

Disasters, economic growth and fiscal response in the countries of Latin America and the Caribbean, 1972-2010

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Abstract

The aim of this study is to estimate the impact of geological and climate-related disasters on the per capita growth rates of gross domestic product (GDP) and fiscal expenditure in Latin American and Caribbean countries. The results show that the effects vary by type of disaster and by subregion. In the Caribbean countries, the per capita GDP growth rate has typically responded negatively to climate disasters, whereas the response to a geological disaster has generally not been statistically significant. In Central American countries, the response of the per capita GDP growth rate was found to be negative in the first year and positive in the third year in the case of climate disasters, but positive in the second and third years for disasters of geological origin.

Keywords

Natural disasters, economic growth, gross domestic product, public expenditure, Latin America and the Caribbean

JEL classification

Q54, L6, L7, L8

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I. Introduction

Disasters are shocks that can affect a country's various environmental, economic and social variables.² They are commonly occurring phenomena, and their frequency has been increasing.³ According to the Emergency Events Database (EM-DAT) of the Office of Foreign Disaster Assistance and the Centre for Research on the Epidemiology of Disasters (OFDA/CRED) of the Catholic University of Louvain in Brussels, which has the most extensive record of disasters around the world, in 1970-2010, there were 10,271 disasters worldwide, of which 23.7% occurred in America (16.9% in Latin American and Caribbean countries), while Asia was the worst affected continent (39.3% of disasters occurred in that region). The database defines a disaster as an event that meets one of the following criteria: (i) 10 or more deaths are reported; (ii) at least 100 people are reported as being affected; (iii) a state of emergency is declared, or (iv) a request for assistance is issued.

The same source reports that 1,737 disasters occurred in Latin America and the Caribbean in that period, of which 1,392 were of climate-driven, 227 geological, and 118 of biological origin. In the subregions, the frequency of disasters grew fastest in Central America (by 410%) and in the Caribbean (372%);⁴ while in South America the number rose by 288%.⁵ This pattern was determined by the occurrence of climate-driven phenomena, which increased by 448% and 438% in Central America and in the Caribbean, respectively. The evidence presented in the second section of this article shows that the disasters in these subregions have also been more severe in terms of deaths, population affected, and material damage.

Disasters can be classified alongside the varied disturbances that affect the economies of the region, including the business cycles of high-income countries —the international trade repercussions of which trigger changes both in export volumes, particularly commodities, and in their prices⁶— and disturbances on international financial markets. In the last 40 years, there have been various episodes such as debt crises, the saving and loan crisis in the United States, the Mexican crisis, the Asian crisis, the Argentine crisis, and the crisis in the United States real estate market, all of which have affected the Latin American and Caribbean countries through different mechanisms (see, for example, Titelman, Pérez and Pineda (2009), De Gregorio and Valdés (2001) and Reinhart and Rogoff (2008)). It is well documented that reductions in GDP in developed countries, the prices of commodity exports and external interest rates are factors that help to explain, among other things, various episodes that have hindered the economic performance of the Latin American and Caribbean countries.⁷

² This article uses the term "disasters," because these situations are the outcome of a natural event (for example, an earthquake, volcanic eruption or hurricane) and of human error. Accordingly, for many years, the community that analyses the topic has replaced the term "natural disasters" by "disasters."

³ According to Stromberg (2007), the increase in the number of disasters is related to three factors: (i) the reporting of small-scale disasters is probably more complete in recent years; (ii) the world's population has grown, so a larger number of people are exposed to natural hazards, and (iii) climate events are more frequent.

⁴ Central America includes Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama; the Caribbean includes Antigua and Barbuda, the Bahamas, Barbados, Cuba, Dominica, the Dominican Republic, Grenada, Haiti, Jamaica, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, and Trinidad and Tobago.

⁵ South America includes Argentina, the Bolivarian Republic of Venezuela, Brazil, Chile, Ecuador, Guyana, Paraguay, Peru, the Plurinational State of Bolivia and Suriname.

⁶ Except for Mexico and Brazil, in 2000-2010 more than 45% of the annual average export basket of Latin American countries consisted of commodities.

⁷ Laeven and Valencia (2008) note that 13 of the 41 banking crises on which they report occurred in Latin America.

From the economic standpoint, disasters produce both effects and impacts. The former involve damage to assets and changes in flows, which are the additional losses and costs. The impacts are consequences of the effects on different social and economic variables, such as family incomes, unemployment, GDP growth and the fiscal deficit, among others.⁸ It is therefore to be expected that the destruction of assets by a disaster will temporarily interrupt production flows and affect the public finances, for example through the reduction in tax revenue and the additional costs that the emergency may generate.

This article estimates the impacts of different types of disaster on two variables: the per capita GDP growth rate and the rate of growth of per capita fiscal spending in Latin American and Caribbean countries, and in the two subregions most intensively affected by these events, the Caribbean and Central America.

The article is organized as follows: section II presents the stylized facts of the disasters that have occurred in Latin America and the Caribbean; section III contains a review of the literature on the impact of disasters on economic activity, public finances and social variables; section IV sets out the estimation methodology and the variables used; section V discusses the estimated impulse-response functions of the per capita growth rates of GDP and government spending, in response to shocks in the variables studied. The final section contains a number of evaluations of the results.

II. Stylized facts on the disasters that have occurred in Latin America and the Caribbean

This section analyses the trend of disasters and some of the measures of intensity generally used, such as deaths, population affected and damage. The emphasis is placed on disasters occurring in Latin America and the Caribbean.

1. Number of disasters

The frequency of disasters, of all types, has increased in all continents during the period analysed,⁹ although those of climate origin have increased the most (see figure 1).¹⁰ Climate-driven disasters can be classified as follows: (i) storms, and (ii) other climate disasters, including floods, droughts and wet mass movements. Table 1 reports the dynamic of these events by decade in Latin America and the Caribbean, showing that both storms and other climate-related disasters have grown steadily.¹¹ Between the 1970s and the 2000 decade, climate disasters increased by 326%, owing to the frequency of storms, which increased by 453%. In the Caribbean and Central American subregions, storm frequency rose by 540% and 533%, respectively, while the frequency of other climate disasters increased by 309% and 425%.

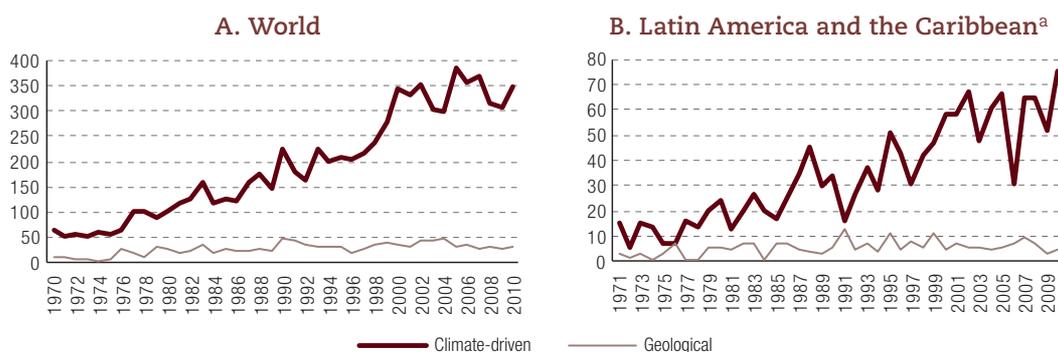
⁸ See ECLAC (2014).

⁹ See Stromberg (2007).

¹⁰ The classification used follows Skidmore and Toya (2002).

¹¹ To reduce the noise that might be caused by considering individual disasters, the information is presented by decade, specifically the four decades spanning 1970-1999.

Figure 1
World and Latin America and the Caribbean: disasters by climate
or geological origin, 1970-2010
(Number of disasters)



Source: Emergency Events Database (EM-DAT) of the Office of Foreign Disaster Assistance (OFDAT) and the Center for Research on the Epidemiology of Disasters (CRED) of the Catholic University of Louvain.

^a Latin America and the Caribbean includes: Antigua and Barbuda, Argentina, Bahamas, Barbados, Belize, the Bolivarian Republic of Venezuela, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, Ecuador, El Salvador, Grenada, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, the Plurinational State of Bolivia, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Suriname, Trinidad and Tobago, and Uruguay.

Table 1
Latin America and the Caribbean: disasters by type of event and decade
(Number of disasters)

Decade	Storms	Other climate disasters	Geological disasters	Total
Latin America and the Caribbean^a				
1970-1979	34	100	30	164
1980-1989	70	186	52	308
1990-1999	130	226	76	432
2000-2009	188	383	62	633
Total	422	895	220	1 537
Caribbean^b				
1970-1979	15	11	4	30
1980-1989	42	38	0	80
1990-1999	67	30	6	103
2000-2009	96	45	7	148
Total	220	124	17	361
Central America^c				
1970-1979	6	16	11	33
1980-1989	6	21	23	50
1990-1999	21	39	37	97
2000-2009	38	84	21	143
Total	71	160	92	323

Source: Emergency Events Database (EM-DAT) of the Office of Foreign Disaster Assistance (OFDAT) and the Center for Research on the Epidemiology of Disasters (CRED) of the Catholic University of Louvain.

^a Latin America and the Caribbean includes: Antigua and Barbuda, Argentina, Bahamas, Barbados, Belize, the Bolivarian Republic of Venezuela, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, Ecuador, El Salvador, Grenada, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, the Plurinational State of Bolivia, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Suriname, Trinidad and Tobago, and Uruguay

^b The Caribbean includes: Antigua and Barbuda, Bahamas, Barbados, Cuba, Dominica, Dominican Republic, Grenada, Haiti, Jamaica, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, and Trinidad and Tobago.

^c Central America includes: Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama.

2. Deaths

Of the various measures of disaster intensity, mortality is the most affected by specific events. In 1970-2010, a total of 3,450,255 people died worldwide as a result of disasters.¹² Of that total, 498,030 deaths occurred in Latin America and the Caribbean, and 73.1% of those deaths occurred as a result of five events:¹³ (i) the earthquake in Chimbote (Peru, 1970); (ii) the earthquake in Guatemala City (1976); (iii) the eruption of the Nevado del Ruiz Volcano (Colombia, 1985); (iv) the landslide in Vargas (Bolivarian Republic of Venezuela, 1999), and (v) the earthquake in Port-au-Prince (Haiti, 2010).¹⁴ Table 2 shows the trend of the deaths per 1,000 inhabitants by decade. During the course of these decades, the number of deaths in Latin America and the Caribbean fluctuated, but disaster mortality rates in the Caribbean and in Central America outpaced the entire region in every decade studied.

Table 2
Latin America and the Caribbean: disaster-related deaths, by decade
(Number of deaths per 1,000 inhabitants)

Decade	Latin America and the Caribbean ^a	Caribbean ^b	Central America ^c
1970-1979	0.063	0.011	0.452
1980-1989	0.014	0.007	0.015
1990-1999	0.017	0.008	0.065
2000-2009	0.004	0.021	0.012
2010-2011	0.403	8.914	0.014

Source: Emergency Events Database (EM-DAT) of the Office of Foreign Disaster Assistance (OFDAT) and the Center for Research on the Epidemiology of Disasters (CRED) of the Catholic University of Louvain.

^a Latin America and the Caribbean includes: Antigua and Barbuda, Argentina, Bahamas, Barbados, Belize, the Bolivarian Republic of Venezuela, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, Ecuador, El Salvador, Grenada, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, the Plurinational State of Bolivia, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Suriname, Trinidad and Tobago, and Uruguay.

^b The Caribbean includes: Antigua and Barbuda, Bahamas, Barbados, Cuba, Dominica, Dominican Republic, Grenada, Haiti, Jamaica, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, and Trinidad and Tobago.

^c Central America includes: Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama.

In the 1970s and 1980s, 81% of fatalities were caused by geological disasters. In contrast, in 1990-2009, 80.1% of the losses of human life were a result of climate-related disasters. This pattern is very likely to reverse in the current decade owing to the number of deaths caused by the 2010 earthquake in Haiti.

In Central America, climate events caused 49.2% of disaster-related deaths, whereas geological events caused 48.9%. In that region, there were fatalities in 65% of climate-related disasters, with an average of 216 deaths in each event. In the Caribbean, geological events caused 92.2% of the deaths, while climate events accounted for 5.4%. Fatalities occurred in 56.6% of climate events, with 63 people dying on average. The number of deaths per 1,000 inhabitants caused by geological disasters increased sharply in 2010-2011, as a result of the 2010 earthquake in Haiti, which was the single event that caused most deaths in the region.

¹² Throughout this article, mention of "disaster" refers to the occurrence of a disaster in one country. If an event, such as Hurricane Mitch, affects several countries, an observation is made for each of the countries affected.

¹³ Worldwide, 10 disasters caused 53.8% of all of these fatalities. The only disaster occurring in Latin America and the Caribbean included among them is the Port-au-Prince earthquake of 2010.

¹⁴ Cavallo and Noy (2010) claim that 96% of the deaths caused by disasters in 1970-2008 occurred in Africa, Latin America and the Caribbean, and Asia, which jointly account for 75% of the world's population. Stromberg (2007) argues that in 1980-2004, for every death caused by disasters in high-income countries, there were 12 deaths in low-income countries. These results stem from the four events that caused most of the fatalities: the 1984 droughts in Sudan and Ethiopia, the 1991 cyclone in Bangladesh and the 2004 tsunami in the Indian Ocean.

3. Population affected

Between 1970 and 2009, 6.308 billion people around the world were affected by disasters. The numbers affected increased in both types of climate disaster considered, whereas the population affected by geological disasters, rose and fell alternately during those decades.¹⁵ Of those affected, 89% lived in Asia and 3.3% lived in Latin America and the Caribbean. The vast majority of people affected suffered from climate-related disasters, in contrast to the figures reported above on fatalities. For the world as a whole, 97% of the population affected corresponded to climate events, and 2.7% corresponded to geological events. In Latin America and the Caribbean, the equivalent proportions were 83.9% and 14.9%, respectively.¹⁶

Another measure of disaster intensity is the number of persons affected per 1,000 inhabitants in the countries in which the disasters occurred. Evidence based on this measure shows that geological disasters and storms have been more severe in the Caribbean and in Central America than in South America (see table 3).

Table 3
Latin America and the Caribbean: persons affected by disasters, 1970-2009^a
(Number of persons affected per 1,000 inhabitants)

Decade	Storms	Other climate disasters	Other geological disasters	Total
Caribbean^b				
1970-1979	16.1	16.6	20.8	24.2
1980-1989	30.9	11.5	0.0	28.1
1990-1999	17.0	20.8	94.8	28.2
2000-2009	34.1	2.4	3.4	33.7
Total	24.5	12.8	29.8	28.5
Central America^c				
1970-1979	21.7	4.2	62.9	60.5
1980-1989	4.6	7.2	6.3	9.4
1990-1999	14.9	12.4	3.2	21.4
2000-2009	4.9	13.3	10.2	21.0
Total	11.5	9.3	20.6	28.1
South America^d				
1970-1979	0.8	14.8	24.7	20.1
1980-1989	0.5	23.7	2.5	20.8
1990-1999	0.6	7.0	2.8	7.5
2000-2009	0.3	6.2	2.2	6.9
Total	0.5	12.9	8.1	13.8

Source: Emergency Events Database (EM-DAT) of the Office of Foreign Disaster Assistance (OFDAT) and the Center for Research on the Epidemiology of Disasters (CRED) of the Catholic University of Louvain.

^a In the Caribbean, 3.7 million people were affected by geological events in 2010, compared to 107,200 affected by storms, and 59,200 people by other climate-related events. In Central America, the equivalent figures were 1,800, 436,800 and 170,900, respectively.

^b The Caribbean includes: Antigua and Barbuda, Bahamas, Barbados, Cuba, Dominica, Dominican Republic, Grenada, Haiti, Jamaica, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, and Trinidad and Tobago.

^c Central America includes: Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama.

^d South America includes: Argentina, the Bolivarian Republic of Venezuela, Brazil, Chile, Colombia, Ecuador, Guyana, Paraguay, Peru, the Plurinational State of Bolivia, Suriname and Uruguay.

¹⁵ Worldwide, the quotient between the number of persons affected and deaths caused by disasters was 1,826. The corresponding figures for geological and climate disasters were 3,178 and 128, respectively.

¹⁶ In 1980-2009, over 90% of persons affected corresponded to climate disasters.

4. Damage

In 1970-2011, the damage caused by climate-related disasters represented 72.9% of global disaster damage, whereas that caused by geological disasters accounted for 27%.¹⁷ Storms caused 53.4% of climate-related damage, while other climate-driven disasters caused 46.6%. Of total damage, 9.1% occurred in Latin America and the Caribbean.

Despite being the most comprehensive database of disasters in the world, EM-DAT underestimates disaster damage, because it only records damage in 32.1% of the events registered.¹⁸ If this figure is broken down by the type of threat causing them, damage is recorded in just 32.3% of geological disasters, 50.8% of storms and 29.3% of other climate-related disasters. Two factors seem to explain the preponderance of damage caused by climate disasters: the increase in this type of event worldwide compared to those of geological origin, and the larger proportion of events of this type with a record of damage. Nonetheless, the average damage per geological event exceeded the average per climate event. A similar result was obtained by Bello, Ortiz and Samaniego (2014) using a database containing estimates of natural disaster impacts in Latin America, which was maintained by ECLAC for internal use between 1972 and 2010.

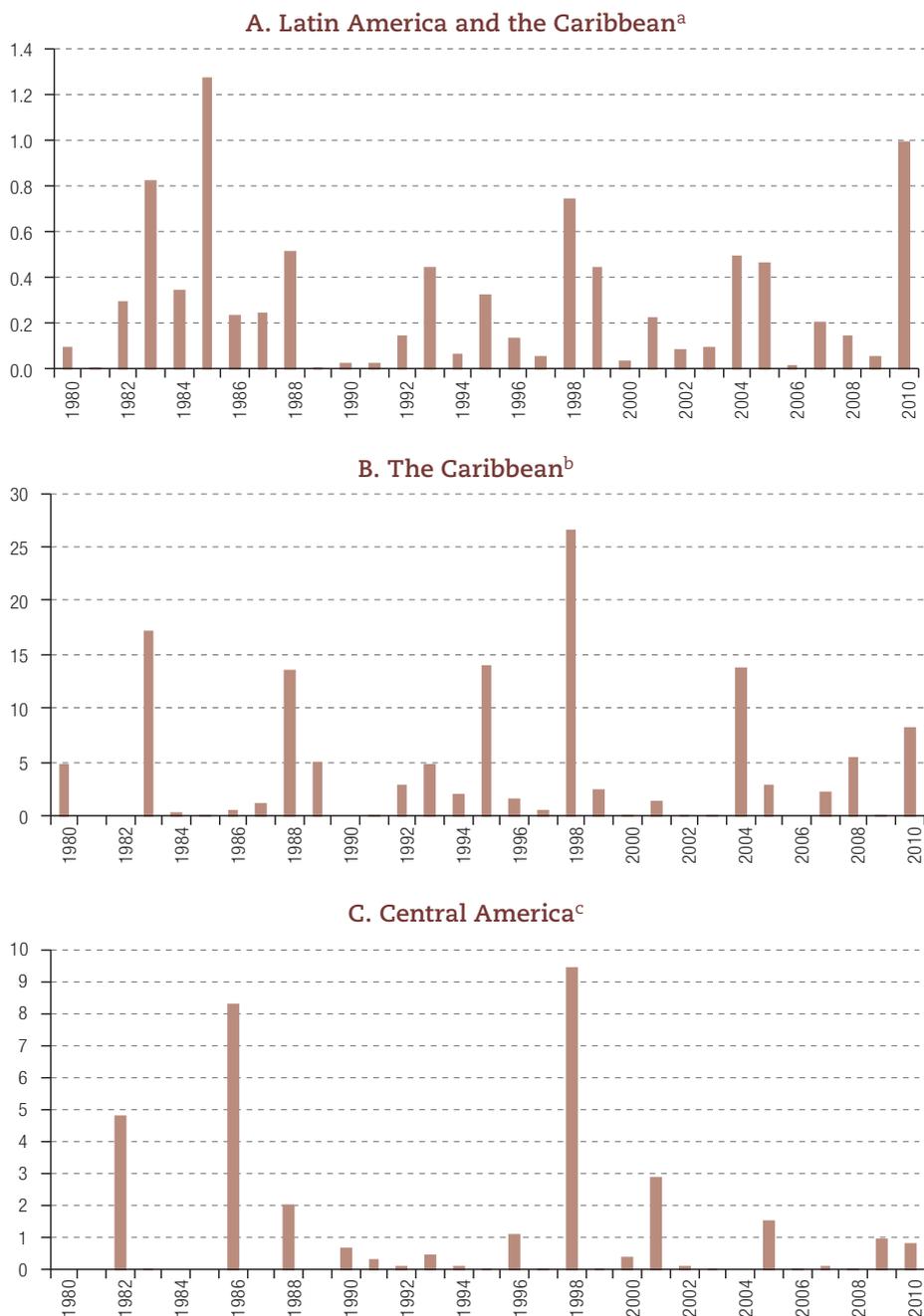
Instead of absolute values, damage is better expressed as percentages of GDP of the countries affected by disasters in each region and in each year. The Caribbean is the region in which disaster damage, on average, has represented the largest share of GDP, surpassing 8% seven times. It is followed by Central America, where disaster damage exceeded 8% of GDP twice. In Latin America and the Caribbean, this indicator reached at least 1% of GDP of the countries affected on just two occasions.

In short, the Caribbean and Central America are the two subregions most affected by disasters, in terms of both population and material effect. Compared to South America and Mexico, they are smaller territories and have few inhabitants. A characteristic of disasters is that in most cases they only affect one area, one region, or one specific department of a country. The exception is the Caribbean, where some of the small islands have been overwhelmed by hurricanes. As described in Albaladejo (1993), disasters are generally confined to a specific space, and indirectly affect the rest of the economy through the links between the local and national systems. The stronger these links are, the greater the potential for transmission. When the effect of the disaster is measured in terms of a national economic indicator, such as GDP, this does not express its true extent in the regional economy, which in practice is likely to suffer the greatest impact; but in large countries, the regional may be minimized, as shown in figure 2A.

¹⁷ The question that arises from this evolution is "how much of this is attributable to climate change?" An answer was provided in the Special Report of the Intergovernmental Panel on Climate Change (IPCC) of 2012. This panel states that until now the trends of disaster damage, adjusted for wealth and population, are not attributable to climate change.

¹⁸ This percentage has been similar in the four decades considered: 35.4%, 29.9%, 39.4% and 28.1%, respectively. In the case of Latin America and the Caribbean, the proportions were 38.7%, 31.1%, 34.0% and 25.8%, respectively.

Figure 2
Latin America and the Caribbean: damage caused by disasters, 1980-2010
(Percentages of GDP)



Source: Emergency Events Database (EM-DAT) of the Office of Foreign Disaster Assistance (OFDAT) and the Center for Research on the Epidemiology of Disasters (CRED) of the Catholic University of Louvain.

Note: GDP: Gross domestic product.

^a Latin America and the Caribbean includes: Antigua and Barbuda, Argentina, Bahamas, Barbados, Belize, the Bolivarian Republic of Venezuela, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, Ecuador, El Salvador, Grenada, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, the Plurinational State of Bolivia, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Suriname, Trinidad and Tobago, and Uruguay.

^b The Caribbean includes: Antigua and Barbuda, Bahamas, Barbados, Cuba, Dominica, Dominican Republic, Grenada, Haiti, Jamaica, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, and Trinidad and Tobago.

^c Central America includes: Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama.

III. Economic impacts of disasters

As noted above, disasters are a shock that can affect various economic variables, such as GDP, public finances and prices, as well as social variables such as the poverty index. The impact on the first of these variables has been studied extensively.¹⁹ A pioneering analysis of the subject is made by Albala-Bertrand (1993), who studies the short-term impacts of disasters. This author used data from 28 disasters of different origin occurring in 26 countries between 1960 and 1979, and found that there was a positive impact on GDP growth of 0.4%.²⁰ Rasmussen (2004) used a similar methodology to analyse a sample of 12 major disasters that occurred in the countries of the Eastern Caribbean Currency Union in 1970-2002, and noted a negative impact on GDP in the year in which the disaster occurs. In terms of the fiscal accounts, the fiscal balance deteriorated owing to a fall in revenue and a spike in expenditure.²¹ Similar criticisms have been made of each of these studies: the samples are small and the conclusions are not based on a formal statistical method.

In response to these misgivings, a set of research projects arose that use both a broader database, namely EM-DAT, and formal statistical methods.

These studies include Noy (2007), who uses the three-stage Hausman-Taylor estimation method on a database that includes a sample of developed and developing countries in 1970-2003. The study found that disasters have an adverse impact on the GDP growth rate in the short run. Following a disaster of similar magnitude, developing countries, particularly the smallest ones, suffer steeper falls than developed countries. A better institutional framework and easier credit conditions in developed countries might explain this result, along with the fact that disasters are more likely to assume national proportions in small countries, such as those of the Caribbean.

Other studies have analysed the impacts of different disasters on economic activity in the short and long terms. Raddatz (2009) uses panel time series techniques (autoregressive distributed lag (ARDL) and autoregressive vector (VAR) models) to estimate the short- and long-term GDP effects of climate disasters, controlling for other variables. The sample includes countries that have suffered at least one major climate disaster since 1950. This author concludes that disasters have statistically significant impacts on output, causing a 1% drop in per capita GDP —greater than the typical impact of terms-of-trade shocks (which are considered major sources of fluctuation). The cumulative effect of a climate disaster is 0.6 percentage points of per capita GDP (0.5 points in the first year). In contrast, geological disasters do not generate statistically significant impacts on that variable. This result, like those of other studies, shows that treating disasters as a single aggregate can be misleading.

Loayza and others (2009), using a dynamic panel estimator (generalized method of moments (GMM)) on a sample of 94 developing and developed countries in 1961-2005, found that: (i) a generalized indicator of disasters does not affect the GDP growth rate; but, if different types of disaster are considered separately, only the impact of floods was statistically significant and positive, and (ii) in the case of growth rates in specific sectors such as agriculture, manufacturing and services, droughts and storms negatively affected the first, while floods had a positive effect.²² There are no statistically significant impacts of any type of disaster on manufacturing GDP. Growth in the commerce sector responded positively to flooding. In the sample of developing countries, the only types of disaster that

¹⁹ For a detailed review of all economic aspects of the topic of disasters see Cavallo and Noy (2010).

²⁰ Includes earthquakes, tsunamis, cyclones, floods and droughts; mainly considers African, Asian and Latin American countries, with one European country; the impact estimates used by the author show that there was damage, in other words destruction of assets.

²¹ Dos Reis (2004) cites the aggregate costs for the countries of the Eastern Caribbean Currency Union in 1970-2000, as justification for a fiscal insurance mechanism in the countries of that region.

²² For a discussion on the sectoral effects of the different types of disasters in terms of methodological concepts of damage and loss, see Bello, Ortiz and Samaniego (2014).

affected the GDP growth rate were droughts (negatively) and floods (positively). These results hold for the GDP growth rates of both manufacturing and agriculture. Moreover, in the case of manufacturing GDP, storms and earthquakes also had a positive growth effect. Lastly, no type of disaster had a statistically significant impact on the services sector.

Similarly, Jaramillo (2009), who estimated regressions of the type used by Islam (1995) to analyse disasters classified by incidence, concludes that disasters, particularly those caused by climate events, have a short-term impact lasting between two and five years. The author also establishes that only a small group of countries (those that have been negatively affected by disasters) suffer permanent impacts to the per capita GDP growth rate.

In their study on growth collapses, Hausmann, Rodríguez and Wagner (2006) conclude that disasters are not statistically significant in explaining the likelihood that a country will suffer a temporary reversal in its per capita GDP. Other events, such as wars, political transitions, exports collapses or sudden stops in capital flows, were statistically significant in determining that variable. A key study on this point is that of Cavallo and others (2010), which uses the comparative event study methodology. These authors conclude that even in the case of major disasters, there is still no long-term impact on economic growth. In the only cases which displayed long-term impacts —Nicaragua and the Islamic Republic of Iran— the result was associated with major political changes occurring a few years after the event, which led to a regime change. These authors do not establish a causality relation between the two disasters considered and the political changes that occurred.²³

Other studies on this subject include Cuaresma, Hlouskova and Obersteiner (2008) and Raddatz (2007). The first estimated a gravity model for a sample of 49 countries, and observed that only countries with a certain development level succeed in improving their capital stock following a disaster. Raddatz (2007), using a VAR model with panel data, estimated the effect of exogenous shocks on GDP in 40 countries classified as low-income by the World Bank in 1965-1997. Apart from disasters, the exogenous shocks considered were fluctuations in commodity prices, international interest rates, and the economic activity level in the developed countries. The results show that, although these external shocks have a small but significant impact on per capita GDP in low-income countries, they can only explain a small portion of the total variance of per capita GDP in those countries. Even in the long run, they explain no more than 11% of the variance. The remaining 89% reflects factors outside the set of exogenous variables considered, in other words domestic factors such as conflicts, political instability and economic mismanagement.

In short, in the literature there is no consensus on the sign of the short-term impact of disasters, or any subset of them on the GDP growth rate.²⁴ In the long run, the evidence shows that disasters do not have impacts on GDP growth. If this is true, disasters cannot be considered the cause of some countries' poor secular economic performance.

With regard to other variables that might be affected by disasters, Cavallo, Cavallo and Rigobón (2013), using real-time data, studied two typical impacts: interruptions to goods supply and prices.²⁵ The study in question considered two events: the earthquake that occurred in Chile on 27 February 2010, and the earthquake off the Pacific coast that affected Japan on 11 March 2011. The authors found that, the number of goods available for sale fell by 32% in Chile and by 17% in Japan. These estimations were based on the lowest supply point, which occurred 61 and 18 days

²³ Rodrik (1998) suggests that domestic social conflicts are a key to understanding why some countries have experienced reductions in their growth rates since the mid-1970s. In particular, he suggests that the explanation is associated more with the way in which domestic social conflicts interact with external shocks (such as natural hazards), and the extent to which local institutions are capable of managing these conflicts.

²⁴ The literature referred to here focuses on geological or climate-driven disasters. For other types of disaster, see Olaberria (2009), which focuses on epidemiological disasters.

²⁵ The data used in this study come from the Billion Prices Project of the Massachusetts Institute of Technology (MIT). See [online] <http://bpp.mit.edu>.

after the earthquakes, respectively. Volpe and Blyde (2013) analyse the effect of a specific event, the 2010 Chilean earthquake, on that country's exports. Using the differences-in-differences estimator, they identify a negative effect on that variable, for which the transmission channel is damage to road infrastructure.

In the case of public finances, Melecky and Raddatz (2011) estimate the impact of disasters on fiscal sustainability. They analyse how fiscal expenditure and revenues respond to different types of disaster, and how these responses are related governments' ability to borrow and the availability of private financing sources for private and public reconstruction. The results show that the three categories of disaster considered cause GDP to fall, but these effects are not statistically significant. Nonetheless, they do detect clear consequences on fiscal policy following a climate disaster.

The economic impact of a disaster is likely to be reflected in social variables. The empirical evidence seems to indicate that disasters have a negative effect on overcoming poverty. Using data on rural households in Kenya, Christiaensen and Subbarao (2005) find that the inhabitants of arid zones are more vulnerable, in other words they are more likely to be poor than those in fertile zones, owing to the variability of rainfall. Elbers, Gunning and Kinsey (2002), using longitudinal data from Zimbabwe, and Lybbert and others (2004) and Dercon (2005), using longitudinal data from Ethiopia, find that disasters partly explain why individuals fail to overcome poverty. These studies use household panel data, which can introduce a number of econometric problems associated with the mean error or the reduction of the longitudinal sample. To overcome these problems, Rodríguez-Oreggia and others (2013) use municipal data from Mexico and find that, municipalities that experience disasters display lags in certain social indicators, such as the human development index and several poverty measures. These conclusions are based on the differences-in-differences indicator.

IV. Estimation methodology

Following the methodology used by Raddatz (2007) and by Melecky and Raddatz (2011), this analysis estimates the impact of disasters on the per capita GDP growth rate adjusted for purchasing power parity (PPP), and on the growth rate of per capita central government expenditure (GG), of the countries of Latin America and the Caribbean, based on annual data spanning 1970-2010.²⁶ The aim is to measure the magnitude and duration of the response to a disaster, by economic activity and a policy variable such as fiscal expenditure.²⁷ These estimates controlled for other variables also expressed in the form of growth rates, calculated from logarithmic differences, such as the GDP of high-income countries (PIBPAI) and the Deaton-Miller (DM) terms-of-trade index. The international interest rate (R) was also used. The estimate was made using a panel-data autoregressive vector model (PVAR).

PPP-adjusted real per capita GDP was obtained from the Penn World Tables (version 7.0), whereas per capita government spending was obtained from World Development Indicators (WDI) published by the World Bank.

Disasters are measured by country and by year, and are classified as follows: (i) geological (GEO), which includes storms, landslides, volcanic eruptions and tsunamis; (ii) storms (TOR), and (iii) other hydro-climatic disasters (OT), which include floods, droughts and extreme temperatures. In each category, the disasters are measured as a dummy variable. The criterion used to define it, in other words when it takes the value 1, is as follows: when considering all disasters in a given category in a

²⁶ It is important to bear in mind that the estimates made in this research only cover the countries of Latin America and the Caribbean, a smaller sample than that used in the studies cited in the third section of this article, which are based on global data, so they will have a greater variance.

²⁷ The variable "Per capita public spending" was preferred to other fiscal variables such as revenue or public debt, because it better reflects the government reaction to shocks such as a disaster.

single year, the total number of fatalities is greater than 1 per 10,000 inhabitants; or the percentage of persons affected is greater than 5% of the population; or the total damage is greater than 5% of GDP.

The other variables used in the estimate aim to control for other shocks that could affect the countries of Latin America and the Caribbean, such as the performance of the global economy, the evolution of the terms of trade and the behaviour of the international financial market. As regards the first of these, the growth rate of (log) GDP of high-income countries, as defined in the World Bank's World Development Indicators database was used. For the evolution of the terms of trade, the Deaton-Miller index was constructed for each country, using the methodology described in Deaton and Miller (1996), which captures fluctuations in the prices of the most important commodities for the economy of each country. Commodity prices were obtained from the data series supplied by the United Nations Conference on Trade and Development (UNCTAD), while each country's foreign trade statistics were obtained from the United Nations Commodity Trade Statistics Database (COMTRADE). Lastly, the interest rate on United States government bonds was used as a proxy for international financial conditions.

For a country i , the structural model can be expressed as follows:

$$A_0 x_{i,t} = \alpha_i + \beta_i t + \sum_{j=1}^q A_j x_{i,t-j} + \varepsilon_{i,t} \quad (1)$$

where

$$x_{i,t} = (z'_{i,t}, y'_{i,t}) \quad (2)$$

$$z'_{i,t} = (TOR_{i,t}, OT_{i,t}, GEO_{i,t}, PIBPAI_{i,t}, DM_{i,t}, R_t) \quad (3)$$

$$y'_{i,t} = (PIB_{i,t}, GG_{i,t}) \quad (4)$$

Expressions (3) and (4) are the vectors of the model's exogenous and endogenous variables, respectively. Six variables, TOR, OT, GEO, DM, PIB and GG, have sub-indices i and t because they correspond to country i and vary through time t . The other two variables PIBPAI and R, only have the subindex t because they are common to all countries in the sample, and the variation occurs through time.

The main identification assumption used in this study is that the variables of the vector Z do not respond to the variables in the vector Y with any lag, which is equivalent to imposing a block diagonal structure on the matrices A. This means that the occurrence of disasters, the GDP of high-income countries, the terms of trade and the international interest rate are not influenced by the past economic performance of the Latin American and Caribbean countries or by per capita government spending; but all of these variables probably exert contemporary or lagged effects on economic performance.

The assumption that the A matrices are block diagonal, enables us to identify the effect of each variable in the vector Z on the variables in the vector Y; but identifying the impact of the variables on vector Z requires stronger assumptions. Firstly, it is assumed that the occurrence of disasters is completely exogenous; in other words, not only is it unrelated to the variables in the vector Y, it is also unrelated to the other variables in the vector Z, for which a lower triangular structure is imposed on matrix A. The specification proposed assumes that the order goes from the GDP of the high-income countries to the terms of trade, and to the international interest rate.

The dynamic of this model, represented by the matrices A, is assumed common to all units of the cross-section, in other words to each country. The reason for this assumption is that, given the

size of the time dimension of the data, it is impossible to estimate specific dynamics for each country without considerably reducing the number of exogenous variables or the number of lags considered. The contrasts used to determine the optimal number of lags gave a result of between two and three. Given the size of the database, a lag of two was used in the estimations of the PVAR model.²⁸

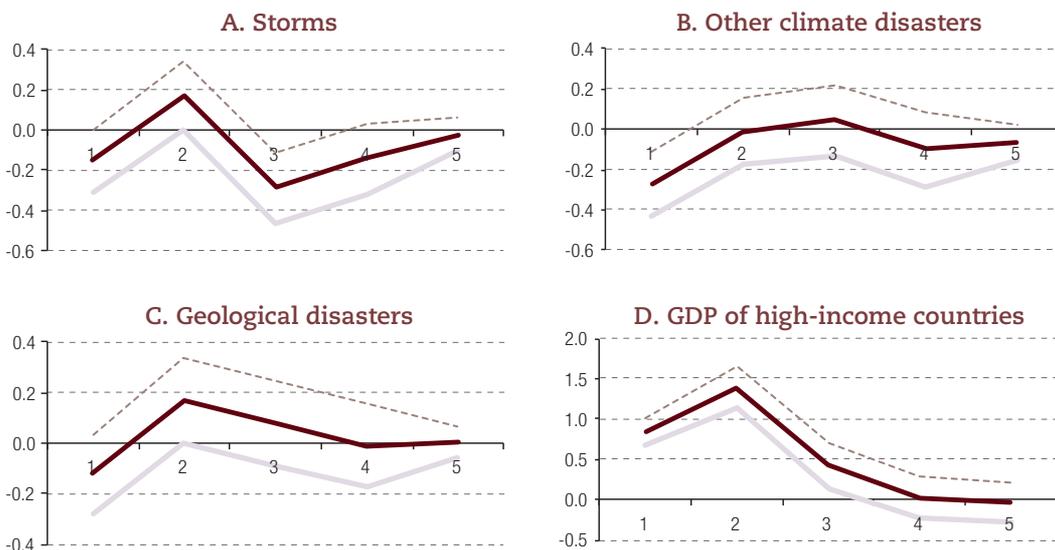
With all of these assumptions, impulse-response functions (IRFs) were estimated for the per capita GDP growth rate and rate of growth of per capita government spending, in response to changes in each of the variables contained in the vector Z . The IRFs are calculated for a five-year period. Estimations were performed for three samples: (i) for all countries of Latin America and the Caribbean (the full sample); (ii) for the countries of the Caribbean, and (iii) for the Central American countries.²⁹

V. Estimations

1. Impulse-response functions of the per capita GDP growth rate

In relation to the full sample and for the two subregions considered, figures 3, 4 and 5 show the IRFs of the per capita GDP growth rate with respect to shocks in each of the variables of the vector $z'_{i,t}$, for a five-year period. All of the figures follow the order of identification used. These display the adjusted IRFs at a 95% confidence interval.

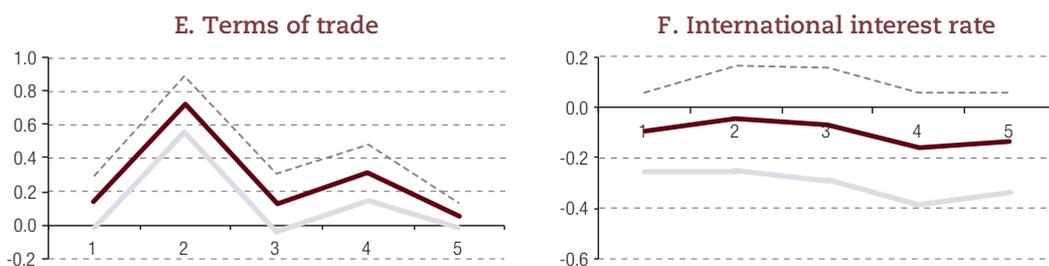
Figure 3
Latin America and the Caribbean: impulse-response functions of GDP
(Percentage points and years)



²⁸ To check the robustness of the results, three lags were used. The IRFs do not change substantially relative to those presented in the next section.

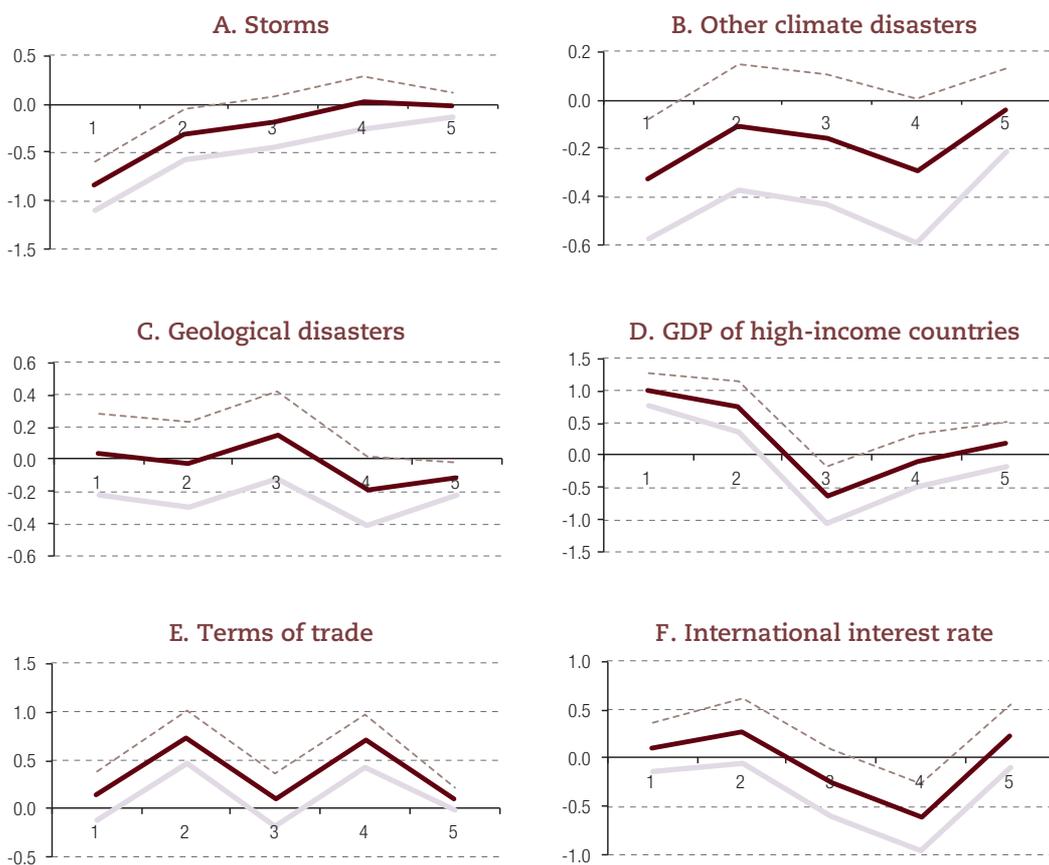
²⁹ Estimates were also made for South America, which, for space reasons are not reported in this paper, but can be requested from the author. In that case, the response of per capita GDP growth to shocks in the variable “Other climate disasters” was significant and negative in the second and third years. No statistically significant response was obtained from the growth of per capita government spending in response to a shock in any of the disaster categories used.

Figure 3 (concluded)



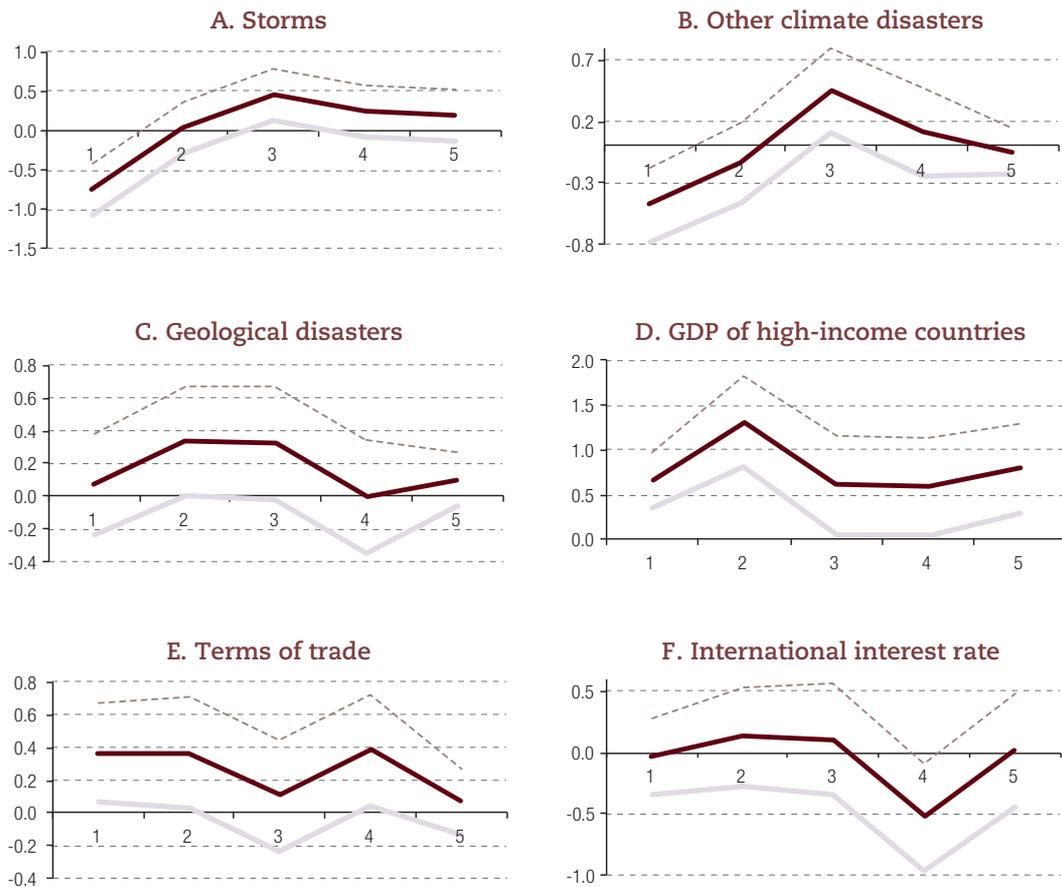
Source: Prepared by the author.

Figure 4
The Caribbean: impulse-response functions of GDP
(Percentage points and years)



Source: Prepared by the author.

Figure 5
Central America: impulse-response functions of GDP
(Percentage points and years)



Source: Prepared by the author.

In Latin America and the Caribbean, the variable “Storms” has a first-year negative impact on the per capita GDP growth rate of roughly 0.16 percentage points, which is reversed in the second year, with an impact of 0.2 percentage points. The variable “Other climate disasters” has a statistically significant impact on the per capita GDP growth rate of roughly -0.24 percentage points, but only for one year. In the case of the variable “Geological disasters,” the impact is positive, of 0.18 percentage points in the second year (see figures 3 A, 3 B and 3 C). The two variables whose shocks most affect the per capita GDP growth rate are GDP growth in high-income countries and the rate of variation in the terms-of-trade index (see figures 3 D and 3 E). A shock to the GDP growth rate of high-income countries has a positive effect on GDP growth: in the first year, this is around 0.8 percentage points, rising to 1.4 percentage points in the second year, and roughly 0.5 points in the third year. As from the fourth year, the effect converges to zero. In contrast, a positive shock to the rate of change of the terms of trade has positive impact lasting for four years. As would be expected, in the first year the GDP growth effect is positive at around 0.1 percentage points; and this is followed by even stronger impact in the second year, of roughly 0.7 percentage points. In the third year, the growth effect declines to

around 0.1 points before rising to 0.3 percentage points. As from the fifth year, the per capita GDP growth impact converges to zero. Lastly, the effect of an international interest rate shock does not have a statistically significant effect on the per capita GDP growth rate.

The estimates for the Caribbean show stronger evidence of the impact of climate disasters on the per capita GDP growth rate. A shock in the variable “Storms” causes a statistically significant negative response in the first two years, of roughly 0.7 and 0.3 percentage points, respectively (see figure 4 A). A shock in the variable “Other climate disasters” has a negative and significant effect of around 0.3 percentage points for one year only (see figure 4 B). Shocks caused by geological disasters do not have a significant impact on GDP in this region. In terms of the shock to the per capita GDP growth rate of the high-income countries, and in the region as a whole, the greatest effect is on the per capita GDP growth rate of the Caribbean countries, which display responses of around 1 and 0.8 percentage points in the first two years, respectively. As from the third year, the effect ceases to be statistically significant (see figure 4 D). In the case of a terms-of-trade shock, there are positive effects in the first two years of 0.1 and 0.7 percentage points, respectively; and again in the fourth year of 0.7 percentage points (see figure 4 E). Lastly, the regional result is repeated in respect of a variation in the international interest rate.

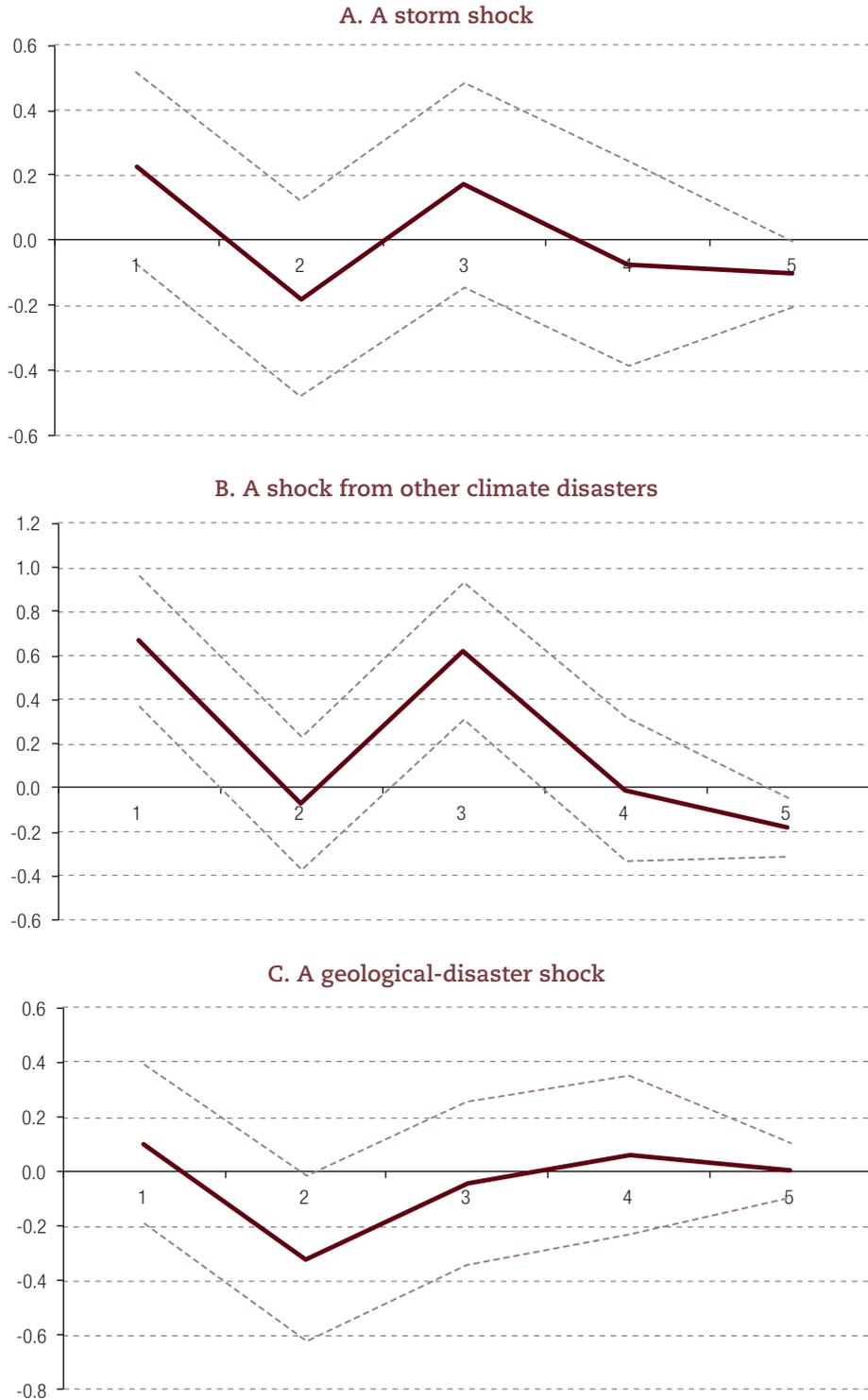
In the case of Central America, shocks in the variables “Storms” and “Other climate disasters” generate the same response pattern in the per capita GDP growth rate: a decrease in the first year of roughly 0.8 and 0.5 percentage points, respectively; and in both cases, a recovery of around 0.45 points in the third year (see figures 5 A and 5 B). Geological disasters did not produce a significant effect in the first year; but in the second and third years, there was an upturn of around 0.4 percentage points (see figure 5 C). In all three types of disaster, convergence occurs in the fourth year. In the IRFs of other variables, similar results are obtained, in other words the most important variable in terms of the magnitude of effect on the GDP growth rate of the Central American countries is a growth shock in the high-income economies. That impact does not fully dissipate in five years.³⁰

2. Impulse-response functions of the growth rate of per capita government spending

In this case, the analysis focuses on the response of the rate of growth of per capita government spending to shocks in the disaster variables, and only the IRFs corresponding to those events are presented, as shown in figures 6, 7 and 8. In the case of Latin America and the Caribbean, shocks in the variable “Storms” did not have a statistically significant effect on per capita government expenditure, whereas shocks in the variable “Other climate disasters” produced a positive and statistically significant response in the first three years, of 0.5, 0.6 and 0.5 percentage points, respectively.

³⁰ The effect of this shock converges to zero in eight years.

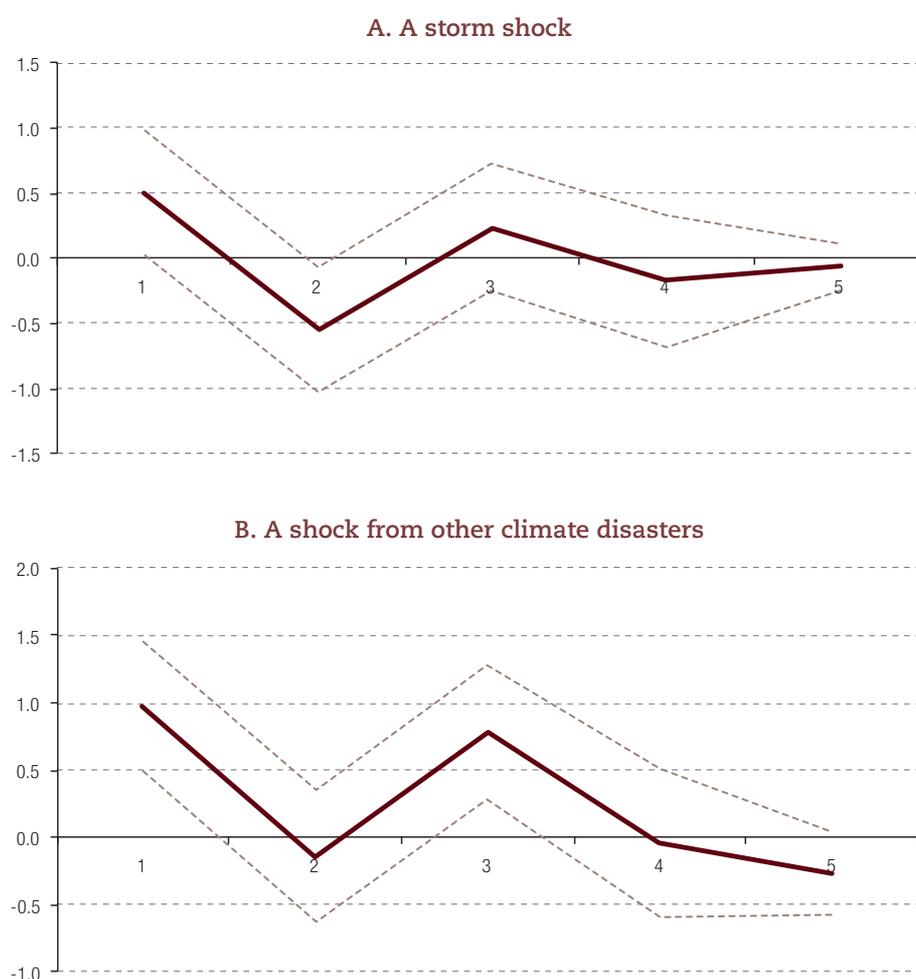
Figure 6
 Latin America and the Caribbean: impulse-response functions of per capita government spending
 (Percentage points and years)



Source: Prepared by the author.

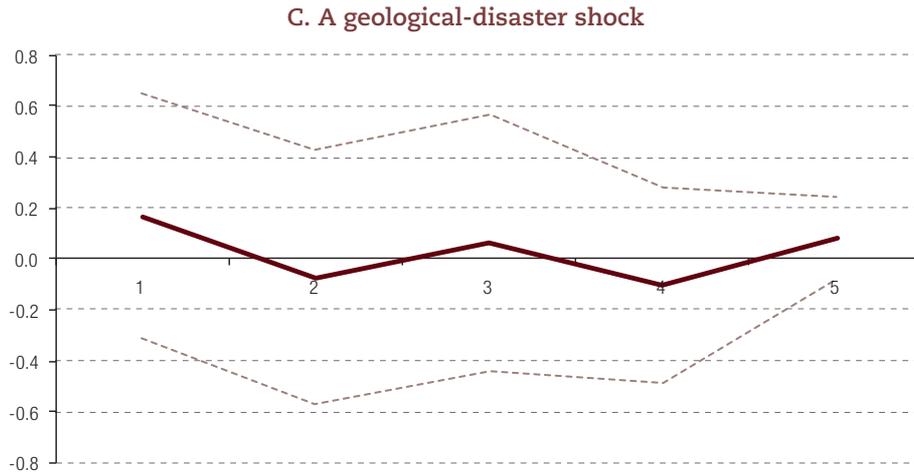
In the Caribbean countries, the response of the growth rate of per capita government expenditure was statistically significant in relation to the occurrence of storms and other climate disasters in the first year. In the case of storms, the growth rate increased by 0.7 percentage points, whereas in the case of the variable “other climate disasters,” the rate rose by 1 percentage point in the first year, and by 0.8 points in the third.³¹ Nonetheless, bearing in mind the negative effect that both storms and other climate disasters had on GDP (see figure 4) it can be said that the increase in government expenditure did not make up for the fall in other components of aggregate demand caused by the disaster. In the case of geological disasters, these did not have a statistically significant effect on the exogenous variable analysed. This result may reflect the fact that there are very few disasters of this origin in that region, as noted in the second section of this article.

Figure 7
The Caribbean: impulse-response functions of per capita government spending
(Percentage points and years)



³¹ This result differs from that obtained for the whole sample (Latin America and the Caribbean), because in that case the response was not statistically significant.

Figure 7 (concluded)



Source: Prepared by the author.

In the case of Central America, the IRFs of the growth rate of per capita government expenditure in response to a shock in the variable “Storms” shows that the statistically significant impact lasts two years. As a result of this shock, the rate of growth of per capita government spending rose by 0.6 percentage points in the first year and by 0.8 percentage points in the second. As in the Caribbean countries, this result differs from that displayed by the sample as a whole. In the case of other climate disasters, the statistically significant impact lasts three years, with increases of roughly 0.6, 0.9 and 0.8 percentage points during the period. As with the Caribbean countries, this expenditure growth was not enough to compensate for the reduction in other flows, and the final result was a drop in the GDP growth rate. In the case of geological disasters, there was a statistically significant effect in the first two years, of roughly 0.5 and 0.6 percentage points, respectively.

Figure 8
Central America: impulse-response functions of per capita government spending
(Percentage points and years)

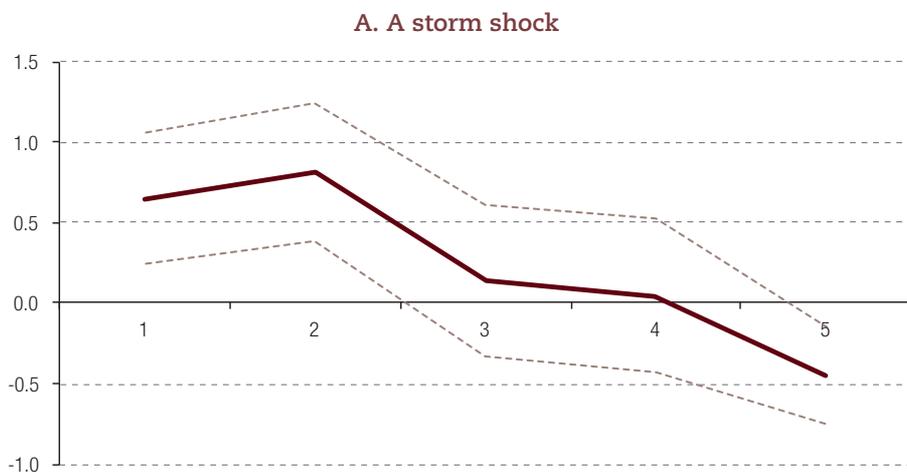
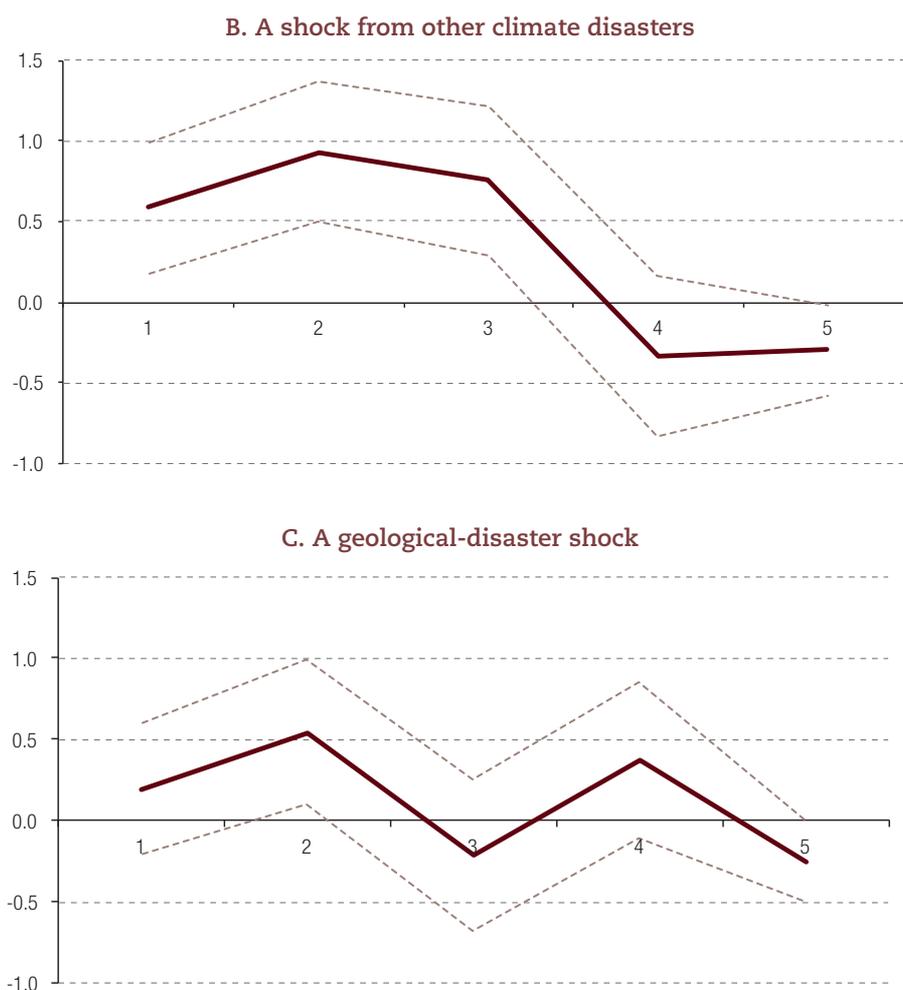


Figure 8 (concluded)



Source: Prepared by the author.

VI. Evaluation of the results

This article makes a contribution to the debate on the impacts of disasters in Latin America and the Caribbean, particularly in the two subregions most intensely affected: Central America and the Caribbean. The econometric estimations are focused on the responses of economic activity and a policy variable, fiscal expenditure.

Three aspects of the results should be highlighted. Firstly, the response of the per capita growth rates of both GDP and government spending, is greater with respect to shocks to the per capita GDP growth rate of high-income countries and terms-of-trade shocks, than to shocks in variables that proxy the different types of disaster. This is explained by the fact that the first two are shocks that affect the whole economy, whereas the other two, in most cases, are of a local nature, affecting one province or region of the country (the exceptions have been specific disasters, mainly hurricanes that have affected whole countries in the Caribbean), so their impacts become diluted when national magnitudes are considered, in terms of both scale and the spatial redistribution of expenditure.³²

³² On this point, see the interesting discussion contained in Albala-Bertrand (2013).

Thus, assistance to deal with the emergency caused by the disaster can be largely obtained in other provinces or departments, so sectoral activity, despite suffering regional upheavals, may not suffer at the national level. By not capturing the local nature of the disaster, measurement of the aggregate impact alone would be shrouding the effect on the regional economy (see ECLAC, 2014). In many cases, highlighting the local dimension is limited by data availability; so, the correct measurement of the impact of the disaster, to make the effects on the local economies of the country visible, should make use of subnational accounts, which have been developed in some countries of the region.³³ It is worth reiterating that, while a disaster might not have a major macroeconomic impact, it may have one at the local level, seriously affecting the lives of the inhabitants of territories where the event occurred. Hence the need to develop disaster risk management policies that are inclusive of local governments and communities.

Secondly, with respect to the results obtained from the disasters themselves, it should be noted that the longest duration of their impact is three years. In other words, a disaster apparently does not affect long-term per capita GDP growth or per capita fiscal spending in the economies of Latin America and the Caribbean. Nonetheless, this is an average, and the result also reflects the PVAR model used, which assumes that the dynamic is the same for all countries. Lastly, given the size of the sample, the robustness of this result cannot be verified, considering only the largest disasters.³⁴ For example, Loayza and others (2009) observed nonlinear disaster-intensity effects.

In terms of more specific results, in the Latin American and Caribbean countries, the IRFs of the per capita GDP growth rate with respect to each of the disaster types considered show that there are differentiated effects between them —negative in the case of storms and other climate disasters and positive in the case of the variable that proxies for geological disasters. The response to the first was statistically significant for three years, but only for one year in the other two cases. An assumption of the PVAR model used is that the same dynamic is being attributed to each country, which might be questionable given the heterogeneity of production patterns in Latin America and the Caribbean. For that reason, estimations were made for groups of countries displaying greater similarities, such as those of Central America and the Caribbean, which are also the two subregions most intensely affected by disasters.

When the Caribbean and Central America are analysed, the conclusions change. In the Caribbean countries, the response of the per capita GDP growth rate to shocks in the variables “Storms” and “Other climate disasters” was negative, lasting for two years in the first case and one year in the second. The response to a geological disaster was not statistically significant. In the Central American countries, the response of the per capita GDP growth rate to storms and other climate disasters was similar, negative in the first year positive in the third; and whereas it was not compensated in the first case it was in the second. The response to a disaster of geological origin was positive in the second and third years. These results show that, in both subregions, the two types of climate disaster, which are the disaster types that have grown most in the last few decades, in all cases had a statistically significant negative response in per capita GDP growth in the first year, accumulating a negative response in three out of four cases. This could be evidence that processes to rebuild or repair the damage caused by those disasters may have been insufficient. Cuaresma, Hlouskova and Obersteiner (2008) observed that, following a disaster, only countries with a certain level of development succeeded rebuilding and achieving improvements relative to the situation prior to the event.

³³ Thus far, seven Latin American countries have this type of subnational account: Brazil, Chile, Colombia, Ecuador, Mexico, Peru and the Plurinational State of Bolivia.

³⁴ The database used here only included countries from Latin America and the Caribbean, so it is a lot smaller than that used in other studies, such as Loayza and others (2009), Jaramillo (2009) and Raddatz (2007 and 2009), among others, which used global data.

In the case of the growth rate of real per capita public spending, the IRF corresponding to the Latin American and Caribbean countries was statistically significant only for a shock in the variable “Other climate disasters” in the first and third years. In the Caribbean countries, that response was statistically significant and positive only for climate disasters —in the first year in the case of storms, and in the first and third years for other climate disasters. In the Central American countries, the response to shocks in the variables of all types of disaster was positive and statistically significant. The response lasted for the first two years in the case of storms, but extended to three for other climate disasters. For geological disasters, the response lasted a year. In short, the results show that the rate of growth of per capita government spending increased as a consequence of a disaster in six out of nine cases. Nonetheless, the results obtained for per capita GDP suggest that this reaction was insufficient to prevent a fall in the growth rate of this indicator. It could be that the reaction has been affected by institutional constraints in each country or by the amount of fiscal slack existing before the event. This constitutes a strong argument in favour of countries enhancing the institutional consolidation of their disaster-risk reduction policy, to incorporate it into public investment policies.

Bibliography

- Albala-Bertrand, J. (2013), *Disasters and the Networked Economy*, New York, Routledge.
- (1993), *The Political Economy of Large Natural Disasters*, Oxford, Clarendon Press.
- Bello, O., L. Ortiz and J.L. Samaniego (2014), “La estimación de los efectos de los desastres en América Latina, 1972-2010”, *Medio Ambiente y Desarrollo series*, No. 157 (LC/L.3899), Santiago, Economic Commission for Latin America and the Caribbean (ECLAC).
- Cavallo, A., E. Cavallo and R. Rigobón (2013), “Prices and supply disruptions during natural disasters”, *NBER Working Paper*, No. 19474, Cambridge, Massachusetts, National Bureau of Economic Research.
- Cavallo, E. and I. Noy (2010), “The economics of natural disasters: a survey”, *IDB Working Paper Series*, No. 124, Washington, D.C., Inter-American Development Bank.
- Cavallo, E. and others (2010), “Catastrophic natural disasters and economic growth”, *IDB Working Paper Series*, No. 183, Washington, D.C., Inter-American Development Bank.
- Christiaensen, L. and K. Subbarao (2005), “Towards an understanding of household vulnerability in rural Kenya”, *Journal of African Economies*, vol. 14, No. 4, Centre for the Study of African Economies.
- Cuaresma, J., J. Hlouskova and M. Obersteiner (2008), “Natural disasters as creative destruction? Evidence from developing countries”, *Economic Inquiry*, vol. 46, No. 2.
- De Gregorio, J. and R. Valdés (2001), “Crisis transmission: evidence from the debt, tequila and Asian flu crises”, *World Bank Economic Review*, vol. 25, No. 2, Oxford University Press.
- Deaton, A. and R. Miller (1996), “International commodity prices, macroeconomic performance and politics in Sub-Saharan Africa”, *Journal of African Economies*, vol. 5, No. 3, Centre for the Study of African Economies.
- Dercon, S. (2005), “Growth and shocks: evidence from rural Ethiopia”, *Journal of Development Economics*, vol. 74, No. 2, Amsterdam, Elsevier.
- Dos Reis, L. (2004), “A fiscal insurance scheme for the Eastern Caribbean Currency Union” [online] <http://www.iadb.org/WMSFiles/products/research/files/pubS-242.pdf>.
- ECLAC (Economic Commission for Latin America and the Caribbean) (2014), *Handbook for Disaster Assessment* (LC/L.3691), Santiago.
- Elbers, C., J. Gunning and B. Kinsey (2002), “Convergence, shocks and poverty”, *Discussion Paper*, No. 2002-035/2, Amsterdam, Tinbergen Institute.
- Hausmann, R., F. Rodríguez and R. Wagner (2006), “Growth collapses”, *CID Working Paper*, No. 136, Cambridge, Massachusetts, Harvard University.
- IPCC (Intergovernmental Panel on Climate Change) (2012), *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation*, Cambridge University Press.
- Islam, N. (1995), “Growth empirics: a panel data approach”, *Quarterly Journal of Economics*, vol. 110, No. 4, Oxford University Press.
- Jaramillo, C. (2009), “Do natural disasters have long-term effects on growth?”, *Documentos CEDE*, No. 24, Bogota, University of the Andes.

- Laeven, L. and F. Valencia (2008), "Systemic banking crises: a new database", *IMF Working Paper*, No. 224, Washington, D.C., International Monetary Fund.
- Loayza, N. and others (2009), "Natural disasters and growth - going beyond the averages", *Policy Research Working Paper Series*, No. 4980, Washington, D.C., World Bank.
- Lybbert, T. and others (2004), "Stochastic wealth dynamics and risk management among a poor population", *Economic Journal*, vol. 114, No. 498.
- Melecky, M. and C. Raddatz (2011), "How do governments respond after catastrophes? Natural-disaster shocks and the fiscal stance", *Policy Research Working Paper Series*, No. 5564, Washington, D.C., World Bank.
- Noy, I. (2007), "The macroeconomic consequences of disasters", *Working Paper*, No. 7, Honolulu, University of Hawaii.
- Olaberria, E. (2009), "Economic impacts of epidemics", unpublished.
- Raddatz, C. (2009), "The wrath of God: macroeconomic costs of natural disasters", *Policy Research Working Paper Series*, No. 5039, Washington, D.C., World Bank.
- (2007), "Are external shocks responsible for the instability of output in low-income countries?", *Journal of Development Economics*, vol. 84, No. 1, Amsterdam, Elsevier.
- Rasmussen, T. (2004), "Macroeconomic implications of natural disasters in the Caribbean", *IMF Working Paper*, No. 04/24, Washington, D.C., International Monetary Fund.
- Reinhart, C. and K. Rogoff (2008), "This time is different: a panoramic view of eight centuries of financial crises", *NBER Working Paper*, No. 13882, Cambridge, Massachusetts, National Bureau of Economic Research.
- Rodríguez-Oreggia, E. and others (2013), "Natural disasters, human development and poverty at the municipal level in Mexico", *Journal of Development Studies*, vol. 49, No. 3, Taylor & Francis.
- Rodrik, D. (1998), "Where did all the growth go? External shocks, social conflict, and growth collapses", *NBER Working Papers*, No. 6350, Cambridge, Massachusetts, National Bureau of Economic Research.
- Skidmore, M. and H. Toya (2002), "Do natural disasters promote long-run growth?", *Economic Inquiry*, vol. 40, No. 4.
- Stromberg, D. (2007), "Natural disasters, economic development, and humanitarian aid", *Journal of Economic Perspectives*, vol. 21, No. 3, Nashville, Tennessee, American Economic Association.
- Titelman, D., E. Pérez and R. Pineda (2009), "The bigness of smallness: The financial crisis, its contagion mechanisms and its effects in Latin America", *CEPAL Review*, No. 98 (LC/G.2404-P), Santiago, Economic Commission for Latin America and the Caribbean (ECLAC).
- Volpe, C. and J.S. Blyde (2013), "Shaky roads and trembling exports: assessing the trade effects of domestic infrastructure using a natural experiment", *Journal of International Economics*, vol. 90, No. 1, Amsterdam, Elsevier.