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Hurricanes and Long-term GDP Growth: The Role of Institutional Quality

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April 26, 2016

Abstract

This paper compares the long-term effects on real per-capita GDP of two hurricanes in 1992, hurricane Andrew in Florida and hurricane Iniki in Hawaii. The literature suggests that the long-term effect on GDP of a natural disaster for a region with good pre-disaster institutional quality may be positive (i.e., GDP levels exceed those which would have materialized without the disaster) because the destruction of capital induces firms to investment in more technologically advanced structures and machines. In contrast, a region with bad pre-disaster institutional quality should experience a negative impact because it face severe limits in the amount it can borrow in international markets to replace the destroyed capital. If this claim holds, Florida, a state with poorer institutional quality, should not have performed as well as Hawaii, a state with stronger institutions, after each was hit by a hurricane in 1992. By analyzing twenty years of data for the two states using the synthetic control method, this paper shows that the pre-disaster institutional quality was not a powerful determinant of the long-term GDP growth in these two states. That is, Hawaii's observed per-capita GDP values remained significantly lower than what Hawaii would have experienced without hurricane Iniki, while the gap between the observed values and the expected values was smaller for Florida. I speculate that other differences between these two economies, such as their size or proximity to the U.S. mainland, might explain why Hawaii was more adversely affected by hurricane Iniki.

Economists know little about the long term effects of natural disasters. Theoretically, a natural disaster can have a positive or negative effect on the damaged economy depending on a number of conditions. A natural disaster can improve the economy if the country takes the disaster as an opportunity to invest in new technology and replace antiquated machines and structures. Skidmore and Toya (2002) show that this so-called “creative destruction” is observed in the real world by analyzing the effects of historical disaster frequency and current disaster frequency on the averaged current GDP growth rate for 1960 to 1990 using OLS. They find that a country that has a high disaster frequency either historically has experienced or currently does experience higher GDP growth. On the contrary, a natural disaster can harm an economy’s long-term growth prospects if a destruction of capital is not followed by reconstruction. For example, Noy and Nualsri (2007) use a data set for 98 countries from 1975 to 1999 and show that a natural disaster decreases growth rate because human capital is affected by the natural disaster.

Recent studies show that a natural disaster can increase or decrease economic growth depending on the characteristics of the affected country, but they have not agreed on what characteristics matter most. For example, Cuaresma et al. (2008) examine the evolution of investment from abroad and conclude that creative destruction occurs in countries with high per-capita incomes, but not in developing countries. They explain that developing countries have large spillover on investment when a natural disaster occurs and thus cannot take advantage of a natural disaster as a creative destruction. Toya and Skidmore (2007) conclude that countries with higher income, higher educational attainment, greater trade, more complete financial systems and smaller government consumption experience fewer losses following a natural disaster. Noy (2009) argues that countries with more foreign exchange reserve, higher levels of domestic credit and less-open capital accounts are better able to endure natural disasters. All of these studies suggest that the impact of a natural disaster on economic growth is conditional on the fundamental characteristics of the economy hit by the external shock.

Barone and Mocetti (2014) further examine the long-term effects of natural disasters by focusing on earthquakes that occurred in two different regions of Italy in 1976 and 1980. They hypothesize that lower economic growth is more likely to occur in regions with lower pre-quake institutional quality (i.e., Irpinia) versus regions with better institutions (i.e., Friuli), and their empirical analysis supports this conjecture. This study is superior to other studies for two reasons. First, Barone and Mocetti’s analysis uses the synthetic control method, which compares the observed value of GDP growth after the natural disaster to estimated values that would have been observed in the absence of the external shock. The latter is estimated by creating a synthetic economy using economic performance observed in unaffected regions that resemble the affected region in different way. This methodology, unlike that of estimating the coefficient of a dummy disaster variable common in other research, controls for forces that may have affected GDP-growth and are unrelated to the natural disaster (e.g., a change in the national business cycle). The other strength of this study is that Barone and Mocetti (2014) look at differences across regions rather than countries. The effects of natural disasters should be clearer if we look at regions rather than countries because even humongous disasters usually do not affect an entire country.

In this paper, I examine the long-term effects of hurricanes in the U.S. using the synthetic control method employed by Barone and Mocetti (2014). My objective is to explore whether their findings hold in countries other than Italy and for natural disasters other than earthquakes. In order to do so, I examine two hurricanes that caused significant damage to different regions of the U.S. in 1992. One is Hurricane Andrew, which damaged the South East region of the country and Florida in particular, and the other one is Hurricane Iniki, which hit Hawaii. I chose these two hurricanes because they occurred in the same year, caused significant damages, and no other significant hurricanes occurred in these locations for more than ten years. Moreover, focusing on hurricanes has the potential to shed greater light on the impact of natural disasters because consistently-measured regional-level data is available for the U.S. for many important variables. Another benefit of focusing on these two hurricanes is that the effected regions differ in several important ways including their institutional quality. Focusing on two hurricanes in different regions with different regulations and cultural norms allow us to better analyze the effect of institutional quality. My findings have the potential to suggest ways that U.S. state governments might prevent the negative effects after a hurricane in addition to add another perspective in the discussion of long-term effects of natural disasters.

I compare the impact of hurricane Andrew and hurricane Iniki on long-term GDP growth rates. Both of these hurricanes occurred in 1992 and were costly. Hurricane Andrew caused immediate damage in Florida equal to 8.6% of Florida’s Gross State Product or $1,852 per capita. Hurricane Iniki in Hawaii produced damage equal to 5% of Hawaii’s Gross State Product, or $1,561 per capita. Neither state was hit by a hurricane of the same or larger cost until Florida was hit by hurricane Katrina in 2005. Thus there are 13 years to study the post-hurricane economies for both cases, which is enough to call it a long-term. My finding is that both Florida and Hawaii observed lower GDP than what they would have had in the absence of the hurricanes, and the damage in long-term GDP is bigger in Hawaii than in Florida. This finding conflicts with that of the Italian studies as the region with better institutional quality, Hawaii, was worse-off with the hurricane and was even more negatively affected than Florida. Possible explanations for why Florida's economic growth did not fall more than Hawaii's are their sizes or proximity to the U.S. mainland.

This paper flows as followed. I first discuss related studies. I summarize what economists have said about hurricanes and then look at studies on the economic effects of natural disasters in general. Following the literature review, I explain why a natural disaster can have positive or negative effect on economic growth. Then I discuss the methodology that I employ and describe my data. Following the data section, I describe my result. Lastly, I conclude my study and give suggestions on future research.

Literature Review

Many researchers have completed studies to measure the costs of hurricanes. When it comes to the power of hurricane itself, Nordhaus (2006) finds that economic vulnerability, measured as damage per GDP, increases sharply with maximum wind speed of the hurricane. His estimations suggest that the damage of a hurricane in dollars is approximately equal to the maximum wind speed raised to the eighth power. He explains that the high elastic effect of the maximum wind speed on cost is due to the threshold effect and the duration of a hurricane. Each man-made object has a certain stress capacity. The damage of a storm remains minimal until it exceeds the stress capacity, but increases drastically once the threshold is surpassed. The maximum wind speed is also correlated with the life of a hurricane so the damage increases if a hurricane has a long duration.

However, the cost of a hurricane cannot be estimated solely by its power. Other researchers investigate why the impacts of similarly-intense hurricanes differ by region and the state of the economies which are affected by them. Perez-Maqueo, Intralawan, and Martinez (2007) study how regional characteristics, which is measured by human, built, natural and social capital, contribute to affect the impact of hurricanes. Their results suggest that a semi-altered landscape, which they define as “a combination of infrastructure and relatively well preserved natural ecosystems”, and the level of GDP significantly reduce the mortality rate produced by hurricanes. Natural capital such as coastal terrestrial ecosystems and aquatic ecosystems may reduce hurricane’s impact, but is not sufficient to prevent the loss of human lives on its own. Sadowski and Sutter (2005) conclude that the reduction in hurricane lethality has a statistically significant and quantitatively large effect on damages on the portions of the coast most prone to hurricanes. Fronstin and Holman (1994) look at the impact of hurricane Andrew and find that subdivisions with higher average home prices suffered less damage because the value of a home indicates the quality of the construction. They also note that newer subdivisions, ones built after 1970s, suffered greater damage from hurricane Andrew, even though those areas experienced relatively slower wind speeds, because building codes became less stringent after 1970. Smith (1996) also analyzes the effects of hurricane Andrew. He uses the field survey to estimate the population in Florida because hurricane Andrew destroyed the statistical basis for producing local population estimates. His population estimates show that population distribution in south Florida was significantly impacted by the hurricane.

The impact of a hurricane is not limited to infrastructure damage; it can also damage economic activity. Coffman and Noy (2009) analyze the impact of hurricane Iniki on the Hawaiian island of Kauai in 1992. Using a nearby island that was not affected by the hurricane as a control, they conclude that the hurricane destroyed tourism infrastructure and increased the unemployment rate and out-migration. Although the unemployment rate and per-capita income recovered to previous levels after seven years as tourism infrastructure, and tourist levels in Kauai roughly reached their pre-Iniki levels, they concluded that the population has not grown back and is unlikely to grow back any time soon. Lynham and Noy (2012) also examine hurricane Iniki and reach similar conclusions. Using other Hawaiian islands as a control group, they argue that the hurricane sped up the rise in unemployment, which had started in 1990, and slowed population growth.

While scholars who studied the long-term consequences of hurricane Iniki arrived at similar conclusions, cross-country studies on the long-term effects of a natural disaster are limited and inconclusive. Skidmore and Toya (2002) analyzed the relationship between the average annual GDP growth rate for the period of 1960 and 1990 and the frequency of natural disasters focusing on 89 countries with varying per capita income levels. Their OLS regressions included averaged annual GDP growth rate for 1960 through 1990 as the dependent variable and two sets of disaster frequency data – one is for the period of 1800 to 1990 and the other is for the period of 1960 to 1990 – along with other control variables as explanatory variables. Their empirical study showed that an economy with a frequent natural disaster occurrence tends to have better economic growth in the later period whether they have high disaster frequency historically (the period of 1800 through 1990) or more recently (the period of 1960 through 1990). Their explanation for the finding is that an economy expands following a natural disaster due to so-called "creative destruction" meaning the economy replaces destroyed capital investing in new technology. Cuaresma et al. (2008) confirm this result for countries with high income per capita, but show the opposite result for developing countries. This finding is important because it suggests that structural differences of economies can have significant implications for how they respond to natural disasters.

Hallegatte and Dumas (2009) disagree with Skidmore and Toya (2002). They used a calibrated endogenous growth model to examine the creative destruction hypothesis. Using their model and panel estimation for the period of 1975 through 1999 on 98 countries, they conclude that the local economy goes into poverty traps if a disaster is so large that it overwhelms the reconstruction capacity. Lynham and Noy (2012) argue that these studies are inconclusive because even a very costly disaster is not large enough to impact an entire nation in the long-term.

Such disagreement may be potentially resolved by looking at the characteristics of the damaged region. Barone and Mocetti (2014) study two Italian earthquakes in two different regions for 20 years post-shock and argue that differences in institutional quality can have large effects on economic growth after an earthquake. To measure the quality of institutions, they use the intensity of corruption and fraudulent behavior, the fraction of national members of parliament appointed in each region who were involved in scandals, the political participation, and the citizen's informed-ness measured by newspaper readership. Regarding the latter variable, the more informed are the citizens, the better are choices that they make. Then they use the institutional quality measure and other explanatory variables for GDP per capita to create a synthetic economy for each effected region so that the synthetic regions acts like the affected region before the earthquakes. Thus the synthetic region tells how the affected region would have been without the disaster. With this methodology, they find that, 20 years after the event, the region with better institutional quality experienced higher GDP growth than it would have without the earthquake, whereas the region with poor institutional quality had lower GDP growth rate than what it could have had without the earthquake (Figure 1).

Other economists agree with Barone and Mocetti (2014) that institutional quality is a determinant of damages caused by a natural disaster at least for the short run. Some argue this point by looking at the number of deaths. Athey and Stern (2002) point out that when a shock takes place, death counts are higher if the nation does not have access to good medical care and emergency treatment and crisis management. Kahn (2005) shows that less democratic nations and nations with more income inequality suffer more deaths. According to his analysis, if a nation with a population of 100 million experienced a GDP per capita increase from $2000 to $14000, the nation would suffer 764 fewer natural-disaster death per year. Yamamura (2012) generally agrees with Kahn, although Yamamura define variables differently. In particular, Yamamura uses ethnic polarization to measure ethnic heterogeneity, which is a component of the institutional quality measure in their studies, instead of ethnic fractionalization that Kahn uses. Noy (2009) argues that the institutional quality can be a determinant of economic damage as well. His finding is that GDP growth is less affected by natural disasters in countries with higher literacy, higher per capita incomes, higher degree of openness, and better institution.

More studies are needed to determine the long-term effects of natural disasters in general, and such studies with a focus on the institutional quality are especially valuable as they can add to the debate initiated by Barone and Mocetti (2014). This paper contributes to the field by analyzing the economic activities after hurricane Andrew and hurricane Iniki.

Theory

The Solow model is often used to explain how a society might experience output growth. In this section, I relax an important assumption of the model, that of a fixed and exogenous savings rate, to explore how an autonomous decline in capital produced by a natural disaster might affect transitional and steady-state growth. In particular, the basic motivation to smooth consumption over time, along with the impact of institutional quality on the ability of a region to attract lending from external soruces, can impact the pace of capital accumulation and economic growth following a natural disaster.

To begin, let N equal the current population. The future population N_{t+1} is

$$N_{t+1} = (1 + n)N_t \tag{1}$$

where n is the population growth rate. N is also the labor force. On the consumers' side, consumption C must equals income Y minus savings S, that is,

(2) $$C_t = Y_t - S_t$$

This can also be written as

(3) $$C_t = (1 - s)Y_t$$

where s is the saving rate. Firms produce output using capital K and labor N. Letting z stand for technology measure, aggregate output is given by

(4) $$Y_t = zF(K_t, N_t)$$

Assuming constant return to scale, per-capita output is

(5) $$\frac{Y_t}{N_t} = zF(\frac{K_t}{N_t}, 1)$$

By setting y=Y/N, k=K/N, and f(k)=F(K,1), the equation (5) can be rewritten as

(6) $$y = zf(k)$$

Also, capital may increase or decrease depending on gross investment and depreciation. Thus future capital K_{t+1} is a function of current capital, depreciation rate d, and investment I

(7) $$K_{t+1} = (1 - d)K_t + I_t$$

In equilibrium in a closed economy, investment equal savings, so using equation (2),

$$C_t = Y_t - I_t$$

(8) $$Y_t = C_t + I_t$$

Then use equation (3) and (7) to rewrite equation (8) as

$$Y_t = (1 - s)Y_t + K_{t+1} - (1 - d)K_t$$

(9) $$K_{t+1} = sY_t + (1 - d)K_t$$

Using equation (4), equation (9)can be written as

(10) $$K_{t+1} = szF(K_t, N_t) + (1 - d)K_t$$

Dividing each term in equation (10) by population N, we get

(11) $$\frac{K_{t+1}}{N_t} = szF(\frac{K_t}{N_t}, 1) + (1 - d)\frac{K_t}{N_t}$$

Using equation (6) and the notation used in equation (6) where lower case letters stand for per-capita values, equation (11) is

$$(1 + n)k_{t+1} = szf(k_t) + (1 - d)k_t$$

(12) $$k_{t+1} = \frac{szf(k_t)}{1+n} + \frac{(1-d)k_t}{1+n}$$

Graphically, equation (12) is as shown in Figure 2.

The Solow model predicts that an economy grows until it hits its steady state. A steady state is where the amount of capital per capita is stable. That is where today's per-capita capital, k_t, equals future's per-capita capital, k_{t+1}, shown as k* in Figure 2. If an economy is not at its steady state, k_1 for example, its future per-capita capital must equals k_{1+1} as equation (12) shows. Then in the next period, the current per-capita capital is k_{1+1}, which is also k_2, and the future per-capita capital is k_{2+1}. This system of growth continues until k_n=k_{n+1}=k*.

For a region with high institutional quality, a natural disaster does not cause a long-term effect, but there is a short-term effect – a spurt of higher transitional growth from a lower capital stock level – thanks to the region's ability to restore and reconstruct. Figure 3 illustrates this hypothesis. The short-term effect of a natural disaster is a fall in capital from k_{pre} to k_{post} in the figure. If a natural disaster does not change the steady state equilibrium, as expected in one with high institutional quality, the society will experience faster growth than the pre-disaster growth as it is further away from the steady state than it was prior to the disaster. Due to consumption smoothing motivations, we would expect the savings rate, s, to decline as households save less to maintain their consumption levels. However, the decline in the domestic savings rate will put upward pressure on interest rates, which will attract foreign savings. In the region has strong institutions that protect the property rights of lenders, agents from outside the region should lend to the region hit by the natural disaster until real interest rates are driven back to their original level. In essence, the savings rate – which reflects both domestic savings and that which flows into the region from abroad – should remain the same and the economy's steady state capital stock is not influenced by the natural disaster.

In contrast, the region with low institutional quality may actually see a decline in its per-capita steady-state capital after a natural disaster. As we saw above, they may would experience a decrease in the domestic saving rate due to consumption smoothing. However this is not offset by investment from outside. Unlike regions with high institutional quality, investors are worried that the region with low institutional quality may allocate capital inefficiently or default on the money they invested. In such case the value of s declines and the curve of $\frac{\mathrm{szf}(\mathrm{k}_t)}{1+\mathrm{n}} + \frac{(1-\mathrm{d})\mathrm{k}_t}{1+\mathrm{n}}$ shifts down, and this result in lower steady-state capital (Figure 4). Then, depending on the magnitude of the shift of the curve, the post-disaster per-capita capital, k_{post}, may be more than the new steady-state capital, k^*_{post}, in which case the economy experiences negative per-capita GDP growth.

Methodology

Following Barone and Mocetti (2014), this paper uses the synthetic control method to examine the impact of the two hurricanes. The synthetic control method has been adopted in other case studies analyzing the impact of a sudden change in a society such as a terrorism attack in Basque Country of Spain (Abadies and Gardeazabal, 2003) and a tobacco control program in California (Abadie, Diamond, and Hainmueller; 2010). This method compares the observed value of the variable of interest to the synthetic value of the variable of interest. The synthetic value is the predicted value that the effected region would have had if it was not affected by a disaster.

To compute the synthetic value, one first creates a synthetic region using comparable regions and assigning a weight to each region so that the composite acts like the affected region as a group. That is, the synthetic value is the weighted average of the observed values of the variable of interest of all the regions used in the synthetic region. Thus synthetic values should act the same as observed values of the region of interest until a disaster occurs and then departs from the observed values after a disaster assuming that a disaster affects those values.

Mathematically, I solve for the vector of weights W* that minimizes $(X_1 - X_0 \cdot W)'$ $V (X_1 - X_0 \cdot W)$ to create a synthetic region. A vector X_1 stands for values of outcome predictors for an affected region, so it is a $(K\times1)$ vector where K is the number of predictors for an outcome. X_0 stands for the values of outcome predictors for comparable regions, so it is a $(K\times J)$ vector where J is the number of comparable regions. In my case, X_1 is the real per-capita GDP of the affected state; K is the number of explanatory variables, which is 13; X_0 is the real per-capita GDP of each of the unaffected regions; J is the number of states except Florida and Hawaii, which is 48. V is a diagonal metric that shows how much each X variable contributes to predict an outcome. Finally, W are the weights given to each comparable region that tells how much it contributes to the prediction of the affected region. Any weights should be more than or equal to zero and less than or equal to 1; a weight of zero means that a region does not contribute to the creation a synthetic region, and a value one means that a region behaves the same as the affected region for the period before the disaster. All weights added equals one.

The advantage of this methodology is its ability to create a synthetic region. A problem in analyzing the long-term effects of a natural disaster is the difficulty in determining how the affected region would have behaved without the disaster. Because of that, it is difficult find out whether an observed negative growth in GDP, for example, is due to the disaster or a trend that the region would have experienced even in the absence of the disaster. The synthetic control method solves this issue by creating the synthetic region using regions that were not hit by the disaster. Because the synthetic region is made to act like the affected region before the disaster, the synthetic region tells how the affected region would have been without the disaster. Thus the synthetic control method enables us to compare the observed behavior of the affected region to the behavior of the controlled group and spot the effects of the natural disaster.

Data

In order to be consistent with the study by Barone and Mocetti (2014), I use the same variables as they do in their study. Many of the time-series data at the state level are drawn from the U.S. governmental data bank. These include real GDP, real per-capita GDP, and real GDP by the nine major industry category[1], which are retrieved from U.S. Bureau of Economic Analysis; population, area, and share of population with a college degree, which are retrieved from U.S. Census Bureau; and the violent crime rate which is retrieved from Uniform Crime Reporting Statistics. Some of the other variables are taken from economics research papers. Investment spending, a component of GDP, by state is taken from Garofalo and Yamarik (2002) and Yamarik (2013). Official corruption convictions per 100,000 people is taken from Bologna (2015). The last variable, the voter turnout rate, is drawn from United States Election Projects. Every variable has an annual observation from 1987 to 1991 except for voter turnout rate, which is only available for even years during the five years, and for official corruption convictions, which is the

1 The categories are agriculture, mining, construction, manufacturing, wholesale trade, retail trade, transportation and warehousing, finance, and services.

average score from 1995 to 2009. In addition, real per-capita GDP data is collected for 1987 to 2011. Having this range enables me to compare the observed values and synthetic values both before and after the hurricanes. Real GDP per capita data is collected using Standard Industrial Classification (SIC) until 1997 and using North American Industrial Classification System (NAICS) since 1998, but this difference should not affect my conclusion because the shift from SIC to NAICS happens int the same year in every state.

I construct the measure of institutional quality the same way that Barone and Mocetti (2014) did. That is, I take the first component of principal components analysis on official corruption convictions, the voter turnout rate, and the violent crime rate. The principal component analysis finds common trends in the distribution of the three variables, and I use the dominant trend as the measure of the institutional quality. The only difference between the methodology of Barone and Mocetti (2014) and the methodology employed in this paper is that I do not include the variable of newspaper readership. Barone and Mocetti included this variable to measure the informedness of the citizens. However, Edmonds et al (2013) shows that newspaper readership in the United

States is highly correlated with education level. Thus this paper omits this variable to prevent multicollinearity.

With the principal component analysis, the first component has the eigenvalue of 1.406 and accounts for 0.469 of the variation. The first principal component has strong positive correlation with violent crime rate and strong negative correlation with voter turnout rate (Table 1). This suggests that the state's institutional quality is bad if it has a big number for the institutional quality measure. Table 2-1 shows the overall characteristics of the measure. Table 2-2 shows the institutional quality measure for Florida, Hawaii, and the rest of the states. It implies that Florida is one of the worst state in terms of institutional quality and Hawaii has slightly better institutional quality than an average state.

This institutional quality measure is then used as an explanatory variable for per-capita GDP. The other explanatory variables are components of real GDP, which is GDP by each industry category and investment divided by real GDP, population density, which is calculated as population divided by area, and share of the population with a college degree. The summary of those variables is shown in Table 3.

Result

For Florida, the synthetic control method delivers positive weights for Arizona (0.538), Tennessee (0.224), Nevada (0.130), South Dakota (0.055), and Maine (0.053). For Hawaii, the method delivers positive weights for Colorado (0.419), Delaware (0.378), Connecticut (0.086), Nevada (0.061), and Alaska (0.057). Table 4-1 compares the actual and synthetic values of the growth determinants for Florida for 1987-1991. The table, together with table 3, shows that the synthetic values are within one standard deviation of the corresponding observed values, except for the share of mining in the GDP and institutional quality. Table 4-2 compares the actual and synthetic values of the growth determinants for Hawaii for 1987-1991. Together with table 3, this shows that the synthetic values are within one standard deviation of the corresponding observed values except for the share of mining in GDP, the share of construction in GDP, and the share of manufacturing in GDP.

For Florida, a state that had low-quality institutions before the hurricane, observed real per-capita GDP is lower than the synthetic value starting in 1992, the year it was hit by the hurricane (Figure 5). The gap ranges from $2,000 to $3,300, or 8 to 13 percent of the observed per-capita GDP, for the first ten years after the hurricane, and then the gap becomes smaller. By 2005, the gap is minima, which is the year that hurricane Katrina, a hurricane more costly than hurricane Andrew, hit Florida and surrounding states.

For Hawaii, a state that had moderate to high institutional quality before the hurricane, observed real per-capita GDP turns out to be less than the synthetic value (Figure 6). Hawaii's real GDP per capita keeps declining for 6 years after hurricane Iniki and creates a big gap with its synthetic value. Importantly, the gap does not seem to close even after Hawaii's GDP per capita starts increasing. The biggest gap is at nine years after the hurricane where the synthetic per-capita GDP is nearly 30 percent higher than the observed GDP. This is surprising given the relatively high quality of Hawaii's institutions. We would expect Hawaii's observed GDP to be much closer to its synthetic GDP as Hawaii moves back to its steady state equilibrium.

The result in Florida is consistent with the finding from Barone and Mocetti (2014) for Italian province, but the result in Hawaii is inconsistent. A difference between their result and the result in Florida is that the gap between the observed and the synthetic per-capita GDP values starts to diminish after the first 10 years in the case of Florida whereas the gap expands after the first 10 years in the case of the earthquake in the Italian region, Irpinia, with lower quality institutions. The Italian region with better institutional quality, Friuli, had GDP that was 23% higher than the synthetic GDP 20 years after the earthquake. In contrast, in Hawaii, the region with better institutional quality in my study, observed GDP remained lower than synthetic GDP for the entire twenty years.

To test the robustness of these findings, I ran the synthetic control method without the state with the biggest weight for each state. Comparing this result to the earlier result shows how sensitive the result is to the states that are used to create the synthetic state. Thus I take out Arizona, which had the biggest weight of 0.538 in the first regression, to test the robustness of the result in Florida. For Hawaii, I take out Colorado, which had the biggest weight of 0.419.

With this change to each regression, for Florida, the synthetic control method now delivers weights for Maine (0.552), Georgia (0.239), Tennessee (0.089), North Dakota (0.073), and Nevada (0.047). The weights for Hawaii are Delaware (0.537), Nevada (0.298), Montana (0.092), Mississippi (0.032), Alaska (0.029), Maryland (0.012), and New York (0.001). Table 5 compares the growth determinants' values of 1987-1991 between the affected regions and corresponding synthetic regions. Table 5-1 shows that the synthetic values resemble the observed values for Florida; only the share of manufacture and the institutional quality are more than one standard deviation away from the observed value. For Hawaii, the synthetic values are more than one standard deviation away for the share of mining, the share of construction, the share of manufacture, the share of retail, and the share of college degree (table 5-2).

The results still contradict theory and the findings of Barone and Mocetti (2014). When we consider Florida with Arizona's weight restricted to be zero (figure 7), it is more inconsistent with theory than the original result. The gap between the observed per-capita GDP values and the synthetic per-capita GDP values is smaller than in the original result. Furthermore, the observed values exceed the synthetic values after 12 years, which is unexpected for a state with bad institutional quality. The result for Hawaii without Colorado (figure 8) is very similar to the first result. The observed per-capita GDP values are lower than the synthetic values, and moreover, the gap between the observed values and the synthetic values is bigger for Hawaii than for Florida. This is the opposite of what was expected for the two states.

Overall, my result contradicts the finding of Barone and Mocetti (2014). The region with better institutional quality, Hawaii, is worse off after the hurricane than the region with poorer institutional quality, Florida. As mentioned earlier in this section, Florida's synthetic institutional quality is skewed positively in both regressions. If the theory holds and having high institutional quality allows the region experience a smaller negative impact from a hurricane, fixing the skewedness would only make Florida less worse-off if there is any effect. That makes my result even less consistent with what theory predicts. Furthermore, the magnitude of the damage was bigger in Florida. The cost of hurricane Andrew to Florida was 8.6% of Florida's GDP, and the cost of hurricane Iniki to Hawaii was 5% of Hawaii's GDP. Given that the shock was bigger for Florida, we would expect its GDP performance to be relatively weaker, but this was not the case. Thus my results suggest that institutional quality is not one of the main determinants of economic growth after a hurricane.

There are several possible explanations for why Florida's economic growth did not fall more than Hawaii's. The first is the location; Florida is bordered by other states, while Hawaii is almost 2,500 miles from California and thus faces higher transaction costs for trade. The location of Florida may give it better access to reconstruction resources, domestic trade and aid.

The second possible explanation is the size of the economy. Although Hawaii has higher per-capita GDP than Florida, Florida's overall GDP is about seven times bigger than Hawaii's. Florida also has a much larger population and a larger land mass than Hawaii does; the population of Florida is about 11.5 times as big as the population of Hawaii, and the area of Florida is as 6 times as big as the area of Hawaii. Florida may have an advantage in reconstruction due to its accessibility to resources such as labor, land, and capital from the unaffected parts of the state. The size difference might also have given Florida an advantage due to scale economies. For example, the average cost of supplying tourism services might have risen much more in Hawaii after the hurricane because the industry was smaller and relatively less efficient to begin with.

The third possible difference is the demographic of the outside investors. Hawaiirelies on the investment of Japanese companies and tourists. The bursting of Japanese real estate bubble in 1992 might have affected Hawaii's post-hurricane GDP significantly, and this would not have been picked up in the synthetic model because the states most similar to Hawaii which contributed to the model probably were not impacted much by the economic contraction in Japan during the 1990s.

A final possibility is that the economies of Florida and Hawaii differed in their structural diversities and less reliance on a few industries in Florida might have caused it to be more resilient. However, this is not very likely because Florida and Hawaii have similar GDP components. For example, finance and investment are the top two sectors in both scoring over twenty percent in both, and services is the third main industry making up about ten percent of state GDP in both economies.

Conclusion

By examining per-capita GDP of Florida and Hawaii after each state was hit by hurricane in 1992, I conclude that the pre-disaster institutional quality was not a main determinant of long-term economic growth after the destructive event. This finding contracts with that of Barone and Mocetti (2014) who show that the region with high quality institutions observed higher GDP than what would have had without the disaster, while the region with poorer institutional quality observed lower GDP growth than what would have observed without the disaster. Florida had one of the poorest institutional qualities of the fifty U.S. states before the hurricane, and Hawaii had institutional quality that was slightly better than an average U.S. state. If the finding of Barone and Mocetti (2014) about Italian earthquakes were applicable to other countries and other types of natural disasters, Florida would have been worse off than Hawaii. However, per-capita GDP differed from synthetic per-capita GDP more for Hawaii than for Florida. Thus there must be factors other than the pre-disaster institutional quality that made Hawaii suffer more than Florida.

As 1992 is a unique year to have two substantial hurricanes in two different locations, future research should further analyze the cause of the difference in long-term effects between Florida and Hawaii. Why did Hawaii experience a bigger negative impact after hurricane Iniki than Florida did after hurricane Andrew, despite the fact that hurricane Andrew caused bigger damage? Future research may alter the list of explanatory variables to answer the question. It can also explore the characteristics of the two states in the recovery process, which the synthetic control method does not, to see if post-disaster characteristics have any effects in the long run.

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Table 1-1: Principal Components Correlation

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	1.40591	0.41049	0.4686	0.4686
Comp2	0.99543	0.39677	0.3318	0.8004
Comp3	0.59866	.	0.1996	1
Number of Obs.				100
Number of Comp.				3
Trace				3
Rho				1

Table 1-2: Principal Components (Eigenvectors)

Variable	Comp1	Comp2	Comp3	Unexplained
turnout rate	-0.6901	0.2066	0.6939	0
politicians involved in scandal	0.1642	0.9781	-0.128	0
crime rate	0.7049	-0.0256	0.7089	0

Table 2-1 Institutional Quality Measure Summary

Observations	Mean	Standard diviation	Min	Max
100	0.000006	1.185712	-2.087152	3.204643

Table 2-2 Institutional Quality Measure by State

	Florida	Hawaii	Overall average	Overall min	Overall max
1988	1.5416251	-0.6452174	-0.5673002	-2.0871515	1.5416251
1990	2.7951193	-0.1806303	0.5673002	-1.4424295	3.2046430
average	2.1683722	-0.4129239	0	-1.7647905	2.3731340

Table 3: Summary of the Estimation Variables

Variable	Mean	Std.Dev.	Min	Max
rGDP per capita	30515	7019	15468	54747
agri/GDP	0.0216	0.0195	0.00396	0.0985
mining/GDP	0.0310	0.0682	0.000133	0.360
const/GDP	0.0447	0.0107	0.0127	0.0796
manu/GDP	0.160	0.0665	0.0351	0.290
trans/GDP	0.0810	0.0185	0.0372	0.140
whole/GDP	0.0529	0.0124	0.0160	0.0816
retai/lGDP	0.0830	0.0129	0.0333	0.106
finance/GDP	0.174	0.0531	0.0446	0.395
services/GDP	0.189	0.0453	0.0473	0.384
invest/GDP	0.133	0.0922	0.00263	0.687
popdensity	139.4	182.7	0.813	892.6
share college degree	20.42	4.095	11.10	32.20
institutional quality	0	1.1858	-2.0871	3.2046

Note: all the monetary values are in 1997 USD. Population density is thousand people per one square miles. Share of college degree is in percentage. Real GDP per capita is the dependent variable and collected for 1987-2011. Other variables are explanatory variables and collected for 1987-1991

Table 4-1: Comparison of Characteristics: Florida

Variables	Observed	Synthetic	Difference	S.d.
agri/GDP	0.0195663	0.0190585	0.0005078	0.0195
mining/GDP	0.0030314	0.0120287	-0.0089973	0.0682
const/GDP	0.0561121	0.0541045	0.0020076	0.0107
manu/GDP	0.0853284	0.124185	-0.0388566	0.0665
trans/GDP	0.0774987	0.0792729	-0.0017742	0.0185
whole/GDP	0.0595315	0.051199	0.0083325	0.0124
retail/GDP	0.102635	0.0966567	0.0059783	0.0129
services/GDP	0.2350078	0.226526	0.0084818	0.0531
finance/GDP	0.2107534	0.1807318	0.0300216	0.0453
invest/GDP	0.1237441	0.1409615	-0.0172174	0.0922
popdensity	192.1351	46.48756	145.64754	182.7
college	19.2	19.409	-0.209	4.095
institutional quality	2.168372	0.6034331	1.5649389	1.1858

Table 4-2: Comparison of Characteristics: Hawaii

Variables	Observed	Synthetic	Difference	S.d.
agri/GDP	0.0132752	0.0132888	0.0000136	0.0195
mining/GDP	0.0005916	0.289092	-0.2885004	0.0682
const/GDP	0.0574386	0.0423754	0.0150632	0.0107
manu/GDP	0.0407119	0.1536412	-0.1129293	0.0665
trans/GDP	0.0828549	0.0734989	0.009356	0.0185
whole/GDP	0.0325303	0.0419037	-0.0093734	0.0124
retail/GDP	0.0951798	0.0737015	0.0214783	0.0129
services/GDP	0.207995	0.1873345	0.0206605	0.0531
finance/GDP	0.2463166	0.2461456	0.000171	0.0453
invest/GDP	0.0937719	0.1136871	-0.0199152	0.0922
popdensity	100.3016	164.653	-64.3514	182.7
college	24.6	24.31677	0.28323	4.095
institutional quality	-0.4129239	0.0700472	-0.4829711	1.1858

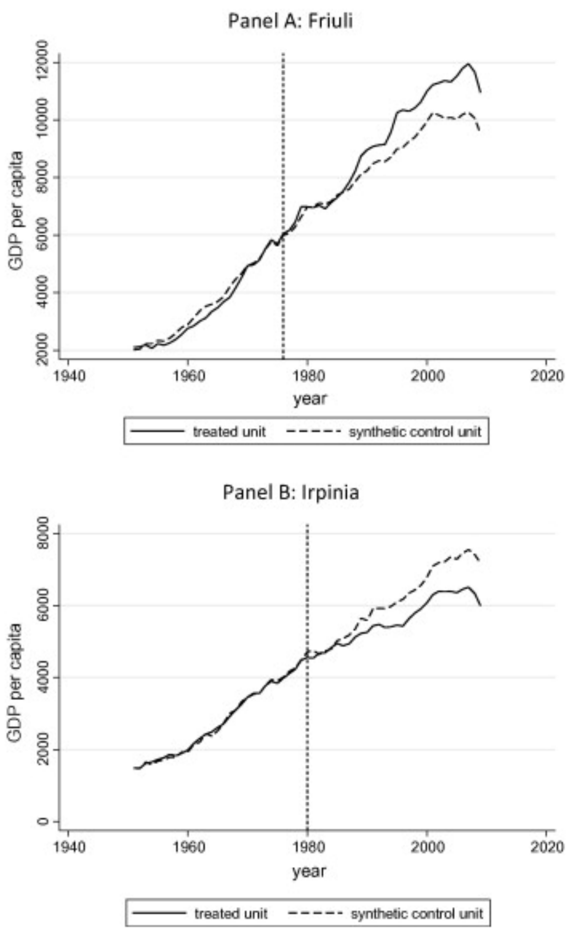
Table 5-1: Comparison of Characteristics: Florida (without Arizona)

Variables	Observed	Synthetic	Difference	S.d.
agri/GDP	0.0195663	0.0200906	-0.00052	0.0195
mining/GDP	0.0030314	0.0071355	-0.0041	0.0682
const/GDP	0.0561121	0.0541898	0.001922	0.0107
manu/GDP	0.0853284	0.1655719	-0.08024	0.0665
trans/GDP	0.0774987	0.0769131	0.000586	0.0185
whole/GDP	0.0595315	0.059505	2.65E-05	0.0124
retail/GDP	0.102635	0.0959738	0.006661	0.0129
services/GDP	0.2350078	0.1941088	0.040899	0.0531
finance/GDP	0.2107534	0.1660211	0.044732	0.0453
invest/GDP	0.1237441	0.1288601	-0.00512	0.0922
popdensity	192.1351	56.12376	136.0113	182.7
college	19.2	18.86883	0.33117	4.095
institutional quality	2.168372	-0.5473215	2.715694	1.1858

Table 5-2: Comparison of Characteristics: Hawaii (without Colorado)

Variables	Observed	Synthetic	Difference	S.d.
agri/GDP	0.0132752	0.013426	-0.0001508	0.0195
mining/GDP	0.0005916	0.0246716	-0.02408	0.0682
const/GDP	0.0574386	0.0463939	0.0110447	0.0107
manu/GDP	0.0407119	0.1464652	-0.1057533	0.0665
trans/GDP	0.0828549	0.0654776	0.0173773	0.0185
whole/GDP	0.0325303	0.0351945	-0.0026642	0.0124
retail/GDP	0.0951798	0.0703825	0.0247973	0.0129
services/GDP	0.207995	0.2079892	5.8E-06	0.0531
finance/GDP	0.2463166	0.2438054	0.0025112	0.0453
invest/GDP	0.0937719	0.1285387	-0.0347668	0.0922
popdensity	100.3016	152.1353	-51.8337	182.7
college	24.6	19.1885	5.4115	4.095
institutional quality	-0.4129239	0.4079691	-0.820893	1.1858

Figure 1: Findings of Barone and Mocetti (2014)



Note: Friuli has good institutional quality. Irpinia has bad institutional quality.

e 2: Solow Model Overview

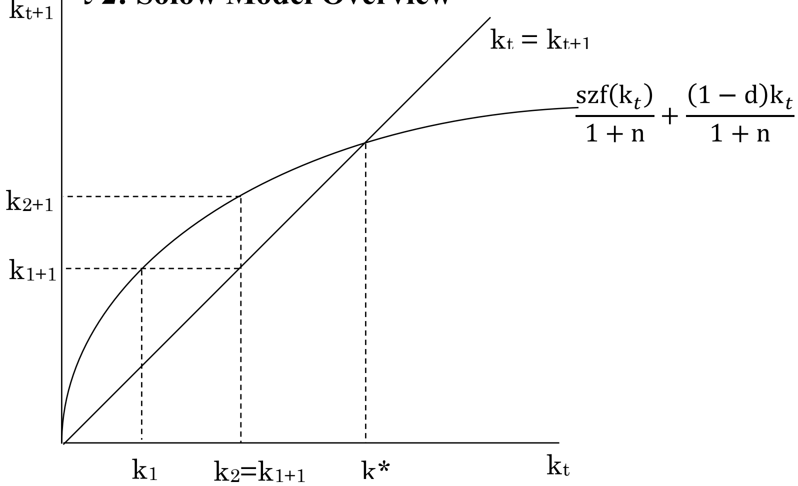


Figure 3: How a Region with Good Institutional Quality can Experience High GDP Growth

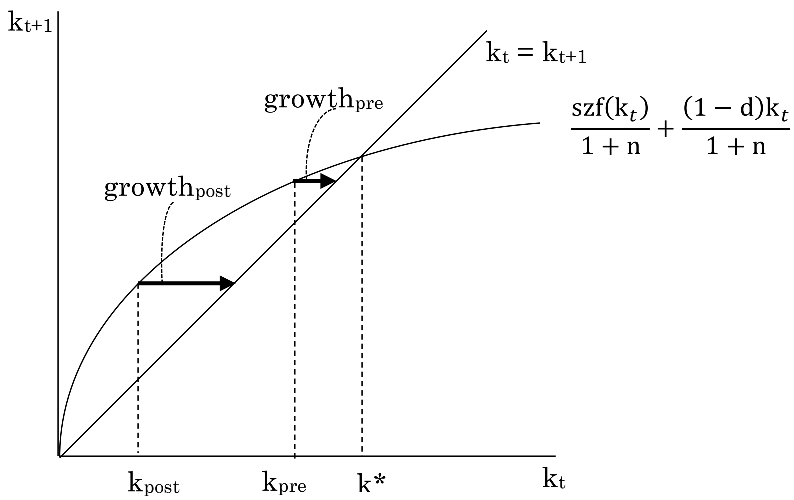


Figure 4: How a Region with Bad Institutional Quality may experience Negative GDP Growth

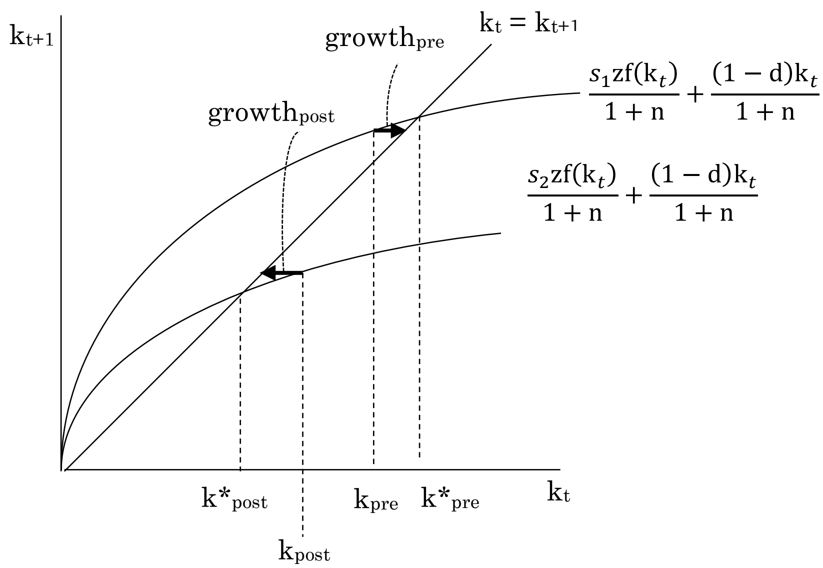
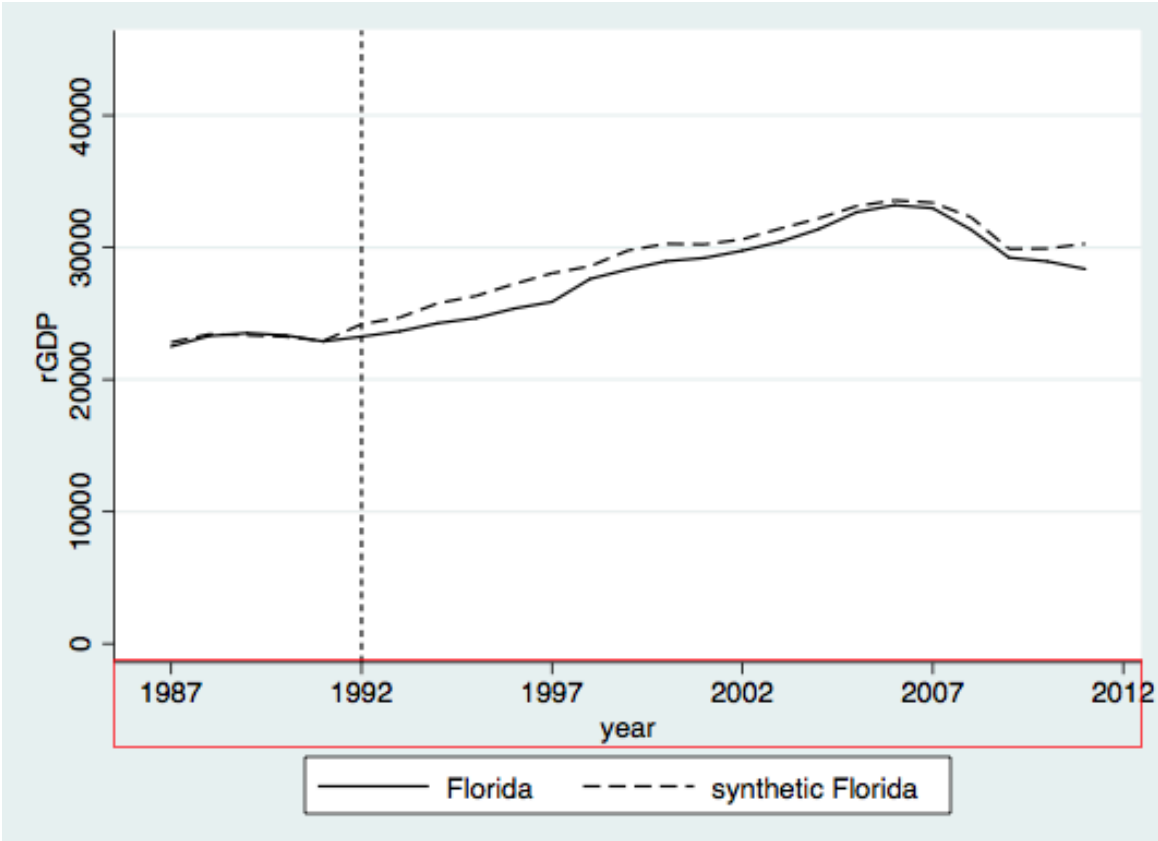
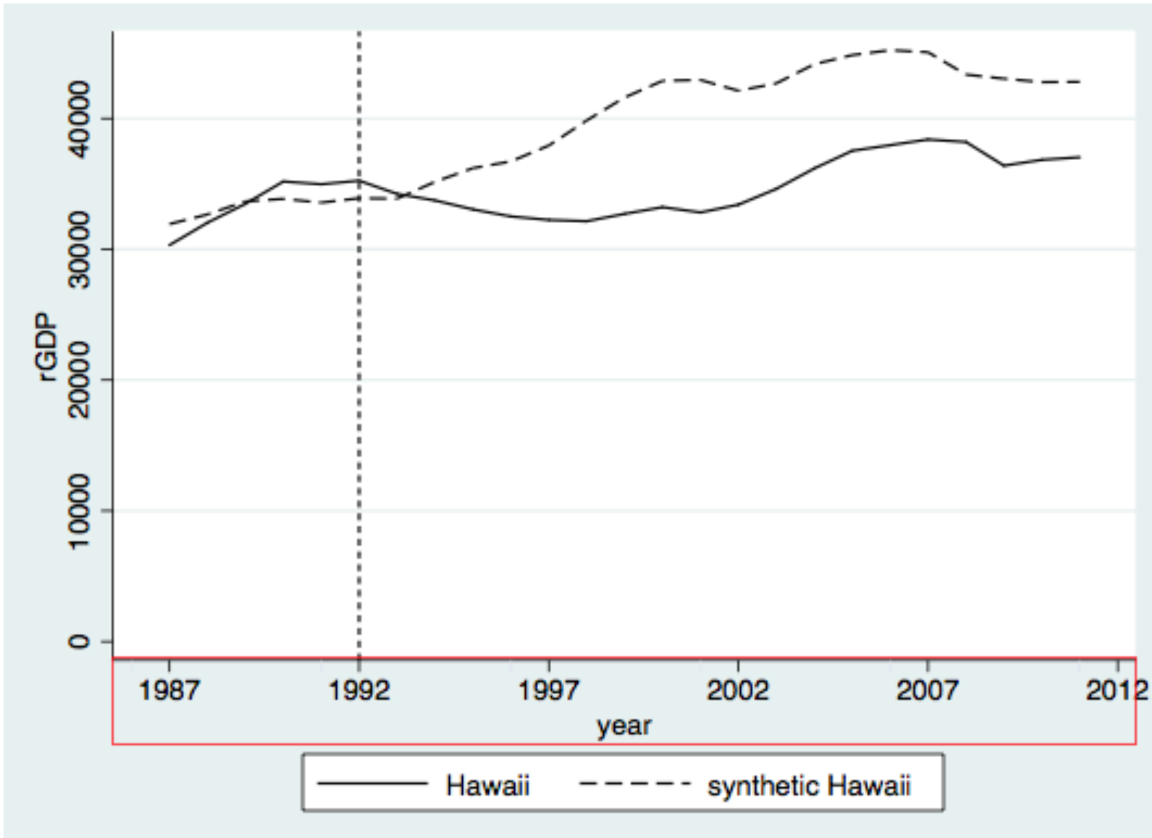


Figure 5: Real Per-Capita GDP Comparison: Florida



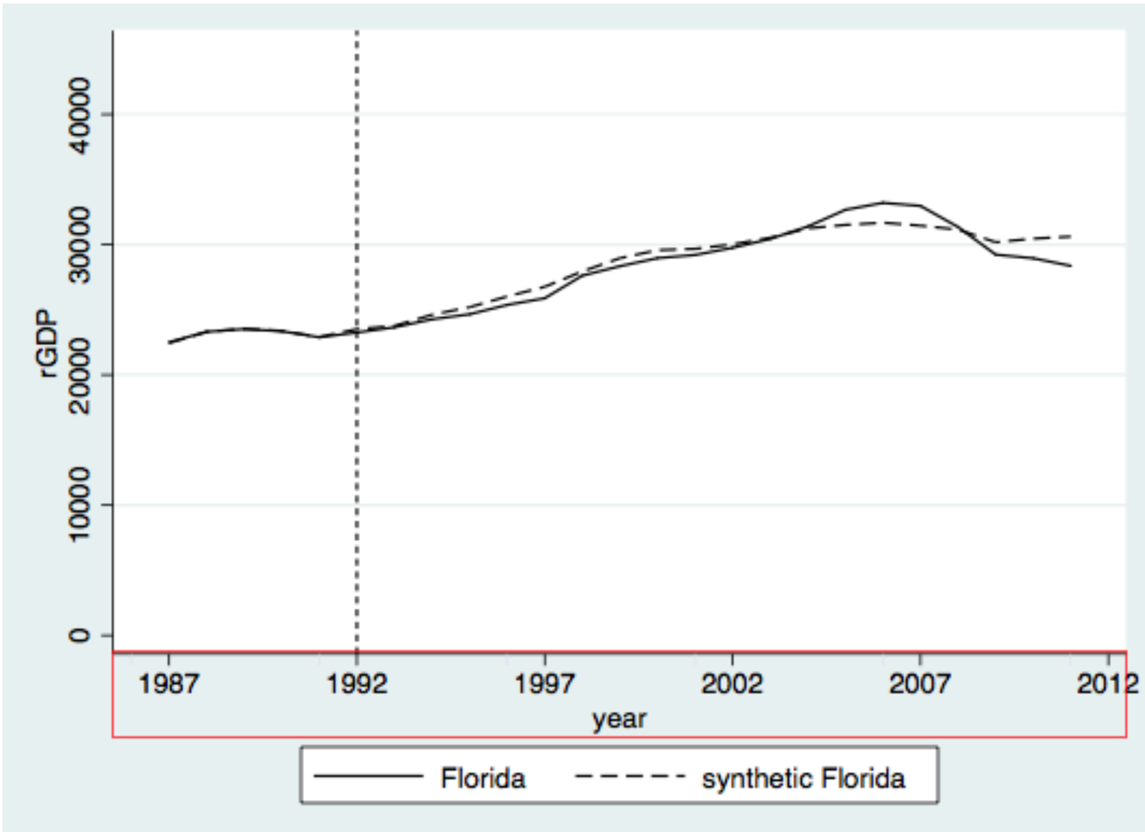
Note: this is the graph based on table 4-1.

Figure 6: Real Per-Capita GDP Comparison: Hawaii



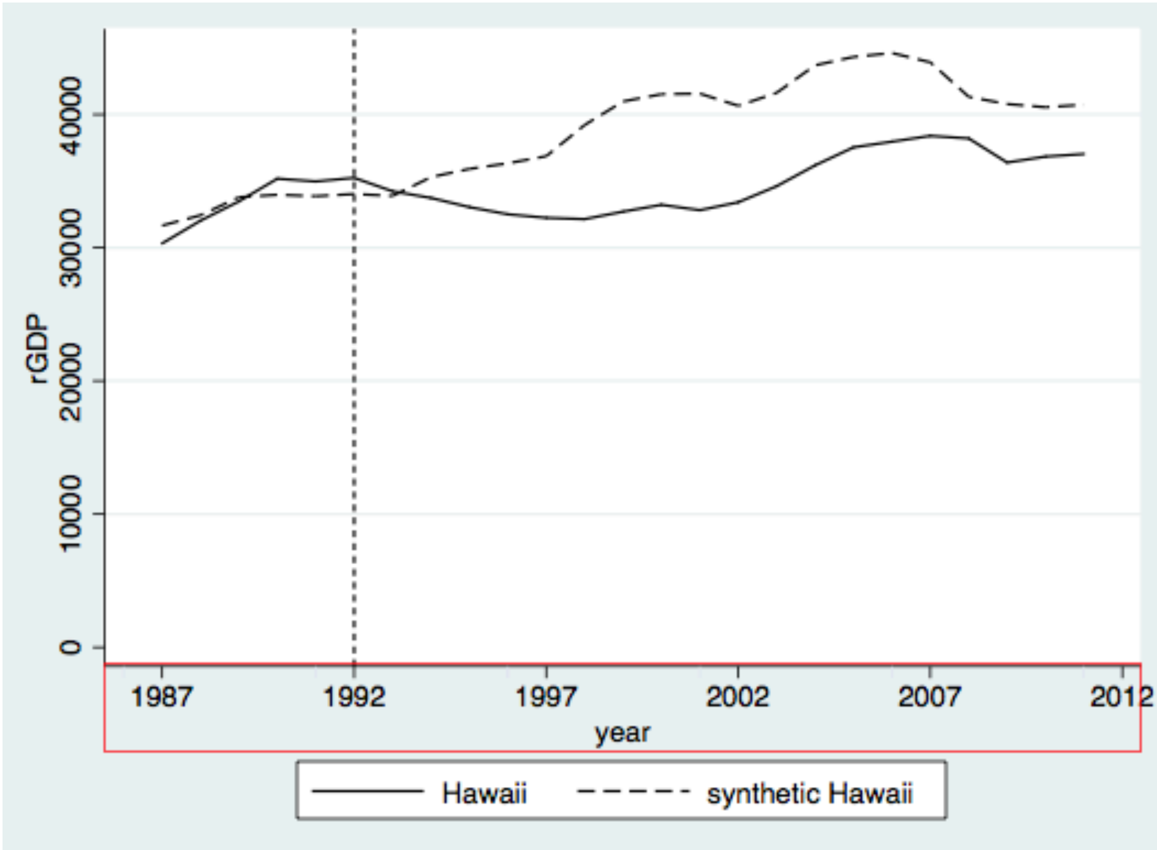
Note: this is the graph based on table 4-2.

Figure7: Real Per-Capita GDP Comparison: Florida (without Arizona)



Note: this is the graph based on table 5-1.

Figure 8: Real Per-Capita GDP Comparison: Hawaii (without Colorado)



Note: this is the graph based on table 5-2.