the state-level in government spending, population growth, and per pupil spending on education.We included these factors because we believed that these additional indirect factors also could prove to be statistically significant in their relation to per capita GDP. Multiple Regression Model 1 displayed that finance was significant at the 1% level, population growth was significant at the 5% level, and government spending was significant at the 10% level.

Multiple Regression Model 2 provided statistically significant coefficients for growth in the state-level finance industry at 1% and growth in high school educational attainment, with coefficients of 0.249 and 0.784; the entirety of the descriptive statistics for Multiple Regression Model 2 are provided in Table 5. The rest of our independent variables remained insignificant even at the 10% level with relatively p-values of 0.15 or greater, along with relatively low t-values of 0.61 or less. However, the model produced a high $R^2$ value of 0.506, meaning 50.6% of the variation in states' per capita GDP could be explained by the activities of those particular states' finance industries.

## V. Extensions

### Robustness Tests

Considering the levels of significance of the variables in our multiple regression, we conducted an F-test to determine if our five insignificant variables might be jointly significant. By running an F-test, we'll be able to determine whether or not these five variables are contributing any sort of explanatory power to our model at all. For the F-test, our null hypothesis and alternative hypothesis are stated as follows:

$$H_0: \widehat{\beta_2} = \widehat{\beta_3} = \widehat{\beta_4} = \widehat{\beta_5} = \widehat{\beta_7} = 0$$

$$H_1: H_0 \text{ not true.}$$

Because the unrestricted model still includes the statistically significant variables, it reflects the Multiple Regression Model 2 that we have become familiar with. The restricted model, however, only includes the five variables that were determined statistically insignificant, which are growth in government output, growth in the manufacturing industry, state job growth, growth in postsecondary education appropriations, and college educational attainment. The unrestricted and restricted regression models are shown as follows:

Unrestricted Model (Multiple Regression Model 2):

$$\widehat{gdp\_pc} = \widehat{\beta_0} + \text{fin}(\widehat{\beta_1}) + \text{gov}(\widehat{\beta_2}) + \text{manu}(\widehat{\beta_3}) + \text{jobgrowth}(\widehat{\beta_4}) + \text{publicuni}(\widehat{\beta_5}) + \text{educhs}(\widehat{\beta_6}) + \text{educuni}(\widehat{\beta_7})$$

Restricted Model:

$$\widehat{gdp\_pc} = \widehat{\beta_0} + \text{gov}(\widehat{\beta_2}) + \text{manu}(\widehat{\beta_3}) + \text{jobgrowth}(\widehat{\beta_4}) + \text{publicuni}(\widehat{\beta_5}) + \text{educuni}(\widehat{\beta_7})$$

*See Appendix: Output 2 for the Restricted Multiple Regression Model 2 Output.*

| **Table 3: Restricted Model F-Test Results** | |
|---|---|
| F-statistic ($F_{5, 45}$) | F-statistic Critical Value |
| 3.46 | 0.009 |

In Table 3, we can see that the F-statistic is 3.46 while the critical value for the F-statistic is 0.009. Because the F-statistic is calculated to be relatively high at 3.46, we know that a degree of explanatory power exists in our restricted model. And because the F-statistic critical value, 0.009, is less than 0.1, we can reject the null hypothesis of our F-test at a 99% level of significance and determine that the coefficients of our five insignificant variables are not all equal to 0.

**Different Functional Forms**

In terms of using different functional forms to make the model's variables more conductive to answering the questions central to our project, one of the first functional forms we considered changing were those for high school and college educational attainment. As it stands in our model, over the ten year period between 2006 and 2016, we track our educational attainment variables in terms of the average of the static rates over the course of the ten-year period, instead of using the average percentage changes from year to year. Even though we track our other five variables in terms of year-to-year growth rates, we chose to monitor the static rates of educational attainment because of most states' relatively level trends in increases or decreases in educational attainment. However, measuring the log of high school and college educational attainment instead would effectively allow us to measure percentage change in high school and college educational attainment rates, and would keep all of our regression model's variables consistent as far as their study of growth levels between 2006 and 2016.

Below, Table 6 shows our multiple regression using the log of high school educational attainment and college educational attainment.

**Table 6: Descriptive Statistics - Revised Multiple Regression Model 2**
**(using log of high school educational attainment and log of college educational attainment)**

| Variable | Coefficient | Standard Error | T-Value | P-Value |
|---|---|---|---|---|
| **fin** | 0.25 | 0.06 | 3.87 | 0.000 |
| **manu** | 0.5 | 0.68 | 0.74 | 0.463 |
| **gov** | -0.09 | 0.16 | -0.59 | 0.556 |
| **jobgrowth** | 0.68 | 0.5 | 1.35 | 0.184 |
| **publicuni** | 0.13 | 0.21 | 0.6 | 0.548 |
| **leduchs*** | 0.65 | 0.38 | 1.67 | 0.102 |
| **leducuni*** | -0.05 | 0.07 | -0.66 | 0.51 |
| **constant** | -0.06 | 0.08 | -0.74 | 0.465 |

*See Appendix: Output 3 for STATA regression output of Revised Multiple Regression Model 2.*

Compared to the original Multiple Regression Model 2, the revised version shows us that when measuring the log of both the educational attainment variables in our model, the manufacturing industry coefficient increases, the finance industry, government output, and public university appropriation coefficients stay about level, while the jobgrowth coefficient and constant term decrease noticeably.
As far as the original and revised versions of the variables, the log of high school educational attainment shows a smaller coefficient and, just barely, is determined by the model to be statistically insignificant. The log of college educational attainment show a much smaller coefficient along with a higher p-value.

## VI. Conclusions

In developing our final model regression model, we came away with a lot of insights as to how economic activity happens at the state level, and how to use robust methods of econometric analysis in order to track this activity. Our final regression model included the growth rates of the state-level finance industry, manufacturing industry, government spending and enterprise, job growth, and public university appropriations, as well as measures of high school and college educational attainment rates. However, in the end, our regression model only included two statistically significant variables: growth of states' finance industries and the rate of high school educational attainment.

Perhaps most importantly, the central takeaway from this project is that our final regression model could not very effectively explain the growth of states' per capita GDP. And while it is always a valid critique that when choosing the variables for our regression model, we could have been more selective and conscientious, but in collecting data for this project, we came to appreciate how difficult it is to find robust databases and well-maintained collections of state-level economic data. The detailed and interactive nature of the U.S. Bureau of Economic Analysis website was incredibly helpful in finding different measures of economic data for U.S. states, but not many other resources outside of it were as helpful or user-friendly in allowing us to find data to use for this project. Also, because data-collection efforts are not as active for state-level economies, we were unable to find many of the potentially explanatory variables that we sought to include in our model. In the end, these issues speak to the fact that it would be useful to economists, social scientists, and university students across the country if there were more active initiatives, groups, or public infrastructure that supported gathering robust measures of economic data at the state level.

Fortunately, though, in completing this project, we were able to uncover a lot of incredibly interesting insights about the economic and governmental activity of many states between the years of 2006 and 2016. We credit this to the fact that uncovering unique or one-time shifts in state economic activity and policymaking is much easier when tracking rates of growth for economic indicators, instead of just tracking the static levels. For instance, in looking at four of the independent variables that we measured - per capita GDP growth, finance industry growth, job growth, and annual per pupil spending - North Dakota serves as the highest observation for all of them. In fact, excluding annual per pupil spending, all of these variables show that North Dakota's observation is actually the sole positive outlier, so after noticing this trend and performing a few quick Google searches, we found out that between the years of 2006 and 2016, two major phenomena unique to North Dakota greatly impacted the state's economy: the activity of the completely state-owned and operated Bank of North Dakota (the only one of its kind in the United States), and the discovery of the Parshall Oil Field in 2006. Since after World War II, the Bank of North Dakota has been promoting and financing the enterprise of many types of businesses in North Dakota, but from 2008 to 2011, the Bank of North Dakota served a much more timely purpose. The state's well-supported and widespread public banking system was able to effectively shield North Dakota's financial industry from the effects of the U.S. financial crisis by actively supporting the financial activity of local and community banks, which might be the reason that over the course of this ten year period, per capita GDP, output of the finance industry, and the state's employment rate all grew so rapidly. And even further, around the same time, the start of the North Dakota oil boom commenced once the Parshall Oil Field was discovered in the northwestern part of the state. The boom is considered to have started in 2006 and to have peaked around 2012, and during this time, news media outlets documented the overnight boom in the North Dakota's economy by publishing articles with titles like "New Boom Reshapes Oil World, Rocks North Dakota", "North Dakota sees increases in real GDP per capita following Bakken production", and even "Double your salary in the middle of nowhere, North Dakota." However, as far as the incredible increases in economic activity that North Dakota experienced over the course of this decade, it was not the only state that experienced significant and documented changes in its economic and governmental landscape. For example, the lowest observation that was recorded for the post-secondary education appropriations variable was Illinois. In the summer of 2017, CNN Money published an article titled "Illinois is starving state colleges and universities", documenting the state funding decreases that had taken effect during the 2015-2016 school year, and even pointing out reasons for the lack of public financing: "Democrats control the state legislature and continue to spar with Republican Governor Bruce Rauner about how to address the state's financial crisis, which stems from years of fiscal mismanagement… [s]ince 2015, lawmakers have funded colleges and other state services with a patchwork of emergency payments that are paltry compared to previous years." Using this research as a means to measure the very unique economic landscapes of each state was a great opportunity and provided a unique way to to use quantitative, concrete methods of econometric analysis to hone in on real economic trends with real implications for citizens living in the United States.

Lastly, there are a huge number of ways to take this research even further and arrive at even more important, perhaps not-yet-uncovered conclusions. While being more creative about variables to include or measure differently is always an option, this research project also lends itself to performing interesting sensitivity analyses. One way this could be done would be to do a regional, instead of state-by-state, analysis of the United States, in order to see if any of these variables are affected by economic trends that manifest in stronger ways in certain geographic regions of the United States. In terms of the conclusions for this project, a regional analysis might also be able to uncover any spillover effects of individual states' economic activity that could go on to affect the economies of surrounding states in concrete ways.

## References


Digest of Education Statistics, 2017. (2018, January). Retrieved November 19, 2018, from https://nces.ed.gov/programs/digest/d17/tables/dt17_333.30.asp

GDP by Industry. (2018, November 1). Retrieved November 18, 2018, from https://www.bea.gov/data/gdp/gdp-industry

Goldsmith, R.N. (1969). Financial Structure and Development. Yale University Press, New Haven.

Levine, Ross. (2005). "Finance and Growth: Theory and Evidence," Handbook of Economic Growth, in: Philippe Aghion & Steven Durlauf (ed.), Handbook of Economic Growth, edition 1, volume 1, chapter 12, pages 865-934 Elsevier

Levine, Ross. (1997). "Financial Development and Economic Growth: Views and Agenda." Journal of Economic Literature, vol. 35, no. 2, 1997, pp. 688–726.

Lobosco, K. (2017, June 29). Illinois is starving its public colleges and universities. Retrieved November 19, 2018, from https://money.cnn.com/2017/06/29/pf/college/illinois-budget-higher-education/index.html

Popov, Alexander. (2017). "Evidence on Finance and Economic Growth." *Working Paper Series*, European Central Bank, 8 Dec. 2017.

Teame Ghirmay. (2004). "Financial Development, Investment, Productivity and Economic Growth In The U.S." Southwestern Economic Review, 2004, pp. 23-40.

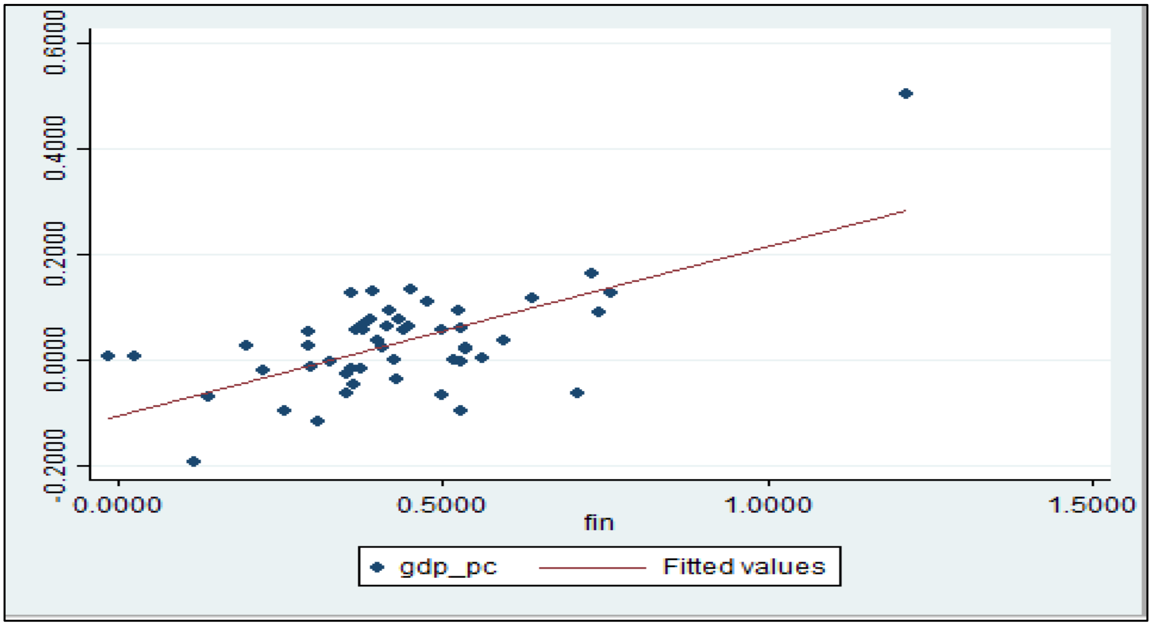
**VIII. Appendix**

**Appendix: Table 1 - List of U.S. states included in the dataset***

| | | | | |
|---|---|---|---|---|
| Alabama | Alaska | Arizona | Arkansas | California |
| Colorado | Connecticut | Delaware | Florida | Georgia |
| Kentucky | Idaho | Illinois | Indiana | Iowa |
| Kansas | Kentucky | Louisiana | Maine | Maryland |
| Massachusetts | Michigan | Minnesota | Mississippi | Missouri |
| Montana | Nebraska | Nevada | New Hampshire | New Jersey |
| New Mexico | New York | North Carolina | North Dakota | Ohio |
| Oklahoma | Oregon | Pennsylvania | Rhode Island | South Carolina |
| South Dakota | Tennessee | Texas | Utah | Vermont |
| Virginia | Washington | West Virginia | Wisconsin | Wyoming |

*Because of the sizable population and economic contributions of the District of Columbia, we also include observations for the District of Columbia in our statistical tests and calculations.

**Appendix: Figure 1 - Scatter plot and trend line illustrating the variances of observations**




**Appendix: Output 1 - Correlation coefficients between independent variables**

```
. corr fin manu gov jobgrowth publicuni educhs educuni
(obs=51)
```

| | fin | manu | gov | jobgro~h | public~i | educhs | educuni |
|---|---|---|---|---|---|---|---|
| fin | 1.0000 | | | | | | |
| manu | 0.1500 | 1.0000 | | | | | |
| gov | 0.2991 | 0.4409 | 1.0000 | | | | |
| jobgrowth | 0.5245 | 0.3030 | 0.6045 | 1.0000 | | | |
| publicuni | 0.1084 | 0.2888 | 0.3546 | 0.2521 | 1.0000 | | |
| educhs | 0.0621 | 0.3055 | 0.0645 | 0.0822 | 0.2709 | 1.0000 | |
| educuni | -0.0757 | -0.0620 | 0.0126 | 0.2027 | 0.1389 | 0.4085 | 1.0000 |

**Appendix: Output 2 - Restricted Multiple Regression Model 2 output**

```
. reg gdp_pc manu gov jobgrowth publicuni educuni

      Source |       SS           df       MS      Number of obs   =        51
-------------+----------------------------------   F(5, 45)        =      3.46
       Model |  .135444134         5  .027088827   Prob > F        =    0.0099
    Residual |  .352288852        45  .007828641   R-squared       =    0.2777
-------------+----------------------------------   Adj R-squared   =    0.1974
       Total |  .487732986        50   .00975466   Root MSE        =    .08848

------------------------------------------------------------------------------
      gdp_pc |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        manu |   .8311359   .7558094     1.10   0.277    -.6911424    2.353414
         gov |  -.1545101   .1851016    -0.83   0.408    -.5273238    .2183037
   jobgrowth |   1.613166   .5192432     3.11   0.003     .5673569    2.658976
   publicuni |    .206482   .2424989     0.85   0.399    -.2819359    .6948999
     educuni |  -.1922486   .2142224    -0.90   0.374    -.6237147    .2392175
       _cons |   .0697944   .0836308     0.83   0.408    -.0986467    .2382354
```

**Appendix: Output 3 - Revised Multiple Regression Model 2 (using log of high school educational attainment and log of college educational attainment)**

```
. reg gdp_pc fin manu gov jobgrowth publicuni leduchs leducuni

      Source |       SS           df       MS      Number of obs   =        51
-------------+----------------------------------   F(7, 43)        =      6.28
       Model |  .246599171         7  .035228453   Prob > F        =    0.0000
    Residual |  .241133815        43  .005607763   R-squared       =    0.5056
-------------+----------------------------------   Adj R-squared   =    0.4251
       Total |  .487732986        50   .00975466   Root MSE        =    .07488

------------------------------------------------------------------------------
      gdp_pc |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         fin |   .2537274   .0655875     3.87   0.000     .1214577    .3859971
        manu |   .5061872   .6834554     0.74   0.463    -.8721319    1.884506
         gov |   -.093307   .1572037    -0.59   0.556    -.4103385    .2237246
   jobgrowth |   .6842745    .507121     1.35   0.184    -.3384325    1.706981
   publicuni |   .1262761   .2087214     0.60   0.548    -.2946507    .5472029
     leduchs |   .6521185   .3903893     1.67   0.102    -.1351766    1.439414
    leducuni |  -.0457236    .068847    -0.66   0.510    -.1845667    .0931196
       _cons |  -.0581621   .0789831    -0.74   0.465    -.2174467    .1011224
```