Estimating the Potential Economic Impact of Haiti's 2021 Earthquake

Eduardo Cavallo
Laura Giles Alvarez
Andrew Powell

September 2021

Estimating the Potential Economic Impact of Haiti's 2021 Earthquake

Eduardo Cavallo
Laura Giles Alvarez
Andrew Powell

Inter-American Development Bank

September 2021

Abstract

This paper employs a simple methodology to estimate the potential economic damages of the 2021 earthquake in Haiti. The country registered a magnitude 7.2 earthquake off the South Coast on August 14, 2021, that resulted in 2,248 deaths, 12,763 injured and substantial damages to houses and other infrastructure. An additional 329 persons remain missing. We estimate economic damages using econometric techniques and a dataset on natural disasters across a wide range of countries and over an extended time period. Based on this analysis, damages for the 2021 earthquake in Haiti are estimated to reach US$1.6 billion (9.6 percent of GDP) for a scenario with an impact of 2,500 dead or missing. We also generate confidence intervals on these results. We hope these early estimates will provide a useful input to the ongoing Post-Disaster Risk Assessment (PDNA) and will assist the government and its international partners plan efforts to assist the country in terms of relief and reconstruction.

Contents

Acronyms

CI	Confidence Interval
COUN	Centre d'Operations d'Urgence National
GDP	Gross Domestic Product
IID	Independent and Identically Distributed
PDNA	Post-Disaster Needs Assessment
CPI	Consumer Price Index
OLS	Ordinary Least Squares
US	United States

1. Introduction

On August 14, 2021, Haiti registered one of the strongest earthquakes recorded in the past several decades, followed by the arrival of Tropical Storm Grace. The epicenter of the 7.2 magnitude earthquake, which struck on August 14, 2021, was located near the Southern Coast of the country and had major effects on the Departments of Nippes, Sud and Grand'Anse in the Southern Peninsula of the country. A second 5.8 magnitude afterquake was registered on Sunday August 15, 2021, and various smaller aftershocks were felt throughout the days that followed. Tropical Storm Grace also hit the country between Monday August 16 and Tuesday August 17, which halted rescue efforts for several hours and further complicated the response of relief teams attempting to assist the victims.

The human and infrastructure losses have been severe. The country registered 2,248 deaths and 12,763 injured; an additional 329 persons remain missing. There are also severe effects on housing and services infrastructure in the most affected areas. In terms of housing infrastructure, 53,815 houses were destroyed and 83,770 were damaged. Several roads were rendered impassable, or badly affected, which hindered rescue and humanitarian response efforts. Damages were also reported to churches, a prison, health facilities and schools. Electricity, port and airport infrastructure, however, remained largely intact (COUN, 2021).

In order to estimate the monetary damages caused by the earthquake, we make use of the methodology developed in Cavallo, Powell and Becerra (2010). This paper estimated the damages stemming from the 2010 earthquake and became an important input for initial response measures. The methodology is based on a simple linear regression estimation technique, assessing the dollar amount of damages for each event as a function of the number of dead or missing, the level of the country's economic development, country size, regional dummies and a linear trend. Out-of-sample predictions are then used to predict the expected value of dollar amount of damages, given the number of dead or missing.

A comprehensive database including natural disasters and country socioeconomic variables is used for this exercise. The data used for these estimations is obtained from the International Disaster Database (EM-DAT, maintained by the Center for Research on the Epidemiology of Disasters at the Catholic University of Louvain, Belgium) and various other sources, including UN agencies, non-governmental organizations, insurance companies, research institutions, and press agencies. It covers approximately 2,000 events between 1970 and 2008. The

World Bank's WDI database is then used to calculate out-of-sample estimations and includes the rebased real GDP series.[1] Damages are estimated for three scenarios. We find that with a disaster scale of 2,000 dead or missing, damages are expected to reach US$1.5 billion (8.9 percent of GDP); in a scenario with 2,500 dead or missing, damages are expected to be US$1.6 billion (9.6 percent of GDP); and in a scenario with 3,000 dead or missing, the expected damages are US$1.7 billion (10.3 percent of GDP). Nevertheless, the errors attached to these estimates, obtained by bootstrapping, remain quite large—ranging between US$1 billion and US$2.5 billion at the 90 percent confidence interval for the scenario with 2,500 dead or missing.

These estimates are extremely useful to put the event into perspective and inform the damages and losses assessment taking place on the ground. Our analysis provides useful rapid estimates of the potential magnitude of the event, with important consequences for initial response efforts and the dialogue amongst key actors. These estimates do not, however, replace more exhaustive assessments of damages and losses on the ground, such as the PDNA which is currently being conducted by the Government of Haiti, the United Nations, the World Bank, the European Union and the Inter-American Development Bank. These estimates are, however, an input to the PDNA, which will provide the official assessment of the monetary impact, and on which aid allocations and a recovery framework will be settled.

This paper is structured as follows. Section 2 provides the country's context at the time of the disaster. Section 3 presents the model specification and methodology, and Section 4 presents results. Section 5 presents a policy discussion and conclusions.

2. Context

Due to its geographical location, Haiti suffers from recurrent earthquakes. The country is located at the intersection of two tectonic plates, the North American plate and the Caribbean plate, and a number of fault lines between those plates cut through or near the island of Hispaniola, shared by Haiti and the Dominican Republic. Haiti's vulnerability is further increased by high population density and lack of infrastructure in adequate condition infrastructure. The August 2021 earthquake likely occurred along the Enriquillo-Plantain Garden fault zone, which cuts across Haiti's southwestern Tiburon Peninsula and is the same fault zone that caused the devastating 2010

---

[1] The Institute for Statistics reviewed and rebased the national accounts in 2020-2021. The new series has been used for these estimates.

earthquake. This fault zone was also likely the source of three other big earthquakes in Haiti between 1751 and 1860.

An estimated 1.6 million people live in the three most affected departments. The latest census was conducted in 2003, but more recent estimates suggest that 0.8 million people lived in the Sud department, 0.5 million in Grand'Anse and 0.3 million in Nippes at the time of the disaster.[2] These departments are predominantly rural, so while population densities are relatively low, there are challenges to connectivity and road and telecommunication infrastructure is sparse. Agriculture (especially animal husbandry) and fishing are the main economic activities.

The 2021 earthquake quickly brought back memories of 2010. Haiti registered a magnitude 7.0 earthquake in 2010, resulting in approximately 250,000 dead, many more thousands of displaced persons, severe infrastructure damage and estimated economic damages of US$8 billion. The 2010 earthquake epicenter, however, was only 25km southwest of the capital Port-au-Prince, the most populated territory in the country. Contrastingly, this earthquake's epicenter was located in the sea, and it affected much less densely populated areas, with less housing and other infrastructures. However, the earthquake did affect the country during a very challenging sociopolitical and economic period. President Jovenel Moise was assassinated in July 2021, leaving a power vacuum, as he had been ruling by decree since the beginning of 2020. The current government is headed by the Prime Minister Ariel Henry but has also faced a strong political divide in the run-up to general elections.[3] In addition, the combination of the COVID-19 pandemic and rising insecurity and violence resulted in restricted mobility, affecting service delivery in recent months and ultimately the earthquake's response efforts.

3. Methodology

Cavallo, Powell and Becerra (2010) developed an econometric methodology to obtain preliminary estimates of the economic losses stemming from the 2010 earthquake.[4] Harnessing the same methodology with updated data provides an initial estimate of the potential extent of economic damages for the 2021 earthquake. The methodology is based on an OLS

---

[2] https://www.populationdata.net/pays/haiti/
[3] At the time of writing, general elections are set for November 2021.
[4] For further details of the methodology, see "Estimating the Direct Economic Damage of the Earthquake in Haiti," Eduardo Cavallo, Andrew Powell and Oscar Becerra (2010), *Economic Journal* 120(546): F298-F312. Note that the US$8.0 billion final estimate of economic damages was very close to the central estimate of US$8.1 billion and well within the statistical errors of the estimate from that exercise.

regression in logarithms (equation 1) using an extensive dataset of major events across the world. Data are compiled from various sources, including EM-DAT, United Nations, non-governmental organizations, insurance companies, research institutions, and press agencies.[5] The dollar amount of damages caused by the immediate impact of a disaster in country i at time t (DIS_{it}) is estimated as a function of a vector of control variables that capture the vulnerability of the country to natural disasters and the country's demographic characteristics (captured in X_{it}). The vector includes the number of dead or missing, the level of economic development (real GDP per capita), country size (measured with population size, real GDP or land area), regional dummies and a linear trend. ε_{it} is an independent and identically distributed (iid) error term.

$$DIS_{it} = \alpha + \beta X_{it} + \varepsilon_{it} \quad (1)$$

The model is first estimated for the full sample of events in the dataset between 1970 and 2008. The regression results (coefficient estimates â and $\hat{\beta}$) are then used to produce out-of-sample predictions regarding the estimated value of damages (in US dollars and as a percentage of GDP) that can be expected for a country with Haiti's economic and demographic characteristics in the aftermath of this earthquake. The basic assumptions are presented in Table 1. Bootstrapping simulation methods are then carried out to determine the confidence intervals around those predictions.

Table 1. Estimated Damaged for Haiti, Basic Assumptions

|	
Richter scale measure	7.2
Number of people killed	2,000
	2,500
	3,000
GDP (constant 2010 US$, 2020)	13,549,581,658
GDP per capita (constant 2010 US$, 2020)	1,188
Population (2020)	11,402,533
Land Area (sq km)	27,560

Source: WDI and Civil Protection https://protectioncivile.gouv.ht/

---

[5] For comparability purposes, all estimations are done in 2009 US dollars and converted to current values using the United States' Consumer Price Index (CPI).

4. Results

The out-of-sample predictions for Haiti estimate the economic damages at US$1.6 billion (9.6 percent of GDP). The results are obtained by first carrying out an out-of-sample estimation using equation (1) for $X_{Haiti,\ 2021}$. The basic assumptions used for this estimation are presented in Table 1 for an impact of 2,500 dead or missing. This is the closest scenario to the impact currently reported by COUN (2021). Compared to the 2010 earthquake, the extent of damages in 2021 is expected to be significantly lower, as the affected areas were less densely populated and the impact was lower. As the estimates of the total number of people killed will still take some time to be confirmed, three scenarios are presented in this paper. A matrix is then drawn with estimation results based on the extent of casualties at 90 percent confidence intervals to provide a range of possible extent of damages. These results are presented in Figures 1 and 2 and Table 2.

Figure 1. Potential Damages (US$ billion with a 90 percent confidence interval)
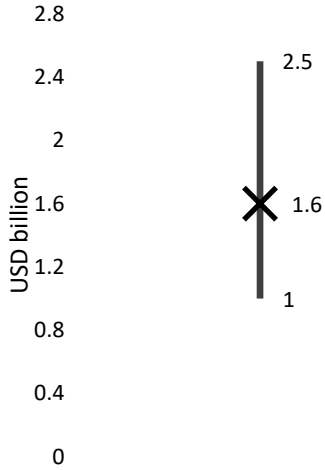
Figure 2. Potential Damages (percent of GDP with a 90 percent confidence interval)
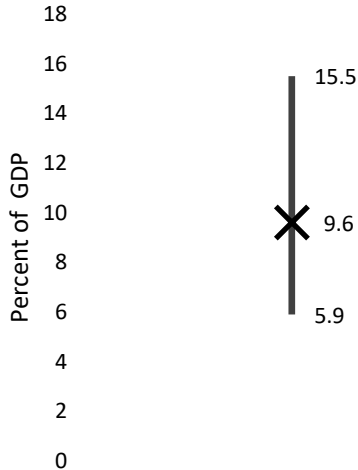
Note: These estimates assume 2,500 casualties. The x marks the linear estimate, and the line runs from the 10 percent confidence interval estimate to the 90 percent confidence interval estimate.
Source: Authors' estimates using WDI.

Table 2. Estimation Results

	US$ billion			% GDP		
Deaths	Linear estimation	Lower bound (10% CI)	Upper bound (90% CI)	Linear estimation	Lower bound (10% CI)	Upper bound (90% CI)
2,000	1.5	0.8	2.2	8.9	5.2	13.3
2,500	1.6	1.0	2.5	9.6	5.9	15.5
3,000	1.7	1.1	2.8	10.3	6.6	17.0

Source: Authors' estimates using WDI.

The results range from US$1.5 billion to US$1.7 billion, depending on the number of casualties. Based on the results shown in the figures below, assuming a death toll of 2,500 persons, the central estimate of damages is US$1.6 billion (with the 10 percent and 90 percent confidence intervals ranging between US$1 billion and US$2.5 billion). This is equivalent to 9.6 percent of GDP (with confidence intervals ranging from 5.9 percent of GDP to 15.5 percent of GDP). Based on the final number of casualties, damage estimates could range from US$1.5 billion (8.9 percent of GDP) to US$1.7 billion (10.3 percent of GDP).[6]

5. Conclusion

This paper has estimated the potential damages resulting from the August 2021 earthquake, based on the methodology developed in Cavallo, Powell and Becerra (2010). By means of a simple regression technique using data on damages estimates for a range of countries, damages are estimated to reach US$1.6 billion (9.6 percent of GDP) for a scenario based on an impact of 2,500 dead or missing. However, damage estimates could range from US$1.5 billion (8.9 percent of GDP) to US$1.7 billion (10.3 percent of GDP), depending on the number of casualties used to measure the impact of the event.

While this methodology is capable of providing rapid estimates and indicates potential confidence intervals, several caveats should be taken into account. First, the extent of damages is directly related to the total number of casualties, which may take further time to confirm and, in the case of Haiti, could be underestimated. Second, the threshold used to assess which events constitute a natural disaster is relatively strict and therefore does not take into consideration many types of events. Third, to avoid over-representation of small events and obtain

---

[6] For this exercise, we make use of WDI estimates of real GDP in USD 2010 prices. These estimates take into account the revised GDP series that was published by the institute of statistics in 2021.

a parsimonious representation, approximately 250 very small events (less than 10 people reported dead or missing and/or with damages of less than US$10 million) are excluded. Fourth, any update to GDP or other macroeconomic variables underlying the model will impact the estimates. Finally, as per any econometric exercise the estimates are subject to any errors in the specification of the model and the usual statistical errors.

These estimates hold significant implications for Haiti and the international community. The estimated extent of damages has significant political implications. Eligibility for most insurance or response mechanisms in the case of disasters is often tied to the extent of damages, which are normally related to or at least partly measured by the extent of monetary damages. Currently, a detailed PDNA is being conducted by the Government of Haiti in coordination with international partners, which will determine official response measures and aid allocations. The estimates in this paper are being used as an input in this process and do not in any way attempt to replace the results of the PDNA. Instead, they provide a benchmark, alongside other available estimates being carried out by international organizations and the private sector, which support the initial dialogue amongst key actors. Going forward, there are still grave challenges being faced by response teams, particularly in terms of financing and execution. Raising the required funds could have an impact on the government's fiscal stance and will entail further coordination amongst all local and international actors. Beyond funding, enhancing execution mechanisms will also be required, particularly given the challenges of reaching the departments that were most affected, as road infrastructure is in poor conditions and recent confrontations between gangs blocked the transport routes that were needed for relief and aid. Sustainable long-term solutions will thus be required for reconstruction efforts to take place effectively.

References

Cavallo, E., A. Powell and O. Becerra. 2010. "Estimating the Direct Economic Damages of the Earthquake in Haiti." *Economic Journal* 120(546): F298-F312. Available at: https://academic.oup.com/ej/article-abstract/120/546/F298/5089603

Centre d'Operations d'Urgence National (COUN). 2021. "Rapport d'étape du Centre d'opérations d'urgence national Tremblement de terre Samedi 14 août 2021—Péninsule Sud." Available at: https://protectioncivile.gouv.ht/wp-content/uploads/2021/09/Seisme-du-14-Aout-2021._-Rapport-de-situation-detape-No-1-du-Coun.pdf