"The Economic Cost of A Hurricane: A Case Study of Puerto Rico and Hurricane Georges 1998 Using Synthetic Control Method"

Albalate D & Padró-Rosario G

Abstract

The aim of this study is to evaluate the long–term effect of a hurricane in the output of a country. The study estimates the effects of Hurricane Georges on Puerto Rico in 1998 using aggregated level data. To do so, this research uses a suitable method for comparative studies, the synthetic control method. Hurricane Georges caused an estimate of US$4.3 billion in direct damages. The results give validity to recent studies on natural disasters providing negative effects on growth. It was found that the Purchasing Power Parity over GDP could have been 9 percent higher by 2010 if the hurricane would have never affected Puerto Rico. Moreover, it shows that Puerto Rico's economy has yet to recover after 12 years of the event. The case of Georges brings an insight into the long–term impacts of a natural disaster as a singular event. A difference in time and country is conducted as an alternative method with also negative effects on the dependable variable.

JEL classification: C20, O04, Q54

Keywords: Synthetic Control Method, Hurricane Georges, Puerto Rico, Growth

Daniel Albalate: Universitat de Barcelona, Departament d'Estadística, Econometria i Economia Aplicada, Avda. Diagonal 690, 08034 (Barcelona), Telf: +34.93.4031131, E-mail: albalate@ub.edu

Gabriel R. Padró-Rosario: Departament de Econometria, Estadística y Economia Aplicada, Universitat de Barcelona, John Maynard Keynes 1-11, 08034, Barcelona. E-mail: gpadroro22@alumnes.ub.edu

Acknowledgements

This research has enjoyed financial support from the Spanish Ministry of Economy and Competitiveness (ECO2016-76866-R) and the Government of Catalonia (2017 SGR644).

1. Introduction

Natural disasters can be seen as surprising and at the same time intriguing events by their power and grace. Researchers have the impression that they are an inescapable economic event that occurs naturally and alters the economy. These stunning natural phenomena can cause tremendous damage in a short period. Given the location of Puerto Rico in the Caribbean, Puerto Rico encounters some natural disasters including hurricanes, flooding and the consequences of climate change. The impact can have a noticeable immediate effect and an ambiguous effect in the future. Thus, researchers study the effects in the short-run or the long–term. The long-term studies try to evaluate the effects over time and to associate with a specific event. Most disaster assessments projects use pre-disaster trends of selected economic variables and then determine the adjustment path to those trends as a measure of post–disasters impacts. One potential fault of this method is that the same variable can influence by exogenous events not associated with the disaster.

Most of these studies focus on the natural aspects and the social impacts of natural disasters. The one done on social impacts deal with post–traumatic stress disorders and psychological distress following a natural disaster (Steinglass and Gerrity (1990), and Satter et al. (2002)). Whereas in natural science there is even more research with attention to the impact of the flora and coast erosion due to hurricanes (Boose et al. 2004, and Scatena and Larsen 1991). However, the literature analyzing the cost of a natural disaster and their consequences using aggregated data are still limited. Current surveys, as the work of Cavallo and Noy (2010), are essential to acquaint new methodologies and help uncover the long–term costs of natural disasters. As for Puerto Rico, the economics literature on the economic costs of a natural disaster is merely inexistent.

Hurricane Georges hit Puerto Rico the 21 of September of 1998 as category three hurricane. Georges was the first hurricane in 66 years to cross the entire island of Puerto Rico.[1] Georges brought a damage estimate of 4,287 billion of dollars by March of 1999.[2] Infrastructure had the most significant share, 66.4 percent. The reasons to select Georges 1998 where the followings: (1) when observing the Economic Activity Index of Puerto Rico,[5] a deeper drop is seen at Hurricane Georges 1998 rather than in Hurricane Hugo 1989; (2) is one of the recent strong hurricanes with available data; (3) there are more than 20 years of detailed analysis of post–disaster and pre–disaster economic data; (4) is a natural experiment that was expected but only at a certain point. In other words, one can only prepare that much; (5) the hurricane experience is not unique to Puerto Rico, many of the Caribbean islands had similar experiences.

It is not clear whether there is a relationship between natural disasters and economic growth (Cavallo et al. (2010). Cavallo et al. (2010) found that even in sizeable natural disaster events output is affected in neither the short–run nor long-run. Although, when the significant event is related to a political movement or uprising, the results are different. Ergo, any investigation of the

[1] In late September 1932 Hurricane San Ciprian crossed Puerto Rico.

[2] See Impacto Economico del Huracan Georges en Puerto Rico (1999), Junta de Planificacion de Puerto Rico.

[5] Constructed monthly by the Government Development Bank of Puerto Rico.

long–term effects of natural disasters is relevant since growth theories, and empirical results get contradicting results. Along these lines, our study of Georges kick–offs lacking solid antecedent literature.[3]

The purpose of this work is to assess the long–term effects of a Hurricane Georges on the economy of Puerto Rico by trying to find out what would have happened if the hurricane never hit Puerto Rico. The impact can be estimated with the simple difference between the outcome of actual Puerto Rico and the outcome of synthetic Puerto Rico. The geography area to be analyzed would be the country of Puerto Rico during 1998 hurricane Georges. The work will benefit from empirical research behind the work of Coffman and Noy (2010) of Hurricane Iniki in Hawaii also using a synthetic control method. The next section discusses relevant empirical work regarding the post-period impacts of large disaster events. In section 3 there is a description of the economy of Puerto Rico and Georges initial impact on Puerto Rico. Section 4 describes the method and data literature involving Abadie et al. (2010) synthetic control method applied to Hurricane Georges. Section 5 details the results of the synthetic control method followed by Section 6 with the Placebo studies. Section 7 presents a complementary analysis using the differences between countries in time. Finally, section 8 ends with the discussion and conclusion.

2. Natural Disasters

Hurricanes, cyclones, and typhoons are all the same weather phenomenon. Scientist call these storms depending on where they occur. In the Atlantic and northern Pacific, the storms are called hurricanes after the Caribbeans native god of evil *Juracan*. From *Juracan* the word *Huracan* was derive from Spanish and eventually the English word *Hurricane*.

Globally, over the 1970—2004 period an average of 85 hurricanes were formed. For the United States, the year 2005 was an outlier in terms of hurricane power since was the year of most storm activity and the year when experienced their deadliest and powerful hurricane yet, Katrina. Another iconic hurricane was Iniki in Hawaii island of Kauai, being the strongest hurricane to hit Hawaii.
Iniki brought an estimated direct damage of US$7.4 billion (2008).

[3] See Coffman and Noy (2010).

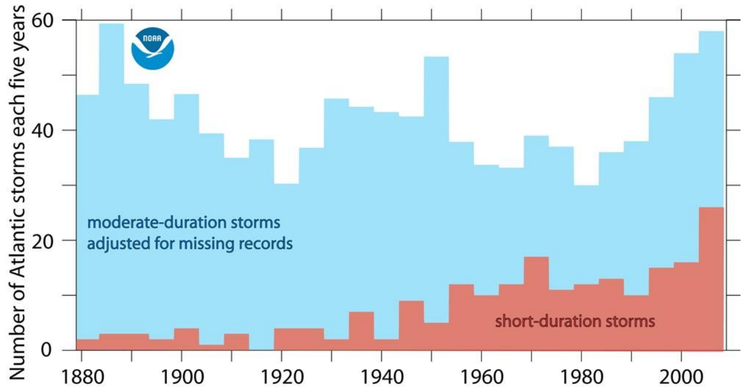


Figure 1: Intensity of Storms from 1880 – 2000
Source: National Oceanic and Atmospheric Administration of the US (NOAA)

Figure 1 of the National Oceanic and Atmospheric Administration of the U.S. (NOAA), shows how tropical storms lasting more than 2 days (moderate–duration storms) have not increased in number, instead, storms lasting less than two days have increased sharply (Figure 1). A study by NOAA says that Puerto Rico, on average, experiences one tropical storm every five years and less frequent for hurricanes.[4] There are studies that quantify the cost of hurricanes in the United States, but none analyze data for Puerto Rico.

Many researchers already have examined natural disaster events such as 1995 Kobe earthquake in Japan, the 2001 earthquake in El Salvador, Hurricane Katrina in 2005 and, the 2010 earthquake in Haiti. The fact that natural disasters are associated with catastrophes has made investigators consider this area of research. Even though, these studies are relevant, they only examine the impacts short after the event and relayed on the short–run impacts. By not explaining the long–run effect we might not differentiate between different effects. [5] Is important to discuss the distinction between both since the effects varies depending of the strength of the country.

One of the primary goal of countries is to achieve sustainable growth. The neo–classical growth models can predict that physical or human capital destruction affects short–term growth by explaining how the country moves from its steady state. [6] This example can help visualize it better. Lets say we start in steady state and suppose that a natural disaster destroys a substantial fraction of the capital stock. In neoclassical growth theory there are at least two things might happen. A behavior theory would say that to the return to the initial steady state can take a very long time because saving-investment rate is fixed at its original value; the optimizing version gets back to its steady state much sooner.[7] The problem might be proving this models with empirical studies. According to Noy and Nualsi (2007), the neoclassical model does not deal very well with the growth

[4] See Center, T. P. (2007).
[5] See Cavallo and Noy (2010).
[6] See Solow R. (1999).
[7] See King and Rebelo (1993).

experience of developing countries. They concluded that a negative shock has more effect in the stock of human capital than stock of physical capital. Negative shocks in the stock of human capital decreased growth rate with no eventual return to the previous growth path, while negative shocks to the stock of physical capital do not seem to have much statistically observable effect on long–run growth. The reduction in capital stock is not necessary to be a reduction on the output since in the short-run productivity is reduced. In the post–event short–term, natural disasters indirectly lower economic growth because productivity decreases. Both output and capital generated by a worker decreases after a natural disaster. The decline in productivity might depend on the strength of the economy. In the long–run economies recover and the rate of consumption both private and public is foreseen to increase. This can be translated into an increase in GDP and positive economic growth can be level the pre–event output. As Cavallo et al. (2010) explained, unless a natural disaster is caused by a substantial political change, the economy will not experience (positive) growth.

Usually a regression framework is applied to evaluate the determinants of the consequent impacts of disasters. For example, Raddatz (2007) used a regression to estimate the effect of external shocks on short-term output in developing countries. He found that natural disasters have an adverse short-run impact on output by a small fraction in low–income countries. Also, described some structural and institutional details that make the negative effect more pronounced. Later, Noy (2009) complements the regression analysis by Raddatz (2007) concluding that countries with higher education, better institutions, higher income per capita, higher degree of openness to trade, higher levels of government spending and, more foreign exchange reserves are better able to withstand the initial disaster shock and prevent further externalities. Later on, Raddatz (2010) extended his analysis to different income groups. This time concludes that smaller and poorer states are more vulnerable, especially to climate events, and most of the output cost of climatic events occurs during the year of the disaster.

The short–run impact of natural disasters in a given economy, on average, has a negative impact on economic growth (Raddatz (2007), Rodriguez–Oreggia et al. (2009) Strobl (2011)). In fact, the effect is most compelling for developing countries and small economies (Lozayza ey al. (2009), Noy (2009)). Yet, a need to examine the methods of evaluation can help determine whether the effects are temporary or enduring. When compared with short–term studies, the literature on the long–term effects of natural disasters is limited and the results inconclusive. Is important to separate the short–term impacts from the long–term ones. A short-term work could not consider the ongoing trends and can bias the results.

Some studies had question the role of monetary response in a natural disaster. Albala–Bertrand (1993) suggested that foreign and public disaster response may be better used to help actual victims and affected activities directly than belief that the economy will be heavily affected by the disaster. Years later, Raddatz (2010) supports his findings mentioning that allocation of aid has historically done a small impact in diminishing the output consequences of climatic disasters.

Raddatz (2010) found that the level of external debt has no relation to the output impact of any type of disaster. This is usually linked to the government's ability to manage and respond to natural disaster.

On monetary policy there is even less research of the disaster dynamics. Natural disasters involve risks and vulnerabilities. Many recent disasters have happened in heavily insured countries. Each economy response to natural disaster is different. It is certain that the exact quantity to reestablish the economy and social structure remains uncertain. Albala–Bertrand (1993) concluded that the expected fall in growth rate of output after a natural disaster appears to represent be a small fraction of the loss–to–output ratio therefore, the reconstruction investment required to maintain output level as it was pre-event appears to be a small fraction of the disaster loss ratio. Is sure that the implementation of specific policies can help reduce the damage after a natural disaster. Since government are typically held accountable for their response to disasters, they have strong incentives to invest in reconstruction. The direct impact of natural disaster first affects infrastructure, capital stock and natural resources.

A reason for the lack of studies, if not the main one, is the difficulty of constructing a counterfactual. A counter–factual would explain, for example, what would happen to the output of a country in absence of the natural phenomenon. Hochrainer (2009) used an autoregressive model (ARIMA) to extrapolate pre–disaster trends in GDP and construct counter–factuals of a medium–term evolution of *GDP* if the disaster would have not occurred.[8] He finds that natural disasters on average lead to negative consequences, but the effects are significant only in the case of large shocks. Nonetheless, Coffman and Noy (2012) also provided an alternative method for case studies of natural disasters to deal with the counter–factual problem by constructing a proper one.

3. A Peek at Puerto Rico's Economy with Georges

Like many islands, tourism characterizes Puerto Rico's economy. Figure 2 illustrates the trend of one of the primary indicators of the tourism sector. In 1998, the number of tourist arrivals reached the lowest point caused by the direct damage of Georges. After 1998, the construction of new hotels and the Puerto Rico Convention Center increased the number of registrations.

[8] Up to 5 years after the disaster event.

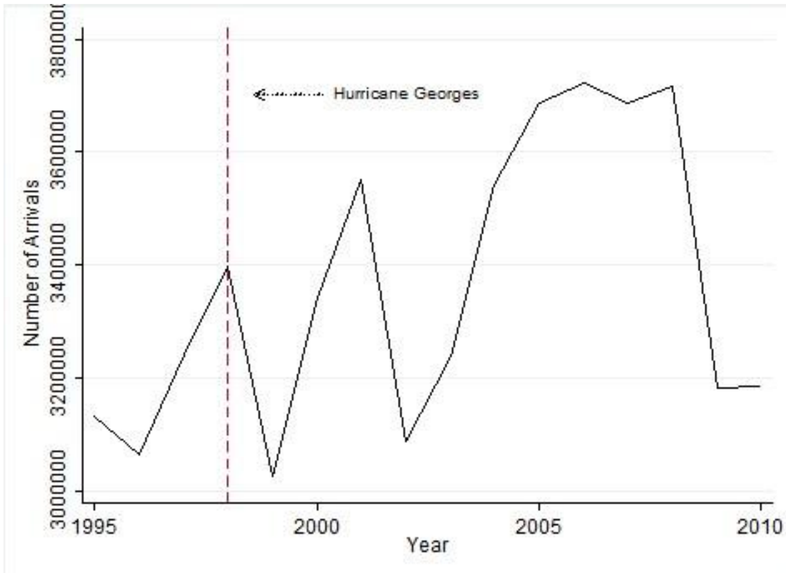
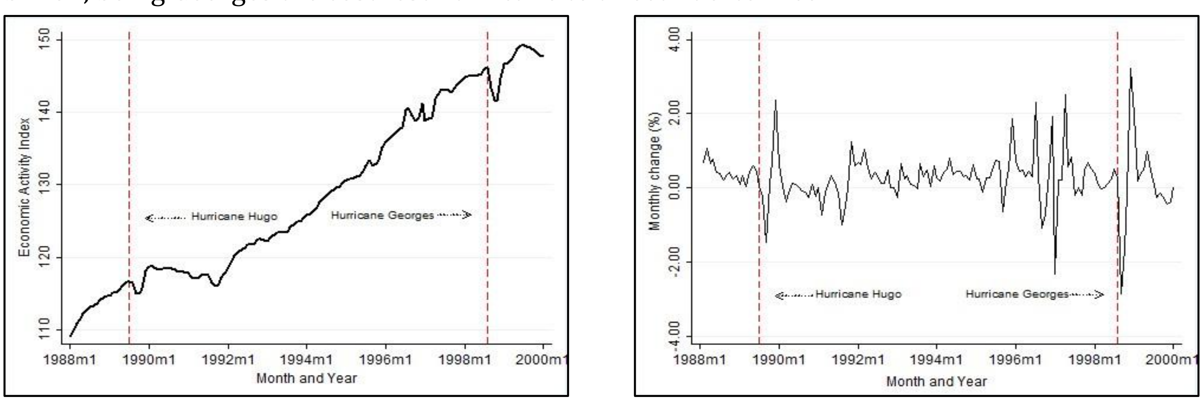


Figure 2: International Tourism by Number of Arrivals, Puerto Rico, 1995 - 2010

Between the period of 2001—2010, the North American economy experienced two economic recessions. The first between March and November 2001 and the second between December 2007 and June 2009, the latter with an adverse global impact. Both recessions affected the arrival of tourists to the Island, reducing the volume of visitors in the years after both recessions, mainly due to the high dependence of the North American tourist.[9]

Many hurricanes had cross Puerto Rico, but both Hugo in 1989 and Georges in 1998 were the most important.[10] According to the National Oceanic and Atmospheric Administration of the U.S. (NOAA), the estimated damage for Georges was US$3.6 billion, and for hurricane Hugo was US$1 billion, being Georges the costliest hurricane to affect Puerto Rico.



(a) Yearly

(b) Percentage Change

Figure 3: Economic Activity Index of Puerto Rico, 1988 - 2000

9 An approximate of 60 percent of the visitors of the Island come from the United States.

10 This is before September of 2017 Hurricane Maria

From figure 3 it can be seen the magnitude of both Hurricanes in the economy of Puerto Rico. Figure 3a and figure 3b show the EAI (Economic Activity Index of Puerto Rico) from January 1988 to January 2000. The EAI is a coincident indicator of the economy of Puerto Rico but has a different growth rate than the Gross National Product (GNP)[11] even though, is highly correlated with the real GNP.[12] This index is composed of four indicators which are Cement sales, Gasoline consumption, Electric power generation and, Total non–farm payroll employment.

Georges formed on September 15 of 1998 as a tropical depression in the far eastern Atlantic and reached category four intensity on the Saffir–Simpson Hurricane Scale on September 19th of 1998. In the Caribbean, Georges came across Puerto Rico, the island of Hispaniola (the Dominican Republic and Haiti), and Cuba the 21st through 24th. Two days before Georges came across Puerto Rico, on September 19, the authorities issued a hurricane watch and a day later the watch upgraded to a hurricane warning for the entire island. More than 1,600 people evacuated to public schools and public buildings. Later on, Puerto Rico is declared a state of emergency.

The Planing Board Of Puerto Rico is the government organization responsible of making a report of the damages caused by natural phenomenons. By March of 1999, the total estimate of the damages were US$4.287 billion.[13] This meant almost a 12 percent of the GNP and a 8 percent of the GDP. Georges affected the entire infrastructure of the Island, damaging all sectors of the economy. Infrastructure had the biggest share, 66.4 percent.

Among the damages, the energy distribution network was not functioning for two days, disabling almost all economic activity. Approximately 1.3 million customers, equivalent to 100 percent, lost electric power service. Besides, the internal communication routes suffered considerable damage, with the destruction of bridges and roads next to the debris dragged by the winds of the hurricane. The damage of Hurricane Georges in Puerto Rico included eight indirect fatalities. Most of the indirect fatalities were due to carbon monoxide poisoning after operating a gasoline–powered generator inside homes. There was considerable damage to homes throughout the island. A total of 72,605 homes were damaged, of which an estimate of 39 percent destroyed (Guiney, J. L. (1999)). Many rivers overflowed, from 3—6 meters of storm surges appeared in succession, and three tornadoes developed.

Earlier hurricanes like San Ciriaco in 1899 (deadliest so far), 3,369 people were killed and 312 in San Felipe in 1928. The main difference between both was that the Puerto Rico Weather Bureau sent radio warnings to dozens of police district to announce the hurricane and this prevented many casualties, even though the damage was still high. Hence, the surprise effect was not present.

---

[11] The EAI uses Gross National Product (GNP) instead of Gross Domestic Product (GDP) since the US$18,975.7 million gap between GNP (1998), US$35,110.8 million, and GDP, US$54,086.4 million, represents the profits of individuals and companies (primarily American multinational companies) that operate in Puerto Rico with base of operations not in the Puerto Rico. Figures in current US$.

[12] See Economic Report to the Governor 1999, Table 1, Planning Board of Puerto Rico.

[13] See Impacto Economico del Huracan Georges en Puerto Rico, Planing Board of Puerto Rico

Even though the initial impact of the hurricane was negative, an extraordinary injection of funds that followed influenced economic activity in the upcoming year 1999.[14] The economic activity indicators fell during September and October. By November, stable signs of recovery begin to register. In 1999 the GNP increased by 4.2 being the first time in 20 years to pass a 4 percent growth.

The aid, both federal and local, contributed to the rapid short–term recovery of the economy. The total amount approved by FEMA (Federal Emergency Management Act) was US$2.530 billion. On behalf of private sources, such as insurance companies and the Red Cross, Puerto Rico received an estimated 1.31 billion dollars. In the first two months after Georges made its final in the United States, the American Red Cross spent 104 million dollars on relief service.[15]. Together with the contribution of the state government, the funds for restoration were US$4.081 billion, which was a 95 percent of the estimated cost of the hurricane. In general, the recovery was achieved in a short time, apart from the agricultural sector.

Some papers may suggest that foreign and public disaster response may be better used to help actual victims and affected activities directly than belief that the economy will be heavily affected by the disaster[16].

4. Synthetic Control Method (SCM)

The methodology was introduced initially by Abadie and Gadeazabal (2003) to develop a synthetic Puerto Rico. In their work, the synthetic control method was used to evaluate the impact of terrorism in the Basque Country in Spain. The authors used Catalunya to create the synthetic Basque Country because of their similarities. In later work, Abadie et al. (2010) formalized the model to assess the impact of Proposition 99 in California on tobacco use. Abadie demonstrated that the synthetic control method could estimate unbiased coefficients with relatively few pre–event observations. Both studies use a different rage in hire pre–treatment period. For instance, in Abadie and Gadeazabal (2003) the period had only 13 years of pre-event data, on the other hand, Abadie et al. (2010) used 30 years (1970—2000).

The base of the synthetic control methodology is constructing a counter–factual group obtained as a weighted combination of non–treated countries. The counter–factual is not constructed by extrapolating pre–event trends from the treated countries but instead by building a synthetic control group; using as control group other untreated countries that estimate the missing counter–factual. The advantage of building a counter–factual is that the pre-intervention characteristics of the treated unit can be approximated by a combination of untreated units than by any single

[14] See Budget Report 2001, Economics Office, Government Development Bank of Puerto Rico

[15] This includes the Virgin Islands, Puerto Rico, Alabama, Louisiana, Mississippi, the Florida Keys and the Florida Panhandle.

[16] See Albala–Bertrand (1993).

untreated unit. The countries in the donor pool used to obtain the synthetic control must not be affected by the treatment.

A vital element of the synthetic control method is an adequate donor pool as the control group. When comparing studies that aim to identify the impact of an event, researchers rely on an event of considerable magnitude and similar unit of observations that do not experience the event. By using several controls that together can build a statistically reasonable counter–factual. The donor pool use includes a total of 62 other countries. Their combination can provide a better comparison for Puerto Rico than any single unit alone.

The counter–factual plays a significant role when analyzing policy in Social Sciences but sometimes is non–existent or is difficult identifying it. Is then when the researcher must conduct a comparative study or use a traditional statistical method. Both approaches have their benefits and disadvantages. A case study allows the researcher to make an in–depth analysis of a policy implication, but quantitative inferences are hard to make. Regression analysis would provide an estimate of the average impact of the policy or event and could hide cross–unit disparities. However, difference–in–difference analysis and randomized trials are used as an alternative to a counter–factual analysis. An alternative is the use of the synthetic control method by Abadie and Gadeazabal (2003) which offers a combination of qualitative and quantitative methodologies.

The weights assigned to the non–treated countries used to build the synthetic control must minimize the mean squared error of pre–treatment outcomes. The variables to evaluate the pre–treatment characteristics must approximate the path of the treated country but should not vary that could anticipate the result. The synthetic control method provides an innovative procedure to compare and unit when no untreated unit can make a good comparison for the event, in our case a hurricane. The results of the study will depend on our counter–factual and how well it simulates the treated unit.

Now we will describe more formally the synthetic control method.

4.1. Model

This paper follows Abadie et al. (2015) to formalize a model for only one treated unit. Let $J + 1$ be the available countries in the sample (62 countries) classified by sub–index j being $j = 1$ the treated unit or Puerto Rico and $j = 2$ to $J + 1$ the potential controls that form the donor pool. Table 4 of the appendix illustrates the donor pool that will function as a source for potential comparison units. The units are supposed to approximate the counter–factual of the country of interest with no intervention hence, is important choose in the donor pool countries with similar outcomes and exclude all countries that were affected by the event found in table 6 of the appendix. A balanced panel with longitudinal data is constructed with all countries are observed from periods, $t = 1,2,...,T$. The sample includes a positive number of pre–hurricane periods, T_0, as well as a positive number of post–hurricane periods, T_1, with $T = T_0+T_1$. Unit 1 is exposed to the hurricane during period $T_0 + 1,...,T$, and the intervention does not affect during the pretreatment period $1,...,T_0$. To measure the effect of Georges, we need a combination of untreated countries, rather than only one, that better approximate the treated country. By producing a weighted average of the countries in the donor pool, the synthetic control is created. The idea the synthetic control can be represented by a $(J * 1)$ vector of non–negative weights $W = (w_2,...,w_{J+1})$, for $j = 2,...J$ and $w_2 + + w_{J+1}$ which sum to one. Each different value for W produces a different synthetic Puerto Rico and therefore choosing a value for W is equivalent to choosing a synthetic control. Let X_1 be a $(k * 1)$ vector containing the values of the pre–hurricane characteristics of the treated unit of which is aiming to match. X_0 is to be the matrix of values of the same variables for the countries in the donor pool with a dimension of $k * J$. The pre–hurricane characteristics in X_1 and X_0 may include pre–intervention values of the outcome variable.

The difference between the pre–hurricane characteristics of the treated unit (Puerto Rico) and a synthetic control (Synthetic Puerto Rico) is given by the vector $X_1 - X_0W$. Synthetic Puerto Rico is given by weight, W^*, that minimizes the size of this difference. According to Abadie and Gardeazabal (2003) and Abadie, Diamond, and Hainmueller (2010) and (2015), W^* is the value that minimizes:

$$\Sigma_{m=1}^{k} v_m (X_{1m} - X_{0m} W)^2$$

Where $m = 1,...,k,$ and X_{1m} is a value all the way to the m-th variable for the Puerto Rico and X_{0m} be a vector $(1*J)$ with values to the m–th variable but for the donor pool. Moreover, v_m is a weight assigned to the m-th variable to measure disparity in X_1 and X_0W. Then, let Y_{jt} the outcome of j at time t and, let Y_1 be a vector $(T_1 * 1)$ for the values of the Puerto Rico (treated unit). Hence, $Y_1 = (Y_{1T0},...,Y_{1T})^0$. Similarly, let Y_0 be a matrix $(T_1 * J)$ where a column j includes the values of post–hurricane of the outcome for unit $j + 1$.

The comparison of the post–period gives the synthetic control estimator hurricane outcomes between the Puerto Rico (treated unit), who is exposed to the hurricane, and Synthetic Puerto Rico (control), who is not exposed to the hurricane, $Y_1 - Y_0W^*$. To sum up, in a post–hurricane period t ($t \geq T_0$), the synthetic control estimator can be described as:

$$Y_{1t} - \Sigma_{j=2}^{J+1} w_j^* Y_{jt}$$

Only the units that are similar in both observed and unobserved determinants of the outcome variable should produce similar paths of the outcome variable over the period.

Two assumptions need to fulfil for the efficiency of the method. These assumptions can be summarized in two effects, the anticipation effect and, spillover effect. First, there must not be any effect on the outcome before the implementation. To verify the outcome, placebo test to verify the robustness of the result. Second, the outcomes of the untreated units cannot be affected by the intervention in the treated unit.

4.2. Data

To perform the synthetic control method, we need to find potential control units that share the same characteristics but not subjected to the same treatment as the treated unit. Finding acceptable potential units is challenging. The variables used in the study are due to their availability in pre-event and post-event period of Georges. The variable under study is Purchasing Power Parity over GDP. Using this indicator as a dependent variable is easy to compare results between countries considering is a conversion to evaluate the difference in prices levels between countries. Since the synthetic control method uses a weighted average of the variables, we gather variables that included population, consumption, prices, trade, GNP to GDP ratio, industry employment, education and life expectancy for a group of countries. These macroeconomic variables reflect the economic status of each country and will help construct the counter–factual needed to compare synthetic Puerto Rico with actual Puerto Rico. The database includes different sources. Some of the data came from the World Data Bank and the Penn World Tables version 7.1. published by the University of Groningen.[17] The tables have available ten years of pre–event data necessary to study Hurricane Georges. This empirical analysis uses annual country–level panel data for period 1991—2010. A detail specification of the variables appears in the appendix.

The World Data Bank provides macroeconomic data which includes world development indicators compiled from international sources. They have available international data that includes national, regional and global data. The education data for Puerto Rico is retrieved from a national database different from every other country. For tourism, is used the number of arrivals found World Bank for Puerto Rico.

5. Synthetic Puerto Rico and the Effects on the GDP

The difference between the behavior of the treated unit and that of its synthetic control after treatment gives us the estimated effect of Georges. The outcome variable of interest, Y_{jt}, is the Purchasing Power Parity over GDP for country *j* at time *t*. The Purchasing Power Parity (PPP) is in national currency units per US dollar. As predictors, we rely on a standard set of economic growth indicators for the treated countries.

Table 1 presents the selected donor countries for the construction of Synthetic Puerto Rico. Puerto Rico's counter-factual is best reproduced by the weighted average of Ethiopia, Gambia, Ireland, Saint Lucia and, Tonga. For the rest of the countries, the weight was either 0 or lower. Of these five countries, Ireland has the most substantial weight (76 percent). Following by Saint Lucia (13 percent).[18] Tonga followed with a 10 percent and Ethiopia with 1.2 percent. The smallest weight was Gambia with 0.1 percent.

[17] The 7.1 version of PWT is not the latest one available but is one of the recent versions that includes Puerto Rico.
[18] The country issued a storm alert but was discontinued and did not suffer any damage from Georges in 1998

Country	Weight	Country	Weight
Ethiopia	0.012	Saint Lucia	0.125
Gambia	0.001	Tonga	0.104
Ireland	0.758		

Table 1: Donor pool countries and their weight

Figure 4 displays the path of the Purchasing Power Parity over GDP of Puerto Rico versus the potential controls including all 62 countries from 1991 to 2010. There is a noticeable difference

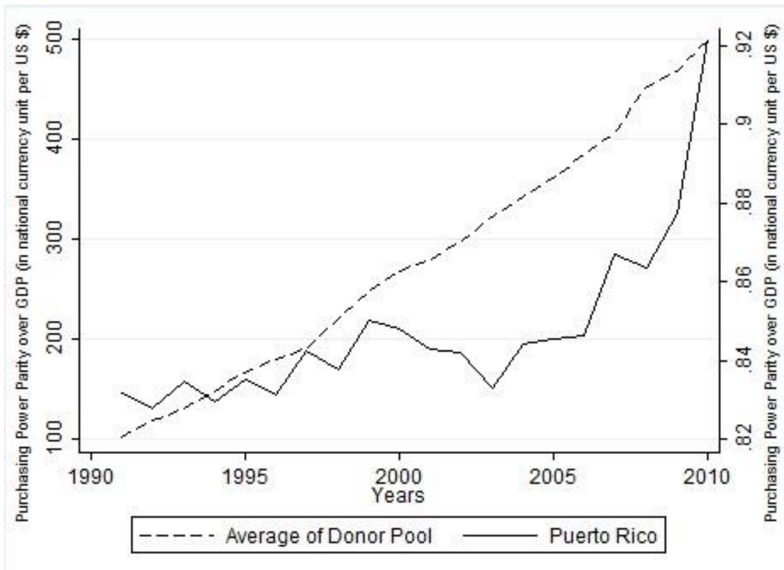


Figure 4: Donor Pool and Puerto Rico

in magnitude between Puerto Rico and the donor pool, but they share the same upward trend. To prevent bias, we must select countries with some similarities as possible controls. Thus, in the potential controls, there are countries located in the Caribbean that were not affected by the event, Saint Lucia.[19]

[19] Jamaica was finally excluded from the potential control due to the availability of education data.

Predictors	Puerto Rico Real	Puerto Rico Synthetic	Average of 62 control countries
Population (in thousands)	3,654.2	3,409.1	36,334.8
Consumtion share of PPP (%)	62.5	62.3	69.0
Price Level of GDP (US = 100)	83.3	83.4	64.4
Openness at Current Prices (%)	126.9	121.1	79.0
Ratio of GNP to GDP (%)	67.9	93.3	98.4
PPP Converted GDP Per Capita	19,400.3	18,140.9	14,809.3
Industry Employment	23.0	26.9	21.8
Primary Education Pupils	362,118.3	333,326	3,959,188
Life Expectancy at Birth (years)	74.1	74.0	68.9

Table 2: PPP over GDP predictor means

The table 2 compares the pre-event fit of Synthetic Puerto Rico and a population-weighted average of the countries in the donor pool. We can notice that the pool does not reflect much similarities with Real Puerto Rico and Synthetic Puerto Rico is much closer to the Real than the average of 62 countries. The predictors of our dependable variable do not include any lagged values of the dependent variable considering the contributing by Kaul et al. (2015) that using all outcome lags as separate predictors cause all other covariates irrelevant.

5.1. Effects of Hurricane Georges

Figure 5 displays the path of the Purchasing Power Parity over GDP of Puerto Rico versus synthetic Puerto Rico from 1991 to 2010. The synthetic control method minimizes the root mean square prediction error (RMSPE) between the actual and synthetic Puerto Rico. The RMSPE measures the lack of fit between the path of the outcome variable for any particular country and its synthetic counterpart. The pre–1998 RMSPE for Puerto Rico is 0.0112. The Purchasing Power Parity over GDP in synthetic Puerto Rico follows actual Puerto Rico until a bit before Hurricane Georges, meaning that synthetic Puerto Rico appears to be a control for the real Puerto Rico. After 1998, both curves diverge and without reaching previous levels during the rest of the period.

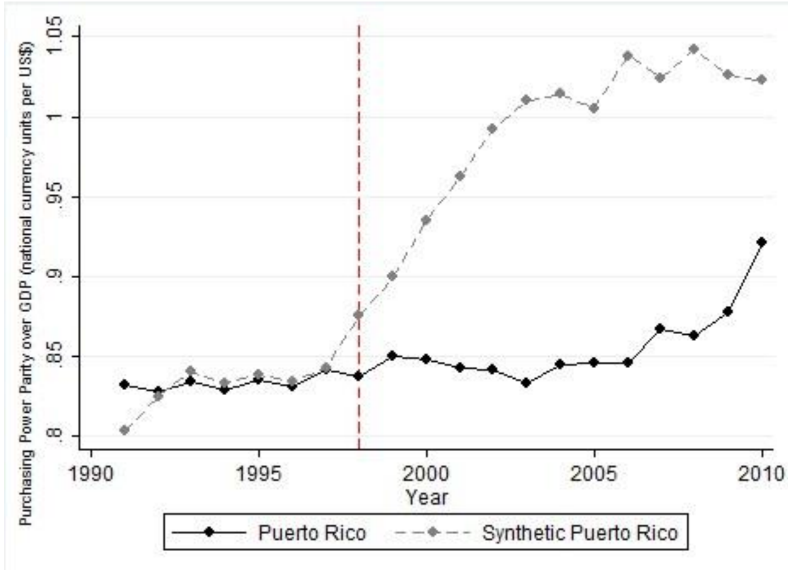


Figure 5: Puerto Rico vs Synthetic Puerto Rico

The difference between actual Puerto Rico and Synthetic Puerto Rico gives us an estimate of the effect of Hurricane George in Puerto Rico. Figure 6 shows the difference between our counter–factual and control twelve years after the event.[20] In the pre–hurricane period the difference between treated and donor pool is very close except for the first year on analysis. The highest point in the gap can be noticed in 2006 with up to minus 19 percent of the difference. At the beginning of 1998, an adverse effect is shown just before the event. One reason might be that the data used to construct our panel data is annually the immediate effect of the hurricane pull the average down in 1998. The gap keeps growing once the hurricane has occurred and remains unclosed in 2010. Overall, figure 6 suggest an average of 9 percent loss in Purchasing Power Parity over GDP cause by Georges.

[20] The estimation uses an option that uses more time but gives a better fit and the synthetic weights.

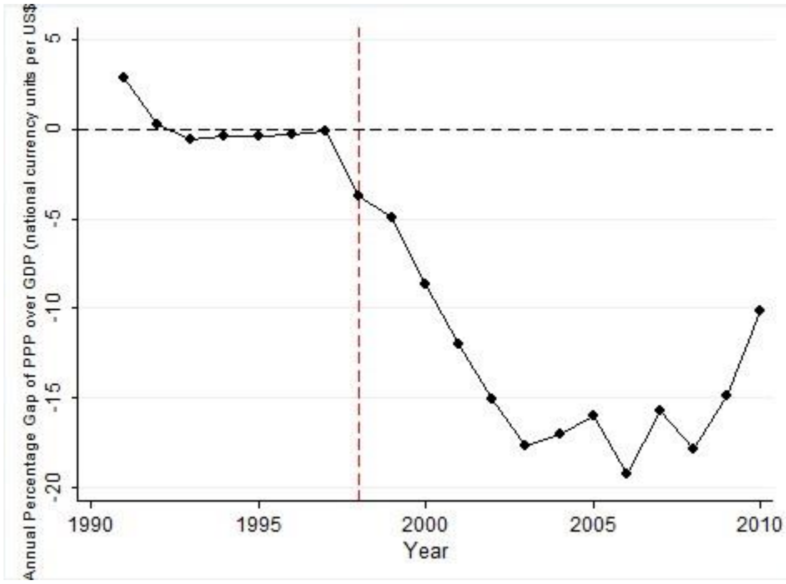


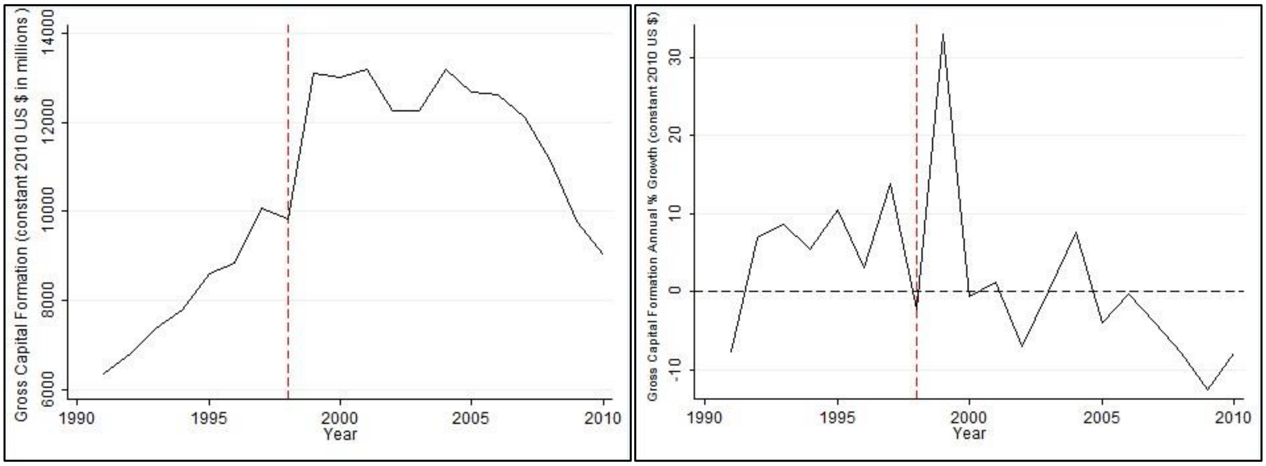
Figure 6: Annual gap between Puerto Rico and Synthetic Puerto Rico

One concern in the context of this study is the potential existence of spillover effects. In particular, it is possible that Georges had effects on our PPP variable in countries other than Puerto Rico. However, the limited number of units in the synthetic control allows the evaluation of the existence and direction of potential biases created by spillover effects (Abadie et al., 2015). Another concern involves the inability of our dependent variable to capture the whole effect of the hurricane, for instance, the loss of capital.

Figure 5 suggests indeed that recovery was until the next year. Our dependent variable returns to pre–Georges levels in 1999. The possible cause may be thanks to the amount of recovery funds and aids transferred. Those funds stimulated the economy until 2002.

Figure 7 consists of outlays on additions to the fixed assets of the economy plus net changes in the level of inventories.[21] The curve diminishes a year before the event and increases soon after. This hike in the post-event period can be as a result of an increase in construction and economic activity. Capital formation reaches 1997 level ten years later. Puerto Rico went from a 13.82 percent positive growth in 1997 to a negative growth of 2.3 in 1998 in capital formation. The sharp increase in 1999 in figure 7b can be due to the response of disaster relief funds. The level of growth in 1997 was not achieved in the examined period, excluding the 1999 growth change. After the monetary aid, the percentage change in the gross capital formation became unstable. In figure 7b the curve had more values beneath the zero-reference line than in the pre–event period.

[21] The fixed assets include land improvements, as fences, ditches, drains, machinery and equipment acquisitions, construction of roads, schools, offices, hospitals and, commercial and industrial buildings. Inventories are stocks of goods held by firms to meet temporary or unexpected fluctuations in production or sales.



(a) Yearly

(b) Percentage Change

Figure 7: Gross Capital Formation of Puerto Rico, 1991 - 2010

6. Placebo Studies

By conducting a placebo test we evaluate the robustness of the results. A placebo test consists of two type of tests. The first, a placebo test in–time, can be conducted by randomly reassigning the invention time for example, to pre-intervention dates or changing the treatment year. Second, is a placebo test in–time which consisted of changing the treatment country different from Puerto Rico. If overall predictability somehow fell after 1998, or if our synthetic control was a poor predictor of Hurricane Georges compared to what could be achieved for other countries, then our results would not be informative.

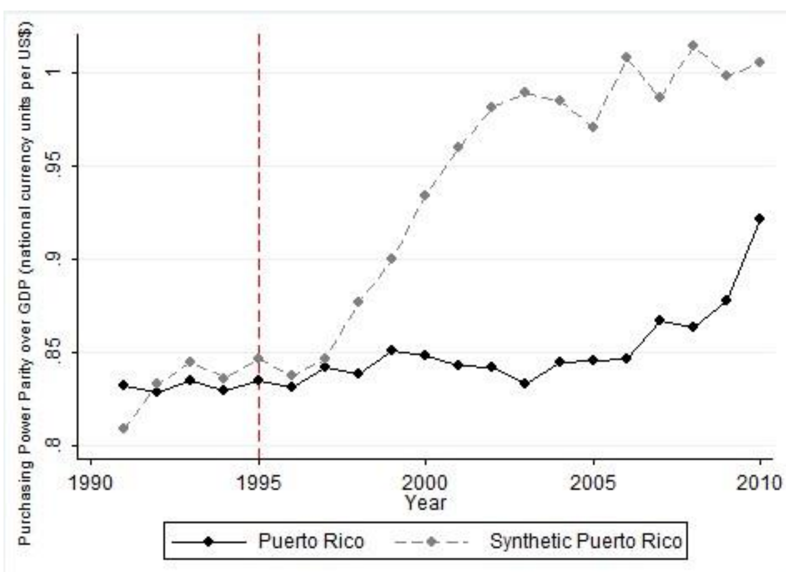


Figure 8: Placebo effect in time

Figure 8 displays the path of synthetic Puerto Rico and Puerto Rico when the treatment time is changed three years earlier to 1995. After the event, we can notice a similar trend as the pre–period. Since the synthetic Puerto Rico estimation has an MSPE of 0.0112, if the pre-event MSPE is lowest than the post–event MSPE which signifies that if a country is selected randomly from the sample the chances to obtain the same results is 1/62 (2015) w 0.16.[22]

Another option of a placebo test in–space. To do so, the country with the most similar characteristics is selected as the treated unit.[23] If we follow the results from table 1, the synthetic control method shows that the country that attributes most weight is Ireland since is almost three-quarters of Synthetic Puerto Rico. Next, the placebo in–space is performed using Ireland as the treated unit.

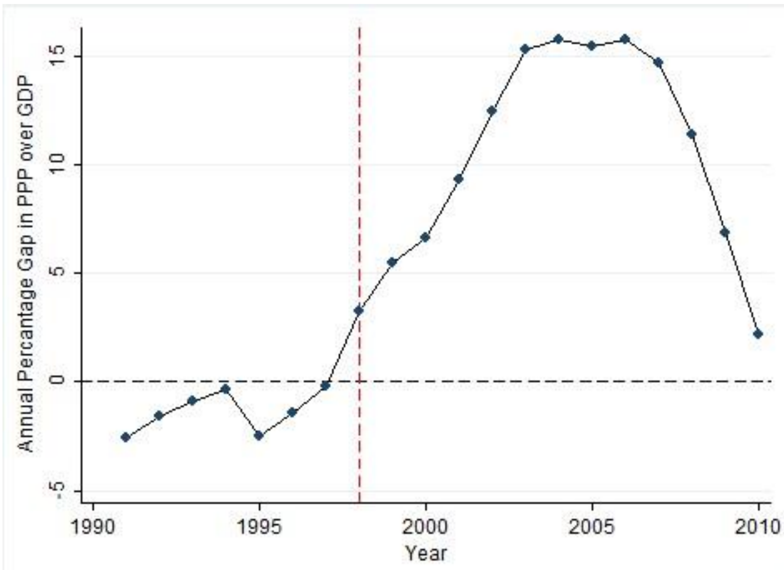


Figure 9: Placebo effect in space, Ireland

In figure 9 a positive effect is noticed in the placebo test of Ireland. Reaching pre-event levels in early 2010. Ireland experienced a positive effect due to an event in 2008 contradicting most of the literature in case studies. Then the effect of the event was not significant for Ireland.

To account for any unobservable characteristics during are treatment period a difference in differences method is applied in the next section.

7. Alternative Analysis: Difference-in-Difference Approach

To assess the possible unobserved characteristics in the donor pool, a different and complementary method is considered. A double difference estimation allows for the presence of unobserved characteristics by restricting the effect of the control group constant in time, so it can be eliminated. The difference–in–difference method considers the inability to account for all

[22] See Abadie et al.,. 2010.

[23] Another option in the estimation was used and some goodness of fit was sacrificed. The synthetic weights where not given using the rest of the countries.

missing factors that might influence the dependable variable. The aim is still the same, evaluate the effects in Puerto Rico of Georges in 1998. The difference in difference method relies on a comparison between the affected country as a participant and the unaffected countries as non-participants before and after the event or intervention.

Table 3 shows the output of three different estimations. Column 1 shows the output of a difference in difference procedure using all non–participants of the event to construct the counter–factual. Column 2 includes all the variables used in the Synthetic Control Method. Column 3 does a difference in difference synthetic approach because uses synthetic Puerto Rico as the only non–participant of the event. We include an interaction term between time and treatment group as the dummy variable in a regression named *DiD*. The differences–in–differences estimators (coefficient of *DiD*, in all columns, present a small p–value which indicates strong evidence against the null hypothesis. The effect is statistically significant. With this test, we can conclude that the treatment has a negative effect on the treated unit.

The reason to include column (3) of Synthetic Puerto Rico and Real Puerto Rico is that we benefit from the way the SCM constructed an almost similar trend in the pre–treatment period, so it does not violate the parallel trend assumption. On the other hand, the column (1) and (2) use all the data from the control group. The method is applied taken into consideration that some serial correlation could occur.

Variables	GDP (PPP)		
	(1)	(2)	(3)
Time	204.9*** (39.94)	128.9*** (38.88)	0.157*** (0.0159
Treated	-150.5*** (20.13)	-265.4** (115.2)	0.00199 (0.00530)
DiD	-204.9*** (39.94)	-258.8*** (44.89)	-0.135*** (0.0173)
Constant	151.3*** (20.13)	-49.25 (303.9)	0.831*** (0.00500)
Population (in thousands)		0.00289 (0.00248)	
Consumption share of PPP (%)		-5.271*** (1.343)	
Price Level of GDP (US = 100)		-6.633*** (1.187)	
Openness at Current Prices (%)		1.703* (0.972)	
Ratio of GNP to GDP (%)		-1.343 (2.583)	
PPP Converted GDP Per Capita		-0.0104*** (0.00242)	
Industry Employment		-19.23*** (3.791)	
Primary Education Pupils		-2.09e-05 (2.13e-05	
Life Expectancy at Birth (years)		23.13*** 4.647)	
Observations	1,240	1,230	40
Control Group #	62	62	2
R-squared	0.016	0.146	0.815

Robust standard errors in parentheses

***p<0.01, **p<0.05, *p<0.1

Table 3: (1) DD, (2) DD with other variables,(3) DD of Synthetic Puerto Rico

8. Recent Economic Shocks

Recently, Puerto Rico encountered two significant economic shocks. The first one was when on may of 2017 Puerto Rico's governor officially declares "bankruptcy", or a form of government default since in the U.S law is not allowed for P.R to declare bankruptcy. Approximately about US$74 billion in bond debt and US$49 billion in unfunded pension obligations. Puerto Rico in two years made an attempt to reduce its debt burden and save the economy. However, it was proved to be unsuccessful and motivation for the governor to declare the bankruptcy. Even though this is mostly a type of bankruptcy case, since Puerto Rico is banned from using Chapter 9 bankruptcy chapter, it received a new federal law instead for insolvent territorial governments by the name of Puerto Rico Oversight, Management and Economic Stability Act.

Puerto Rico has been in an aching recession since 2006. The beginnings go back to the 1980s when the government from both principal political parties in the island started financing infrastructure with bonds money. The crisis has many origins. The main one was to issue too much bond debt and rely on borrowed funds to balance the budget. To name a few more reasons, the Jones act of 1917, the disappearing tax advantages (Section 936) and population decline.

The second hit was in September 2017. In early September, and by natural causes due to Caribbean weather, two major hurricanes of the highest categories hit the island in a period of two weeks from each other. The second one, Maria, was the strongest and most destructive storm to hit the island in 80 years. The cost, both human and financial, have just begun to be accounted. What is certain is that Puerto Rico now confronts a more profound economic crisis and humanitarian crisis.

Many problems arose from this hurricane. The island was short on water, food and medical supplies up to a hazardous level. The infrastructure was the most affected sector with a widespread power outage since the storm knocked out almost the 90 percent of the island's transmission lines. Many service industry jobs have been impacted, especially those in hospitality and the food industry. Is too soon to estimate the long–term effects of these hurricanes on employment and economic activity but will motivate the argument behind this work.

The costliest hurricane in U.S history was 2005 Hurricane Katrina with an estimated death toll of 1,833. To compare the magnitude of Maria, a recent study by Harvard estimates Maria's death toll at 4,645, even though the official government death was 64.[24]

Although Maria escalated Puerto Rico's financial adversity into a humanitarian crisis, the island had already been reeling from years of financial missteps and economic struggles. Nevertheless, if we consider Raddatz (2009), the country's level of external debt has no relation to the impact on the output by a natural disaster. Given these circumstances, for a country in a recession economy hit by a natural disaster, a future analysis using a synthetic control method can help estimate the long–term effects of these hurricanes in the economy of Puerto Rico.

[24] Kishore, N., et al. (2018)

9. Conclusion and Unanswered Questions

To date, many case studies have used the synthetic control method to evaluate policy and natural disasters. This case is not an exception. The synthetic control method turned out to be a useful tool to analyze the effect of a hurricane. The estimated damage of Hurricane Georges was of US$4.99 billion which is 1998 represented an 8 percent of the GDP of Puerto Rico. This study estimates an adverse effect by Georges of a 9 percent average gap in the Purchasing Power Parity over GDP in 12 years, with the highest effect of 16 percent in 2006. Hurricane Georges was a significant economic shock with negative consequences to Puerto Rico (See Hochrainer (2009)).

After the event the economy experience (positive) growth. Indeed, productivity fell, and capital formation increased post-event as found by Albala–Bertrand (1993). We can attribute the increase of output to the amount of aid received. According to Hochrainer (2009), higher aid reduces the adverse macroeconomic consequences of the event. Despite the substantial aid transfers from the federal and local government and, private sources, Puerto Rico did not close the gap in the 12 years after the event when compared with the synthetic part. The presence of the stimulus package as a response to the damage of Georges was indeed crucial in the stabilization of the economy of Puerto Rico.

The results were subjected to placebo tests and a complementary difference-in-difference analysis. By conducting two types of placebo test, it can be concluded that the results are a robust and not mere coincidence. The placebo test in–time suggest that nothing occurred before the event in 1998 that cause a divergence between Puerto Rico and its synthetic part. This approach tries to capture the failure to account for all potential factors that might influence the dependent variable. The difference–in–difference supported the results obtained by the synthetic control method.

Is sure that the economics of natural disasters can predict an eventual stabilization of growth rate but is difficult to compensate for its more significant loss. Beyond these results, is challenging to address with certainty the socio–economic impact. In short, the real cost of a hurricane is not captured in this case study, since we cannot quantify the individual experiences of the victims. The GDP can sometimes omit the damage of the capital and human destruction. Using the parable of the parable the broken window by French economist Frederic Bastiat, theory is confined to that which is seen; it takes no account of that which is not seen, meaning that if a window is broken it may increase the GDP but may harm the economy.[25]

A major challenge is identifying additional key predictors for the dependable variable but not less important finding affinity between them in the synth procedure. Apparent improvements for future studies might be the use of other variables that allow the inclusion of a more similar potential units. Two variables that seem interesting are external debt and monetary transfers but was not included due to the availability and small sample. A more detail analysis including both could be a valuable contribution for future work.

[25] From Essays on Political Economy (1850) ”That which is seen, and That which is not seen”. By Frederic Bastiat.

10. References

Abadie, A., Gardeazabal, J. (2003). The economic costs of conflict: A case study of the Basque Country. American economic review, 93(1), 113-132.

Abadie, A., Diamond, A., Hainmueller, J. (2010). Synthetic control methods for comparative case studies: Estimating the effect of Californias tobacco control program. Journal of the American statistical Association, 105(490), 493-505.

Abadie, A., Diamond, A., Hainmueller, J. (2015). Comparative politics and the synthetic control method. American Journal of Political Science, 59(2), 495-510.

Alan Heston, Robert Summers and Bettina Aten, Penn World Table Version 7.1 Center for International Comparisons of Production, Income and Prices at the University of Pennsylvania, November 2012.

Albala-Bertrand, J. M. (1993). Natural disaster situations and growth: A macroeconomic model for sudden disaster impacts. World Development, 21(9), 1417-1434.

Bastiat, F. (1869). Essays on political economy. What is seen and what is not seen. Ideas on Liberty, 51, 12-16. Western news Company.

Barro, R. J. (1998). Determinants of Economic Growth: A Cross-country Empirical Study. MIT Press.

Boose, E. R., Serrano, M. I., Foster, D. R. (2004). Landscape and regional impacts of hurricanes in Puerto Rico. Ecological Monographs, 74(2), 335-352.

Cavallo, E. A., Noy, I. (2009). The economics of natural disasters: a survey. Bureau of Economic Research.

Cavallo, E., Powell, A., Becerra, O. (2010). Estimating the direct economic damages of the earthquake in Haiti. The Economic Journal, 120(546), F298-F312.

Cavallo, E., Galiani, S., Noy, I., Pantano, J. (2013). Catastrophic natural disasters and economic growth. Review of Economics and Statistics, 95(5), 1549-1561.

Center, T. P. (2007). The deadliest, costliest, and most intense United States tropical cyclones from 1851 to 2006 (and other frequently requested hurricane facts) (p. 43). Miami: NOAA/National Weather Service, National Centers for Environmental Prediction, National Hurricane Center.

Coffman, M., Noy, I. (2012). Hurricane Iniki: measuring the long-term economic impact of a natural disaster using synthetic control. Environment and Development Economics, 17(2), 187-205.

Guimaraes, P., Hefner, F. L., Woodward, D. P. (1993). Wealth and income effects of natural disasters: An econometric analysis of Hurricane Hugo. The Review of Regional Studies, 23(2), 97.

Guiney, J. L. (1999, January). Preliminary Report Hurricane Georges, National Hurricane Center. Retrieved from (www.nhc.noaa.gov/data/tcr/AL071998 Georges.pdf) Updated 9 September 2014 for U.S. damage. National Oceanic and Atmospheric Administration.

Hallegatte, S. (2012). Economics: The rising costs of hurricanes. Nature Climate Change, 2(3), 148-149.

Hochrainer, S. (2009). Assessing the macroeconomic impacts of natural disasters: are there any?. The World Bank.

Hurricane Georges - September 1998. Retrived from (www.weather.gov/mob/georges)

Kaul, A., Klner, S., Pfeifer, G., Schieler, M. (2015). Synthetic Control Methods: Never Use All Pre-Intervention Outcomes Together With Covariates.

King, R. G., Rebelo, S. T. (1999). Resuscitating real business cycles. Handbook of macroeconomics, 1, 927-1007.

Kishore, N., Marqus, D., Mahmud, A., Kiang, M. V., Rodriguez, I., Fuller, A., ... Maas, L. (2018). Mortality in Puerto Rico after Hurricane Maria. New England journal of medicine.

LA ECONOMIA EN EL AO FISCAL 1999: PRODUCTO BRUTO. (n.d.). Retrieved from (pre-supuesto.gobierno.pr/PresupuestosAnteriores/af2001/INFOREFE/cap economia.htm Banco Gubernamental de Fomento- Oficina de Economa.)

Loayza, N., Olaberria, E., Rigolini, J., Christiaensen, L. (2009). Climate change and growth: going beyond the averages. World Bank Policy Research Working Paper, 4980.

Nejm.org. (2018). Mortality in Puerto Rico after Hurricane Maria. The New England Journal of Medicine. Massachusetts Medical Society[online] Available at: www.nejm.org/doi/pdf/10.1056/NEJMsa1803972 [Accessed 30 May 2018].

Nordhaus, W. D. (2006). The economics of hurricanes in the United States (No. w12813). National Vecchi, G. A., Knutson, T. R. (2008). On estimates of historical North Atlantic tropical cyclone activity. Journal of Climate, 21(14), 3580-3600.

Noy, I. (2009). The macroeconomic consequences of disasters. Journal of Development economics, 88(2), 221-231.

Noy, I., Nualsri, A. (2007). What do exogenous shocks tell us about growth theories? (No. 07-16). Working Papers, Santa Cruz Center for International Economics.

Raddatz, C. (2007). Are external shocks responsible for the instability of output in low-income countries?. Journal of Development Economics, 84(1), 155-187.

Raddatz, C. (2009). The wrath of God: macroeconomic costs of natural disasters. The World Bank.

Rodriguez-Oreggia, E., De La Fuente, A., De La Torre, R., Moreno, H. A. (2013). Natural disasters, human development and poverty at the municipal level in Mexico. The Journal of Development Studies, 49(3), 442-455.

Sattler, D. N., Preston, A. J., Kaiser, C. F., Olivera, V. E., Valdez, J., Schlueter, S. (2002). Hurricane Georges: A cross-national study examining preparedness, resource loss, and psychological distress in the US Virgin Islands, Puerto Rico, Dominican Republic, and the United States.
Journal of Traumatic Stress, 15(5), 339-350.

Scatena, F. N., Larsen, M. C. (1991). Physical aspects of hurricane Hugo in Puerto Rico. Biotropica, 317-323.

Solow, R. M. (1999). Neoclassical growth theory. Handbook of macroeconomics, 1, 637-667.

Steinglass, P., Gerrity, E. (1990). Natural Disasters and Posttraumatic Stress Disorder ShortTerm versus LongTerm Recovery in Two DisasterAffected Communities 1. Journal of applied social psychology, 20(21), 1746-1765.

Strobl, E. (2011). The economic growth impact of hurricanes: evidence from US coastal counties. Review of Economics and Statistics, 93(2), 575-589.

11. Appendix A

Data Sources

- Purchasing Power Parity over GDP (in national currency units per US$) Source: Penn World Tables 7.1 (retrieved from Groningen Growth, University of Groningen, and Development Centre) Note: Over GDP, 1 US dollar (US$) = 1 international dollar (I$).

- Consumption share of PPP (%)Source: Penn World Tables 7.1 (retrieved from Groningen Growth, University of Groningen, and Development Centre).

- Population (in thousands) Source: Penn World Tables 7.1 (retrieved from Groningen Growth, University of Groningen, and Development Centre)

- Price Level of GDP, G-K method (US = 100) Source: Penn World Tables 7.1 (retrieved from Groningen Growth, University of Groningen, and Development Centre).

- Openness at Current Prices (%) Source: Penn World Tables 7.1 (retrieved from Groningen Growth, University of Groningen, and Development Centre).

- Ratio of GNP to GDP (%)Source: Penn World Tables 7.1 (retrieved from Groningen Growth, University of Groningen, and Development Centre).

- PPP Converted GDP Per Capita (Laspeyres), derived from growth rates of c, g, i, at 2005 constant prices Source: Penn World Tables 7.1 (retrieved from Groningen Growth, University of Groningen, and Development Centre).

- Employment in industry (% of total employment) (modeled ILO estimate) Source: World Data Bank. Define by the World Bank as persons of working age who were engaged in any activity to produce goods or provide services for pay or profit, whether at work during the reference period or not at work due to temporary absence from a job, or to working-time arrangement. The industry sector consists of mining and quarrying, manufacturing, construction, and public utilities (electricity, gas, and water), in accordance with divisions 2-5 (ISIC 2) or categories C-F (ISIC 3) or categories B-F (ISIC 4).

- Education: Puerto Rico Department of Education Enrollment by Grade. Number of students enroll in primary education primary education from 1-7 grade of school (approximate age of 5 - 12 years old). Source: Instituto de Estadisticas de Puerto Rico (retrieved from indicadores.pr/dataset) Primary Education, Pupils (for every other country) Define as the total number of pupils enrolled at primary level in public and private schools. Source: UNESCO Institute for Statistics(retrieved from World Data Bank).

- Gross capital formation (constant 2010 US$) Source:World Bank national accounts data, and OECD National Accounts data files.

- Tourism: International tourism, number of arrivals for Puerto Rico. Fiscal year end: June 30. International inbound tourists (overnight visitors) define as the number of tourists who travel to a country other than that in which they have their usual residence, for a period not exceeding 12 months and whose main purpose in visiting is other than an activity remunerated from within the country visited. Source: World Tourism Organization, Yearbook of Tourism Statistics, Compendium of Tourism Statistics and data files.

- Economic Activity Index, Historical Data (January 1980 = 100) Source: Government Development Bank for Puerto Rico.

- Life expectancy at birth, total (years) indicates the number of years a newborn infant would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life. various sources (retrieved from World Data Bank).

Table 4: Affected Countries

Countries Affected by Hurricane Georges in 1998	
Antigua and Barbuda	Puerto Rico*
Guadeloupe	United States
St. Kitts and Nevis	*Alabama*
British Virgin Islands	*Florida*
Dominican Republic	*Georgia*
Haiti	*Louisiana*
Bahamas U.S. Virgin Islands* Cuba	

*Unincorporated & Organized U.S Territory

Table 5: Potential Units and Weights

List of Affected Countries							
Country	Weight	Country	Weight	Country	Weight	Country	Weight
Albania	0	Germany	0	Saint Lucia	0.125	Uganda	0
United Arab Emirates	0	Guinea	0	Lesotho	0	Poland	0
Australia	0	Gambia	0.001	Morocco	0	Puerto Rico	Treated
Austria	0	Greece	0	Mexico	0	Paraguay	0
Benin	0	Hungary	0	Mali	0	Qatar	0
Bulgaria	0	Indonesia	0	Malta	0	Romania	0
Bolivia	0	India	0	Mongolia	0	Senagal	0
Brunei Darussalam	0	Ireland	0.758	Mauritania	0	Slovakia	0
Bhutan	0	Iran	0	Maurutius	0	Sweden	0
Algeria	0	Iceland	0	Namibia	0	Swaziland	0
Ecuador	0	Italy	0	Niger	0	Chad	0
Spain	0	Japan	0	Nicaragua	0	Tonga	0.104
Ethiopia	0.012	South Korea	0	Netherlands	0	Tunisia	0
Finland	0	Kuwait	0	Norway	0	Tanzania	0
France	0	Lao	0	New Zealand	0	Uruguay	0
Vietnam	0	Peru	0				

Institut de Recerca en Economia Aplicada Regional i Pública
Research Institute of Applied Economics
Universitat de Barcelona
Av. Diagonal, 690 • 08034 Barcelona

WEBSITE: www.ub.edu/irea/ • **CONTACT:** irea@ub.edu