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INDUSTRIALES PUERTO RICO
MANUFACTURA ■ SERVICIO ■ COMPETITIVIDAD ■

Preliminary Estimate: Cost of Damages by Hurricane María in Puerto Rico

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Highlights

- Hurricane Maria made landfall in Puerto Rico on Wednesday, September 20th, with sustained winds of 155 mph and gusts of up to 175 mph, causing tremendous devastation and destruction to the island's infrastructure.
- This report provides an initial measurement of estimated damages and partial lost revenues caused by hurricane Maria. Two methodologies were used for the total damage assessment:
    - Research by the International Monetary Fund (IMF)[1] that provided measurements of damages from wind speed as percent of GDP;
    - An extrapolation of damages recorded in Puerto Rico after hurricane Georges in 1998.
- The most destructive hurricane in recent memory (and the closest comparable event to hurricane Maria) is Hurricane Georges. Total damages left by Georges were estimated by FEMA at $5.7 billion, with over $4 billion inflicted upon housing and other structures, and $350 million in damages to the electrical grid.[2]
- Damage by Hurricane Maria is estimated between **$16 and $20 billion** – 3 to 4 times the present (2016) value of the damages by Hurricane Georges. Electric and communications infrastructures are estimated to be impacted by **up to $1.6 billion and $567 million**, respectively.
- **At least $1 billion in additional economic losses** can be attributed to lost income by employees, which would have gone towards consumption expenditures.

Concept	Impact Georges	Impact Maria (Lower Bound)	Impact Maria (Upper Bound)
Infrastructure Damage	$5,179	$15,135	$18,956
Electric	$358	$1,300	$1,600
Water	$21	$60	$75
Transportation	$31	$100	$120
Housing & Other Structures	$4,746	$13,275	$16,594
Communications	$22	$400	$567
Economic Damages	$500	$1,050	$1,313
Agricultural Output	$166	$116	$145
Government	$334	$934	$1,168
Total	**$5,678**	**$16,185**	**$20,268**

Sources: US Federal Emergency Management Agency (1999), Plan de Acción Presidencial Para la Recuperación a Largo Plazo de Puerto Rico.PR Planning Board (2001), Impacto Económico del Huracán Georges 1999. Acevedo, S. (2016). Gone With the Wind: Estimating Hurricane Climate Change Costs in the Caribbean [Working Paper]. Retrieved from the International Monetary Fund Database. 1Represents lost revenue from stoppages in service, estimated by multiplying a $30 monthly average telephone bill by 2 months, and multiplying said subtotal by the affected consumers. 2According to the PR Planning Board, room-nights lost by tourism cancellations were offset by increased room nights from additional assistance personnel. 3Estimated by assuming partial damages worth 10% of the median household value, and a value of $50,000 for total losses in households.

[1] Acevedo, S., *Gone With the Wind: Estimating Hurricane and Climate Change Costs in the Caribbean*, IMF Working Paper, October 2016.

[2] Impacts are given in 2016 dollars, after adjusting for inflation using the Puerto Rico Consumer Price Index (CPI) for fiscal years 1998-2016.

Introduction

Hurricane Maria made landfall in Puerto Rico on Wednesday, September 20th, with sustained winds of 155 mph and gusts of up to 175 mph. This caused tremendous devastation and destruction to the island's infrastructure, leaving most residents without access to electricity, water, telecommunications and fuel. As a result of the fuel shortage, businesses and individuals have severely restricted their operations, and many employees have been left temporarily unemployed. Estimates to repair and reestablish these key services are measured in months.

The key element in the damages suffered has been the impact that a weakened and obsolete electric power infrastructure has had on a number of other activities and entities such as hospitals, transportation and, in general, the reconstruction efforts. Two weeks after Maria, electricity has been restored to fewer than 10% of users. The hurricane has made clear the need not just to return the system to its pre-hurricane status, but to transform it into a modern, resilient and efficient electric power system. This is essential for the Island not only to recover from María, but to return to sustainable economic growth.

This report provides an initial measurement of estimated damages and partial lost revenues caused by hurricane Maria. Two methodologies were used for the total damage assessment:

1. Research by the International Monetary Fund (IMF)[3] that provided measurements of damages from wind speed as percent of GDP;
2. An extrapolation of damages recorded in Puerto Rico after hurricane Georges made landfall in 1998.

The report begins with the economic context detailing the state of the economy prior to Maria as well as the differences with respect to 1998. This was the last year a hurricane of this magnitude made landfall in Puerto Rico, hurricane Georges. Cost estimates of Georges as well as aid received afterwards are detailed after this section. A literature review and methodology section is also provided. Estimates of the cost of damages, loss of tourism income, and impact on economic growth are presented in the final sections.

The damages, lost economic activity in two key utilities (PREPA and PRASA), and economic impacts presented in this report utilize information made public during the

[3] Acevedo, S., *Gone With The Wind: Estimating Hurricane and Climate Change Costs in the Caribbean*, IMF Working Paper, October 2016.

first two weeks after hurricane Maria made landfall. As such there is a margin of error that must be considered. As more information is made public in the coming months this estimate will be revised and could probably increase. Any estimate has a risk element, sometimes these are downside and other times upside. In our case all risk elements in the estimates suggest that the final cost estimate will be higher, not lower than the likely estimate in this report of some $20 billion.

Previous Experience: Hurricane Georges[4]

The most destructive hurricane in recent memory (and the closest comparable event to hurricane Maria) is Hurricane Georges. Hurricane Georges made landfall in Puerto Rico on September 1998 and left a tremendous amount of devastation. An estimated damage assessment by FEMA was published in 1999 (FEMA, 1999), detailing a total damage estimate of $5.7 billion.[5] Over $4 billion of the damages caused by the hurricane was inflicted upon housing & other structures; damage to the electrical grid was estimated at over $350 million, and the communication sector suffered an estimated $22 million in damages.

It must be remembered that the communications sector in 1998 had very little internet/cell phone infrastructure and cell phones were still considered a luxury. In addition, these costs could be underestimated as they do not take into account losses in individual income and/or consumption.

[4] An important source of information used in this report is the Action Plan published by FEMA after hurricane Georges made landfall in Puerto Rico (FEMA, 1999). This plan served as the basis for the costs of hurricane Georges.

[5] Impacts are given in 2016 dollars, after adjusting for inflation using the Puerto Rico Consumer Price Index (CPI) for fiscal years 1998-2016.

Table 1 – Cost of Damages of Hurricane Georges

Concept	Impact Georges
Infrastructure Damage	$5,179
Electric	$358
Water	$21
Transportation	$31
Housing & Other Structures	$4,746
Communications	$22
Economic Damages	$500
Agricultural Output	$166
Government	$334
Total	**$5,678**

Influx of Federal Funding

In response to the aforementioned damage, over $6 billion dollars were injected in the island's economy through a combination of federal relief funding, central government investment, the Red Cross, and private insurers' disbursements.[6] The largest sources of relief funding were federal funds and insurance disbursements. In addition, approximately 12,500 assistance personnel were deployed, who generally stayed in hotels throughout the length of the relief efforts.

Although the mitigating funds may seem larger than the aforementioned damage estimates, relief funds and insurance disbursements are not limited to infrastructure recovery, but also cover lost economic activity such as individual income and consumption.

[6] See footnote 3.

Table 2 – Funds Received to Mitigate the Impact of Hurricane Georges

Funding Source	Estimate ($ millions)
Federal Funds	$3,835.9
FEMA (Individuals and Government)	$2,260.5
Insurance Reimbursements	$1,835.4
Central Government	$243.1
Red Cross	$104.4
Total	**$6,018.7**
Number of Assistance Personnel	12,500

Source: PR Planning Board (1999). *Impacto Económico del Huracán Georges.*

Key Differences with Respect to the Historical Experience

The experience with Hurricane Georges provides detailed insights into the expected recovery response to Maria. However, two main differences exist: the scale of damages, and the economic context of Puerto Rico. These will be discussed briefly in the following sections.

Scale of Damages

The damage footprint of Maria is noticeably larger than that of Georges. Energy and telecommunications infrastructures suffered dramatic losses: as of October 3, 2017, nearly 78% of all cell phone towers were down, whereas electric coverage in the island is only 6.9%, with very slow recovery due to the collapse of the power transmission infrastructure. In addition, blocked roads, coupled with a shortage of both diesel and manpower made for a large-scale fuel bottleneck. Many coastal areas remain underwater or heavily flooded, and will require specialized equipment to recover.

Economic Context

Compared to Georges, Hurricane Maria impacted an economy that had undergone a long process of economic contraction that had weakened its infrastructure, production activities and, to a significant extent, its resiliency. Infrastructure investment declined significantly and a much more fragile public sector fiscal condition substantially limited its margin for action. A pivotal point in this period is fiscal 2006, which marked the beginning of the contraction in the economy of Puerto Rico. Economic growth, population, and job market trends became especially negative after this year, owing to both external and internal factors.

Figure 1

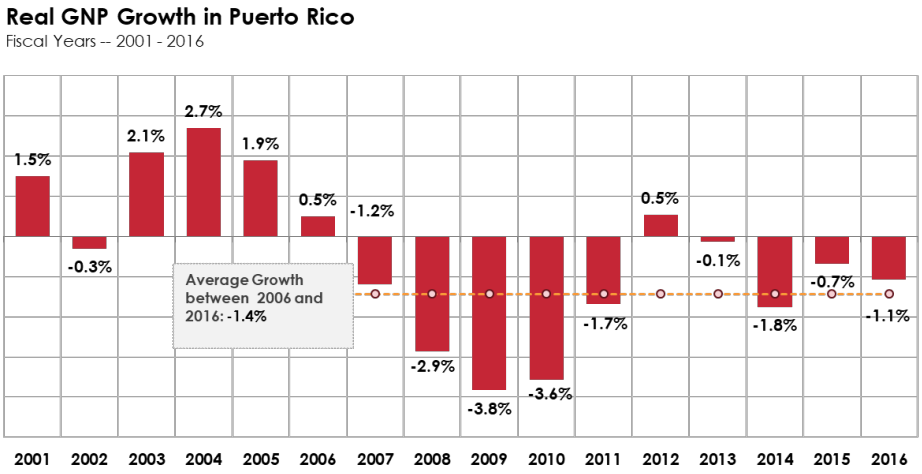
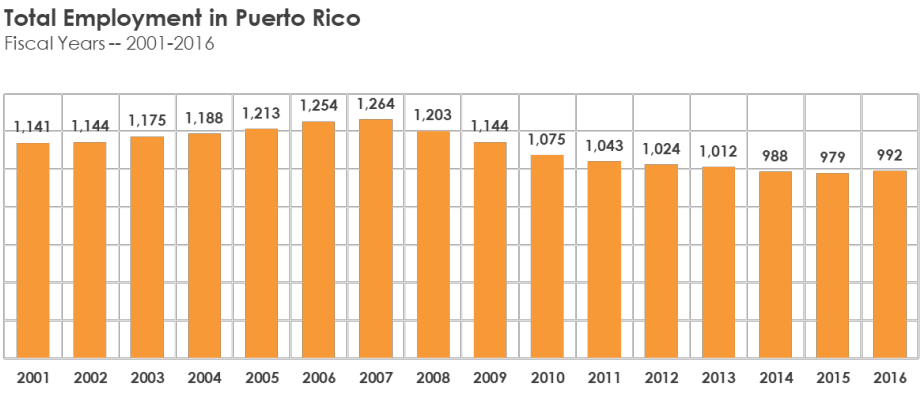
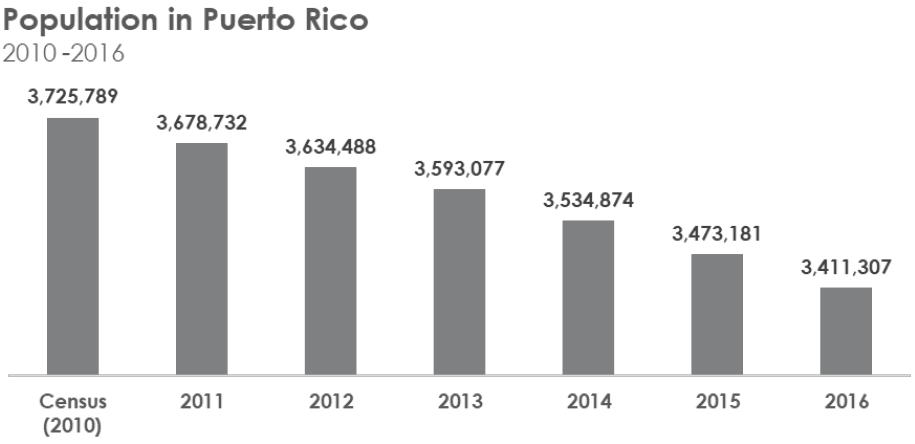


Figure 2



Source: PR Department of Labor and Human Resources (2016). *Serie Histórica Fuerza Trabajadora, Empleo y Desempleo.*

Figure 3



Source: US Census Bureau (2017). Annual Estimates of the Resident Population [Table PEPANNRES].

An important consequence of this prolonged decline is the erosion of important economic sectors in the island, both in terms of size as well as their capital stock. Estudios Técnicos, Inc. (2016) identified four key economic engines that experienced significant declines during the last 10 years: construction, manufacturing, finance, and the public sector (Estudios Técnicos, Inc., 2016). The following table summarizes key indicators that serve to illustrate their current trends, and the extent of their contraction with respect to the beginning of the 2007-2016 decade and 1999 (the year after Georges). The growth observed in 2012 indicators is largely due to ARRA funds spent during that fiscal year.

Table 3

Performance Indicators of Four Key Economic Sectors in Puerto Rico
Fiscal Years 2007, 2012-2016

Indicator	2012	2013	2014	2015	2016	Compound Growth 2007-2016	Compound Growth 1999-2016
Construction			Year over Year				
Gross Domestic Fixed Investment	18.1%	-12.7%	-14.4%	-7.1%	-10.7%	-7.6%	-4.8%
Housing	-21.0%	3.5%	-20.3%	-1.8%	2.8%	-13.8%	-7.0%
Industrial, Commercial and Other Buildings	36.3%	-12.6%	-10.3%	-6.4%	-13.1%	-4.2%	-3.3%
Government	21.5%	-17.8%	-24.4%	-17.9%	-26.3%	-10.2%	-6.2%
Housing Units Sold*	2,575	1,903	1,673	1,470	1,141	-20.5%	
Vacant Housing Units**	3.4%	5.2%	6.2%	4.6%		6.7%	
Manufacturing			Year over Year				
Employment	-2.7%	-6.8%	-1.6%	-1.0%	-1.2%	-4.0%	-3.9%
Number of Establishments	1,983	1,909	1,846	1,819	1,840	-5.4%	-3.2%
Industrial Energy Consumption	-5.3%	-6.7%	-5.1%	-0.9%	-4.5%	-6.0%	-3.3%
Finance							
Total Assets ($ Millions)	$68,128.7	$63,598.8	$60,383.1	$56,519.4	$56,898.6	-5.9%	-4.0%
Net Loans and Leases ($ Millions)	$47,146.1	$43,755.0	$40,472.7	$36,324.4	$34,292.2	-6.3%	1.3%
Deposits ($ Millions)	$49,059.7	$48,013.6	$46,024.9	$44,067.6	$45,112.8	-3.4%	3.3%
Net Income % of Total Assets	0.4%	0.1%	0.9%	0.5%	0.3%		
					2007-2016 Average:	0.1%	
Public Sector			Year over Year				
Employment	0.3%	-5.8%	-4.3%	-1.7%	-2.0%	-3.1%	-1.5%
Government Consumption Expenditure	1.3%	-2.1%	7.4%	-10.2%	-4.8%	-1.9%	-0.5%
General Fund Net Revenues	6.2%	-1.2%	5.5%	-0.8%	2.4%	0.4%	1.6%
Debt % of GNP	95.1%	94.2%	97.8%	95.1%	91.6%		
					2007-2016 Average:	88.4%	76.5%
Budgetary Imbalance ($ Millions)	$589.2	$574.3	$517.5	$518.1			
					2007-2015 Accumulated:	$9,826.6	$12,522.8

Sources: Puerto Rico Planning Board (2017). Statistical Appendix. Commissioner of Financial Institutions of Puerto Rico (2017). Annual Report. U.S. Census Bureau (2017). American Community Survey (B25002). Bureau of Labor Statistics (2017). Current Employment Statistics and Quarterly Census of Employment & Wages. Puerto Rico Electric Power Authority (2017). Generation, Consumption, Costs, Income, and Clients of the Electrical System of Puerto Rico. Puerto Rico Treasury Department (2017). Statistics and Revenues. Puerto Rico Office of Management and Budget (2017). Statistics Tables.
Notes: *Compound Growth (2011-2016). **Compound Growth (2009-2015)

The expected impacts of hurricane Maria were atypically high in comparison with previous experiences, due to the prolonged deterioration of the island's infrastructure

and a very weak economy. The public sector is also in a weak fiscal condition, that limits the deployment of needed relief funding and constrains cash reserves.

Literature Review

This section explores previous research into hurricane damage estimates. Emphasis was given to studies providing detailed estimation methodologies, and to those focused upon the Caribbean. The studies and reports presented in this section were used as the basis for the estimates presented later on.

Acevedo (2016)

A key report analyzing the wind-speed damage elasticity in the Caribbean was a working paper by Acevedo (2016), published by the International Monetary Fund (IMF). This paper analyzed the economic costs of hurricanes in the Caribbean between 1950 and 2014, with the aim of determining the wind-damage elasticity of tropical cyclones in the Caribbean. The elasticity allows the researcher to estimate the cost of the damage as a percentage of GDP, given the highest sustained winds felt in the Island, whether the hurricane made landfall or passed nearby, and the distance to the nearest measurement station (typically the airport).

Key Findings

The report included the following findings:

1) The wind-damage elasticity was estimated at approximately 2 for cyclones that did not make landfall and 3 for those that did.

2) The impact of natural disasters is felt mainly through the destruction of capital stock. In other words, damage to housing, crops, roads, buildings, among others. This means that damages can exceed a country's GDP, given that a country's capital stock can be much larger than its GDP. Smaller Islands, which are more susceptible to suffering the effects of a tropical cyclone throughout the entire Island, are more likely to have damages that represent damage percentages higher than 100%.

3) Ten hurricanes accounted for 71% of all the damage caused by tropical hurricanes in the region. This means that most of the damage caused by hurricanes in the Caribbean were caused by hurricanes that had a particularly destructive path.

Methodology Used in the Report

A key strength of the report lay in the wealth of information and in-depth methodology used for generating the estimates. Acevedo (2016) compiled a panel data set by

merging three main sources: i) the International Disaster Database (EM-DAT); ii) the Caribbean Hurricane Network (CHN); and iii) National Oceanic and Atmospheric Administration (NOAA). The dataset includes all Caribbean countries, and even considers Puerto Rico and the impact of hurricanes Hugo and Georges. All damages in the dataset were afterwards adjusted by inflation and presented in 2010 constant US dollars.

In addition, significant controls and instruments were placed upon the econometric model. For example, the regression considered distance between the cyclone and the Island, and whether it made landfall, and incorporated population, and highest sustained wind. Several sets of estimates were conducted, with differing assumptions and results for each one. Finally, adjustments were made for underreporting of damages in past hurricanes (1950s-1960s), for the size of each island, and for the distances with respect to the nearest measurement station.

When comparing estimated with actual damages reported by Acevedo (2016) estimates for Puerto Rico are quite accurate although, as with any estimate, it is subject to a margin of error.

Other Studies

Wind-damage elasticities were calculated by several other researchers, although mainly for the US (Norhaus, 2010). In fact, only one study measuring the effects of hurricanes outside the US was found: a paper by Hsiang and Narita (2012) estimating the semi-elasticity of damages to wind-speed. This however, poses significant problems, given the higher value of the US's capital stock. For example, wind-damage elasticity was estimated by Norhaus to be closer to 9 – more than 3 times the estimate by Acevedo. The large variation in wealth between the US and Puerto Rico suggests that the US estimates should not be applied, as they could lead to an overestimation of the cost of damages.

Hsiang and Narita (Hsiang & Narita, 2012), estimated a semi-elasticity of damages to wind speed at 0.1. This means that for every 1.9 knots of increase in wind speed, damages increase by 10%. This is further proof that even a slight increase in wind speed can have a devastating effect on the residents of the impacted region.

Additional sources were also used such as local news outlets, newspapers and the Commonwealth's website which provides up to date information about the state of the recovery after hurricane Maria. The most current information available was utilized to estimate the cost of damages.

It should also be highlighted, as outlined by Hsiang & Narita (2012), that the effects of hurricanes can persist over many years, by reducing potential real GDP growth rates. As such the adverse effect of hurricane Maria will likely be felt over the coming years.

Methodology for Cost Estimates

Hurricane Maria has quickly become one of, if not the most, devastating hurricane in Puerto Rico's history. Given that only two weeks have passed since Maria made landfall, estimating the damage caused by such a hurricane is a challenging task. In this report, a two-part methodology was used to determine the damages caused by hurricane Maria: the first part estimates the overall expected impact, whereas the second part estimates the impacts by sector.

Estimates of Total Impact

For the first part, the methodology established by (Acevedo, 2016) was used. In his model, the natural logarithm of the highest reported sustained wind, and the wind-damage elasticities are used to estimate the total damage as a percentage of GDP according to the following formula:

$$LN(Wind) * \epsilon = Damage$$

Where:

LN = Natural Logarithm;

$Wind$ =Highest sustained wind reported;

ϵ = Wind-damage elasticity, as estimated by (Acevedo, 2016);

$Damage$ = Cost of Damages, as percentage of Puerto Rico's GDP.

This estimate was used as a lower bound, given that the case of Maria and Puerto Rico is significantly more destructive; a higher-than-average strength hurricane made landfall upon a weaker-than-average infrastructure in Puerto Rico. The margin of error thus carries a higher upward risk.

Estimates by Sector

The second part involved extrapolating the costs of hurricane Georges by each of its affected areas. Under this methodology, the distribution of damages by sector was assumed similar to that of hurricane Georges (after adjusting for inflation). However, several adjustments were made, considering that certain sectors such as telecommunications and utilities have likely suffered greater-than-proportional damages.

Estimates of damage to the electric power grid and sewage systems consider both capital damages and lost income as a result of lack of service. Approximately 1-2 months of revenue for the electric and water utility were expected to be affected. Telecommunications infrastructure damage, on the other hand, was estimated using the approximate cost per tower, ranging from $100,000 to $350,000 per tower.[7]

Infrastructure damage was adjusted using a new residential damage estimate, which considered the USGS report of 29,000 total losses in housing units, and 72,000 housing units with partial damages. An average value of $50,000 was given to total losses, as these housing units tend to be of lower built value and frequently are located in areas susceptible to flooding, landslides, and other such phenomena, thus lowering their value.

Estimates of Damages and Mitigation Funding

This section presents estimates of the cost of capital damages and the direct economic impacts of hurricane Maria. Afterwards, scenarios of possible inflows of federal and private mitigation funding are discussed. The cost estimates presented in this section relate solely to capital stock that is affected directly by hurricane Maria. For these purposes, capital stock includes agricultural crops, housing, roads, buildings, infrastructure. These estimates do not necessarily include lost economic activity because of the difficulty in estimating such losses given information constraints. Some numbers have been mentioned that are much higher than those in this report, both by the Fiscal Oversight and Management Board (FOMB) and the Government. The cost estimates in the report do not include the cost of reconstruction, but limit themselves to actual losses as indicated above, and follow closely the approach used by FEMA and NOAA. The estimates are not necessarily incompatible with those of the FOMB and the Government.

The estimates included here pertain solely to damage, and are not estimates of recovery costs. Recovery estimates will likely be costlier, as they include the additional capital and manpower required to rebuild the damaged infrastructure. Finally, it must be remembered that these are early-stage estimates, and could therefore change in the coming weeks as 1) more information about the damages caused by the hurricane are known and/or 2) important policy decisions are taken with respect to the relief efforts.

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[7] Cost as described by Airwave Advisors (June 9, 2015). *How Much Does a Cell Tower Cost?* [Web Article]. Retrieved October 4, 2017, from https://www.airwaveadvisors.com/how-much-does-a-cell-tower-cost/ .

Cost of Damages

The following table presents the damage distribution for Hurricane Georges, as well as lower and upper bounds for the estimated damages from Hurricane Maria. Damage caused by Maria ranged from $16 billion to $20 billion, or 3 to 4 times the damage caused by hurricane Georges. The sectors with the highest estimated damages are structures and the electrical grid. Damages to the electrical grid were estimated between $1.3 and $1.6 billion, but could rise as the cost of temporary generators and damages of uninspected areas are better known.

Table 4 – Cost of Damages Hurricanes Maria & Georges (Inflation Adjusted 2016)

Concept	Impact Georges	Impact Maria (Lower Bound)	Impact Maria (Upper Bound)
Infrastructure Damage	$5,179	$15,135	$18,956
Electric	$358	$1,300	$1,600
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Sources: US Federal Emergency Management Agency (1999). Plan de Acción Presidencial Para la Recuperación a Largo Plazo de Puerto Rico.PR Planning Board (2001). Impacto Económico del Huracán Georges 1999. Acevedo, S. (2016). Gone With the Wind: Estimating Hurricane Climate Change Costs in the Caribbean [Working Paper]. Retrieved from the International Monetary Fund Database. 1Represents lost revenue from stoppages in service, estimated by multiplying a $30 monthly average telephone bill by 2 months, and multiplying said subtotal by the affected consumers. 2According to the PR Planning Board, room-nights lost by tourism cancellations were offset by increased room nights from additional assistance personnel. 3Estimated by assuming partial damages worth 10% of the median household value, and a value of $50,000 for total losses in households.

Another sector were costs could increase is telecommunications. This sector will likely take months to return operations to 100%, and the cost of cell towers and antennas that need to be replaced could surpass the estimated $400 to $567 million.

Impact on Economic Activity

Economic activity in September and October of 2017 is expected to be severely hampered. Assuming a month's loss of wages, affected workers in the economy are estimated to have lost at least $1 billion in salary, which translates directly to sales. This will directly impact Commonwealth revenues, as it will likely mean a loss of Sales & Use Tax (SUT) revenue as well as a loss of income tax revenue. Lost Government revenues from these two sources alone over a two-week to one-month period could be well over $120 million.

To reach this estimate it was assumed that all salaried non-farm employees, as reported by the Quarterly Census of Employment (QCEW), were impacted by hurricanes Maria and Irma, both of which affected Puerto Rico. These estimates exclude workers in the

government, utilities, and health sectors which are assumed to have continued to work during the crisis.

This is a conservative estimate given that some sectors were assumed to be impacted for 50% of the time, or only half a month, such as retail, wholesale, transportation, waste management and hotels. Therefore, lost economic activity could be even greater.

Federal Assistance and Impact on Economic Growth

Two scenarios were developed to estimate the impact federal assistance and insurance claims disbursements could have on the local economy. The main difference between both scenarios is federal aid. Scenario 1 assumes that federal aid will total $2.5 billion, while scenario 2 assumes $5 billion in federal aid. Both scenarios assume the following:

- Inflation should increase to 4% due to an increase in spending throughout the year;
- Insurance disbursements total $5 billion;
- The distribution of FEMA funds is similar to that observed after hurricane Georges, 55% to individuals and 45% to the Commonwealth;
- Insurance disbursements and federal aid are assumed to be spent in fixed capital investment (public & private) as well as personal consumption;
- Funds are expected to be received in November and spent over the course of one year. Therefore, 60% of the impact should take place in fiscal 2018 and the remaining 40% will impact fiscal 2019.

Given past experiences with hurricanes in Puerto Rico, like Georges, it's no surprise that under both scenarios an increase in GNP is expected. This was even the case after hurricane Katrina in 2005 when Louisiana's GDP grew by 5.7% in real terms. Costs of damages of Katrina were estimated at $108 billion[8]. While hurricane Sandy, that hit the northeastern US had an estimated cost of $75 billion[9].

[8] Knabb, Richard D; Rhome, Jamie R; Brown, Daniel P; National Hurricane Center (December 2005). Hurricane Katrina: August 23 – 30, 2005 (Tropical Cyclone Report). United States National Oceanic and Atmospheric Administration's National Weather Service.

[9] Blake, Eric S; Kimberlain, Todd B; Berg, Robert J; Cangialosi, John P; Beven II, John L; National Hurricane Center (February 2013). Hurricane Sandy: October 22 – 29, 2012 (Tropical Cyclone Report). United States National Oceanic and Atmospheric Administration's National Weather Service.

The increase in spending fueled by insurance disbursements and federal aid leads to a boom in consumption and investment. The current trend in economic growth was taken into account in these estimates, its presented as the baseline growth. This was the expected growth prior to hurricanes Irma and Maria.

But this expansion in economic activity is only temporary, after 2019 Puerto Rico will likely return to a declining trend in GNP growth. Other socio-economic indicators, like migration, will likely continue to increase. Migration in fiscal 2018 could reach 90,000 to 100,000, further diminishing the Island's capacity to bounce back after the atmospheric and financial crises.

Economic Forecasts

Under scenario 1 GNP is expected to increase by 2.6% in 2018 and 1.7% in 2019. The largest increases are observed in private and public investment in construction which had shrunk considerably in the past years. This scenario assumes federal aid totaling $2.5 billion and insurance claims of $5 billion.

Table 5 – Estimated Economic Impact of Federal Relief Funds and Insurance Disbursements – Scenario 1

Concept	Baseline Growth	Expected Growth (%)	
		2018	2019
Personal Consumption Expenditures	-2.2	-0.04	-0.03
Government Construction Investment	-10.0	67.7	45.1
Private Construction Investment	3.0	107.8	71.9
Machinery and Equipment	0.0	15.1	10.0
GNP	-1.8	2.6	1.7

Source: Estimates by Estudios Técnicos, Inc. (2017).

With scenario 2, a $5 billion injection of federal aid and a further $5 billion from insurance claims economic growth could reach 5.5% in 2018 and 3.7% in 2019. Investment in construction would almost triple over the next two fiscal years.

Table 6 – Estimated Economic Impact of Federal Relief Funds and Insurance Disbursements – Scenario 2

Concept	Baseline Growth	Expected Growth (%)	
		2018	2019
Personal Consumption Expenditures	-2.2	1.2	0.8
Government Construction Investment	-10.0	141.3	94.2
Private Construction Investment	3.0	107.8	71.9
Machinery and Equipment	0.0	15.1	10.0
GNP	-1.8	5.5	3.7

Source: Estimates by Estudios Técnicos, Inc. (2017).

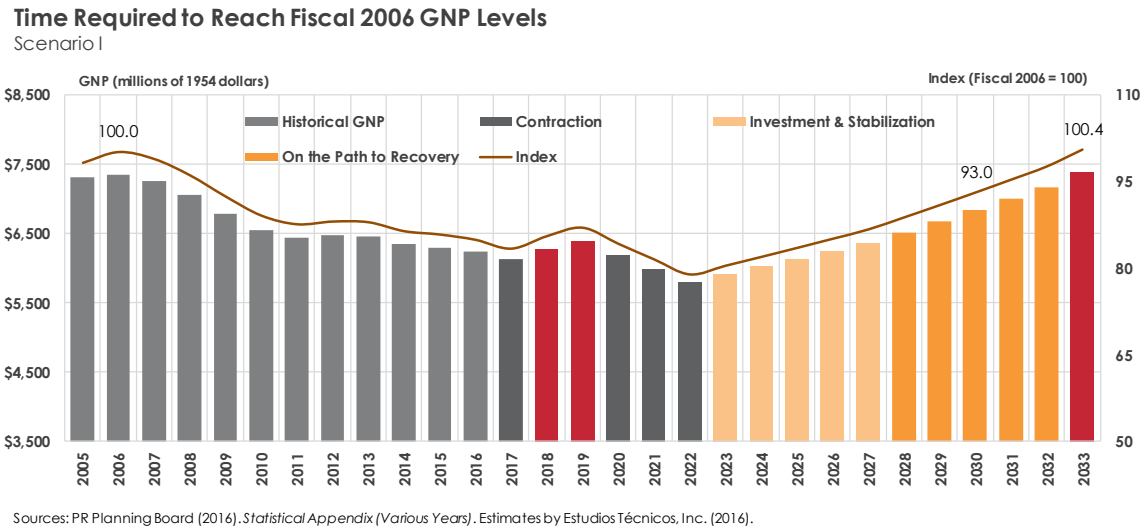
Recovery Scenarios

This section presents an exercise to determine how long it would take Puerto Rico's economy to return to 2006 levels. The exercise was conducted for both scenarios presented earlier, scenario 1 assumes $2.5 billion in federal aid and scenario 2 assumes $5.0 billion in federal aid.

After taking into account federal aid and insurance disbursements under both scenarios, this exercise assumes that after fiscal 2019 the fiscal plan will be reinstated as it currently is structured. This will lead to a contraction in economic activity that should average 3.2% between 2020 and 2023. Between 2023 and 2027 1.9% growth is assumed, 2.4% between 2028 and 2032, and finally 3.0% growth from 2033 onward.

Under scenario 1 it would take until 2033 for the local economy to reach 2006 levels. In scenario 2, 2006 levels would be reached by 2031-2032. This long recovery period is a further indicator of the massive structural damages that the economy has sustained not only from Maria but also from the prolonged economic contraction. Economic recovery will require major structural adjustments and not simply marginal changes to improve efficiency in the public sector. Some of these major adjustments were underway before María.

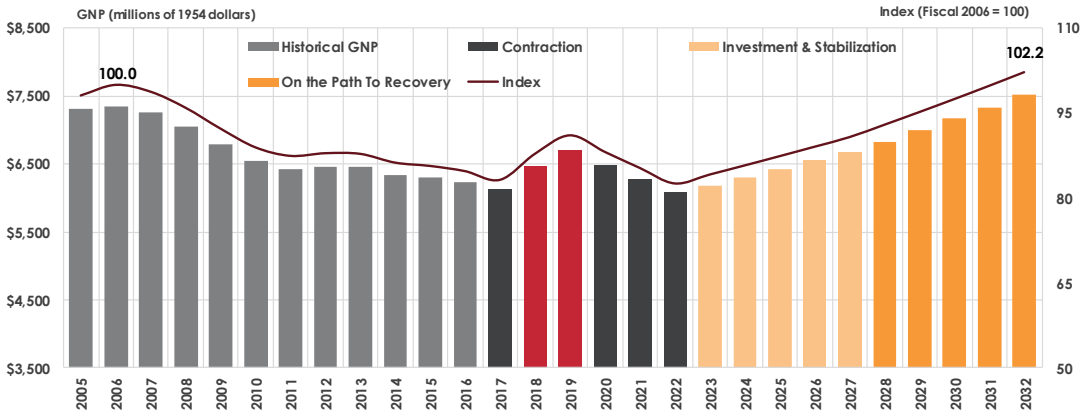
Figure 4 – Scenario 1



Sources: PR Planning Board (2016). *Statistical Appendix (Various Years)*. Estimates by Estudios Técnicos, Inc. (2016).

Figure 5 – Scenario 2

Time Required to Reach Fiscal 2006 GNP Levels
Scenario II



Sources: PR Planning Board (2016). *Statistical Appendix (Various Years)*. Estimates by Estudios Técnicos, Inc. (2016).

Concluding Remarks

Damages caused by hurricane Maria were estimated anywhere between $16 and $20 billion. At least an additional $1 billion in wages lost by workers during the first month post-hurricane should be expected. It should also be pointed out that Maria's impact on economic activity will continue to grow because of delays in reestablishment of critical infrastructure, particularly electricity that, as mentioned, is the key infrastructure in any recovery effort. In addition, the cost of damages caused by hurricane Maria is expected to increase as more official impact assessments are made public. A study by Hsiang, Hsiang & Narita (2012), made the point that the impacts of hurricanes can persist over many years, by reducing potential real GDP growth rates.

The impact estimate included in this study focuses exclusively upon damage costs, and does not take into account the additional costs of rebuilding or substituting the current structures, both private and public. These estimates do not consider loss in value of companies and lost production, as these are highly volatile and their assessment remains speculative. Some of the lost production can be recovered, but some not. In the case of tourism, for example, it is likely that room nights lost will not be recovered because it will take hotels months to reopen. Because of this, the cost of damages presented in this report may differ from damages presented by other sources but is compatible with the damages estimates by FEMA for Georges and thus comparison is possible between the two events.

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