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The End of the Three Percent Rule: How Structural Changes in the U.S. Economy have Impacted Economic Growth

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Abstract

Using data from government sources (FRED, BEA, BLS), the thesis explores the underlying reasons for declining U.S. economic growth. A long standing trend of annual 3% growth no longer seems to hold true for the economy. The paper summarizes current theory as to why the growth has slowed and finds new explanations by analyzing the various major industries which make up GDP. The results show that sectoral shifts in employment from high paying industries to low paying industries help to explain a significant portion of the decline in national growth rates. The decline in growth is primarily driven by about ten poor performing states.

Keywords: Real GDP growth rates, Historical Trends, Structural Employment

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I would like to acknowledge the following people for their support. I could not have completed this thesis without them: my parents, who are always there to encourage and support me; my friends, for spending hours at the Lowe Institute at CMC working with me and offering advice; and Professor Keil, for his support on this paper and throughout my entire college career.

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I. Introduction

If you followed the coverage of the recent presidential election, there is one topic or theme that every candidate, regardless of political party or orientation, agrees on: The U.S. economy is in poor shape. While the perceived causes that resulted in this situation and the severity of the situation vary across politicians, the overall message is dire. Here is a sample of a few:

"This country is in big trouble. We don't win anymore. We lose to China. We lose to Mexico. Both in trade and at the border. We lose to everybody." - Donald Trump

"The greed of the billionaire class, the greed of Wall Street is destroying this economy." - Bernie Sanders

"This country is running out of time. We can't afford to have another four years like the last eight." - Marco Rubio

"We're on the verge of economic collapse." - Ben Carson

"The sad reality is big government, massive taxes, massive regulation, doesn't work." - Ted Cruz

"We must raise incomes for hard working Americans, so they can afford a middle-class life." - Hillary Clinton

"We should be growing at four percent, not this new normal." - Jeb Bush

This kind of skepticism and doomsday mongering is in sharp contrast to the picture painted by the primary, main indicators of economic well-being. On election day, the picture with respect to the economy was as follows:

Table 1: Main Economic Indicators, United States, November 2016

Economic Indicator	Value
Real GDP Growth Rate, 2016, Q3	2.9%
Unemployment Rate, October 2016	4.9%
Inflation Rate, October 2016	1.6%
10-Year Treasury Bond	2.3%

All of these values are quite close to what you would expect to find at full employment with low inflation. As a matter of fact, the literature on voting/approval functions would suggest a win for the incumbent were it not for the fact that the sitting president was not running for re-election, and that the same party had been in power for two terms.[1]

Several business economists have pointed out this fact recently. Mercile (2016) states that the U.S labor market is performing well. The gap between the actual unemployment rate (adjusted for involuntary part time workers and discouraged workers) and the unemployment rate at full employment (natural rate or NAIRU) was 2.6 percentage points at the start of 2015. At the beginning of 2016, that gap had narrowed to 1.3 percentage points and is predicted to reach zero by the end of this year. Schniepp (2016) points out that help wanted indices and real wage increases are at levels corresponding to

[1] The Fair model also has an important variable in its specification: the so-called "Good News" variable. This variable increases by one if growth in per capita income is 3.2% or higher during a quarter. The equivalent in real GDP growth would be roughly 4.2%, which is hard to obtain if economic growth has slowed down when compared to historical averages. The previous administration only had two quarters of such high real growth. (Fair 1996)

full employment. Moreover, the positive labor market picture coincides with real growth in the U.S economy, and we have not seen a recession in about seven years. Note that in February 2017 the current expansion, which started in July of 2009, will become the second longest expansion in U.S. history. From a consumer standpoint, consumer confidence is at levels not seen since the beginning of the Great Recession and personal consumption expenditures have been rising steadily as well.

In the words of this year's Literature Nobel prize winner Bob Dylan, "How does it feel?" Apparently, "not so good" or Hillary Clinton would be president by now. So, what is the underlying source of the malcontent? Maybe politicians simply think that they must spread negativity to create the image of a "savior" for themselves. In that case, it would be easy to dismiss their claims as groundless. However, that is not the case. Instead, there is solid evidence that something is fundamentally different regarding the U.S. economy today.

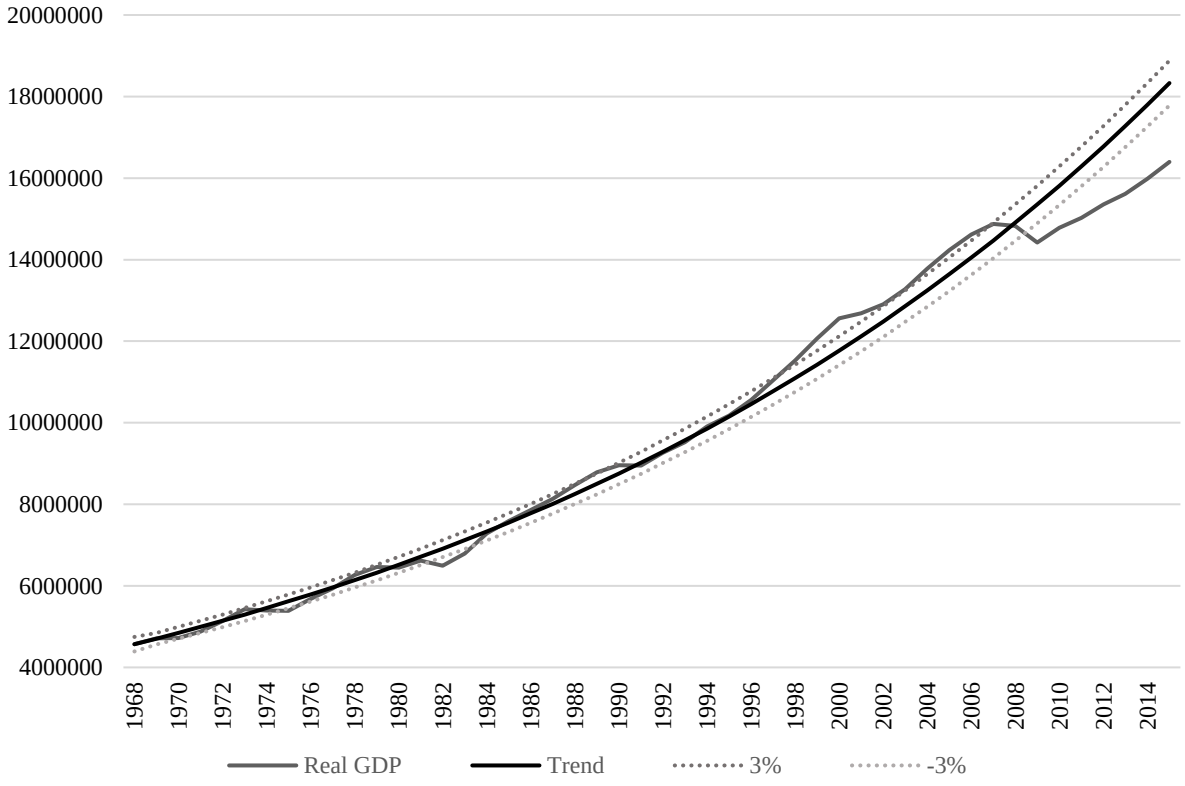
From 1896 to 2008, real GDP grew at approximately 3% per year. There are obvious fluctuations around the trend line that occur with each business cycle, the most obvious being the Great Depression. However, overall economic growth trended at 3% for 120 years. Starting the numerical analysis at a more recent date (1968), trend growth is also 3% with a variation width of plus or minus 3%.

Figure 1 displays actual real GDP, trend growth, and the bandwidth of 3%.[2] There are a few years with real growth domestic product (GDP) levels exceeding or falling below the 3% bounds. However, periods of extreme loss are subsequently offset by abnormally

[2] Trend growth was generated by regressing the logarithm of real GDP on a linear time trend. Predicted values from the regression were then used to convert the numbers into $2009 GDP.

high growth. This pattern changed with the onset of the Great Recession. At that point the economy dipped well below the lower bound initially but was expected to rebound subsequently. Unfortunately, the required strong recovery to accomplish this return never materialized. Had the U.S. economy grown at levels just exceeding 3%, then we would have observed actual GDP slowly inching back towards the trend line from 1968-2008, but that did not happen. Instead average real GDP growth during this long expansionary phase has been only about 2%. As a result, the gap between actual real GDP and the trend line continues to widen.[3] Currently, U.S. real GDP lies almost $2 trillion (in numbers: $2,000,000,000,000 or about 11%) below the level it would have been, had we returned to

Figure 1: Real GDP, United States, Billions of $2009, 1968-2015



[3] "GDP gap" actually is a technical term, and refers to ((Y-Yp)/Yp), where Y is real GDP and Yp is potential ("full employment") real GDP. The gap is measured in percent.

the 3% trend line. Further, there does not seem to be any tendency to return into the band; instead the economy seems to be moving further away.

To put matters into perspective: real GDP would have to grow at a rate of about 4.2% for an entire decade, with no recession intervening, in order to catch up to the trend line by 2026. In essence, this means we have permanently departed from the trend line, and there is little to no hope of returning to the 3% band.

GDP is a comprehensive measure of the economy because it represents the total value added of all products. While a low unemployment rate may be seen as evidence of a strong economy, real GDP[4] and real GDP growth are better indicators because they can identify structural shifts occurring in the economy in a way that unemployment cannot. Imagine a worker earning $100,000 per year is laid off and quickly finds a new job paying $50,000 per year. In this case unemployment and employment levels have not changed, but GDP has fallen because GDP is equal to national income by accounting identity.[5] By intuition, GDP is the value of every final good sold in the economy. Money is being exchanged in the sales of final products, and every cost to a buyer is income to the seller (CEPR 2012). Therefore, declines in real per capita GDP can be thought of as a decline in the real income or standard of living of the average American.

Real GDP per capita peaked before the recession at about $50,000 per person in the fourth quarter of 2007 and did not return to that level until six years later, during the fourth

[4] Per capita GDP, or real GDP divided by the population of a country, was seen by Adam Smith as a proxy for the "Wealth of a Nation."

[5] Technically speaking, this is not quite true since income can be received for sales generated by companies operating abroad, but owned by U.S. citizens. Similarly, GDP also includes sales by companies with foreign ownerships in the U.S. I will ignore the difference between GNP and GDP here.

quarter of 2013. This means that the average American did not see a raise beyond their 2007 income for over six years. Furthermore, income is not evenly distributed. Growth in per capita GDP has been low since 2013, and the median household has barely seen any raise over the last nine years because growth in income was concentrated in the upper fifth percentile of the income distribution ("Lost Decade"). While real GDP is currently not declining, it certainly is not growing at a pace that Americans have become accustomed to, which perhaps explains why many Americans "feel" like we are still in a recession. The natural research question that evolves from here must be: what happened? Something fundamentally has changed in the U.S. economy in terms of output growth. The purpose of this paper is to explain why a forty year "rule" that seemed to govern U.S. economic behavior has now vanished.

The paper proceeds as follows. Section II discusses some of the prevailing thoughts on declines in real GDP growth rates as well as discuss major macroeconomic trends in the labor market. Next, section III attempts to explain what is causing the declines in growth rates as well describe some major trends in the U.S. economy. The analysis will explore real GDP as a function of industries and hours. Section IV breaks down GDP growth rate trends by state. A final section, section V, concludes on the results and discusses avenues for further research into the topic.

II. Literature Review

As you can see from Jeb Bush's quote above, there is an awareness that the low growth rates we are seeing are abnormal and problematic. In fact, some of the quotes offered by politicians provide their insight into what they think the explanation is. Ted Cruz sights government regulation as the problem, while Bernie Sanders blames Wall Street and corporate greed. Perhaps the issue is a bit more complex than what either of them present.

According the Robert Gordon, an economist at the University of Chicago, economic growth is mistakenly considered an economic certainty. He hypothesizes that there are indeed several current day macroeconomic factors slowing down U.S. growth: rising costs and falling quality of education, rising inequality stemming from globalization, environmental regulation and taxes, overhang of consumer and government debt, and an aging population (Gordon 2012). Many of these factors are the kinds of topics that politicians will often point to when discussing a revitalization of the U.S. economy.

However, in addition to these economic "headwinds" Gordon claims that the problem is much more fundamental and unfixable. He says that the main driver in historical U.S. economic growth is innovation. There have been three industrial revolutions in modern history during which major innovations were concentrated. The first industrial revolution occurred from 1750 to 1830 and saw the creation of steam engines, cotton spinning, and railroads. The second industrial revolution occurred from 1870 to 1900 and saw the critical inventions of electricity, running water, and the internal combustion engine (Gordon 2016). The innovations of the second industrial revolution radically transformed human life. Inventions such as home appliances, airplanes, air conditioning, just to name a few, were all made possible by the main ideas that came out of the era. Gordon

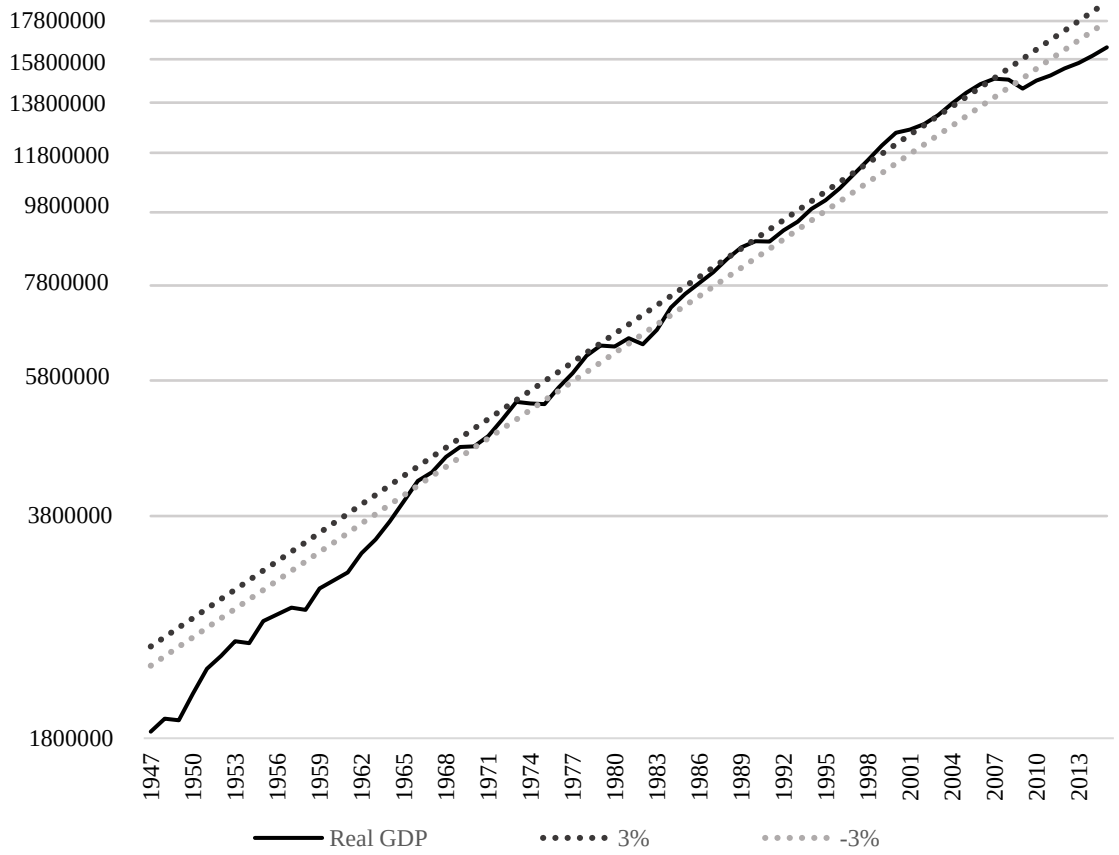
hypothesizes that the effects of the second industrial revolution last well through the 1960's. This might seem like a stretch, but there is definitely some logic to his claim. For example, rural America did not fully receive electricity until the mid-1960's (Genzel 2009).

The essential idea is that economic growth is driven by a major innovation and the resulting improvements on that innovation. The cause of the slow growth, put simply, is that the modern world has not seen a critical innovation in quite some time. There was a third industrial revolution related primarily to technology and computers from about 1960 to 2000; however, the incremental improvements on the boom in technology are increasingly focused on communication and entertainment. It's not to say that the smartphone, for example, is not a great invention, but its improvement on life during the flip-phone days pales in comparison to the improvement on life cars created by replacing horses (Gordon 2012).

The diminishing returns on innovation can be seen in the following graph of U.S. real GDP since 1947. The y-axis is on a logarithmic scale, so constant growth rates will be graphed as straight lines.[6] The plus and minus three percent window with 1968 as the base year is also included. The concave down shape of the curve shows the declining U.S. growth rate overtime. GDP between 1947 and 1968 grew at about 4.0%, between 1968 and 2008 grew at about 3.0%, and between 2008 and 2015 grew at about 1.2%.

[6] The greater the space between grid lines the greater the percent change in the value.

Figure 2: Real GDP, United States, Millions of $2009, 1947-2015



Innovation must certainly influence growth rates, but it also has had an impact on employment in the modern world. MIT economist David Autor explains that the rise of technology has fundamentally changed the roles of labor in our economy. Autor groups employment into four categories: non-routine cognitive, non-routine manual, routine cognitive, and routine manual. He states that the routine cognitive and routine manual jobs are the type of jobs typically occupied by middle class workers. They are procedural type jobs such as factory employees or administrative roles in offices. Because these types of jobs are routine, they are easily replaceable with technology. An example of this would be a typist being replaced by a copy machine or a factory worker being replaced by new

equipment (Canon 2013). As the prices of machines have fallen relative to the price of workers, these types of routine jobs have been automated.

Non-routine cognitive tasks are jobs that involve high level thinking and analysis. They often require higher education, and they pay well. Also, they are not easily automated; a robot cannot be a CEO or represent someone in court. Non-routine manual tasks are jobs that involve little ability, but are difficult to automate (Canon 2013). A good example of this is a janitor. Since almost anyone can clean and lock up a building, it is not a high paying job; however, it is also not easily automated.

The automation of middle paying jobs has caused a shift in labor from middle paying jobs to both low and high paying jobs - what Autor calls job polarization. In a paper written by Autor (2013), he explores the effects of international trade and offshoring, the changing roles of unions, and the minimum wage on job and polarization. He concludes that the key contributor to job polarization is the automaton of routine work (Autor 2013).

Autor never claims that automation is contributing to unemployment (technological advancement and unemployment rates are not correlated at all); rather, he states that it is contributing to structural changes in the employment market. Structural changes in the employment market are directly connected to real GDP growth. If jobs were moving from middle paying sectors to high paying sectors, then perhaps we would expect GDP to grow faster than it had historically. This implies that jobs have probably switched into less productive sectors of the economy. A Wall Street Journal Article from 2013 states:

> *"Economic changes over the past decade have led to a decline across the country in well-paying jobs, such as those in manufacturing, and an increase in jobs that pay less, such as those in hotels and food services . . . Positions are increasingly*

being filled not with the young and inexperienced, but by older and more skilled workers who can't find other jobs."

Overall, current research examines extensively low GDP growth rates and sectoral shifts in employment. However, the majority of the research analyzes the two components individually. This paper will add to existing literature by drawing connections between the two with the goal of understanding of our, to quote Jeb Bush, "new normal."

III. Explaining the Gap[7]

A. Industry Breakdown

One of the benefits to analyzing GDP is that it can be decomposed by industry to give a more complete image of what aspects of the economy have really changed. Decomposing GDP by industry can be described by the following:

$$Y \equiv \sum_{i=1}^{15} \frac{Y_i}{E_i} * \frac{E_i}{E} * E \qquad (1)$$

Where "*Y*" corresponds to Income, "*E*" corresponds to employment and "*i*" corresponds to one of the 15 major NAICS statistical industries.[8] There are fifteen major industries:

- Finance, Insurance, and Real Estate (FIRE)
- Government
- Professional and Business Services
- Manufacturing
- Education
- Wholesale Trade
- Retail Trade
- Information
- Construction
- Leisure and Hospitality
- Transportation
- Mining
- Other Services
- Utilities

[7] Analysis in this paper is done annually with the most recent data point being 2015

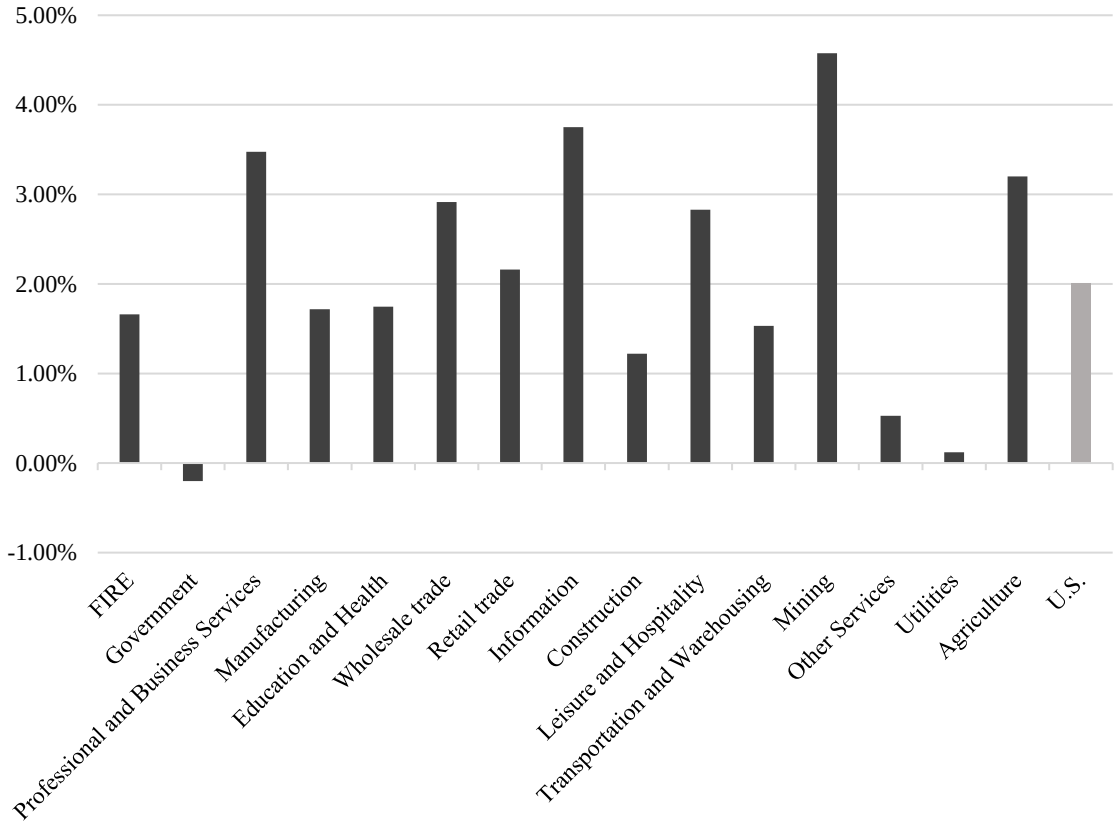
[8] Y_i/E_i can be thought of as output per worker by industry - a measure of productivity by industry. In this section I will use output per worker and productivity interchangeably. E/E_i is the share of total employment held by each industry. The North American Industry Classification System (NAICS) was established in 1997, and is used to provide U.S. industry time series data. It improved on the long-standing Standard Industrial Classification (SIC) system.

- Agriculture

The fall in real GDP growth rates from about 3% to 2% can be thought of as a gap between the 3% trend line shown in **Figure 1** and the actual current level of real GDP. Real GDP as of 2015 was about $16.4 trillion, which leaves a gap of 13% of the trended real GDP. If the gap is based off the lower 3% bound, then the gap shrink to 8%. Either way it is substantial.

One explanation for the decline is that the economy in general has slowed down across all fifteen industries. If this were true, then we should see consistent real GDP growth rates of about 2% per year in each industry. However, average industry growth rates post-recession have varied widely among the different industries. **Figure 3** shows average real GDP growth rates from 2010 to 2015. The growth rates vary as much as 4.5 percentage points across the fifteen industries. Some industries far outperform the average U.S. growth rate of 2% during the period.

Figure 3: Post Recession Average Growth Rates, United States, 2010-2015



Unfortunately, the industries that outperform the U.S. economy and the 3% historical trend tend to be smaller, such as Agriculture and Mining, so their effect on overall growth rates is minimal. **Figure 3's** x-axis is organized by total real GDP share in 2015 from left to right. With the exception of Professional and Business Services, the larger industries perform well below the 3% goal. It's worth noting that the five largest industries (FIRE through Education and Health) account for 65% of total real GDP. Overall, the figure shows that falling growth rates can certainly be attributed to specific industries rather than to the economy as a whole.

A more nuanced way to analyze real GDP is to look at it as a function of industry output per worker and employment in each industry. This is the same as what was described in **Equation (1)**. Holding each component of GDP constant at a historical level and

allowing the others to change as they did in actuality will provide a clue as to which component has negatively impacted growth. For example, if output per worker (Y_i/E_i) is held constant at 2007 levels, and share of total employment by industry (E_i/E) and employment (E) are allowed to adjust normally, this will give us a new estimated real GDP value for every period after 2007. These estimated real GDP values are presented in the following **Tables 2 and 3**:

Table 2: Y_i/E_i constant at 2007 levels, United States, Millions of $2009

Year	Estimated Real GDP	Actual Real GDP	Estimated/Actual
2008	$ 14,779,607	$ 14,842,340	99.6%
2009	$ 14,028,375	$ 14,418,738	97.3%
2010	$ 13,864,061	$ 14,733,166	94.1%
2011	$ 14,011,999	$ 14,945,815	93.8%
2012	$ 14,235,735	$ 15,239,418	93.4%
2013	$ 14,443,157	$ 15,421,934	93.7%
2014	$ 14,684,860	$ 15,753,678	93.2%
2015	$ 14,940,151	$ 16,124,135	92.7%

With output per worker held constant at 2007 levels, real GDP is far below what it currently is today. If the real GDP estimate were higher than actual real GDP that would imply one of two things: either productivity has fallen and real GDP growth is being driven by large increases in employment, or productivity has fallen and real GDP growth is being driven by a massive movement of employment from low productive sectors to high productive sectors. In reality, output per worker has risen nationally since 2007, which is

why holding worker productivity constant did not explain the gap between real GDP and the historical trend line.

Table 3: E_i/E constant at 2007 levels, United States, Millions of $2009

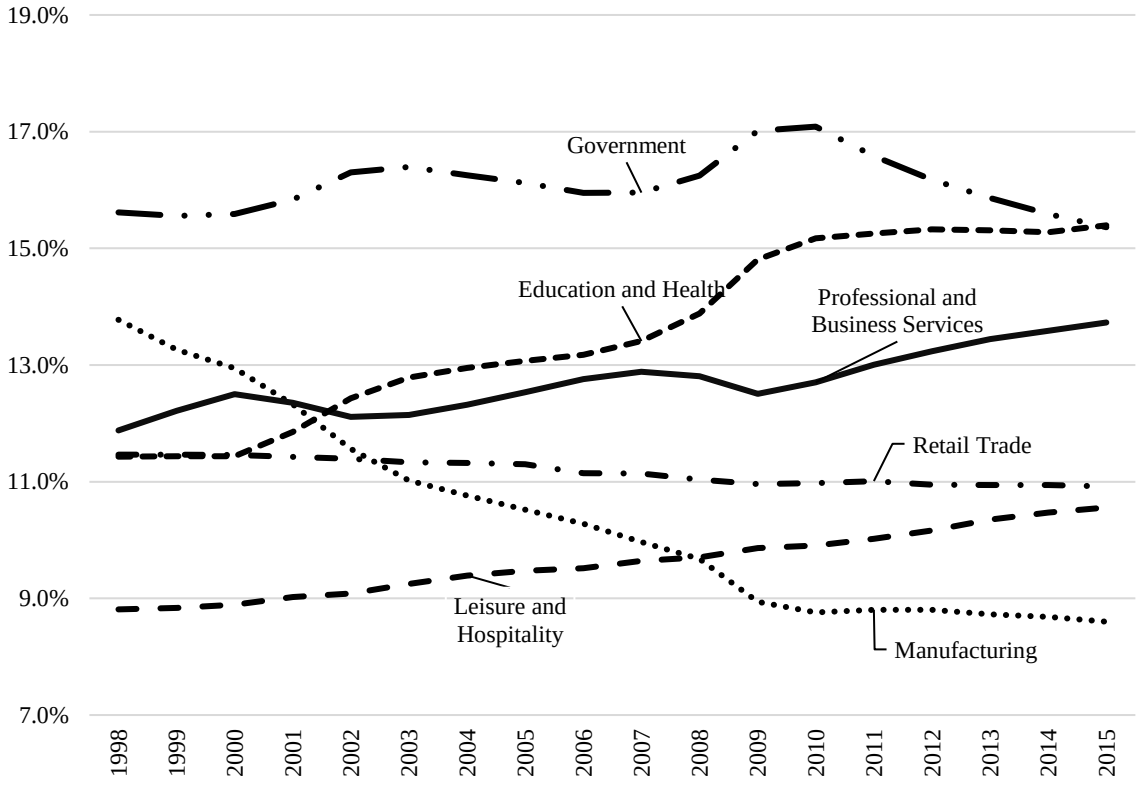
Year	Estimated Real GDP	Actual Real GDP	Estimated/Actual
2008	$ 14,899,922	$ 14,842,340	100.4%
2009	$ 14,604,147	$ 14,418,738	101.3%
2010	$ 15,019,732	$ 14,733,166	101.9%
2011	$ 15,257,155	$ 14,945,815	102.1%
2012	$ 15,574,704	$ 15,239,418	102.2%
2013	$ 15,794,370	$ 15,421,934	102.4%
2014	$ 16,162,691	$ 15,753,678	102.6%
2015	$ 16,602,313	$ 16,124,135	103.0%

Holding employment share by industry constant at 2007 levels does begin to explain the gap. If the share of each industry is held constant at its 2007 level, the ratio of estimated real GDP to actual real GDP slowly increases. In other words, estimated real GDP is growing faster than actual real GDP. If current industry employment shares were at their 2007 level, then real GDP in the U.S. would be about $16.6 trillion.

Since estimated real GDP is higher than actual real GDP, this tells us that there was a structural shift in employment from more productive industries to less productive industries. The ratio between estimated and actual real GDP grows with each period in **Table 3.** This implies that the structural change in employment from high output per worker sectors to low output per worker sectors continued throughout the time period. **Figure 4** helps to visualize the structural shifts in employment. I have selected the six

largest industries in terms of employment in 1998, which account for about 75% of total national employment.

Figure 4: Share of Total Employment, United States, 1998-2015



Downward movement in **Figure 4** shows a falling share in employment for that industry. The big loser is Manufacturing, which falls from second place to last place in this group. The winners are Education and Health, Professional and Business Services, and Leisure and Hospitality. It is important to note that Manufacturing is a highly productive industry, and it is becoming more productive faster. The benefits of having employment share in Manufacturing over Professional and Business Services, Education and Health, and Leisure and Hospitality becomes apparent in **Table 4.**

Table 4: Y/E in select industries, United States, Millions $2009

Year	Manufacturing	Professional and Business Services	Education and Health	Leisure and Hospitality
2000	$ 92,861	$ 84,622	$ 60,479	$ 43,923
2003	$ 112,494	$ 94,385	$ 60,443	$ 43,805
2006	$ 131,736	$ 94,367	$ 61,554	$ 43,640
2009	$ 145,741	$ 100,225	$ 61,854	$ 39,951
2012	$ 153,335	$ 103,503	$ 60,831	$ 41,849
2015	$ 155,147	$ 103,633	$ 61,077	$ 40,824

The fast growth of productivity in Manufacturing and Professional and Business Services contrasts the stagnation in Education and Health and Leisure and Hospitality. Manufacturing's output per worker increases from about $92,000 per year in 2000 to $155,000 per year in 2015. During this same time period, its share of total employment plummeted from about 14% to 8.5%. Education and Health's output per worker was essentially stagnate. During this same time period its share of employment increased from about 11.5% to 15.5%. These two simultaneous trends offer insight into the declining real GDP growth rates in the U.S. We're simply not creating jobs in the "correct" industries.

The loss of potential real GDP when a worker transitions from a Manufacturing job to a job in Health and Education or Leisure and Hospitality is very significant. The average output per worker in Manufacturing in 2015 was $155,000 per year, while the average output per worker in Leisure and Hospitality and in Education and Health was somewhere around $50,000 per year. So, about $100,000 in potential real GDP per year is lost every

time a single worker transitions from a Manufacturing job to a job in one of those industries. This loss, compounded over the last nine years, is what produces the larger estimated real GDP number in **Table 3.**

Figure 4 begins in 1998 to show that the decline in Manufacturing employment share was not a product of the Great Recession. This was a trend that began long before the financial crisis and potentially before 1998.[9] For this reason, **Table 5** holds employment shares by industry constant at 1998 levels, and the resulting estimated real GDP is quite large at $17.2 trillion.

Table 5: E_i/E constant at 1998 levels, United States, Millions $2009[10]

Year	Estimated Real GDP	Actual Real GDP	Estimated/Actual
2008	$ 15,382,485	$ 14,842,340	103.6%
2009	$ 15,090,733	$ 14,418,738	104.7%
2010	$ 15,573,163	$ 14,733,166	105.7%
2011	$ 15,806,524	$ 14,945,815	105.8%
2012	$ 16,119,646	$ 15,239,418	105.8%
2013	$ 16,371,608	$ 15,421,934	106.2%
2014	$ 16,756,478	$ 15,753,678	106.4%
2015	$ 17,214,757	$ 16,124,135	106.8%

[9] Industry analysis in this paper cannot be done prior to 1998 because there is not an accurate way to connect the fifteen major NAICS industries with the SIC system. Several of the major SIC industries were deconstructed and spread out among the new major NAICS industries. Allocating GDP numbers from the decomposed SIC Industries to the major NAICS industries is impossible and would involve making assumptions about the share that each NAICS industry owns.

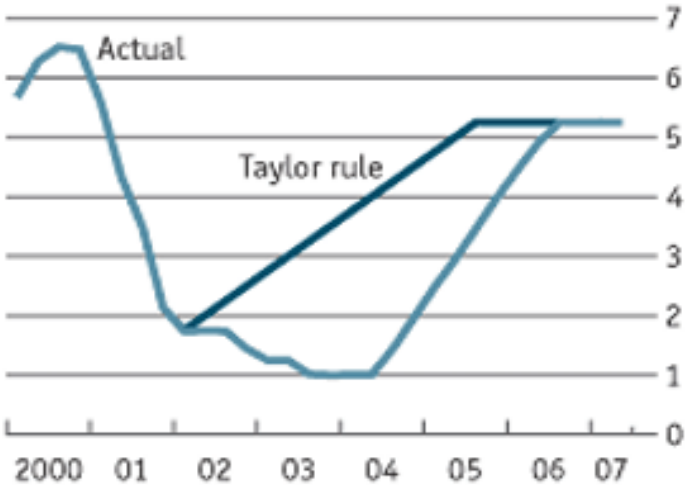
[10] I ran an iteration of **Table 5** holding employment shares constant at every time period between 1998 and 2007. The results from 1998 yielded the highest estimated real GDP figure, so for that reason I left the other iterations out of the paper.

The lower 3% bound of trended real GDP is about $17.7 trillion. Actual real GDP is about 10% below that mark, and estimated real GDP is about 3% below that mark. This means that 70% of the gap between current real GDP and its historical trend can be explained solely by structural changes in employment. Further, the average growth rate of estimated real GDP between 2010 and 2015 is 2.2%, which still leaves the economy 0.8 percentage points below the historical trend, but is 0.3 percentage points above the realized growth rate between 2010 and 2015 of 1.9%. Essentially, this says that about 30% of the decline in growth rates can be explained by structural shifts in employment.[11]

Since structural employment shifts begin in the 1990s it begs the question as to why the U.S. economy did not begin to see sub 3% growth rates far earlier. It seems logical that the gap should begin to appear when the structural changes begin. While the answer to that question is not the goal of this paper, one possible theory is that growth rates were essentially being propped up by low interest rates and the housing bubble. The Taylor Rule states that the Federal Funds Rate is a function of deviations from targeted inflation rates and maximum potential real GDP levels. If the Federal Reserve does not adjust the rate correctly, then there is a risk that the economy will "overheat" because a prolonged low interest rate environment encourages the formation of bubbles (Leamer 2009).

[11] The 30% number was calculated by taking the difference between average estimated real GDP growth, 2.2%, and average actual real GDP growth, 1.9%, and dividing by the difference between the average historical real GDP growth, 3%, and average actual GDP growth post-Great Recession, 1.9%. Which is: (2.2%-1.9%)/(3%-1.9%) = 27%, about 30%.

Figure 5: Federal Funds Rate, actual and counterfactual, %[12]



While there have been many adjustments and critiques to the Taylor Rule as to how exactly it should be calculated, economists agree that rates were too low in the early to mid-2000's.

The conclusions from **Table 5** that relate to 2010-2015 are consistent with the pre-Recession period too. The 0.3 percentage point loss in growth that was discussed earlier holds true for the time period before the Great Recession as well. The average growth rate in estimated real GDP from 1999-2006 is 3% which is 0.3 percentage points above the realized average growth rate of 2.7%. So, the decline in real GDP growth rates caused by structural employment changes begins far prior to the Great Recession; however, it was being masked by the booming economy. As Manufacturing employment began in tumble in the late 90's, the Construction industry was benefiting enormously from the low rates environment and the boom in housing. While overall employment grew by 3% between 2000 and 2006, Construction employment grew by 13%. The Construction industry essentially "hid" some other underlying weaknesses in the economy. This is one possible explanation as to why growth rates did not begin to fall sooner. Perhaps Robert Gordon

[12] Source: John Taylor, "Housing and Monetary Policy," Sept 2007

would say that the economy was still benefiting from the third industrial revolution in the late 1990's and early 2000's.

There is one flaw in holding employment share constant and letting output per worker fluctuate normally. Output per worker is a function of industry employment and employment share is a function of industry employment. Some of the growth in productivity in Manufacturing were a result of not only rises in output but declines in employment too:

$$\frac{\uparrow Y_i}{\downarrow E_i} = \uparrow\uparrow Productivity \qquad (2)$$

The productivity component of GDP benefits from falling industry employment, but usually this would be accompanied by a decline in the employment share of that industry. Since employment share is being held constant at historical levels, that decline never occurs. Therefore, the final GDP estimates in this scenario are artificially high. However, overall employment rises in most industries since 2007 and especially since 1998. In the cases where industry employment is rising the opposite effect occurs where the productivity goes down due to rising employment, but the share of employment is not increasing. Overall, these effects add a little bit of uncertainty to the estimated real GDP figures, but it is unclear in which direction they might be biased.

B. Hourly Breakdown

Section II, A analyzed real GDP as a function of output and employment. Another common way to decompose real GDP is as a function of output per hour and hours worked. This yields the following:[13]

$$Y \equiv \sum_{i=1}^{15} \frac{Y_i}{H_i} * \frac{H_i}{E_i} * \frac{E_i}{E} * E \qquad (3)$$

Hours worked by full time and part time employees has fluctuated since 2000 with dips during recessions and large increases during expansionary periods. It is a rather volatile figure because it is affected by both employment and how "busy" businesses are. Regardless, the total number of hours worked in the U.S. has grown since 2000 despite two recessions. However, hours worked per employee has fallen since 2000 from 1,736 hours per year to 1,719 hours per year. Declines in hours worked per employee is a long-standing trend in the U.S. (in 1960, hours per employee per year was 2,112), so this finding is not surprising. Still, the decline helps motivate the question of if low real GDP growth rates are a product of declining hours worked by American workers. Holding hours per worker by industry constant at their levels in 2000 yields the following table[14]:

[13] Y_i/H_i is output per hour by industry and a measure of productivity. I will use output per hour and productivity interchangeably in this section.

[14] Hours worked by NAICS industry is not available until 2000. The year 2000 was chosen to maximize as much as possible the long standing trend of declining hours per employee nationally.

Table 6: H_i/E_i constant at 2000 levels, United States, Millions $2009

Date	Estimated Real GDP	Actual Real GDP	Estimated/Actual
2008	$ 14,861,577	$ 14,842,340	100.1%
2009	$ 14,552,159	$ 14,418,738	100.9%
2010	$ 14,755,832	$ 14,733,166	100.2%
2011	$ 14,874,315	$ 14,945,815	99.5%
2012	$ 15,133,332	$ 15,239,418	99.3%
2013	$ 15,310,593	$ 15,421,934	99.3%
2014	$ 15,585,311	$ 15,753,678	98.9%
2015	$ 15,956,750	$ 16,124,135	99.0%

It might seem surprising to see estimated real GDP below actual real GDP given the given fact that hours per worker fell nationally from 2000 to 2015; however, the declines nationally were small in the 15-year period. For estimated real GDP to be smaller than actual real GDP, hours per employee must have increased in the most productive industries. This indeed has occurred. For example, Manufacturing hours worked per employee increased from 1970 hours per year to 1993 hours per year while simultaneously increasing output from $55.72 per hour in 2000 to $77.83 per hour in 2015

It is an interesting thought experiment to consider real GDP as a function of hours worked per employee, but in some sense it does not make sense because businesses themselves are concerned with actual output, not "effort." Hours per worker has fallen overtime because workers have taken advantage of technology and become more productive per hour. With that being said, there is some concern that the U.S. will soon begin to see a decline in total hours worked nationally due to the retirement of the Baby

Boomer generation. A shrinking working age population definitely poses a risk to future real GDP growth because it could cause a decline in total hours worked.

This risk is especially prevalent post-Great Recession because nationally there has been hardly any growth in output per hour over the last few years. **Tables 7 and 8** show real GDP growth broken down into two components: growth in output per hour and growth in hours worked:[15]

Table 7: Real GDP as a function of productivity and hours worked, 2001-2006

Year	Growth in Output per Hour	Growth in Hours	Real GDP Growth
2001	1.99%	-1.10%	0.89%
2002	2.57%	-0.91%	1.66%
2003	2.91%	-0.47%	2.44%
2004	2.23%	1.19%	3.42%
2005	1.64%	1.43%	3.07%
2006	0.67%	1.93%	2.60%

Table 8: Real GDP as a function of productivity and hours worked, 2011-2015

Year	Growth in Output per Hour	Growth in Hours	Real GDP Growth
2011	-0.20%	1.64%	1.45%
2012	-0.06%	2.02%	1.97%
2013	-0.50%	1.71%	1.21%
2014	0.00%	2.15%	2.15%
2015	0.36%	1.98%	2.34%

[15] GDP = (Y/H)*H. Therefore, growth rates can be decomposed into growth in hourly productivity plus growth in hours.

Tables 7 and 8 show that U.S growth in output is increasingly driven by increases in hours worked and not productivity growth. This is a potentially dangerous trend because as the Baby Boomer generation retires, hours worked may decline. If that happens and productivity per hour does not improve, future U.S. real GDP growth rates stand to decline. Unlike the overall output per industry figures, output per hour has slowed down across the entire economy. When comparing average growth in output per hour from 2001 to 2006 to average growth in output per hour from 2010 to 2015, almost all of the industries saw declines in growth rates. Additionally, many of the industries that improved, only improved in absolute terms but are still shrinking. That is to say, some industries are still shrinking in output per hour, but are shrinking less than they were in the prior period.

Table 9: Average growth rates in Y/H across selected time periods[16]

Date	2001-2006	2010-2015	Difference
U.S.	2.0%	0.3%	-1.7%
FIRE	1.9%	0.6%	-1.4%
Government	0.4%	0.2%	-0.2%
Professional and Business Services	1.6%	0.3%	-1.3%
Manufacturing	6.1%	0.4%	-5.7%
Education and Health	0.3%	-0.5%	-0.8%
Wholesale trade	3.5%	1.7%	-1.8%
Retail trade	2.9%	1.0%	-1.9%
Information	10.3%	4.3%	-6.0%
Construction	-2.7%	-0.7%	2.0%
Leisure and Hospitality	0.7%	0.2%	-0.5%
Transportation and Warehousing	2.7%	-1.7%	-4.4%
Mining	-1.4%	1.4%	2.8%
Other Services	-1.3%	-0.1%	1.2%
Utilities	-0.3%	0.3%	0.6%
Agriculture	5.1%	0.8%	-4.3%

[16] Rows are organized by share of total GDP.

Real GDP growth rates are suffering from the inability to increase productivity throughout the entire economy. The causes of the stagnation are difficult to determine; perhaps a lack in recent innovation like Gordon hypothesizes is the cause. Regardless, average growth in output per hour of 2% per year prior to the Great Recession (2001-2006) fell to an average of 0% per year post Great Recession (2011-2015). In the same time period, average growth in hours worked increased from .6% per year to 1.9% per year. The 2 percentage point decline in productivity is partially covered by the 1.3 percentage point increase in hours worked between the two periods. Still, a gap of about 0.7 percentage points per year of growth appears on average between the two time periods. Thus, the conclusion can be made that a fall in industry-wide productivity growth has been responsible for about 0.7 percentage points of growth rate decline per year since the Great Recession ended.

IV. Analysis by States

A. Overview

In addition to industry analysis, another way of looking at real GDP figures is as a sum of the underlying states. By identity, the sum of state GDP and national GDP are the same.[17] Similar to the analysis of industry data, it's possible that output by state declined equally throughout the country, or it is possible that recent growth struggles are being driven by specific regions or states.

Comparing average real GDP growth from 1968-2008 to average real GDP growth from 2010-2015 shows that growth rates have declined across the country.[18] The only significant exception to that rule is North Dakota whose economy grew tremendously in recent years during the fracking boom. There are no trends across the various regions of the country, and there are no trends across states of different sizes.[19] The only noticeable trend is that most every state across the country has performed worse since the Great Recession ended. The average decline across all 50 states is about 1.5 percentage points, which is similar to the 1.2 percentage point decline seen in the U.S. across the same period.

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[17] The Bureau of Economic Analysis calculates national GDP figures using various estimation methods. Because of this, there are slight discrepancies between the summation of state GDP and the reported national GDP. However, these discrepancies are negligible, so for the purposes of the paper I will ignore the distinction.

[18] Real GDP by States is not available prior to 1985. I used Nominal GDP from 1968-2015 and adjusted for inflation using the Gross Domestic Product Implicit Price Deflator. The BEA recommends using the national GDP Price Deflator to adjust nominal state data.

[19] I compared changes in growth rates a variety of ways across the eight BEA defined regions and was not able find that one region was the worst. Looking at the question from various angles concludes different regions as the worst or best. For example, the Great Lakes region does the worst in the few years before the recession, but has done relatively well since then. The Far West Region has the opposite pattern. Also, variation across states in the region is extremely large, so none of the differences in mean growth rates by region are statistically significant.

While the national decline and average state decline are similar, this does not necessarily have to be the case. The size of a state's economy influences the degree to which its individual performance affects the nation as a whole. For example, Vermont's real GDP in 2015 was only 1% the size of California's real GDP. Weighting average growth rate declines by the size of the state economy will tell precisely how much each state has contributed to the national decline in real GDP growth rates. The following **Equation 4** was used:

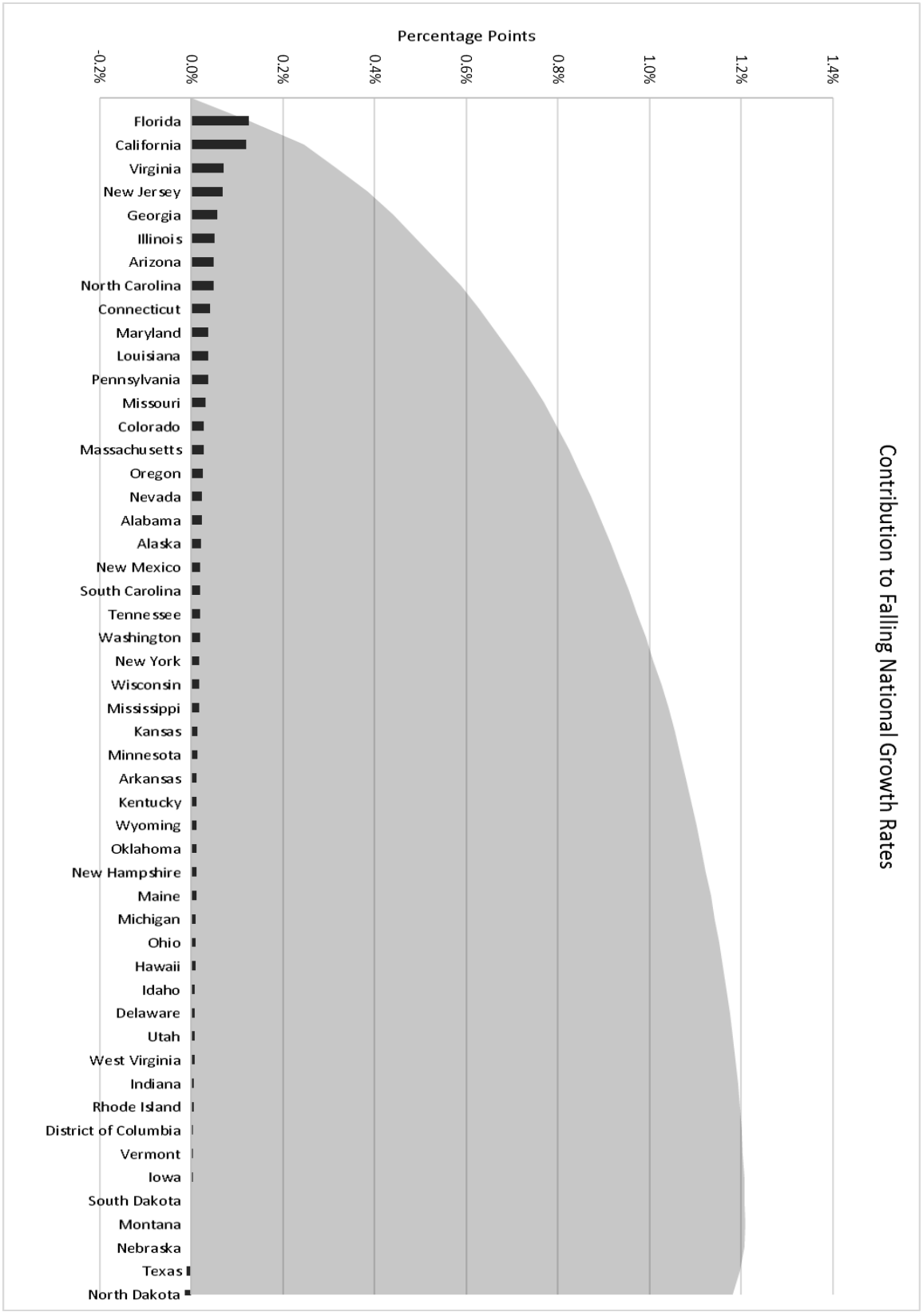
*(Average Share of Total Real GDP(2010-2015)*Average Real GDP Growth(2010-2015)) - (Average Share of Total Real GDP(1968-2006)*Average Real GDP Growth(1968-2006)) = Contribution to National Decline*

With each state weighted for its relative importance to the U.S. economy we can see by how much states have contributed to the 1.2 percentage point decline. **Figure 6** (on page 31) shows the percentage point contribution of each state to the overall national decline. The x-axis is organized from largest contributor to smallest contributor. The grey area shows the total U.S. percentage point decline as each state is added.

The concave down shape of the overall grey area reveals that much of the decline is concentrated in just a few states. The first ten largest contributors (Florida - Maryland) account for almost 60% of the total national decline. Many of these states are simply more populous such as Florida and California; however, size is not a commonality among the group. Connecticut is the tenth largest contributor, but the twenty-ninth largest state. Further, some of the largest states are near the bottom of the list in terms of contribution. Texas, for example, is the second largest state, but fiftieth in terms of contribution. Overall, there are several states that are really driving the national growth rate decline. However,

these states vary by size, industry expertise, and geographic location, so there is really no obvious similarity among poor performing states. Finding a commonality would have perhaps offered insight into what is wrong with the economy nationally.

Figure 6


Percentage Points
-0.2%
0.0%
0.2%
0.4%
0.6%
0.8%
1.0%
1.2%
1.4%
Florida
California
Virginia
New Jersey
Georgia
Illinois
Arizona
North Carolina
Connecticut
Maryland
Louisiana
Pennsylvania
Missouri
Colorado
Massachusetts
Oregon
Nevada
Alabama
Alaska
New Mexico
South Carolina
Tennessee
Washington
New York
Wisconsin
Mississippi
Kansas
Minnesota
Arkansas
Kentucky
Wyoming
Oklahoma
New Hampshire
Maine
Michigan
Ohio
Hawaii
Idaho
Delaware
Utah
West Virginia
Indiana
Rhode Island
District of Columbia
Vermont
Iowa
South Dakota
Montana
Nebraska
Texas
North Dakota
Contribution to Falling National Growth Rates

B. Panel Data Analysis

The dataset I used is a panel of all fifty states from 1991 to 2015. Each state at each given point in time has a growth rate and shares of total employment in Manufacturing, FIRE, Education and Health, and Professional and Business Services.[20] The percentage point changes in growth rates and percentage point changes in Manufacturing, FIRE, Education and Health, Professional and Business Services employment shares were all calculated year over year. The goal of this analysis is to determine if changes in structural employment fundamentally drives real growth rate changes in the U.S. To answer this question I look at a panel of fifty states and control for the differences across them using entity fixed effects.[21] Earlier parts of the paper already provided the intuition that growth rates are affected by structural employment, but proving that these relationships hold true across all fifty states over an extended time period would provide an excellent "punch line."

The regression uses two-way fixed effects to control for entity fixed effects and time fixed effects. There are an innumerable amount of unique characteristics that differ across states and that might also influence their individual growth rates. Using entity fixed effects controls for the variation across the panel of states. Time fixed effects control for some event that affects all the states at the same time. For example, using time fixed effects controls for a recession. The following regression was used to model changes in growth rates across the panel of states:

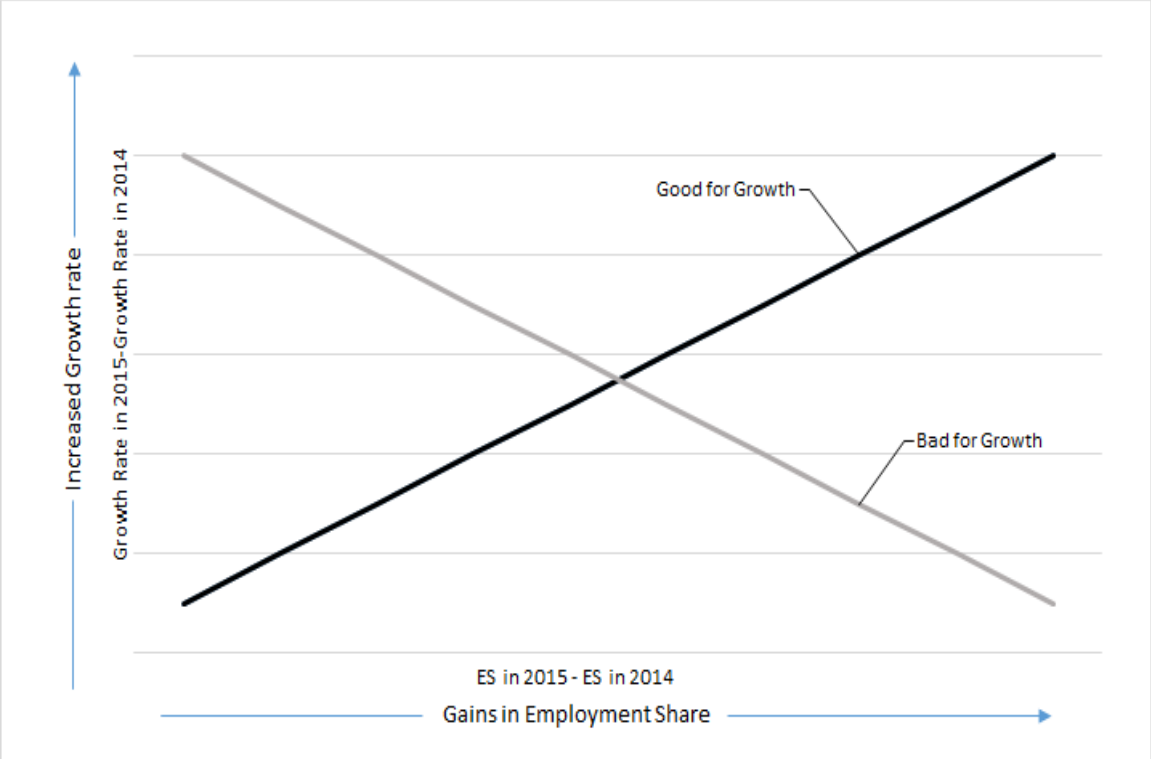
$$(G_{i,t} - G_{i,t-1}) = \beta_0 + \beta_1(ES_{i,t} - ES_{i,t-1}) + \alpha_i + \gamma_2 D_{1992} + \cdots + \gamma_{24} D_{2015} + u_{it} \qquad (5)$$

[20] These are the four largest industries by GDP excluding Government.
[21] I assume a panel of all fifty states is a good proxy for the national economy.

Where i= Alabama, Alaska, Arizona,..., Wyoming, t = 1991, 1992,..., 2015, α = fixed effects, D = Time Dummy variable, and u_{it} = error. The left hand side of the equation can be thought of as the percentage point change in the real GDP growth rate from one year to the next, and the right hand side of the equation can be thought of as the percentage point change in employment share of a selected industry. Running the regression will estimate a coefficient for β_1. A positive β_1 can be thought of as follows: the largest declines in employment share in industry "x" generate the greatest losses in real GDP growth rates.

Figure 7 is a general diagram that helps to understand the coefficients on the independent variables. A positive regression coefficient indicates that an increase in that industry's share of employment results in a rising growth rate relative to the prior year.

Figure 7: Diagram to Help Understand Regression Coefficients



The following tables relate the results of the regressions. I ran several to show the influence that controlling for two-way fixed effects has on the regression coefficients:

Table 10: Definitions of Regression Variables

Variable	Definition
change_grate	The growth rate in a given year minus the growth rate in the prior year
change_man	The percent share of total employment in Manufacturing in a given year minus the percent share of total employment in Manufacturing in the prior year
change_FIRE	The percent share of total employment in FIRE in a given year minus the percent share of total employment in FIRE in the prior year
change_eh	The percent share of total employment in Education and Health in a given year minus the percent share of total employment in Education and Health in the prior year
change_pb	The percent share of total employment in Professional and Business Services in a given year minus the percent share of total employment in Professional and Business Services in the prior year
change_gov	The percent share of total employment in Government in a given year minus the percent share of total employment in Government in the prior year
y91	Dummy Variable for 1991
y92	Dummy Variable for 1992
.	.
.	.
.	.
y15	Dummy Variable for 2015

Table 11: Selected Regressions[22]

Regressor	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
change_man	0.57* (0.32)		0.12 (0.37)	0.87** (0.36)	0.39 (0.42)	0.14 (0.32)	0.01 (0.46)	-0.13 (0.46)
change_eh		-1.11** (0.38)	-1.03** (0.45)		-1.00** (0.47)	-0.43 (0.54)		0.51*** (0.17)
change_fire						-1.01 (1.09)		0.15 (0.32)
change_pb						1.43*** (0.56)		0.14 (0.18)
State Effects?	No	No	No	Yes	Yes	Yes	Yes	Yes
Time Effects?	No	No	No	No	No	No	Yes	Yes

Table 11 relates eight regressions which correspond with the numbers in parenthesis in the first row. Regressions one and two regress change in Manufacturing employment share and change in Education and Health employment share individually on the change in growth rates. These simple models reveal interesting results. Since the coefficient on change in Manufacturing share is positive and statistically significant, this tells us that a 1 percentage point increase in the Manufacturing share will result in a 0.57 increase in the growth rate from the prior year. A 0.57 percentage point increase in the growth rate is substantial; however, a jump that large in one year never actually occurs. Across all fifty states for 25 years the largest jump was a -0.02 percentage point decline, which corresponds to about a 0.01 percentage point decline in the real GDP growth rate.

[22] Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. All regressions use data from 1991-2015.

Further, the model explains virtually none of the variation changes in real GDP growth rates. However, because the variable is statistically significant, we can at least say that increases in Manufacturing share have a positive effect on real GDP growth.

In regression two the results for change in Education and Health share show that increases in employment share produces declines in the growth rate. Similar to Manufacturing, while the coefficient is statistically significant, the maximum year over year change in reality was only a 0.014 percentage point increase, which results in a rather negligible effect on the growth rate.

Mean changes in employment shares across the entire panel for Manufacturing were negative at the 99% confidence level, and mean changes in employment shares across the entire panel for Education and Health were positive at the 99% confidence level. This provides some evidence that overtime growth rates have been consistently damaged by declining employment share in Manufacturing and increasing employment share in Education and Health. The result corresponds nicely with the results found earlier in the paper; however, the simple regressions have large potential for omitted variable bias.

Looking to regressions four and five which introduce fixed effects, the results are not altered significantly. Regression five combines change in Manufacturing share and change in Education and Health share. The resulting output eliminates the significance of the coefficient on the change in Manufacturing share, but Education and Health maintains a statistically significant negative slope, so the same conclusions can be reached. Regression six also introduces fixed effects and includes all four industries. In this model the only statistically significant variable is change in Professional and Business Services share. The coefficient is positive and relatively high at 1.43. Logically this result makes

some sense. The Professional and Business Services industry has continued to grow in productivity per worker nationally despite enormous increases in employment starting in the late 1990s. Unlike Education and Health, jobs in Professional and Business Services are much higher paying and offer a good substitute to the Manufacturing jobs that have been lost.

Regressions seven and eight introduce two-way fixed effects. Regression seven is curious because the coefficient on the change in Manufacturing share is essentially zero, and there is no statistical significance. This is a sharp contrast with the results found in regressions one and four. This shows that changes in Manufacturing employment share offer no explanatory value above and beyond what the business cycle tells us.

Regression eight uses all four independent variables along with the two-way fixed effects. In this model the only statistically significant variable is the change in Education and Health employment share. The coefficient in this case is positive, which is opposite what was seen in the previous models. Regression eight says that increases in employment share in Education and Health actually help increase growth rates once you control for other industries and the two-way fixed effects. The implications of this result are puzzling because previous analysis in this paper showed that employment share is best placed in industries with the fastest growing productivity. Education and Health has had virtually no increase in productivity over the last fifteen years.

Looking at this panel data had the potential to reveal something fundamental about the relationships between changes in growth rates and structural changes in employment. The results of the regression analysis are essentially inconclusive, as the most robust model (regression 8) yielded results that do not make sense logically. Clearly the models are

missing key components as to what is driving changes in growth rates across the panel of states.

V. Conclusion

The topic of real GDP growth rates is important because economic growth is a reflection of our economic and financial improvement as a society. Obviously, we want as many people as possible earning more and improving their standard of living. Unfortunately, U.S. real GDP has stopped growing at its historical trend of about 3% per year. This is especially bad considering the change in growth rates occurred after a severe recession. The recession coupled with the stagnating economy has resulted in a "Lost Decade" for many Americans.

Theory as to why growth rates have fallen ranges widely. Explanations include everything from overregulation to demographic changes to declining innovation. This paper attempts to explain the gap by examining different components which sum together to form real GDP.

Section II, A holds structural employment by industry constant at historical levels. The analysis yields high estimated real GDP figures and begins to explain the current gap. It also tells us that real GDP has been negatively affected by changes in structural employment, specifically movement from the Manufacturing industry to the Education and Health and Leisure and Hospitality industries.

Section II, B analyzes real GDP by output per hour and total hours worked. It shows that stagnated productivity growth across almost every industry has negatively affected real GDP growth rates. Additionally, it showed that real GDP growth in the last few years has been exclusively driven by increases in hours worked rather than by increases in productivity. This suggests that growth is at risk of falling as the nation's demographics change.

Section III, A analyzes real GDP as the summation of all fifty states. The analysis shows that about ten states are responsible for the majority of the economic downturn. However, looking at both their individual performance and their contribution to national decline, I was unable to find any similarities across the worst performing states. One would expect to see some commonality among the worst performing states- perhaps by geography or industry concentration. Given the results of the analysis of national industries, it seemed logical to assume that states with economies centered around Manufacturing would be contributing the most to national decline; however, this is not the case. There are definitely common misconceptions that the worst performing states are isolated to the "Rust Belt."

Section II, B looks to see if changes in employment share of major industries fundamentally drive growth rate changes in the U.S. To answer this question, I look at a panel of fifty states and control for the differences across them using entity fixed effects. The results of this section are inconclusive. While simple models do show the hypothesized relationship between industry employment share and growth rates, once two-way fixed effects are introduced the results are either statistically insignificant or illogical.

The regression analysis focused on structural employment changes as the driving factor in growth rate changes across the U.S., but this culminated in rather inconclusive results. Future research on this topic could dive further into industry analysis of the worst performing states in an attempt to learn from them or look at a panel of states overtime and analyze something other than structural employment.

This paper was introduced with some resoundingly negative quotes about the state of the U.S. economy, and the paper itself adds some validity to their claims by showing that our economy is not performing as well as it has in years past. With this in mind, I

would like to end the conversation with a quote from an interview with Robert Gordon, whose book *The Rise and Fall of American Growth* was the primary motivation for this paper. The interviewer, Stephen Dubner of Freakonomics, after a conversation with Gordon on growth rates, adds an interesting perspective to the challenges that our economy and our society face today:

> *"Gordon's economic conversation tells a different story – that our runaway growth of the past was essentially a golden age. No one has taken away our electricity, or clean water, or refrigeration or air conditioning and the antibiotics and cars and telephones, smart or dumb phones. And it may be that once so many of these external, concrete needs have been met, what's left is the really hard stuff: the internal needs. Things like psychological and cognitive gains. Learning to find true happiness. Or, perhaps better yet, to be satisfied with what we have. If you could achieve that, then yes, it might make even electricity and clean water and antibiotics seem like pretty basic stuff."*

VI. Data Appendix

Variables	Source
Employment, State and National Level	Bureau of Labor Statistics
Employment by Industry, State and National Level	Federal Reserve Economic Database
Gross Domestic Product Implicit Price Deflator	Federal Reserve Economic Database
Real Gross Domestic Product, National Level	Federal Reserve Economic Database
Real Gross Domestic Product per Capita	Federal Reserve Economic Database
Real Median Gross Domestic Product	Federal Reserve Economic Database
Real Gross Domestic Product by Industry, National Level	Bureau of Economic Analysis
Gross Domestic Product, State Level	Bureau of Economic Analysis
Hours by Industry, National Level	Federal Reserve Economic Database
State Population	United States Census Bureau

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