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Exploring the Economic Resilience in the United States Through State GDP Output

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EXPLORING THE ECONOMIC RESILIENCE IN THE UNITED STATES THROUGH STATE GDP OUTPUT

by

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ABSTRACT

Economic resilience is a rising topic in the field of economics. Although there is no standard definition, most literature suggests that the concept of regional economic resilience converged to encapsulate a region's ability to resist, recover from, and restructure itself after an economic or environmental shock. There are a multitude of methods in the literature used to measure economic resilience. All of these methods utilize either GDP, employment, or a combination of both. While both GDP and employment cycles are powerful tools for measuring the impact of a recession on an economy, they measure vastly different things and neither fully captures economic wellbeing. This work uses a lagged fixed-effect regression model to examine the recovery of both Employment and GDP from the 2008/2009 recession. By including economic, socio-economic, and industrial measures in the model we are able to show which impact resilience in terms of employment and output. With a strengthened understanding of a region's ability to withstand and recover from economic shocks, policy makers can better prepare for future recessions.

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INTRODUCTION

Ever since the recession of 2008/09, there has been a renewed focus by policy makers on what makes some regions and nations recover faster from negative economic shocks. There are wide spatial variations between growth rates of states in the US and in many regions statewide output and employment growth rates have not reached pre-recessionary numbers.

This work sets out to understand what factors are contributing to economic resilience across states. Although there is no standard definition or metric for measuring resilience, there has been convergence in the literature suggesting what factors influence resilience. Many studies have been done across Europe to investigate this topic, but the research in the United States is lacking.

This research aims to achieve the following research objectives:

1. Provide a definition of economic resilience based upon the literature and clarify what factors contribute to resilience of states in the United States.
2. Highlight which states are the most resilient and what factors contribute to their resilience
3. Examine the effect of socioeconomic factors such as age and educational attainment on resilience
4. Highlight the impact of the recession on key industries within states: Manufacturing, Educational services, Health care & Social Assistance, Finance and Insurance, and Real Estate & Rental Leasing

LITERATURE REVIEW

Defining Economic Resilience

Economics as a discipline has yet to agree upon a formal definition of economic resilience. Therefore, there are multiple definitions and approaches emerging in the literature. Adam Rose (2007) states "the presentation of a precise definition is important because resilience is in danger of becoming a vacuous buzzword from overuse and ambiguity (Rose, 2007)." The term resilience derives from the Latin root *resilire*: to rebound or spring back. While the concept is new to economics, resilience is a well-developed topic in a number of disciplines such as engineering, architecture, psychology, transportation, business administration, emergency response management, and environmental science (Martin & Sunley, 2015).

The most prevalent approaches within the literature define economic resilience as a measure of economic stability in the case of a crisis, with focus on the economy's ability to return to its original growth pattern. Rose (2007) approaches economic resilience from the disaster planning standpoint. He defines static economic resilience as "the ability of an entity or system to maintain function…when shocked" and dynamic economic resilience as the speed of recovery from shock to a desired growth level (Rose, 2007). Resilience can be inherent, meaning that the system responds naturally to a shock without extraneous effort. An example of this is a market's natural response to reallocate resources based on price incentives. It can also be adaptive, meaning that extra effort is involved in maintaining operation in response to a shock. Both types of resilience take place at the microeconomic, the mesoeconomic, and the macroeconomic level. Microeconomic refers to the manner in which individual firms, households, and organizations behave. The mesoeconomic level is concerned with the behaviors of economic sectors, individual markets, and cooperative groups. Macroeconomic embodies the sum of all individual units, markets, and their interactions (Rose, 2007).

Briguglio et. al. (2006) assess a country's risk based upon its economic vulnerability and resilience. Risk is defined as a combination of two elements: economic vulnerability and economic resilience. This work defines economic vulnerability as permanent or quasi-permanent features of a nation whereas "nurtured" resilience (term coined for this type of economic resilience) represents the "man-made measures," or features of that allow a country to either resist or recover from shocks. The definition of economic resilience in the case of this research considers resilience to be highly controllable and consisting of three parts: the ability to withstand shock, recover from shocks, and avoid shocks. Briguglio et. al. (2006) create a resilience index that describes "what a country can do to mitigate or exacerbate its inherent vulnerability (Briguglio et al., 2006)." A country could be "self-made," meaning that it has high economic vulnerability but compromises for that by building economic resilience, thus reducing risk. A "prodigal son" country is one with low economic vulnerability but utilizes policy that causes them to have low economic resilience. The "best case" scenario means that countries acquire both low vulnerability and maintain high resilience through well executed policy. The "worst case" scenario is the opposite: high vulnerability and low economic resilience (Briguglio et al., 2006).

Simmie and Martin (2010) define resilience based upon adaptive ability as well as through the way that economies respond to shocks and disturbances. "It is the differential ability of a region's or locality's firms to adapt to changes and shocks in competitive, market, technological, policy, and related conditions that shape the evolutionary dynamics and trajectories of that regional or local economy over time" (Simmie & Martin, 2010).

Simmie and Martin (2010) and Martin (2012) define three primary types of economic resilience: engineering resilience, ecological resilience, and adaptive resilience (Martin, 2012; Simmie & Martin, 2010). Engineering resilience, adapted from the physical sciences, evaluates an economy's response to shock by measuring both the initial amount that the shock shifts its growth trajectory from equilibrium as well as the length of time necessary to return to that equilibrium (Simmie & Martin, 2010). This method of measuring resilience centers on the economy's stability near equilibrium. This approach, comparable to the "plucking model" within economics, does not take into account adaptations that take place within the economy when it faces a shock (Martin, 2012).

Bruneau et al (2003) define resilience as a combination of four dimensions: robustness, redundancy, resourcefulness, and rapidity in the context of post-earthquake economic resilience. Robustness refers to minimizing the direct or indirect economic losses, redundancy covers the economy's remaining untapped capacity, resourcefulness discusses the stabilizing methods available, and rapidity is concerned with the duration of time necessary to return the economy to its prior state (Bruneau et al., 2003). Di Caro

(2017) defines engineering resilience as an economy's ability to maintain a stable long-term growth trajectory, despite the influence of a shock (Di Caro, 2017).

Ecological resilience, adapted from the natural sciences, utilizes the concept of hysteresis. This physics concept suggests that a ferromagnetic or imperfectly elastic material alters its response to events based upon its reaction to preceding events (Martin, 2012). Di Caro defines ecological resilience as "the capacity of a particular economic context to resist shocks before switching to different stable or unstable equilibria (Di Caro, 2017). Ecological resilience differs from engineering resilience because it suggests the idea of multiple stability domains. A system pushed beyond its elasticity threshold could be altered and gravitate towards a different equilibrium than it initially began with. A severe shock could modify not only the growth rate of the economy but also the manner in which different factors, such as industrial growth, effect this growth. Martin (2012) refers to this concept as hysteresis. Hysteresis can be either negative, where the recessionary shock leads the economy to exhibit a permanent decline in level of output, or positive, where the economy exhibits a quick turnaround and output grows at an accelerated rate (Martin, 2012).

Adaptive resilience, derived from the complex adaptive systems theory, is an evolutionary view. "Regional economic resilience in this framework could be viewed as having to do with the capacity of a regional economy to reconfigure… so as to maintain an acceptable growth path in output, employment and wealth over time" (Martin, 2012). Recessions help weed out outdated sectors and activities of the economy and prompt reallocation of resources to the development of new ones (Martin, 2012). Adaptive resilience can be cyclical, as shown in Figure 1. The regional growth increases as industries develop during the exploitation phase, and as more human capital and knowledge are acquired, there is a phase of regional growth. The region's resilience to shocks declines as the industries become more interconnected and the development pattern becomes more consistent. When a shock occurs, there is a significant drop in output as firms close down and industries crumple. However, the disconnect between remaining industries caused by the shock raises the resilience of the region and the newly-freed resources are available for the development of new activities and technologies (Simmie & Martin, 2010).

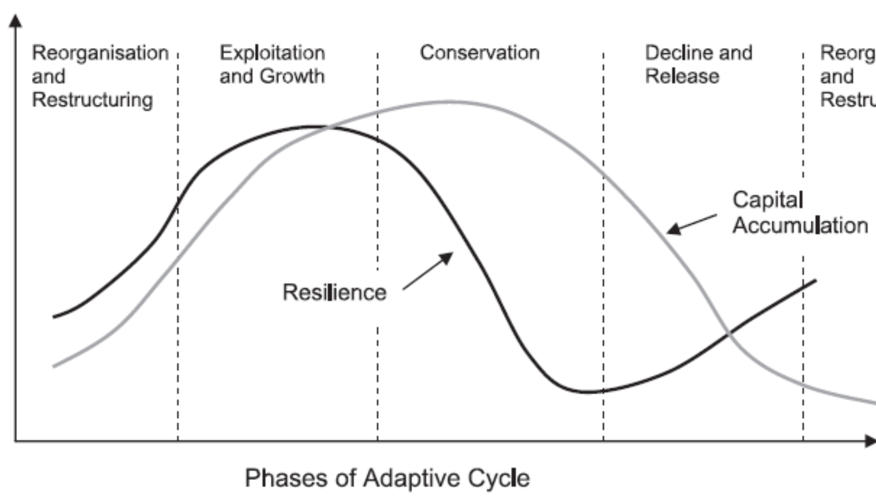

Figure 1. The phases of the adaptive cycle (Simmie & Martin, 2010).

There is debate about how to interpret the resilience of the regional economy because the national economy is constantly changing. "National economies constantly change, which raises the question of how to separate resilience from other reactions to a shock and how to separate shocks from changes that constantly occur in an economy (van Bergeijk, Brakman, & van Marrewijk, 2017)." From the literature it becomes clear that little consensus exists as to what economic resilience should be defined as. Martin and Sunley (2015) define regional economic resilience as:

> "The capacity of a regional or local economy to withstand or recover from a market, competitive and environmental shocks to its developmental growth path, if necessary by undergoing adaptive changes to its economic structures and its social and institutional arrangements, so as to maintain or restore its previous developmental path, or transit to a new sustainable path characterized by a fuller and more productive use of its physical, human, and environmental resources (Martin & Sunley, 2015)."

Webber, Healy, and Bristow (2017) suggest that the concept of regional economic resilience converged to mean "the capacity of a regional or local economy to withstand, recover from, and reorganize in the face of market, competitive, and environmental shocks to its developmental growth path (Webber, Healy, and Bristow 2017)."

The resilience of a region is determined by the economic structure of the region. Conroy (1975) shows that the industrial diversification of a region affects the way in which the economy of the region responds to economic disturbances. In most cases, the more diverse the 'industrial portfolio' of the region, the more resistant the economy would be to shocks; whereas a very specialized economy is much more prone to be vastly impacted by a recession or other disturbance. The diversification of the region is not only dependent on the number of industries within the region, but also on the inter-relatedness of these industries and their size and significance within the regional economy (Conroy, 1975). Different types of industries also respond differently to shocks. Manufacturing and construction industries are impacted to a higher degree by cyclical unemployment and private service industries are less sensitive to business cycle fluctuations than those industries but are more sensitive than public sector services (Martin, 2012).

The economic structure of a region shapes it's resilience. Economic structure is comprised of the skill and size of the labor force, entrepreneurial culture of the area, the strength and innovative capabilities of firms, the network and ease of connectivity between consumers and producers, among other things (Martin, 2012). Political economy also impacts the resilience of a region. This is relevant when considering employment decisions that businesses make in the region, particularly the manner in which they renegotiate work terms in order to cut costs and increase productivity in light of a shock. National government decisions can have a huge impact on the resilience of a region. (Martin, 2012).

Sensier, Bristow, and Healy (2016) map the onset of the 2008/09 recession in Europe through analysis of the employment cycle. Using the responses of the EU nations to the shock, they were able to determine which nations are hit first, are in recession for the longest, and calculate how resilient each nation is as a result. European literature on resilience has been plentiful but less US literature has been published to date. Much of what has been published in the United States focuses on resilience from a disaster standpoint.

Lu and Dudensing (2015) discuss separating out the effects of the recession when studying the impact of Hurricane Ike on the regional economies of Texas (Lu & Dudensing, 2015). Van Bergeijk et. al. (2017) examine the importance of incorporating international trade as an relevant concept when examining the post-recession resilience of a country. Van Bergeijk et. al. argue that the 2008/2009 recession is a perfect shock for research purposes due to its unexpected onset, the limited policy tools (on both a regional and national level) to cope with this shock, the pattern of trade evolution, and the variance of the impact showcasing the difference in resilience between regions. Van

Bergeijk et. al. examine the relationship between size of intra-industry trade (Grubel-Loyd index) and the duration of the decline and recovery. "Intra-industry trade slows down the recovery…but does not seem to be the driver of the collapse (van Bergeijk et al., 2017)".

It is critical to consider the fallbacks of applying the concept of resilience in the context of economics. Martin and Sunley (2015) summarize their concerns with resilience in socio-economic contexts. They call into question whether resilience, a concept originating from engineering and ecology, can be analogously applied in economics. Furthermore, the measures for economic resilience fail to include the human element such as the political climate (Davoudi et al., 2012). While some urban planning literature does discuss the political climate Simmie and Martin explain "the task of resilience analysis in economic geography is first to identify how regions and localities have been impacted by shocks, and then, second precisely to explain the findings in terms of the various factors and processes involved (Simmie & Martin, 2010)." The 'bounce back' aspect of resilience is contested due to the unrealistic notion of equilibrium in functioning markets. Not only is a market only realistically in equilibrium within an economics textbook, but, as discussed previously with evolutionary economic resilience, an economy's growth pattern can become permanently altered by a shock (Martin, 2012; Simmie & Martin, 2010). The assumption that regions and areas are homogeneous is another issue facing resilience researchers. However, this issue transcends economic resilience. Systems are heterogenous and therefore different workers and different economies respond differently to shocks. Understanding a region's resilience goes hand in hand with understanding the internal functions of the system (Zolli & Healy, 2012).

Measuring Economic Resilience

The majority of studies measured resilience using employment and regional output as primary indicators. This alone makes for a simplistic approach, as seen in the Sensier et al study, where they calculated a business cycle and used regional employment data and output data to calculate the speed with which the economy recovered (Sensier, Bristow, & Healy, 2016). Briguglio et al (2006) utilize an immense amount of measures but then continue to aggregate them (Briguglio et al., 2006). Martin (2012) calculate regional resilience using regional employment data and measuring it against national employment data (Martin, 2012). Lu and Dudesing use regional output information in the form of various sectors' quarter on quarter growth (Lu & Dudensing, 2015). Hill et al (2012) utilize the growth domestic product and employment information from the region, measuring industries at a three-digit NAICS code (Hill et al., 2012). Di Caro (2017) utilizes quarterly employment data of regions and compares it against the national GDP growth rate. (Di Caro, 2017).

Briguglio et al (2006) create an index for national economic resilience by finding the average of the four components of resilience: macroeconomic stability, microeconomic market efficiency, good governance, and social development. Macroeconomic stability portion of this index, defined as the relationship between the economy's aggregate demand and aggregate supply, is comprised of the fiscal deficit to GDP ratio, the sum of the unemployment and inflation rates, and the external debt to GDP ratio. The unemployment and inflation rates of the country are identified from the Economic Discomfort (Economic Misery) Index. Microeconomic stability is measured by mimicking the Economic Freedom of the World Index. Instead of using all five of the indicators they only utilize two: government size and freedom to trade internationally. Good governance is also inspired by that index: comprising of judicial independence, impartiality of courts, the protection of intellectual property rights, military interference, and political system integrity. Social development is captured in this study by utilizing the education and health components of the Human Development Index (Briguglio et al., 2006).

For each country, the four elements of the resilience index of this study are standardized on a scale of 0 to 1.

$$XS_{ij}=\frac{X_{ij}-Min_j}{Max_j-Min_j}$$

XS_{ij}=standardized observation i of variable j

X_{ij}=unstandardized (actual) value of observation i

Min_j= minimum value of variable j

Max_j=maximum value of variable j

The results of the four standardized numbers are then averaged, creating the resilience index (Briguglio et al., 2006).

While this utilizes many of the integral components of economic resilience, this method of calculating it does not yield the results that would be useful for a study at a regional level. For example, by this method of capturing resilience the countries with the highest GDP per capita are seen as most resilient. However, a region with more money may not necessarily recover the quickest from a shock. This method seems good for benchmarking, but not for gaining an accurate understanding of an areas ability to resist and recover from economic downturns (Briguglio et al., 2006).

Martin (2012) presents an approach of measuring resilience by comparing regional resilience against the resilience of the nation as a whole.

$$\frac{\Delta E_r}{E_r} = \beta_\tau \left(\frac{\Delta E_N}{E_n}\right)$$

$$\beta_\tau = \frac{\left(\frac{\Delta E_N}{E_n}\right)}{\left(\frac{\Delta E_r}{E_r}\right)}$$

$\frac{\Delta E_r}{E_r}$ = regional percentage change in employment

$\frac{\Delta E_N}{E_n}$ = national percentage change in employment

β_τ = the ‘sensitivity (relative sensitivity of the region)

If β_τ is greater than 1, the region is relatively less resilient. Conversely, if β_τ is less than 1, the region is more resilient than the nation as a whole (Martin, 2012).

Martin (2012) observes the resilience of regions in Great Britain during major recessions, attempting to explain them based upon the 4 dimensions of resilience: resistance, recovery, renewal and re-orientation. During each of the recessionary periods, the sensitivity index is compared against the post-recession growth. The sensitivity index measures the region’s ability to resist shocks. The growth rate, calculated from the regional employment, shows the region’s ability to recover from the recession. The regional resistance and recovery differs from recession to recession. Not all regions recover from the recessions in the same manner. The study touches upon this concept of renewal by mapping the employment growth trends of two regions, one which resumed its previous growth trend after the recession and one which experiences negative hysteresis (Martin, 2012).

Largely inspired by Martin, Sensier et al (2016) measure economic resilience in the European Union by taking a business cycle approach. The study collects regional resilience figures by using the Gross Domestic Product (GDP) and regional employment levels as data. GDP is converted to real GDP with a base year of 2005. The business cycle peaks and troughs located for each region individually. Utilizing the employment cycle in Figure 2, percentage of employment lost is calculated by subtracting the employment level at peak from the employment level at the trough and dividing by peak level.

$$\text{Regional Employment Growth Rate(REGR\%)} = \frac{\text{(Employment at Trough)-(Employment at Peak)}}{\text{(Employment at Peak)}}$$

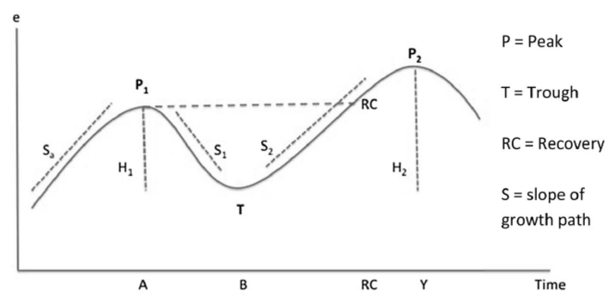

Figure 2. The employment cycle used to measure economic resilience by the business cycle approach (Sensier et al., 2016).

The business cycle, constrained by a minimum of 2 years and no maximum, is measured in years and takes place from A to Y. The downturn goes from A to B. The amount of recovery time is depicted as RC. The intensity, or steepness, of the shock is calculated as the amplitude/ duration. Applying this metric to the individual regions allows for classifying the relative shock resistance and resilience of the regions, as outlined in Table 1. A region whose regional employment growth rate (REGR) remains positive during the economic downturn is considered resistant (RS). A region that has either returned to or surpassed the employment before the shock is seen as recovered (RC). A region is not recovered if it is either yet to reach the trough employment (NR2) or is still recovering to pre-shock levels (NR1) (Sensier et al., 2016).

Regional Resilience Classification	
Resistant (RS)	$\boldsymbol{REGR\% > 0}$
Recovered (RC)	$\boldsymbol{REGR\% \geq P_1}$
Not Recovered (NR1)	$\boldsymbol{T < REGR\% < P_2}$
Not Recovered (NR2)	$\boldsymbol{P_1 > REGR\% > T}$

Table 1. Classification of shock resistance/ resilience of regions based upon employment cycle (Sensier et al., 2016).

This method of measuring economic resilience focuses primarily on engineering resilience. It is a somewhat simplistic approach. However, because the data used for this is publicly available for the US, this method should not be difficult to replicate.

Lu and Dudensing (2015) approach economic resilience in Texas post-Hurricane Ike by focusing on specific industrial sectors. The resilience of each country is measured by considering the effect on quarterly sales within the industries of each sector. The sectors examined are include public administration, services, hotel/ restaurant, entertainment, health services, education, administration, management, professional services, real estate, finance/ insurance, information, transportation/ warehousing, retail trade, wholesale, manufacturing, construction, utilities, mining/oil/gas, and agriculture support. Resilience for each sector is measured in the difference (in number of quarters) between when the county shows negative quarter on quarter (QoQ) growth and when the sector itself shows negative QoQ growth. This shows the differences between the resilience of each sector that can be compared between different counties (Lu & Dudensing, 2015).

This is a great approach to measuring the strength of each sector independently, however it calls into question how comparable the resilience scores are. For example, if a county as a whole did not experience negative QoQ growth until three quarters after the shock and a sector did not exhibit negative QoQ growth until six quarters after the shock, it would have the same resilience score by this index as the same sector that showed negative QoQ growth one quarter after the shock in a county that was hit immediately. Also, the relevance of each sector within the counties is not portrayed by this metric. One county's economy could be based around the restaurant and hotel industry while in another county that industry would be almost insignificant.

Hill et al (2012) uses data from 361 metropolitan statistical areas in the United States and employment data from 37 years (1970-2007). And gross metropolitan product (GMP) from 29 years (1978-2007). In these models, independent variables in the regressions are used to capture the structure of the region: economic structure, labor force, demographics, and other characteristics. The dependent variables, differing dependent on the model, are dummies, set as zero when the shock in question does not occur and one when it does. The major export industries used are durable manufacturing, non-durable manufacturing, healthcare and social assistance, and education. These industries are the three-digit NAICS industries, which are considered major export industries if they have a regional employment share of 1.0% or over and are 80% or more above the percentage of employment of this industry nationwide. The rate of growth before the economic downturn is used to test whether the region's growth impacts its likelihood of an economic downturn. The regional industrial diversity is assessed using the Herfindahl index and the number of export industries in the region.

Hill et. al. (2012) create several models to explain various components of resilience. Model 1 and 4 are a Cox proportional hazards models. Model 1 is run twice to see the impact on both employment and GMP downturn The results show that if the industry composition of the region shows higher employment in durable goods manufacturing, then the region is more susceptible to shocks. Larger amounts of major export industries make the region less susceptible to shocks. Regions with lower levels of education are more susceptible to downturns as are regions with high wealth disparity. Model 4 investigates the duration of time between a shock and the rebound of the region and only observes the regions experiencing a downturn. A region recovers from an economic downturn slower if there is high employment in health care and social assistance, lack of right-to-work laws, and high income inequality. Low education levels actually increase the speed of resilience of the region. When the region experiences a higher growth rate before the shock, it takes longer to recover. While research facilities in the region help the region recover faster with employment, it does not assist with GMP. The Herfindahl index and the number of export regions both have no effect on the speed of resilience (Hill et al., 2012)

Model 2 and 3 are logistic regression models. Model 2 observes the characteristics that make regions shock resistant. The results show that the location of the region (Northeast, Midwest, West, and South) affects how shock resistant the region is. Regions with a more diverse export base are more likely to be shock resistant. Interestingly, regions that pay higher average wages are less likely to be resistant to shock. Model 3 depicts what regional characteristics make an area resilient. Because the durable goods manufacturing and the low-skilled labor markets are cyclical, it explains why the employment demand shows that those industries are more susceptible to downturns. Results from the gross metropolitan product differed from the employment results. High employment ratios in the health care and social assistance industries decrease the resilience of a region for both employment and GMP. Income inequality reduces the employment resilience but increases the GMP resilience of a region. (Hill et al., 2012).

In an Italian study, Paolo Di Caro (2017) compares the quarterly employment data from 20 regions in Italy against the national GDP growth rate. This study tests the lags between unemployment and the level of growth rate using a logistic smooth-transition autoregressive (LSTAR) model. By treating y_t as an index of regional economic activity and s_t as a measure of aggregate output, this model can show the manner in which the economy responds to shock. After testing the lag structure, the study utilizes this information to determine which regions demonstrated the highest degree of resilience. The regions of central/ northern Italy showed higher resilience than the rest of the nation. Overall, the regions with more diversified economies, well developed export industries, and the existence of a skilled labor force show higher economic resilience. This is an interesting approach to measuring resilience because it combines the region's sectors and tests the relationship between output and unemployment (Di Caro, 2017).

Holm and Ostergaard (2015) utilize employment growth rate in the information and communications technology (ICT) sector as a measure of resilience. This sector is comprised of seven service subsectors and seven manufacturing subsect.

$$gEmpl_{i,t} = \frac{(Empl_{i,t+1} - Empl_{i,t})}{Empl_{i,t}}$$

Employment growth in region i at time t is calculated by subtracting employment at time t from employment at time t+1 and dividing by employment at time t. This means of measuring the growth is equivalent to lagging each variable in the model by a year. Eight explanatory variables are used in this model: human capital intensity, total regional employment, percentage of ICT workers in white-collar occupations, percentage of employees employed in ICT sectors, average size of ICT plants, specialization in ICT manufacturing, and industrial diversity. Holm and Ostergaard utilize a fixed-effects model with fixed effects for regions. This is to account for regional differences that cannot be controlled for with explanatory variables. (Holm & Ostergaard, 2015).

Several models are used in a step-by-step manner to analyze regional resilience. They estimate a growth model to explain regional ICT employment growth. Then, they examine how the regional industrial structure effects the business cycle by modeling the relationship between the two. This is Model 1.

$$gEmpl_{i,t} = a_o + a_1 Urban_{i,t} + a_2 MK2_{i,t} + a_3 Diver_{i,t} + a_4 Sales_t + \text{fixed effects for regions} + u_{i,t}$$

This is done for the time periods 1993-2005, 1993-1999, and 2000-2005. In order to examine effect of national ICT revenue on the ICT employment growth, an interaction term is introduced in form of the form of Model 1. This is Model 2.

$$gEmpl_{i,t} = b_o + b_1 Urban_{i,t} + b_2 MK2_{i,t} + b_3 Diver_{i,t} +$$

$$(b_4 + b_5 Urban_{i,t} + b_6 MK2_{i,t} + b_7 Diver_{i,t})\, gSales_t + \text{fixed effects for regions} + e_{i,t}$$

This study shows several significant findings. It demonstrates evolutionary resilience by showing the varying effects across regions and different time periods. Furthermore, it studies the relationship between employment growth and shocks and resilience and determines the effect of regional industrial characteristics on resilience. The results of this study support the argument that regional industrial resilience is adaptive and can be strengthened. They characterized regions as adaptively resilient, rigidly resilient, non-resilient, and entrepreneurially resilient. Unfortunately, the results of this support the literature in stating that policy can have limited effect on resilience. The factors that increased resilience in the ICT sector doubled to stunt the growth of the sector (Holm & Ostergaard, 2015).

METHODS

Resilience is defined in this thesis as the ability of a region to maintain or increase its growth rate despite an economic shock. The economic shock in this study is the 2008/2009 recession in the United States. A region is considered resilient if its post-recessionary growth rate is either equal to or greater than its pre-recessionary growth rate. A region's resilience is dependent on its ability to maintain a steady growth rate, despite the national shock. This study explores US resilience by modeling growth rate before, during, and after the recession in each of the fifty states. DC is omitted along with the US provinces, as those do not fit the criteria of US State. Data from 2005-2015 is used. Although each state enters recession at different time, this study considers only the formal dates the United States is in recession as the recessionary period. This is modeled with the dummy variable *Resilience (R).* This means that 2005-2009 is considered the pre-recessionary period and 2010-2015 is considered post-recessionary period.

Based upon the literature, resilience is comprised of three factors: social, economic, and industrial.

Resilience=f(social, economic, industrial)

This study utilizes several fixed effect panel models to interpret the effect of the recession on resilience, proxied as a growth rate similar to the work of Holm and Ostergaard (2015).

$$y_{it} = \alpha_i + x_{it}\beta + u_{it} \qquad (1)$$

A fixed effect panel model was preferable to the Ordinary Leased Squares (OLS) framework because of the endogeneity problem caused by including a dummy variable for each of the 50 states. The model is robust, meaning that it controls for heteroskedasticity. In order to capture the effect of the recession, two scenarios are run: one calculating the per capita growth rate of GDP one testing those variables against the national recessionary period.

$$\text{GDPpcGR}_{i,t} = \frac{\text{GDP}_{i,t} - \text{GDP}_{i,t-1}}{\text{GDP}_{i,t-1}} \qquad (2)$$

As mentioned previously, equation (2) expresses the growth rate used in this study. This is a common methodology in the literature (Hill et al., 2012; Holm & Ostergaard, 2015; Lu & Dudensing, 2015). GDP per capita is substituted for GDP to control for population differences between states. The GDP data is from the Bureau of Economic Analysis. This is real GDP with a base year of 2005. Equation (1) is equivalent to lagging the explanatory variables by one year. This lag is implemented to mimic the lagged effect of the dependent variables on GDP.

The social variables included in this model are median age (*Age*) and higher education attainment. This data was collected from the Selected Population Profile in the United States from the American Community Survey. Higher educational attainment is converted from it's raw form (percentage of population with bachelor's degree or higher) by taking its natural log (*lnHighEdPercent*).

Economic variables thought to effect resilience are employment, income, job and establishment growth, and employment classification. The employment data utilized in this research was acquired from the Bureau of Labor Statics (BLS) State and Area

Employment, Hours, and Earnings Survey and consists of the non-farm employment in all industries in thousands. Labor force in this study is calculated by multiplying employment by the percentage of the population ages 18 – 65 (*Pop1865*), as is common in the literature. Employment and GDP are highly correlated and both are impacted by economic shocks. Including employment directly would skew the model, therefore employment is included within the industrial mix variables but not as an individual metric. Income is converted to per capita terms and logged (*lnIncomePC*). The establishment data is obtained from the BLS Business Employment Dynamics survey. It is the quarterly private sector establishment gains and losses. It is included in the model as an annualized ratio between establishment gains and losses (*EstablishGL*). A job growth variable was calculated in the same manner but is omitted due to multicollinearity. Entrepreneurial culture is thought to be positively correlated with resilience (Hill et al., 2012). As a proxy for entrepreneurialism, the self-employed percentage of total employment is used.

Industrial mix is included in this model through several industry variables and the Herfindahl index. Manufacturing and educational services and health care & social assistance have been empirically linked to resilience (Hill et al., 2012; Martin, 2012). Finance & insurance and real estate & rental leasing sectors are included for their role in the 2008/09 recession. The industrial data is obtained from the Selected Population Profile of the Census Bureau American Community Survey. In it's raw form, it measures the percentage of total employment represented by each industry. To avoid multicollinearity between variables, they are converted to per-person growth rates. Each industry percentage is multiplied by employment and divided by the labor force. A growth rate is calculated from those results to generate the variables *Manufacturing*, *EducationHealth*, and *Finance*.

The Herfindahl index data is calculated from the Bureau of Economic Analysis.

$$HHI=\sum_{i=1}^{n} s_i^2 \quad (3)$$

s=market share of firm i

The Herfindahl index, also referred to as the Herfindahl-Hirschman index (*HHI*), is calculated by taking the sum of the square of market share of every export industry in a region. In this study, location quotients (LQs) are used to identify the regional export industries. A location quotient measures the size of an industry relative in the region relative to its size nationally (Miller, Gibson, & Write, 1991).

$$LQ_i=\frac{X_{ic}/X_C}{X_{iN}/X_N}=\frac{X_{ic}/X_{iN}}{X_C/X_N}\geq 1 \quad (4)$$

X_{ic}=industry i's employment in county C

X_C=ALL employment in county C

X_{iN}=industry i's employment nationwide

X_N=ALL employment nationwide

Martin (2012) utilizes location quotients in order to show the regional dependence on production industries (Martin, 2012). At a 2-digit NAICS code, if an industry has an LQ greater than 1, it is considered an export industry. The variables utilized in this model are listed in Table 2.

Table 2

Variable	**Description**
lnHighEdPercent	Natural log of the percentage of population with Bachelor's degree or more
Age	Median age
lnIncomePC	Natural log of income per capita
EstablishGL	Ratio of number of private sector establishment gains over losses
SelfWorker	Self-employed workers (in own/not incorporated business) as a percentage of employment
Manufacturing	Growth rate of the percentage of the labor force employed in manufacturing sector
EducationHealth	Growth rate of the percentage of the labor force employed in educational services and health care & social assistance sectors
Finance	Growth rate of the percentage of the labor force employed in finance & insurance and real estate & rental leasing sectors
HHI	Herfindahl index
Recession (R)	Dummy variable (equal to 1 if US is in recession at time t, otherwise equal to 0)

In this study, how a region adapts and responds to shocks constitutes it's resilience. Adopting the methodology used in Holm and Ostergaard, the model is run twice: the second time with the introduction of an interaction term. In Model 2, the interaction term (*Recession*) helps examine the relationship between the recession dummy variable and the rest of the explanatory variables. The use of this dummy is similar to that in the Hill et. al (2012) study.

Model 1:

$$GDPppGR_{i,t} = \alpha_0 + \alpha_1 \ln(HighEdPercent)_{i,t} + \alpha_2 Age_{i,t} + \alpha_3 lnIncomePC_{i,t} + \alpha_4 EstablishGL_{i,t} \ \alpha_5 SelfWorker_{i,t} + \alpha_6 Manufacturing_{i,t} + \alpha_7 EducationHealth_{i,t} + \alpha_8 Finance_{i,t} + \alpha_9 HHI_{i,t} + \text{fixed effects for regions} + u_{it} \quad (5)$$

Model 2:

$$GDPppGR_{i,t} = \beta_0 + \beta_1 \ln(HighEdPercent)_{i,t} + \beta_2 Age_{i,t} + \beta_3 lnIncomePC_{i,t} + \beta_4 EstablishGL_{i,t} \ \beta_5 SelfWorker_{i,t} + \beta_6 Manufacturing_{i,t} + \beta_7 EducationHealth_{i,t} + \beta_8 Finance_{i,t} + \beta_9 HHI_{i,t} + (\beta_{10} + \beta_{11} \ln(HighEdPercent)_{i,t} + \beta_{12} Age_{i,t} + \beta_{13} lnIncomePC_{i,t} + \beta_{14} EstablishGL_{i,t} \ \beta_{15} SelfWorker_{i,t} + \beta_{16} Manufacturing_{i,t} + \beta_{17} EducationHealth_{i,t} + \beta_{18} Finance_{i,t} + \beta_{19} HHI_{i,t}) Recession_t + \text{fixed effects for regions} + u_{it} \quad (6)$$

RESULTS

<table>
<tr><td colspan="4">MODEL 1
Observations:
Groups:
Obs per group</td><td>500
50
10</td></tr>
<tr><td>R-squared</td><td colspan="3">within = 0.281
between = 0.007
overall = 0.108
F(9,49)
rho</td><td>11.97
0.416</td></tr>
<tr><td></td><td>Estimate</td><td>Standard Error</td><td>t</td><td>P > | t |</td></tr>
<tr><td>lnHighEdPercent</td><td>0.031</td><td>0.053</td><td>0.58</td><td>0.566</td></tr>
<tr><td>Age</td><td>0.008</td><td>0.002</td><td>4.03</td><td>0.000</td></tr>
<tr><td>lnIncomePC</td><td>-0.054</td><td>0.028</td><td>-1.91</td><td>0.063</td></tr>
<tr><td>EstablishGL</td><td>0.071</td><td>0.016</td><td>4.45</td><td>0.000</td></tr>
<tr><td>SelfWorker</td><td>0.003</td><td>0.003</td><td>0.78</td><td>0.440</td></tr>
<tr><td>Manufacturing</td><td>0.041</td><td>0.023</td><td>1.77</td><td>0.083</td></tr>
<tr><td>EducationHealth</td><td>-0.041</td><td>0.034</td><td>-1.21</td><td>0.233</td></tr>
<tr><td>Finance</td><td>-0.015</td><td>0.021</td><td>-0.70</td><td>0.485</td></tr>
<tr><td>HHI</td><td>-0.028</td><td>0.166</td><td>-0.17</td><td>0.869</td></tr>
<tr><td>Constant</td><td>0.072</td><td>0.242</td><td>0.30</td><td>0.767</td></tr>
</table>

In Model 1, the variables *Age, IncomePC*, and *EstablishGL* are found to be significant. A greater median age had a positive impact on growth. A greater income had a negative impact on per capita GDP. A higher percentage of self employed workers had a positive impact on per capita GDP as did *Manufacturing*. *EducationHealth* and *Finance* on the other hand had a negative impact. This is unsurprising, because in the literature manufacturing was seen to improve the resilience of a region. The education and the healthcare fields both have lower resilience and the financial sector suffered greatly in the recession.

Higher percentages of college educated people had a positive impact on growth, whereas higher diversity had a negative impact on growth. Both of these variables had low significance within this model. The *HHI* statistic is surprising, as a higher *HHI* is expected to have a positive impact on growth rate. A larger *lnHighEdPercent* makes sense because it suggests that regions with higher educational attainment also have higher output per capita.

MODEL 2			Observations: Groups: Obs per group	500 50 10
R-squared	within = 0.329 between = 0.015 overall = 0.137		F(19,49) rho	13.94 0.44
	Estimate	Standard Error	t	P > | t |
Recession (R)	0.442	0.295	1.50	0.140
lnHighEdPercent	0.060	0.058	1.03	0.306
R*lnHighEdPercent	**0.056**	**0.033**	1.70	0.096
Age	**0.007**	**0.002**	3.30	0.002
R*Age	**0.004**	**0.002**	2.46	0.018
lnIncomePC	**-0.067**	**0.036**	-1.88	0.066
R*lnIncomePC	**-0.082**	**0.040**	-2.07	0.044
EstablishGL	**0.052**	**0.020**	2.63	0.011
R*EstablishGL	**0.082**	**0.039**	2.11	0.040
SelfWorker	0.004	0.003	1.28	0.207
R*SelfWorker	**-0.005**	**0.002**	-2.93	0.005
Manufacturing	0.038	0.027	1.41	0.165
R*Manufacturing	-0.019	0.093	-0.21	0.835
EducationHealth	-0.008	0.032	-0.26	0.794
R*EducationHealth	0.004	0.101	0.04	0.970
Finance	-0.005	0.023	-0.21	0.838
R*Finance	-0.035	0.052	-0.66	0.513
HHI	-0.108	0.163	-0.66	0.511
R*HHI	**0.341**	**0.163**	2.09	0.042
Constant	0.160	0.277	0.58	0.567

Model 2 introduces the *Recession* dummy variable as an interaction term. There are some interesting results from this. In the case of a recession, having a higher education degree becomes significant. A 1% increase in this variable causes the output of an area to increase by over half a percent. During a recession, the SelfWorker variable has a negative effect on growth. This could potentially be explained by the fact that self employed individuals do not have the capital build up to sustain negative growth like a large business. As expected, the *Manufacturing* coefficient becomes negative during recession and the *EducationHealth* coefficient becomes positive.

HHI has the largest impact in the case of a recession. Not only does it go from insignificant to significant, but it also becomes positive and has a huge impact on growth during a recession. Industrial diversity is cited in the literature to have a substantial effect on resilience. Increasing industrial diversity will significantly increase the regional per capita output growth during a recession.

DISCUSSION

The variables most effected by recession are the economic and industrial ones. This is significant because it suggests that the national recession shifts the behavior of the states in a way similar to Martin's (2012) adaptive resilience (Martin, 2012). Income per capita has a negative impact on output. The *EstablishGL* variable is unsurprising, as a region with that is able to maintain a positive gains to losses ratio despite recession will undoubtedly be more resilient.

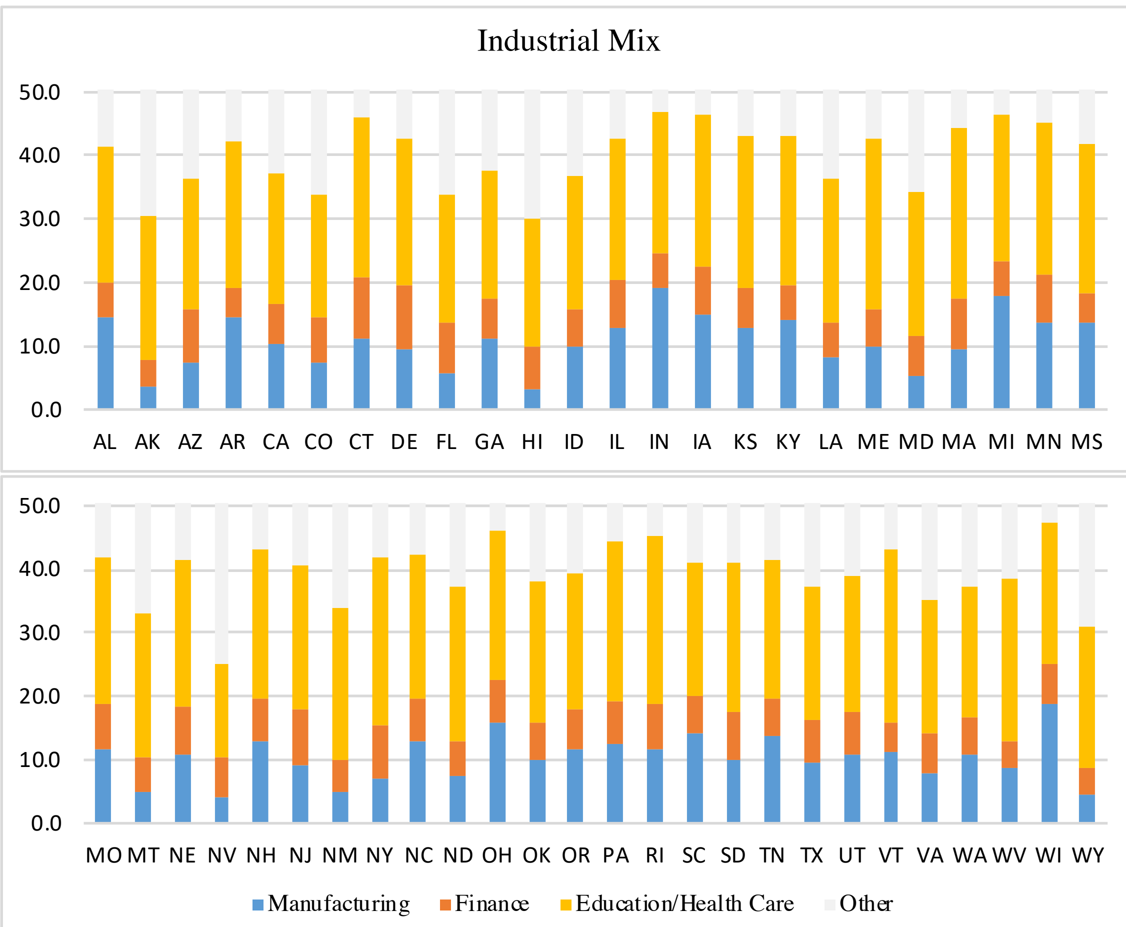

Figure 3: The industrial mix of US States (by percentage of employment)

The industrial mix of a region (Figure 3) has a critical effect on a region's growth rate. States with higher percentages of employment in *Finance* and *Manufacturing* suffered greater in the shock due to cyclical unemployment patterns whereas states with higher employment in *EducationHealt*h were less subject to negative *GDPpcGR*.

Figure 4 depicts the growth rates of states during the pre-recessionary, recessionary, and post-recessionary periods. Based upon the national shock, it is evident that some states experienced drastic decreases in growth rates since the national shock whereas others have been able to withstand or even improve despite national shock.

Table 3 describes the six highest and lowest growth rates during the Pre-Recessionary, Recessionary, and Post-Recessionary time periods.

Pre-Recessionary		Recessionary		Post-Recessionary	
Highest Growth	**Lowest Growth**	**Highest Growth**	**Lowest Growth**	**Highest Growth**	**Lowest Growth**
WY	MI	ND	NV	ND	AK
ND	RI	NE	CT	OK	WY
OR	LA	AK	AZ	TX	LA
AK	DE	SD	FL	CA	CT
UT	OH	OR	MS	CO	WV
KS	NV	NY	NJ	WA	VT

States such as New York managed to maintain the high level of growth rate throughout the recessionary period. Meanwhile, states such as Wyoming, Oregon, and Arkansas suffered profusely, with growth rates dropping from highest to lowest. Texas and Oklahoma became highest growers after the national shock. Wyoming can be seen having the a huge drop from being the top growing state to the second-lowest growing state (Table 3).

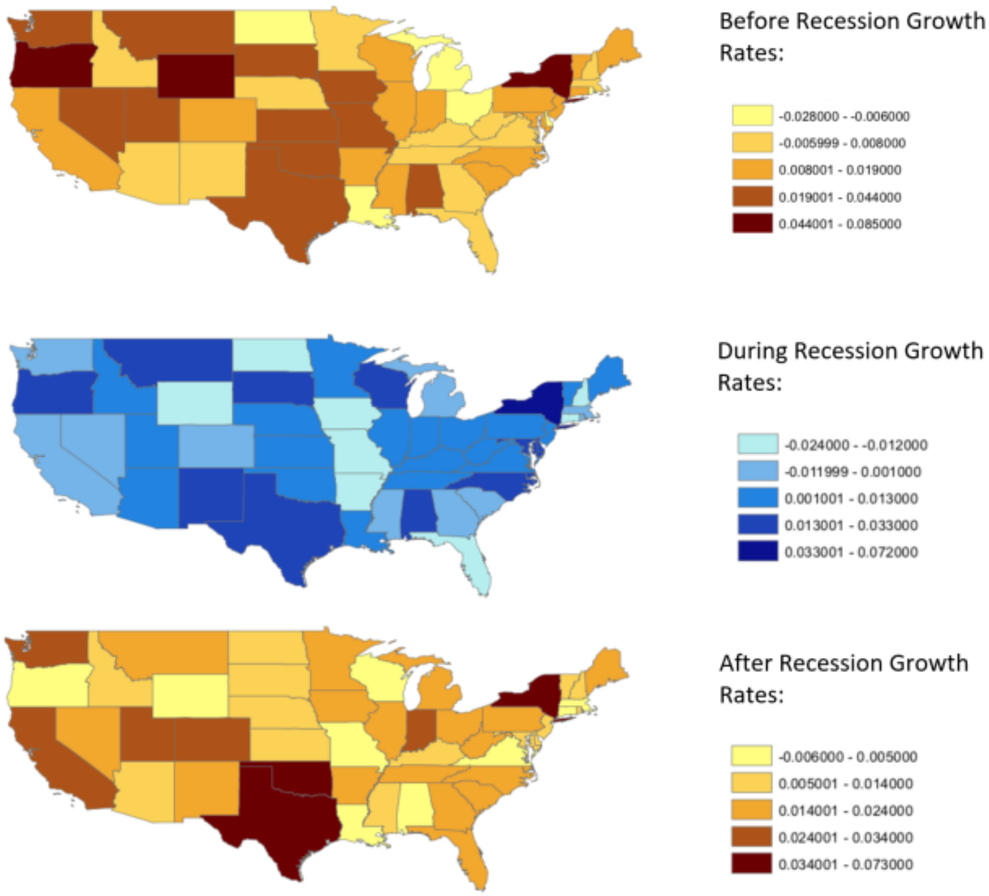

Figure 4 maps the average growth rates before, during, and after the national shock (2010)[1]

Although the panel model controls for spatiality in a statistically significant and economically consistent manner, there are constraints within the model that are difficult to control for. The heterogenous nature of the states, as seen in Figure 5, is ever prevalent in the dependent variable. Furthermore, while the model is able to analyze the effect of the national shock, it cannot capture the moments at which each individual state went into recession.

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[1] Pre-recessionary period is 2005 to 2008. Recessionary period is 2009 to 2011. Post-recessionary period is 2012 to 2015.

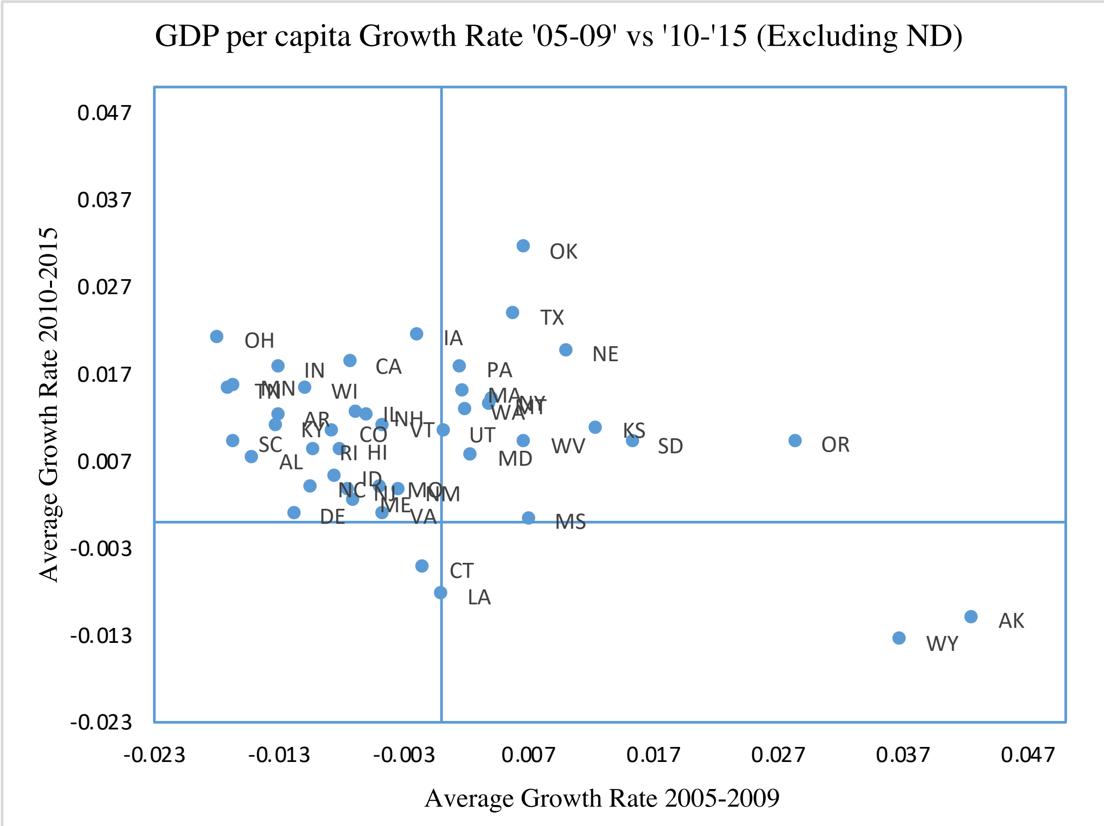

Figure 5: Scatter plot measuring the average GDPpcGR from 2005-2009 vs. 2010-2015.

The econometric model helps determine which factors effect resilience. Examining the effect of the national shock is critical, however, it can be misleading when judging a state's resilience if the state entered recession earlier or later than the United States. In order to measure which states are resilient, GDP growth rate from 2001 to 2015 is used and an average growth rate is calculated before and after the recessionary shock[2].The states that are classified as Not-Resilient are states whose growth rates have significantly decreased[3] after the recessionary shock (Figure 6). Unfortunately, half of the US states fall into this category.

[2] Appendix 2

[3] A decrease of over 0.5%

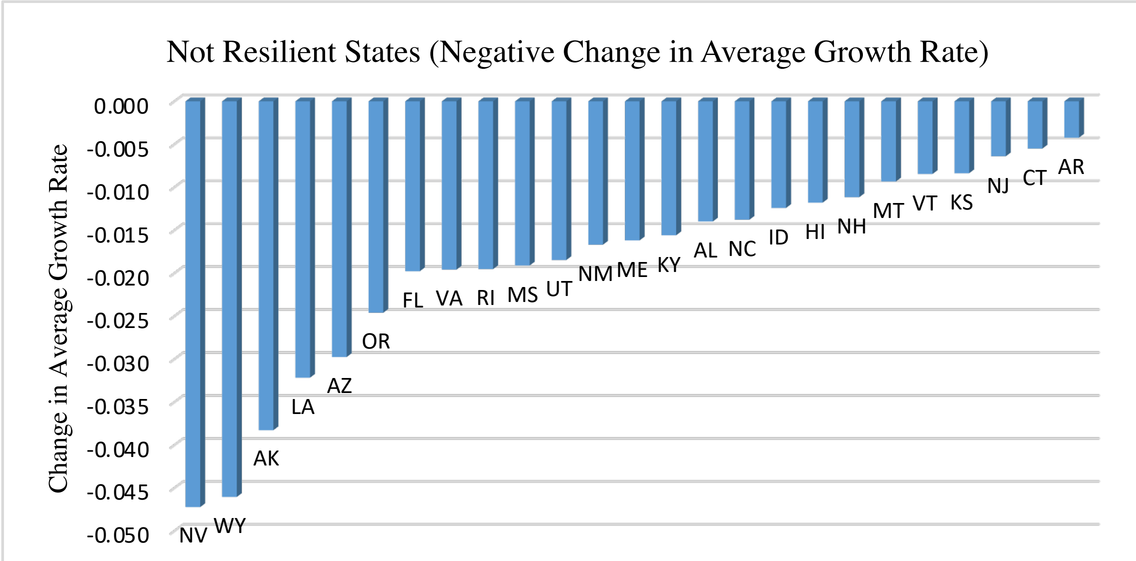

Figure 6: States that exhibited negative change in average growth rate when comparing pre-recessionary and post-recessionary GDP growth rates.

The least resilient state is Nevada, with over a 5% decrease in average growth rate since the recession, closely followed by Wyoming. Nevada's recession lasted from 2007 to 2010 and Wyoming's from 2009 to 2013.

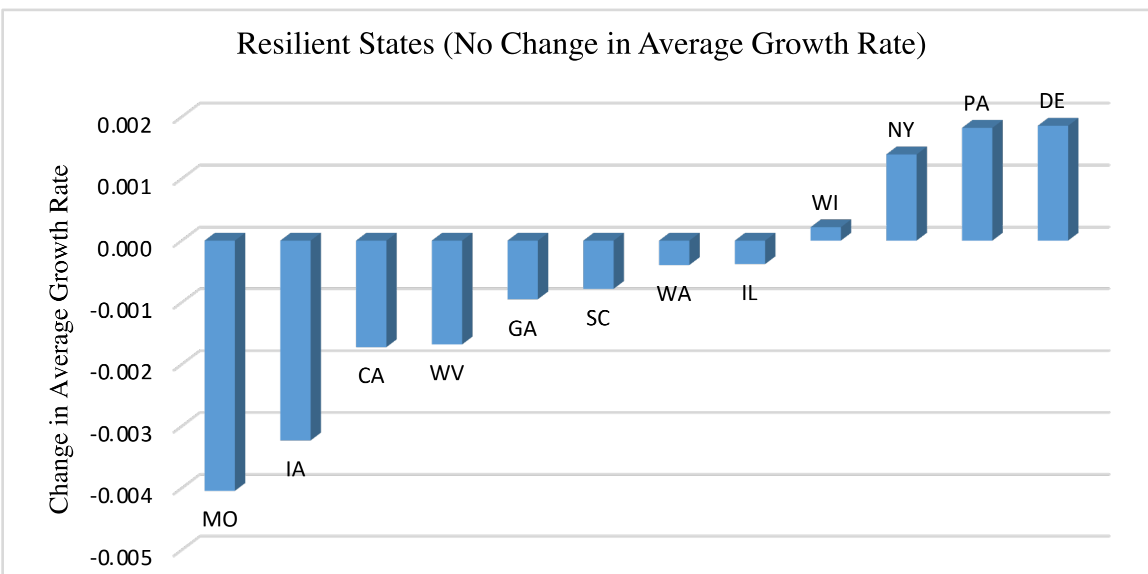

Figure 7 States that exhibited no change (less than half a percent in either direction) in average growth rate when comparing pre-recessionary and post-recessionary GDP growth rates.

Resilient states are states that maintained the same growth rate[4], when comparing pre-recessionary and post-recessionary average growth rates (Figure 7). These states have successfully managed to maintain about the same average growth rate as prior to the recession. There are 12 resilient states in the United States, however only four managed to have a slight increase in growth rate.

Regions are considered highly-resilient if they are able to continue to grow despite the influence of an external shock. There are 13 states that are considered highly-resilient in the United States after the 2008/09 recession. Of these states, four did not experience any negative growth between 2007 and 2011. These states are Maryland, Nevada, South Dakota, and North Dakota.

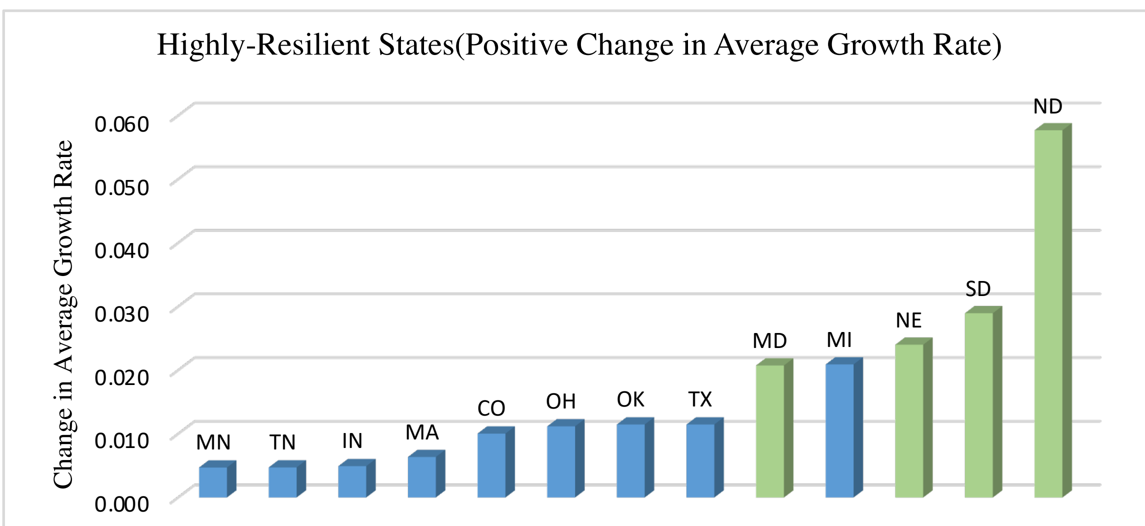

Figure 8 States that exhibited positive average growth rate when comparing pre-recessionary and post-recessionary GDP growth rates.

Model 1 demonstrates what variables affected the regional per capita growth rate. Model 2 depicts the impact of a recession on those variables. An analysis of the state

[4] A difference in average growth rates of -0.5%≤Average GDP growth rate ≤0.5%

GDP data shows what states are resilient and what states aren't resilient both for both the national shock and the individual state shocks. But what makes these states resilient?

Table 4 compares the elements within the model between Not-Resilient and Resilient/ Highly-Resilient States. These are individually listed in Appendix 2 and Appendix 3.

	Not Resilient	**Resilient/ Highly-Resilient**
HighEdPercent	27.51	28.08
Age	37.49	37.55
Employment	1710	3537
Pop1865	1065 (62.66%)	2176 (62.70%)
IncomePC	26050.56	27021.80
EstablishGL	1.05	1.06
SelfWorker	6.73	6.31
Manufacturing (%)	9.14	11.76
EducationHealth (%)	22.47	23.01
Finance (%)	6.11	6.77
HHI	0.053	0.046
ΔGR (US)	-0.01%	0.01%
ΔGR (S)	-0.02%	0.007%
Recession Start Year	2008.22	2008.17
Recession End Year	2009.91	2010.00
Length of Recession	1.70	1.56
Post-Recessionary Shocks	0.91	0.48

Table 4 uses the variables from the model and compares them between Not-Resilient and Resilient/ Highly-Resilient states. States that are not resilient, on average, have 0.57% lower higher-education rates than those that are Resilient/ Highly-Resilient. Resilient and Highly-Resilient regions have a 4% higher *IncomePC*. Both *HighEdPercent* and *IncomePC* can be explained by the fact that jobs that require a higher-education degree are typically higher paying as well as less susceptible to cyclical unemployment. Unsurprisingly, states that are resilient have double the employment/ labor force. This suggests that areas with a larger labor force are more resilient. Although regional *GDPpcGR* suffered from high employment in *Manufacturing*, the regions that are

Resilient/ Highly-Resilient have an average 2.62% higher employment in manufacturing than Not-Resilient regions. Surprisingly, these regions also had higher percentage employment in *EducationHealth* and *Finance*.

Not-Resilient regions, on average, have a higher *HHI* than Resilient/Highly-Resilient Regions. This is odd because during a recessionary shock a region's GDPpcGR is positively affected by higher industrial diversity. This result points to the difficulty of measuring resilience and how there are multiple definitions. When measuring a region's resilience as the ability to maintain growth during a shock, a high *HHI* is more beneficial to region. When measuring a region's ability to recover it's pre-recessionary growth rate, a lower *HHI* is preferable. It is also important to note that *HHI* was not significant in Model 1 and was only significant in recession in Model 2.

After the national shock Not-Resilient regions had an average decrease in output per capita growth of 1% whereas Resilient/Highly-Resilient regions had an average increase of 1%. Separately, Resilient and Highly-Resilient regions had a 0.7% and 1.1% average increase in output per capita, respectively. When examining the individual state shocks, Not-Resilient states had an average decrease of 2% and Highly-Resilient states had an average increase of 0.7%. States entered recession in 2008 and came out of recession in 2010. However, states that are Not-Resilient were in recession slightly longer than Resilient/Highly-Resilient States. Also, states that are Not-Resilient were twice more likely to experience a post-recessionary shock[5].

[5] A post-recessionary shock is a year of negative *GDPpcGR* experienced after the recessionary period in the state is concluded.

CONCLUSION

The research in this thesis examined the resilience of the states in the US. The metric uses output, both of which are critical measures of success in an economy. This work defines regional economic resilience as a region's ability to retain its growth rate despite shock and dependent on social, economic, and industrial factors. It examines which factors affect a regions growth rate and how a national recessionary shock influences these factors. Furthermore, this thesis analyzes individual state growth rates and the state's ability to recover from these growth rates.

Age, income per capita, and establishment growth are significant in measuring output growth. In a recessionary shock, educational attainment, entrepreneurial ability, and industrial mix become significant. States with high employment in industries predisposed to cyclical unemployment have are more impacted by recessionary shocks but also more likely to recover their pre-recessionary growth rate. The industrial diversity of states, measured with the Herfindahl-Hirschman index shows interesting results regarding resilience. Although a higher diversity yields higher regional output growth rate, a region is more likely to recover to its pre-recessionary growth rate with lower industrial diversity and higher specialization.

More work must be done to examine resilience from all angles. Resilience as a recovery in GDP growth rate is one definition and one measure of this vague and diverse topic. It is an important subject that has potential to help policymakers protect their state from recessionary shocks and help states recover faster from national shocks.

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APPENDICES

APPENDIX A

Table 5 details the correlation analysis at a 95% significance as well as the mean and standard deviations of the variables.

Variable	GDPpcGR	lnHighEd%	Age	lnIncomePC*	EstablishGL	SelfWork	Manuf	EdHealth	Finance	HHI
lnHighEd%	0.064									
Age	0.011	0.142*								
lnIncomePC	0.038	0.816*	0.246*							
EstablishGL	0.479*	0.108*	-0.139*	0.043						
SelfWork	0.138*	0.041	0.085*	-0.163*	0.134*					
Manuf	0.199*	-0.001	-0.024	0.012	0.153*	0.002				
EdHealth	-0.223*	-0.060	0.000	-0.083	-0.230*	0.048	-0.152*			
Finance	0.007	-0.010	0.046	-0.024	0.082	0.007	-0.083	-0.160*		
HHI	-0.027	-0.324*	0.153*	-0.238*	-0.065	0.037	0.048	0.012	0.037	
Recession	-0.256*	-0.059	-0.026	-0.093*	-0.438*	0.002	-0.206*	0.355*	-0.105*	-0.010
Mean	0.0047	3.32	37.52	10.18	1.05	6.50	-0.01	0.01	-0.01	0.05
S.D.	0.0265	0.18	2.32	0.15	0.16	1.43	0.07	0.03	0.06	0.01

APPENDIX B

Table 6: Averages by state for all variables used in Model 1 and Model 2.
(*) =thousands (%) = percent of employment

State	Abr	HighEd Percent	Age	Employment (*)	Pop1865 (*)	Income PC	Establish GL	Self Worker (%)	Manufacturing (%)	Education Health (%)	Finance (%)	HI
Alabama	AL	20.45	38	1928	1200	22706	1.00	5.69	14.39	21.50	5.69	0.060
Alaska	AK	26.56	33	326	215	30598	1.03	6.88	3.67	22.75	4.29	0.069
Arizona	AZ	26.32	36	2534	1532	24642	1.09	6.13	7.55	20.83	8.12	0.035
Arkansas	AR	20.63	37	1185	723	21227	1.06	6.71	14.45	23.04	4.92	0.058
California	CA	29.36	35	15078	9550	28620	1.15	8.57	10.16	20.25	6.66	0.024
Colorado	CO	35.97	36	2329	1507	29968	1.10	6.92	7.18	19.50	7.30	0.038
Connecticut	CT	36.50	40	1657	1045	36497	0.99	6.58	11.36	25.28	9.46	0.039
Delaware	DE	29.60	39	430	268	28803	1.02	4.33	9.36	23.26	10.12	0.050
Florida	FL	26.55	41	7641	4646	25701	1.07	6.02	5.54	20.25	7.97	0.050
Georgia	GA	27.96	35	4043	2567	24631	1.04	5.75	10.97	20.21	6.46	0.047
Hawaii	HI	29.58	38	611	384	28341	1.02	7.52	3.16	20.17	6.72	0.069
Idaho	ID	25.02	35	633	383	22122	1.06	8.10	10.12	21.38	5.50	0.043
Illinois	IL	30.65	37	5824	3667	28525	1.02	4.95	12.86	22.05	7.61	0.041
Indiana	IN	24.06	37	2926	1819	23950	0.99	4.90	19.05	22.28	5.41	0.043
Iowa	IA	25.84	38	1510	927	25774	1.04	6.99	15.15	23.77	7.53	0.041
Kansas	KS	29.74	36	1363	839	25887	1.01	6.62	13.05	23.96	6.14	0.039
Kentucky	KY	22.12	38	1822	1147	22471	1.04	5.86	14.22	23.43	5.56	0.048
Lousiana	LA	21.73	36	1923	1205	23037	1.02	5.83	8.23	22.94	5.39	0.053
Maine	ME	26.83	43	606	384	25587	1.01	9.23	9.77	26.65	6.11	0.056
Maryland	MD	35.83	38	2590	1656	34463	1.01	4.98	5.08	22.68	6.55	0.064
Massachusetts	MA	39.44	39	3312	2132	34168	1.16	6.32	9.63	26.94	7.87	0.035
Michigan	MI	27.21	39	4128	2584	25075	0.95	5.30	17.85	23.24	5.57	0.048

State	Abr	HighEd Percent	Age	Employment (*)	Pop1865 (*)	Income PC	Establish GL	Self Worker (%)	Manufacturing (%)	Education Health (%)	Finance (%)	HI
Minnesota	MN	32.16	37	2741	1727	29907	1.00	6.14	13.85	23.91	7.29	0.033
Mississippi	MS	21.30	36	1121	689	19658	0.97	6.04	13.62	23.55	4.85	0.069
Missouri	MO	25.45	38	2732	1699	24637	1.11	6.11	11.75	23.25	6.91	0.046
Montana	MT	28.05	40	440	275	24028	1.08	9.65	4.76	22.58	5.55	0.058
Nebraska	NE	28.82	36	964	591	25542	1.16	7.30	10.84	23.21	7.55	0.051
Nevada	NV	22.55	36	1204	757	26079	1.10	4.99	4.29	14.60	6.24	0.061
New Hampshire	NH	32.52	41	639	412	31656	1.03	7.48	13.04	23.53	6.49	0.047
New Jersey	NJ	35.71	39	3969	2498	34429	1.00	4.86	9.02	22.74	8.86	0.047
New Mexico	NM	26.11	36	819	502	22550	1.03	7.11	5.01	24.05	4.85	0.079
New York	NY	32.69	38	8769	5603	30899	1.06	6.12	6.95	26.80	8.33	0.043
North Carolina	NC	27.61	37	4030	2537	24429	1.08	6.07	13.10	22.77	6.42	0.050
North Dakota	ND	27.39	37	395	251	27801	1.26	8.85	7.30	24.39	5.74	0.054
Ohio	OH	25.45	39	5282	3289	25130	0.94	5.26	15.87	23.57	6.50	0.042
Oklahoma	OK	23.46	36	1598	983	23105	1.08	6.95	10.07	22.12	5.92	0.037
Oregon	OR	28.71	38	1678	1062	25915	1.06	8.13	11.72	21.60	6.06	0.042
Pennsylvia	PA	28.11	40	5734	3577	27169	1.05	5.52	12.68	25.14	6.52	0.043
Rhode Island	RI	30.85	39	476	305	28956	1.00	5.41	11.65	26.40	7.18	0.039
South Carolina	SC	25.19	38	1893	1185	23163	1.04	5.65	14.14	21.11	5.91	0.069
South Dakota	SD	26.33	37	410	249	24407	1.11	9.02	9.77	23.65	7.58	0.064
Tennessee	TN	23.86	38	2744	1726	23612	1.03	7.25	13.70	21.82	5.85	0.042
Texas	TX	25.93	34	10716	6668	24854	1.14	7.00	9.54	20.90	6.72	0.024
Utah	UT	29.33	29	1244	743	22952	1.17	4.98	10.86	21.07	6.86	0.045
Vermont	VT	33.95	42	305	197	27730	0.98	9.91	11.03	27.22	4.78	0.057
Virginia	VA	35.00	37	3734	2401	31981	1.12	5.15	7.82	20.80	6.53	0.050
Washington	WA	19.69	37	2940	504	29600	1.03	6.35	10.64	20.90	5.89	0.044
West Virginia	WV	26.15	41	756	474	21485	0.93	4.96	8.53	25.65	4.31	0.072

State	Abr	HighEd Percent	Age	Employment (*)	Pop1865 (*)	Income PC	Establish GL	Self Worker (%)	Manufacturing (%)	Education Health (%)	Finance (%)	HI
Wisconsin	WI	24.53	39	2817	1772	26577	1.03	5.56	18.71	22.42	6.24	0.048
Wyoming	WY	26.20	37	286	182	27710	1.10	7.16	4.53	22.02	4.26	0.064

APPENDIX C

Table 7 captures the individual state shock analysis. Pre-shock GR is the average growth rate before the state went into recession. Post-shock GR is the average growth rate after the recession. The post-shock column refers to whether or not the state experienced post-recessionary negative growth rate.

State	Abrv	Pre-Shock GR	Post Shock GR	Change in GR	Shock Start Year	Shock End Year	Length of Shock	Post-Shock?
Alabama	AL	0.024	0.010	-0.014	2008	2010	2	0
Alaska	AK	0.039	0.001	-0.038	2010	2011	1	2
Arizona	AZ	0.044	0.014	-0.030	2008	2010	2	0
Arkansas	AR	0.021	0.017	-0.004	2009	2010	1	2
California	CA	0.029	0.027	-0.002	2008	2010	2	0
Colorado	CO	0.016	0.026	0.010	2009	2010	1	0
Connecticut	CT	0.024	0.019	-0.005	2008	2014	6	0
Delaware	DE	0.012	0.014	0.002	2007	2009	2	3
Florida	FL	0.036	0.016	-0.020	2008	2010	2	1
Georgia	GA	0.021	0.021	-0.001	2008	2010	2	0
Hawaii	HI	0.030	0.018	-0.012	2009	2010	1	0
Idaho	ID	0.028	0.016	-0.012	2009	2010	1	1
Illinois	IL	0.014	0.013	0.000	2008	2010	2	1
Indiana	IN	0.017	0.022	0.005	2008	2010	2	0
Iowa	IA	0.030	0.026	-0.003	2008	2010	2	0
Kansas	KS	0.023	0.015	-0.008	2008	2009	1	0
Kentucky	KY	0.022	0.007	-0.016	2007	2008	1	1
Lousiana	LA	0.034	0.002	-0.032	2006	2008	2	2
Maine	ME	0.018	0.002	-0.016	2007	2010	3	3
Maryland	MD		0.021	0.021			0	0
Massachusetts	MA	0.015	0.022	0.006	2009	2010	1	1
Michigan	MI	0.005	0.026	0.021	2006	2010	4	0
Minnesota	MN	0.017	0.022	0.005	2009	2010	1	0
Mississippi	MS	0.021	0.001	-0.019	2009	2010	1	2
Missouri	MO	0.010	0.006	-0.004	2009	2010	1	1
Montana	MT	0.031	0.022	-0.009	2009	2010	1	0
Nebraska	NE		0.024	0.024			0	1
Nevada	NV	0.056	0.008	-0.047	2007	2010	3	1
New Hampshire	NH	0.025	0.014	-0.011	2007	2010	3	0
New Jersey	NJ	0.013	0.007	-0.006	2009	2010	1	1

State	Abrv	Pre-Shock GR	Post Shock GR	Change in GR	Shock Start Year	Shock End Year	Length of Shock	Post-Shock?
New Mexico	NM	0.024	0.007	-0.017	2009	2010	1	1
New York	NY	0.017	0.018	0.001	2008	2009	1	1
North Carolina	NC	0.028	0.014	-0.014	2009	2010	1	1
North Dakota	ND		0.058	0.058			0	1
Ohio	OH	0.011	0.022	0.011	2006	2010	4	0
Oklahoma	OK	0.028	0.040	0.011	2009	2010	1	0
Oregon	OR	0.043	0.019	-0.025	2009	2010	1	2
Pennsylvia	PA	0.018	0.019	0.002	2009	2010	1	0
Rhode Island	RI	0.028	0.009	-0.020	2007	2010	3	1
South Carolina	SC	0.021	0.020	-0.001	2008	2010	2	0
South Dakota	SD		0.029	0.029			0	1
Tennessee	TN	0.018	0.023	0.005	2009	2010	1	0
Texas	TX	0.030	0.041	0.011	2009	2010	1	0
Utah	UT	0.045	0.026	-0.018	2008	2010	2	0
Vermont	VT	0.020	0.011	-0.008	2009	2010	1	2
Virginia	VA	0.028	0.009	-0.020	2008	2009	1	0
Washington	WA	0.025	0.025	0.000	2009	2010	1	0
West Virginia	WV	0.011	0.010	-0.002	2007	2008	1	1
Wisconsin	WI	0.018	0.018	0.000	2008	2010	2	0
Wyoming	WY	0.053	0.007	-0.046	2009	2013	4	0

AUTHOR'S BIOGRAPHY

Mariya Pominova was born on July 27, 1996 in Donetsk, Ukraine. She was raised in Bedford, MA and graduated from Bedford High School in 2014. While attending the University of Maine Mariya studied Economics with minors in Business Administration and Management. Mariya swam for the Umaine Swim and Dive team, specializing in sprint freestyle and butterfly. She was also a member of numerous organizations on campus, including the All Maine Women traditions society and the Student Athlete Advisory Board.

Upon graduation, Mariya plans to continue her education by pursing a masters in Economics. She strives to earn a Ph.D. in Economics and work at the Federal Reserve Bank helping shape economic policy in the United States.