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Macroeconomic Impact of Natural Disasters due to the Occurrence of Natural Events in Latin America and the Caribbean

Economic and Technical Cooperation

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C O N T E N T S

F O R E W O R D

This document has been drafted in compliance with Activity II.1.3 of the Work Programme of the Permanent Secretariat of SELA for the year 2017, called "Macroeconomic Impact of Disasters due to the Occurrence of Natural Events in Latin America and the Caribbean".

The study consists of an Executive Summary, an Introduction and five sections. Section 1, entitled "Review of Literature", is a brief overview of several empirical papers that address this subject, highlighting the estimation strategies employed and the main results achieved. Section 2, known as "Main Facts", describes the most relevant features and patterns of disasters due to the occurrence of natural events in the region, through an intra-regional comparative assessment and with the rest of the world.

Section 3, identified with the name of "Methodology", contains a detailed description of the data used in the research, as well as the definition of the variables taken into consideration. This section also includes the specification of econometric models, as well as the empirical strategies used to measure the impact of disasters on the real per capita GDP and real per capita consumption in government spending. Section 4, entitled "Results", shows the main findings obtained. Lastly, some final considerations, or conclusions, are presented in Section 5.

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EXECUTIVE SUMMARY

Disasters due to the occurrence of natural events are disturbances that affect the environmental, social and economic spheres of a country (Bello, 2017), causing large social consequences and loss of life.

According to the International Disaster Database (EM-DAT), in the period from 1960 to 2016 13,372 disasters occurred as a result of natural events in the world, affecting 7,791 millions of people and causing the death of 5,354,947 people. Among these disasters, 2,524 (19% of the total) occurred in the African continent, 3,255 (24%) in the Americas, 5,308 (40%) in Asia, 1,669 (12%) in Europe and 616 (5%) in Oceania.

This reality positions the American continent as the geographical area with the second largest registry of occurrence of natural events on a global scale. In America, South American countries are those with the largest occurrence of events, accumulating a total of 1,076 events (33% of the total occurred during the period under analysis), followed by North America with 986 (30%), the Caribbean with 506 (16%), Central America with 448 (14%) and finally Mexico, totalling 239 (7%).

In the case of Latin America and the Caribbean, and with the purpose of expounding on the particular characteristics of natural phenomena, the region has been divided according to the structure of subregional integration mechanisms. Specifically, emphasis is made on the performance of the Pacific Alliance (AP), the Andean Community (CAN), the Caribbean Community (CARICOM), the Common Market of the South (Mercosur), the Central American Integration System (SICA) and South America[2].

The goal of this approach is to show the realities and challenges shared by the member countries of integration blocs, considering them a platform to promote common strategies to face the effects and impacts of disasters due to the occurrence of natural phenomena[3].

In the period 1960-2016, Latin America and the Caribbean reported 2,219 disasters (17% of the world total), in which 285 million people were affected (3.6% of the global total) and 532,284 people died (9.9% of the global total). Of these deaths, 248,872 (47% of total fatalities) were inhabitants of the countries of the Caribbean Community (CARICOM), 186,576 (35%) lived in South American countries, 79,133 (15%) were inhabitants of countries of the Central American Integration System (SICA) and 17,703 (3%) were Mexican citizens.

In addition to this type of negative repercussions on the well-being of the population, there are the economic consequences, which can be devastating for a nation. According to Bello (2017), the economic implications of disasters can be divided into effects and impacts. Effects are associated

[2] The PA is made up of: Colombia, Chile, Mexico and Peru. CAN: Colombia, Bolivia (Plurinational State of), Ecuador and Peru. CARICOM: Antigua and Barbuda, Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Haiti, Jamaica, Montserrat, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Suriname, and Trinidad and Tobago; Cuba is also included for reasons of geographical location. MERCOSUR: Argentina, Brazil, Paraguay, Uruguay and Venezuela (Bolivarian Republic of). SICA: Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, Panama and Dominican Republic. South America is made up of: Argentina, Bolivia (Plurinational State of), Brazil, Chile, Colombia, Ecuador, Paraguay, Peru, Uruguay and Venezuela (Bolivarian Republic of).

[3] At the subregional scale, important advances have been made, such as, for example, the creation of the Central American Coordination Centre for Natural Disaster Prevention (CEPREDENAC), the Andean Committee for Disaster Prevention (CAPRADE), Specialized Meeting on Socio-Natural Disaster Risk Reduction, Civil Defence, Civil Protection and Humanitarian Assistance of Mercosur (REHU) and the Caribbean Disaster Emergency Management Agency (CDEMA).

with damages and affectations on the capital stock that alter the flow of economic activity. For their part, impacts are the consequences of effects on economic and social variables, such as employment, public finance, economic growth, external indebtedness and poverty.

In the period from 1960 to 2016, disasters associated with the occurrence of natural events generated economic damage worldwide in the amount of US$ 2,950,249 million. Of this amount, the African continent reported 1%, American nations 36%, the Asian continent 47%, the European countries 13%, and Oceania 3%.

For their part, the economic damage suffered by Latin America and the Caribbean as a result of natural disasters amounted to US$ 212,561 million, representing 7% of the total reported worldwide. Of these regional losses, 21% were suffered by countries of CARICOM, 12% by members of SICA, 45% by South American countries and 22% by Mexico.

Some empirical studies indicate that the effects and impacts of disasters are relatively stronger or more significant, for various reasons, in the developing countries than in high-income nations (Fomby et al, 2009). In this regard, as stated by Bello (2017), disasters join different disturbances (or external shocks) that affect emerging economies, in particular Latin American and Caribbean countries.

This study measures the impact of disasters due to the occurrence of natural events in the rate of change in real per capita GDP and the rate of change in the real government consumption expenditure per capita (as a measure of fiscal policy) in four integration mechanisms of Latin America and the Caribbean and the South American subregion during the period 1960-2014. Integration schemes under analysis are: the Pacific Alliance (AP), the Andean Community (CAN), the Common Market of the South (Mercosur) and the Central American Integration System (SICA)[4].

To this end, two methodological approaches are used. The first one refers to the use of structural vector autoregressive models (SVAR) through the analysis and interpretation of the impulse-response functions (IRF) derived from them, which are widely used in this type of studies. The second analytic approach consists in estimating a series of uni-equational models (multivariate regressions) for each group of countries, with the purpose of obtaining, alternatively, a measure of the impact of disasters on the growth rate of the real per capita GDP.

Based on the impulse response functions (IRFs) derived from the SVARs, different results were obtained in relation to the sign, magnitude and delay in the response of the growth rates of the real per capita GDP and the real general government consumption expenditure per capita (fiscal policy variable) vis-à-vis disturbances stemming from disasters, for the different integration mechanisms and for the subregion of South America.

As a matter of fact, for the Central American Integration System (SICA), the evidence available during the period 1970-2014 suggests that, in the face of a disturbance stemming from disasters, the annual rate of change in the real per capita GDP recorded an average negative response close to 1.0 percentage point, which is statistically significant in the third year after the disturbance. Furthermore, in relation to the evolution of the fiscal policy variable, measured by the rate of change in the real general government consumption expenditure per capita, it reported a positive

[4] In the case of the CARICOM countries, the required data were not available: For that reason, it was not possible to develop the models specified for this subregion.

and statistically significant response in the first year of the disturbance close to 1.0 percentage point.

As regards the Pacific Alliance and the Andean Community, the responses of the economic activity in real and per capita terms to a disturbance due to disasters, during the period 1960-2014, were contrary to the expectations theoretically and empirically, according to the evidence seen in other studies worldwide (negative response of the product to a disaster shock). In these cases, the estimated IRFs from the SVARs reported an increase in the first year of the disaster. This result could probably be affected by factors that were not considered in the general and common specification of the SVAR models and that could be fundamental determinants of economic growth in the short and long terms. The response of the rate of change in the real government consumption expenditure per capita in the Pacific Alliance was not statistically significant, whereas in the case of the Andean Community a positive and statistically significant response was recorded in the second year after the disaster.

In the case of Mercosur, the IRF results suggest that, during the period 1960-2014, the annual rate of change in the real per capita GDP registered a negative and statistically significant response of approximately 0.8 percentage points in the first year, which disappears as of the second year. In turn, the rate of change in the real government consumption expenditure per capita reported a positive and statistically significant response of about 2.5 percentage points in the third year, after a statistically significant decline in the first year after the disaster.

Finally, for the subregion of South America, estimates of the IRFs, during the period under study, report a negative and statistically significant response in the annual rate of change in the real per capita GDP close to 0.6 percentage points in the first year after the disaster. In turn, the rate of change in the real government consumption expenditure per capita showed a positive and statistically significant response of approximately 1.8 percentage points in the third year after the disturbance.

These results are complemented with those obtained from the uni-equational regressions for the growth rate of the real per capita GDP, which contain a specification similar to that used in the SVARs. While it is true that measuring the impact of disasters on the annual rate of change in the real per capita GDP of the groups of countries and the South American subregion differs in both methodologies (SVARs and uni-equational regressions), the sign of the responses of the economic growth rate (change in the real per capita GDP) to a disturbance due to disasters is the same in both approaches.

As a consequence of the diversity of results obtained for the different integration mechanisms and for South America, in terms of magnitude, direction (or sign) and delays in responses of the annual rates of change in the real per capita GDP and the real government consumption expenditure per capita (fiscal policy variable) to disasters, in this study it is no possible to obtain a general or common result concerning the macroeconomic impact of disasters due to the occurrence of natural events for these variables and for groups of selected countries.

INTRODUCTION

Disasters due to the occurrence of natural events are disturbances that affect the environmental, social and economic environment of a country (Bello, 2017), causing strong social consequences and losses of human lives.[5]

A classic study on this subject by Nordhaus (1992) evaluated the adverse effects of global warming, pointing out that, if a strong-impact strategy against this scourge is not implemented, the Earth's average temperature would rise three Celsius degrees during the period 1990-2050. This author estimates conclude that the global warming process could generate a decrease of nearly 0.03 percentage points in the average annual global economic growth, which would represent a drop of one to two percentage points in the world GDP by the year 2050.

According to the International Disaster Database (EM-DAT), during the period from 1960 to 2016, 13.372 natural events occurred in the world. Out of them, 2,524 (19% of the total) occurred in Africa, 3,255 (24%) in the Americas, 5,308 (40%) in Asia, 1,669 (12%) in Europe, and 616 (5%) in Oceania.

This reality positions the American continent as the geographical area with the second largest number of natural events on a global scale. Within the Americas, South American countries are those who recorded the largest occurrence of events, accumulating a total of 1,076 events (33% of the total occurred during the period under study), followed by North America with 986 (30%), then the Caribbean with 506 (16%), Central America with 448 (14%), and finally Mexico totalling 239 events (7%).

Some empirical studies indicate that the effects of the disaster are relatively stronger or more significant, due to various reasons, in developing countries as compared to high-income countries (Fomby et al, 2009). In this regard, as stated by Bello (2017), disasters joined the various disturbances (or external shocks) affecting emerging economies and, in particular Latin American and Caribbean countries.

According to Bello (2017), the economic implications of disasters can be divided into effects and impacts. The effects are associated with the damages and effects on the capital patrimony that alter economic activity flows. In turn, the impacts are the consequences of the effects on economic and social variables such as employment, public finances, economic growth, external indebtedness and poverty.

This study measures the impact of disasters due to the occurrence of natural events on the variation rate in real per capita GDP and the variation rate of the costs of real per capita government consumption (as a measure of fiscal policy) in four integration mechanisms in Latin America and the Caribbean, and the South American subregion, during the period 1960-2014. The integration mechanisms under study are: the Pacific Alliance (PA), the Andean Community (CAN), the Common Market of the South (MERCOSUR) and the Central American Integration System (SICA).

[5] According to the International Disaster Database (EM-DAT), 5.354.947 people died during the period 1960-2016 as a consequence of disasters due to the occurrence of natural events.

The study is organized as follows: After this introduction, it presents a brief review of the literature that addresses the economic impacts of disasters due to the occurrence of natural events. The second section analyses the main facts of disasters, with special emphasis on Latin America and the Caribbean which is the main region under study. The third section briefly explains the methodology used to obtain estimations, the data, the variables and the empirical strategy. The fourth section presents the results from the different estimates. And lastly, the fifth section contains the final considerations of the study.

1. REVIEW OF RELEVANT LITERATURE

Literature on the effects and impacts of exogenous shocks such as disasters due to the occurrence of natural events on social and economic variables is prolific.

In terms of the macroeconomic consequences of natural disasters, special mention should be made of the study carried out by Fomby et al. (2009), who estimated the response of the growth in the Gross Domestic Product (GDP) – aggregated and disaggregated between its agricultural and non-agricultural components – to four types of disasters due to natural events (droughts, floods, earthquakes and storms). For this purpose, they used a methodological approach based on a series of experiences of various countries through time, by using a Vector Autoregressive Model (VAR) to analyse a number of endogenous variables and exogenous shocks applied on a cross-section panel and time series data. Through such analysis, heterogeneous effects of disasters were found on a variety of dimensions. For example, the effects of natural disasters are relatively stronger in developing countries in comparison with high-income countries. Nevertheless, the impact of some disasters can be useful when they are have a moderate intensity, but more severe disasters never have positive effects. Finally, they conclude that not all natural disasters are alike in terms of the effect they have on economic growth.

Similarly, Cavallo et al. (2010) examined the average impact of disasters due to catastrophic natural events on economic growth in the short and long terms, by using the methodology known as case studies or comparative events. This empirical strategy identifies the shocks affecting per capita income after a disaster has occurred through a comparison with a counterfactual series outlined by using control variables. These authors found that natural disasters, even those considered major disasters, do not generate a significant impact on the economic growth of the countries affected by the disaster, neither in the short nor in the long term, with both being statistically significant.

Only in two case studies did these authors find significant impacts on economic growth, although these were accompanied by subsequent events of political revolution. Specifically, Cavallo et al. (2010) noted that in those cases where disasters due to natural events were followed by the emergence of political events involving collective conflicts (specifically the Islamic Revolution in Iran and the Sandinista Revolution in Nicaragua, both in 1979), ten years after the occurrence of the disaster, the per capita product was, on average, 10% lower as compared to the period prior to the disaster, and it would have been 18% higher on a contrary scenario without the occurrence of the disaster. Thus, they conclude that only those extensive natural disasters accompanied by radical political revolutions (which included major changes to the property and social rights system) have persistent negative impacts on economic growth in the long term.

For his part, Acevedo (2014) estimated the impact of disasters on the per capita GDP and on the public debt to GDP ratio in Caribbean countries. For such purpose, the author used the Vector Autoregressive Model to analyse the exogenous shocks of natural disasters in a series of 12 Caribbean countries during a 40-year period. The author took into account two types of natural events (storms and floods, both moderate and severe) and found that both storms and floods have a negative impact on economic growth, highlighting that severe disasters had the greatest impact. In terms of the debt-to-GDP ratio, the study revealed that the debt grows in relation to GDP with floods, but not with disasters associated with storms, even though an analysis by periods showed consequences of the storms on the debt in the short and the long terms. According to this author, the increases in the debt-to-GDP ratio after a disaster not only are due to a decrease in the GDP, but also to an increase in the indebtedness levels to finance the reconstruction efforts and the recovery of the economic activity.

In turn, the work conducted by Wright and Borda (2016) studied the role of a *shock* due to a disaster on the macroeconomic magnitudes of a small and open economy, represented in a dynamic stochastic general equilibrium model. These authors estimated the model through the vector autoregressive methodology (VAR) in panel data for five variables that should reflect the economic relations that determine the dynamics of open small economies (product, investment, trade balance, consumption, and country risk), in order to analyse the economic disruptions stemming from the exogenous shocks of disasters for the countries of Central America and the Caribbean. The findings show that Caribbean countries are better prepared to face this type of exogenous shocks, while Central American countries suffer persistent impacts. Overall, according to these authors, the results indicate that the co-existence of shocks from disasters, financial frictions and permanent productivity problems explains macroeconomic fluctuations in these countries.

With respect to public finances, Desfrancois (2015) estimates the risk represented by natural events (earthquakes, tropical storms, floods and droughts) for the economy of El Salvador through the simulation of the trajectory of public debt in the event of a great magnitude disaster, by applying the vector autoregressive methodology with exogenous variables. The results evidence that in the case of a great magnitude catastrophe due to the occurrence of a natural event, the level of the total debt of the non-financial public sector over the GDP rises, on average, about 5.8% compared to a non-disaster scenario. However, the consequences from small or moderate events do not have significant impacts.

In Desfrancois' opinion, disasters cause an increase in public investment (due to the higher costs of reconstruction), a decrease in revenues, as well as an increase in interest rates and a contraction of GDP. This led the Salvadoran economy to face the risk of a double catastrophe, in which a disaster due to the occurrence of natural phenomena subsequently provokes pressures on public finances.

Recently, and in relation to the impact of disasters on the economic activity and the government's response terms of fiscal policy, the study carried out by Bello (2017) estimated the impact of different types of disasters (geological and climatic) on the rate of growth of the per capita Gross Domestic Product (GDP) and on the growth rate of per capita fiscal spending in two subregions that are particularly affected with greater intensity by such events: the Caribbean and Central America. This author used the methodologies of Raddatz (2007) and Melecky and Raddatz (2011), as well as an estimation through a panel vector auto-regressive model (PVAR) for the period 1970-2010. As a result, he noted that there are effects differentiated by type of disaster and by subregions.

On the one hand, in Caribbean countries, the response seen in the growth rate of per capita GDP to climate-related disasters was negative, but the response to a geologic disaster was not significant in statistical terms. On the other hand, in Central American countries, the response seen in the growth rate of per capita GDP to climate disasters was negative the first year and positive by the third year, and the response to geological disasters was positive in the second and the third years.

2. MAIN FACTS ABOUT DISASTERS DUE TO NATURAL EVENTS IN LATIN AMERICA AND THE CARIBBEAN

This section lists and describes the main features that characterize disasters due to the occurrence of natural phenomena in the region.[6] Specifically, it evaluates the frequency and intensity by category of event, through a comparative intra-regional study and with the rest of the world.

With the purpose of detailing the most outstanding characteristics of natural phenomena in Latin America and the Caribbean, the region has been divided according to the structure of subregional integration mechanisms. Specifically, the study deals with the performance of the Pacific Alliance (PA), the Andean Community (CAN), the Caribbean Community (CARICOM), the Common Market of the South (MERCOSUR), the Central American Integration System (SICA), and a section dedicated to South America.[7]

The purpose of this descriptive approach is to show the realities and challenges shared by the member countries of the integration blocs, understanding them as platforms to promote common strategies that allow for facing the effects and impacts of disasters due to the occurrence of natural phenomena.[8]

2.1. Occurrence of regional natural events within the global context (1960-2016)

During the period 1960-2016, there were 13,372 natural events in the world. As shown in Annex 1, out of them, 2.524 (19% of the total) occurred in Africa; 3.255 (24%) in the Americas; 5,308 (40%) in Asia; 1,669 (12%) in Europe; and 616 (5%) in Oceania.[9] During this period, the decade from 2000 to 2009 stands out as the period with the highest frequency of these phenomena in the whole world.

These data position the American continent as the geographical region with the second largest occurrence of natural events on a global scale. Within the Americas, and as can be seen in Annex 2, such dynamism is led by South American countries where 1,076 events took place (33% of the total occurred during the period under study), followed by North America with 986 (30%), the Caribbean with 506 (16%), Central America with 448 (14%), and Mexico with 239 (7%).[10]

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[6] In this document, the term “the region” refers to Latin America and the Caribbean.

[7] The PA is made up by: Colombia, Chile, Mexico and Peru. The Andean Community (CAN) comprises: Bolivia (Plurinational State of), Colombia, Ecuador and Peru. The members of CARICOM are: Antigua and Barbuda, Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Haiti, Jamaica, Montserrat, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Suriname, and Trinidad and Tobago; Cuba is also included due to its geographical location. MERCOSUR includes: Argentina, Brazil, Paraguay, Uruguay and Venezuela (Bolivarian Republic of). SICA is made up by: Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, Panama and Dominican Republic. And South America encompasses: Argentina, Bolivia (Plurinational State of), Brazil, Chile, Colombia, Ecuador, Paraguay, Peru, Uruguay and Venezuela (Bolivarian Republic of).

[8] On a subregional scale, important advances can be evidenced, such as the creation of the Center for the Prevention of Natural Disasters in Central America (CEPREDENAC), the Andean Committee for Disaster Prevention (CAPRADE), the Specialized Meeting for Socio-Natural Disaster Risk Reduction, Civil Defence, Civil Protection and Humanitarian Assistance (Mercosur’s REHU), and the Caribbean Disaster Emergency Management Agency (CDEMA).

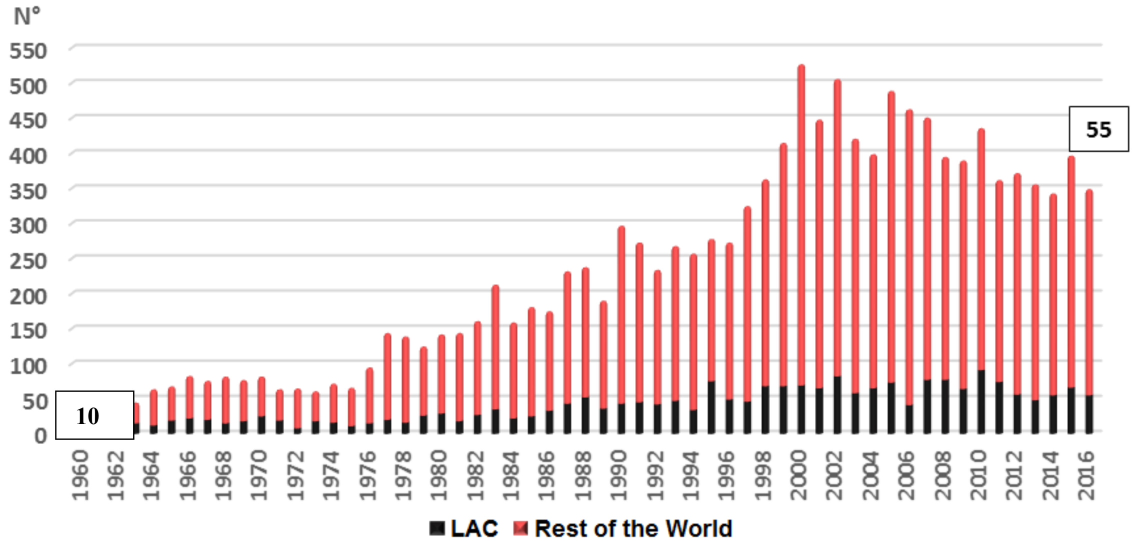
[9] Both the frequency and the number of natural events occurred are closely linked with the extension of the surface of the territory under study.

[10] For the purposes of this analysis, South America encompasses: Argentina, Bolivia (Plurinational State of), Brazil, Chile, Colombia, Ecuador, Paraguay, Peru, Uruguay and Venezuela (Bolivarian Republic of); North America is made up by: the United States of America, Canada and Bermuda; Central America includes: Belize, Costa Rica, El Salvador, Guatemala,

With respect to the performance of Latin America and the Caribbean[11] – the region under study – Chart 1 shows the number of natural phenomena that have occurred annually during the period 1960-2016, as compared to the rest of the world.

CHART 1

Number of natural events occurred in Latin America and the Caribbean and the world (1960-2016)



Source: Calculations by the author, by using data from the International Disaster Database (EM-DAT).

During the period under study, 2,269 (17% of the world total) natural events occurred in the region. In 1960, there were 10 of these events in Latin American and Caribbean countries, which accounted for 25% of the total occurred worldwide that year. In 2016, a total of 55 natural phenomena, i.e., a global relative share of 16%. In spite of the decrease in the relative figure, the average annual variation rate of occurrence in Latin America and the Caribbean (11%) almost doubles the rate experienced by the rest of the world (6%).

Such an increase in the occurrence of natural events can be seen in all the categories.[12] In a comparative exercise covering the decades 1960-1969 and 2010-2016, global hydrological

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Honduras, Nicaragua and Panama; and the Caribbean nations are: Antigua and Barbuda, Bahamas, Barbados, Cuba, Dominica, Grenada, Guyana, Haiti, Jamaica, Dominican Republic, St. Kitts and Nevis, St. Lucia, St Vincent and the Grenadines, Suriname, and Trinidad and Tobago.

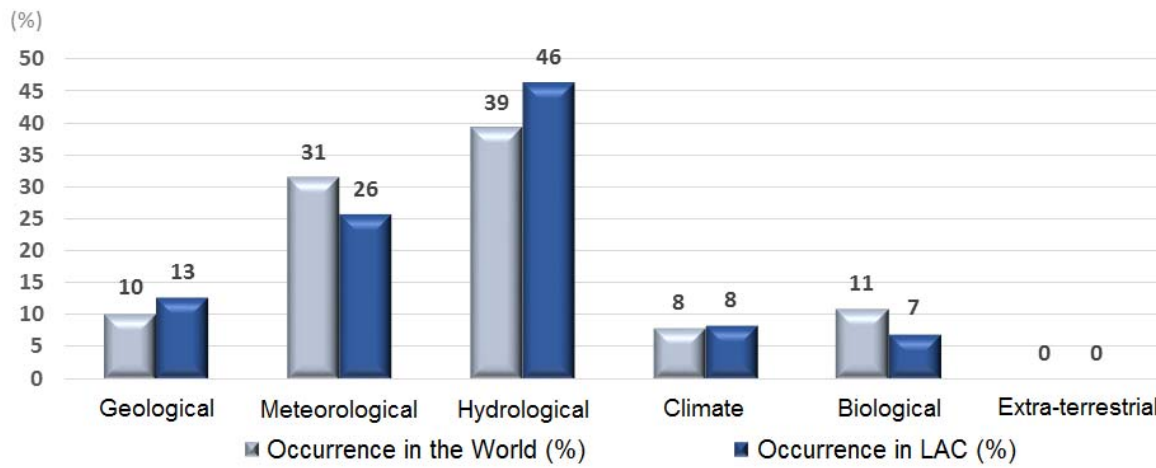
[11] Latin America and the Caribbean is made up by: Antigua and Barbuda, Argentina, Bahamas, Barbados, Belize, Bolivia (Plurinational State of), Brazil, Chile, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, Ecuador, El Salvador, Grenada, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, St Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Suriname, Trinidad and Tobago, Uruguay and Venezuela (Bolivarian Republic of).

12 This comparative analysis is performed with the use of the general classification of the International Disaster Database (EM-DAT) at the level of subgroups. Geological phenomena include: earthquakes, dry landslides and volcanic activity. Meteorological events include: extreme temperatures, fog and storms. Hydrological events are: floods, landslides and action of waves. Climate events include: droughts, phenomena in glacial lakes and fires. Biological phenomena include: epidemics, insect infections and accidents caused by animals. In the case of aliens: impacts and space phenomena.

phenomena stand out with the highest growth rate (568%), followed by biological events (381%), meteorological events (273%), climate events (219%) and geological events (147%). At the regional level, the high variation of hydrological events remains the same (343%), although accompanied by climate phenomena (310%), then biological events (175%), followed by meteorological events (124%) and finally geological phenomena (100%).

Such behaviour in the variation rates leads to patterns of occurrence with marked similarities at the global and regional levels during the period 1960-2016. As shown in Chart 2, the most frequent phenomena are the hydrological events (39% in the world and 46% in the regional totals), then come the meteorological events (31% and 26%), the geological events (10% and 13%), the biological events (11% and 7%), and lastly the climate events (8% and 8%).

CHART 2
Relative share of subgroups of natural events in total occurrence (1960-2016)
(Percentages)



Source: Prepared by the author, based on data from the International Disaster Database (EM-DAT).

At the intra-regional level, during the period 1960-2016, 19% of the total natural events in the region took place in Caribbean countries (CARICOM Member States), while in Central America (SICA sub-region) it was 23% of the total, in South America 47%, and in Mexico 11%. Out of the integration mechanisms with South American countries as members, the Pacific Alliance is the one that reports the largest number of events during the period under study, with a total of 706, followed by 550 in the Andean Community and 452 in MERCOSUR. In all the subregional integration mechanisms, the decade with the highest occurrence of natural events is that comprised between 2000 and 2009 (see Table 1).

TABLE 1
Number of natural events by subregional integration mechanism (1960-2016)

Decade	LAC	CARICOM	SICA	South America	PA	CAN	MERCOSUR
1960-1969	142	34	28	68	38	27	27
1970-1979	174	29	33	95	60	56	35
1980-1989	320	73	51	167	109	89	74
1990-1999	517	99	120	231	170	121	93
2000-2009	671	126	175	304	192	148	138
2010-2016	445	74	112	211	137	109	85
Total	**2,269**	**435**	**519**	**1,076**	**706**	**550**	**452**

LAC: Latin America and the Caribbean.
Source: Prepared by the author, based on data from the International Disaster Database (EM-DAT).

2.2. Measurements of intensity of disasters due to the occurrence of natural phenomena in the region (1960-2016)

This section analyses the main measures of intensity of disasters due to the occurrence of natural events: deaths, total of affected people and economic damage.

2.2.1. Deaths

During the period between 1960 and 2016, 5,354,597 people in the world died because of disasters due to the occurrence of natural phenomena. Out of these victims, 17% lived in Africa, 10% in the Americas, 69% in Asia, 3.9% in Europe and 0.1% in Oceania.

Of these deaths, 41% are caused by disasters associated with climatological events, 26% are linked to geological phenomena, 21% to meteorological events, 7% to hydrological events and 5% to biological events. These data indicate that during the period under study, 18% of the events that occurred (climatological and geological) were the cause of 67% of these deaths. This supports Bello’s argument (2017) that this is the measure of intensity most Influenced by particular events.

During the period 1960-2016, 532,284 people (9.9% of the global total) died in Latin America and the Caribbean due to disasters caused by natural events. Out of these deaths, 248,872 (47% of the total fatalities) were inhabitants of CARICOM countries, 79,133 (15%) were inhabitants of SICA countries, 186,576 (35%) were residing in South American countries, and 17,703 (3%) were Mexican citizens.

Table 2 shows the annual average by decades of the number of people killed per every 10,000 inhabitants because of disasters due to the occurrence of natural events. In Latin America and the Caribbean, the decade 2000-2009 was the period with the highest ratio in this measure of intensity, largely affected by the situation in CARICOM countries, whose levels, together with those of SICA, considerably exceed the rest of the region.

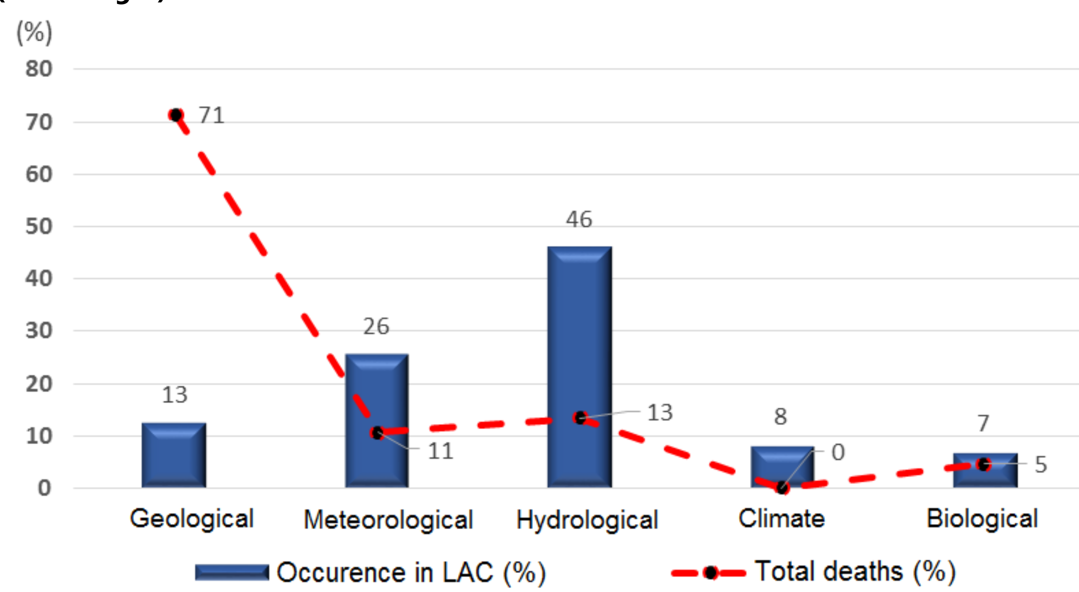
TABLE 2
Number of deaths per every 10,000 inhabitants (annual average by decades)

Decade	LAC	CARICOM[13]	SICA	South America	PA	CAN	MERCOSUR
1960-1969	0.108	0.527	0.107	0.078	0.126	0.030	0.025
1970-1979	0.411	0.019	1.807	0.046	0.072	0.125	0.022
1980-1989	0.126	0.064	0.091	0.138	0.282	0.515	0.015
1990-1999	0.152	0.070	0.508	0.149	0.113	0.221	0.131
2000-2009	0.035	0.265	0.115	0.016	0.021	0.042	0.007
2010-2014	0.801	17.22	0.047	0.029	0.039	0.069	0.013

Source: Prepared by the author, based on data from the International Disaster Database (EM-DAT).

As can be seen in Chart 3, between 1960 and 2016, the subgroup of geological events (13% of the total of natural events) caused 71% of deaths in the wake of disasters due to natural phenomena in the region. In turn, hydrological events, whose occurrence is more frequent at the regional level, caused 13% of total losses of lives.

CHART 3
Deaths by subgroups of natural events in Latin America and the Caribbean (1960-2016) (Percentages)



Source: Prepared by the author, based on data from the International Disaster Database (EM-DAT).

[13] In calculating this measure of intensity for CARICOM countries, data were used on the population of the member countries based on the World Development Indicators (WDI) of the World Bank. For the rest of the groups of countries, population data from the *Penn World Table 9.0* (Feenstra, Inklaar, and Timmer, 2015) were used.

In the Caribbean countries, disasters caused by geological phenomena caused 88% of the deaths due to the occurrence of natural phenomena, while those associated to meteorological events caused 7%. In SICA, the superiority of the impact of geological events remains the same as they caused 46% of the deaths, while meteorological phenomena are associated with 42% of the fatal victims. In South America, disasters linked with the subgroup of hydrological events are the leading cause of death (47%), closely followed by geological phenomena (37%).

2.2.2. Total affected people[14]

In the period 1960-2016, disasters caused by natural events affected 7.791 billion people around the world. Out of this total of affected people, 7% were inhabitants of Africa, 5% of the Americas, 87% corresponded to inhabitants of Asia, 0.6% from Europe, and 0.4% from Oceania.

Meanwhile, in Latin America and the Caribbean, 285 million people were affected, which corresponds to 3.6% of the total number of affected people globally. Within the region, 11% lived in CARICOM countries, 13% in Member States of SICA, 69% in South American nations, and 7% in Mexico.

Table 3 shows a measure of relative intensity of affected people, taking into account the number of inhabitants in each subregion, which makes it possible to clearly see the greater vulnerability of inhabitants of CARICOM and SICA as a result of disasters.

TABLE 3
Total affected people per every 10,000 inhabitants (annual average by decades)

Decade	LAC	CARICOM	SICA	South America	PA	CAN	MERCOSUR
1960-1969	43.3	40.7	27.6	54.6	43.5	30.4	43.3
1970-1979	125.3	80.7	327.8	135.6	97.3	146.4	124.3
1980-1989	157.9	214.5	93.4	196.2	54.7	115.0	227.0
1990-1999	77.1	256.4	174.1	66.8	63.1	115.7	52.5
2000-2009	92.5	455.5	171.3	65.8	101.1	160.2	33.4
2010-2014	223.7	483.3	239.0	242.4	154.4	177.7	259.0

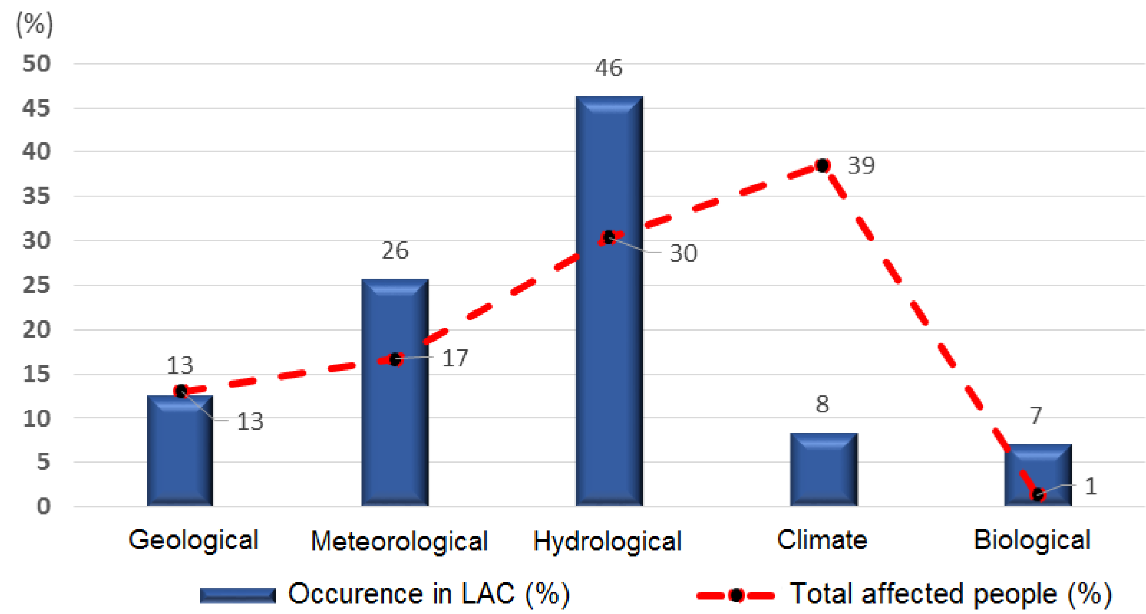
Source: Prepared by the author, based on data from the International Disaster Database (EM-DAT).

At the regional level, during the period under study, the natural events that caused the highest proportion of affected people were climate conditions (39%) followed by hydrological events

[14] According to the International Disaster Database (EM-DAT), the measure of "Total affected people" includes injured persons, affected people, and those who lost their homes, or whose homes were structurally damaged. Affected people are those who, because of the disaster due the occurrence of a natural event, required immediate assistance.

(30%), then meteorological events (17%) followed by geological events (13%) and biological events (1%) (See Chart 4).

CHART 4
Total affected people by subgroups of natural events in Latin America and the Caribbean (1960-2016)
(Percentages)



Source: Prepared by the author, based on data from the International Disaster Database (EM-DAT).

On a subregional scale, between 1960 and 2016, in the CARICOM countries meteorological phenomena were associated with 56% of affected people, followed by the climate events that caused slightly more than 19%. During the same period, in the Member States of SICA meteorological and geological phenomena were equally severe, as they caused 31% and 30% of the total people affected by natural events. In South American countries, climate events caused 48% of those affected accounted for, while hydrological events were responsible for 37%.

2.2.3. Economic damage

In the period between 1960 and 2016, disasters associated with the occurrence of natural events generated economic damage worldwide amounting to US$ 2,950,249 million. Out of this amount, the African continent suffered 1%, American nations 36%, Asia 47% European countries 13% and Oceania 3%.

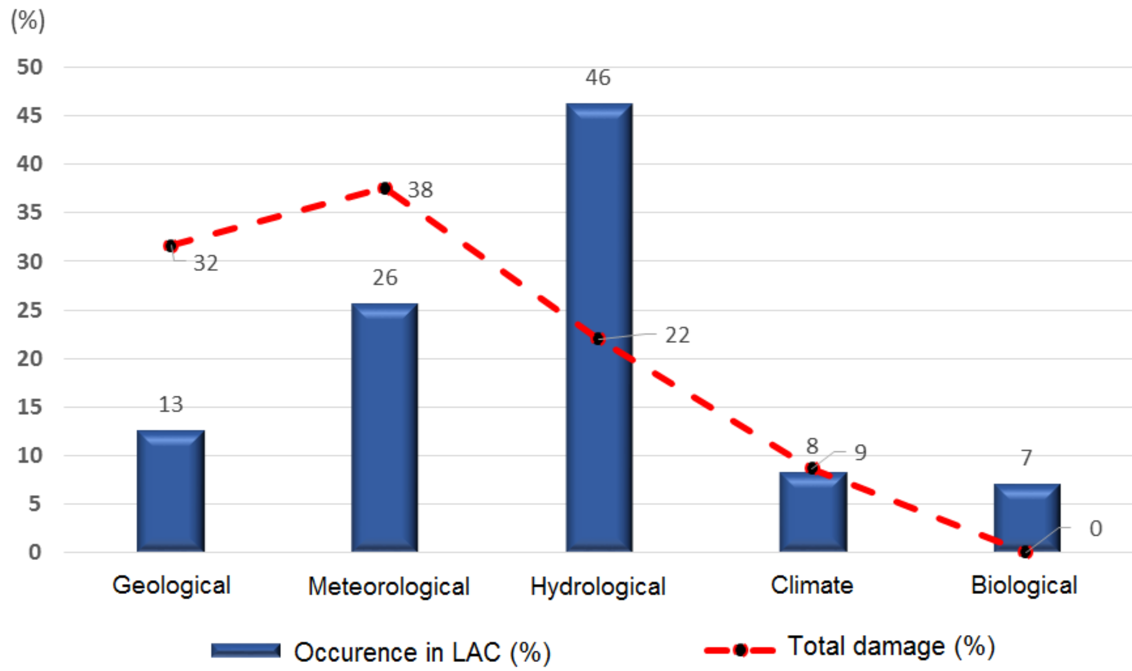
Since 1980 there has been a progressive increase in the adverse economic effects caused by this type of disasters globally, reaching maximum losses in the order of US$ 364,000 million in 2011. Between 1960 and 2016, disasters due to meteorological events caused 39% of the adverse global economic effects, followed by geological phenomena that caused 27% of losses, then the hydrological events which caused 26%, and finally climate events with 8% of monetary losses.

During the period under study, the economic damage suffered by Latin America and the Caribbean because of disasters of a natural origin amounted to US$ 212,561 million, representing

7% of the total losses posted worldwide. Out of these regional losses, 21% were suffered by the CARICOM countries, 12% by members of SICA, 45% by South American countries, and 22% by Mexico.[15]

As can be seen in Chart 5, in the region the disasters caused by climate events are the main cause of economic damage, as they accounted for 39% of the monetary losses between 1960 and 2016. In turn, disasters due to hydrological phenomena caused 30% of adverse economic effects, followed by meteorological and geological phenomena.

CHART 5
Economic damage by subgroups of natural events in Latin America and the Caribbean (1960-2016)
(Percentages)



Source: Prepared by the author, based on data from the International Disaster Database (EM-DAT).

A relative measure that can more easily explain the regressive economic effects of disasters is obtained by compare the size of total damages with the Gross Domestic Product (GDP) of the geographical space under consideration.[16] Thus, Chart 6 shows that, during the period 1980-2014, the economic damage from disasters accounted, on average, for 0.25% of the region's annual GDP. During the years from 1983 to 2010, the adverse economic effects meant little more than 0.8% of annual GDP, although it is in 1985 when the economic damage reached its highest level, representing more than 1.2% of the regional GDP for that year[17] (see Chart 6).

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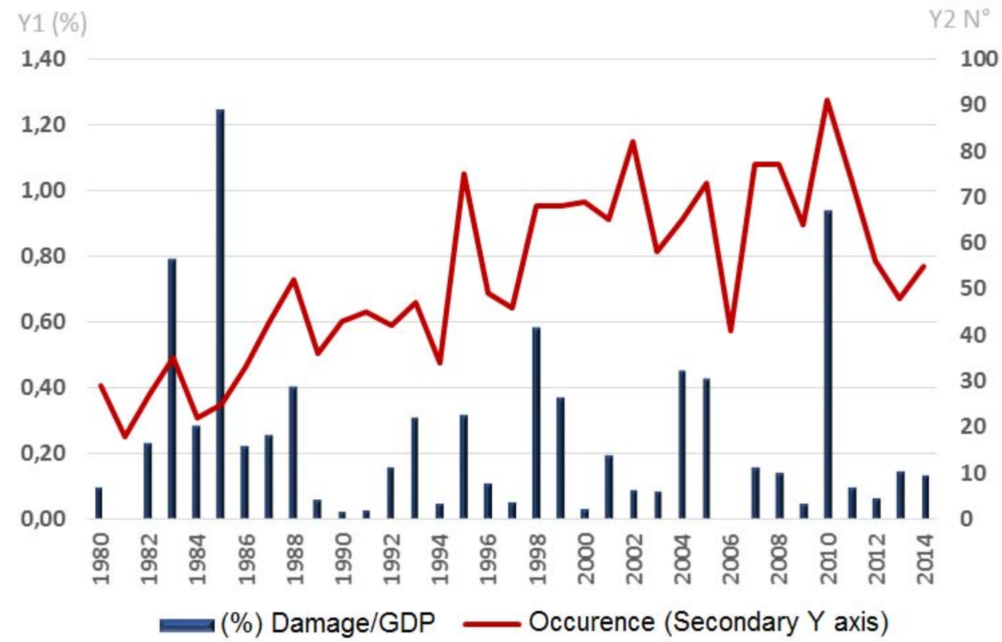
[15] During the sub-period 2010-2016, Mexico suffered 40% of the total economic damage accumulated since 1960.

[16] This measure of intensity is calculated by dividing the amount of the total economic damages by the GDP at current prices. To perform this procedure in the considered integration mechanisms we proceeded to add the total economic damages in the Member countries and their respective GDP at current prices to obtain the required ratio.

[17] The occurrence of disasters of major proportions explains an important part of this behaviour. During the year 1983 heavy rains due to the phenomenon of the "Mega Niño", in 1985 the volcanic eruption of the Nevado del Ruiz in Colombia, and in 2010 the earthquake in Haiti.

CHART 6
Economic damage over the GDP in Latin America and the Caribbean (1980-2014)
(Percentages)



Source: Prepared by the author, based on data from the International Disaster Database (EM-DAT).

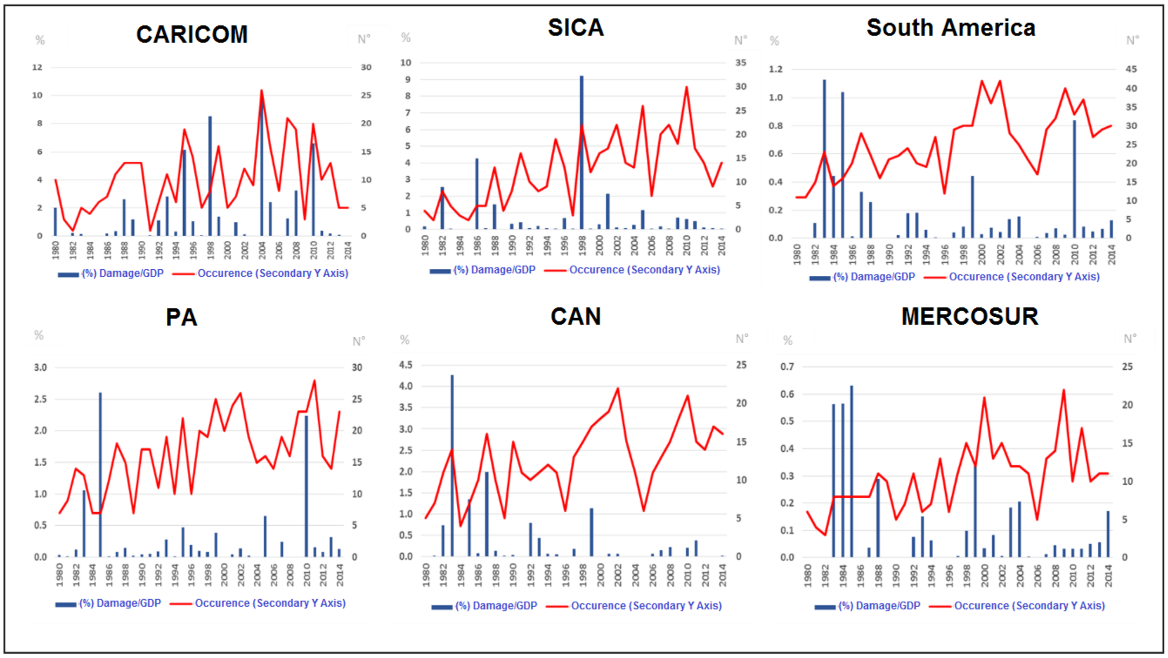
The subregions with the greatest adverse effects caused by disasters are the Caribbean and Central America. In relative terms to the sizes of their economies, during the period 1980-2014, the CARICOM countries suffered adverse monetary effects close to 1.5% of their annual average GDP, exceeding the barrier of 8% of the size of their economies in 2004, 2007 and 2010. In the Member States of SICA, between 1980 and 2014, the economic effects of disasters cause annual average losses of 0.7% of the GDP within the system, with 1998 being the year with the highest economic damage in terms of their GDP.

Between 1980 and 2014, in the South American subregion the economic damage due to disasters amounted, on average, to 0.2% of their annual GDP. In comparative terms regarding losses in the rest of the subregions, South American countries suffer less damage, and only in 1983 and 1985 the losses exceeded 1% of their annual GDP.

With respect to the subregional integration schemes made up by South American countries, the Andean Community is the mechanism with greatest relative losses, averaging damage of 0.4% of their annual GDP between 1980 and 2014. In second place is the Pacific Alliance, whose average losses were equivalent to 0.3% of their annual GDP during the period 1980-2014, showing losses of over 2% of annual GDP in 1985 and 2010. Finally is MERCOSUR, where the adverse economic effects of disasters in terms of its GDP are lower than in the rest of the subregional integration blocs, averaging an annual damage of 0.1% of GDP between 1980 to 2014. Chart 7 presents the economic damage relative to GDP and the occurrence of the number of natural events for the subregional integration schemes and South America.

According to Bello (2017), quoting Albala-Bertrand (1993), these figures for nationwide indicators, and at the subregional level for this study, do not reflect the real adverse effect of disasters due to the occurrence of natural phenomena on the local economy. Due to the fact that natural events are limited to a specific geographical area, the factor that defines the total damage that will suffer the rest of the economy will be the strength of the transmission mechanisms of these monetary losses to the national economy, and hence the subregional economy.

CHART 7
Economic damage over the GDP and occurrence of events by subregions (1980-2014) (Percentages)



Source: Prepared by the author, based on data from the International Disaster Database (EM-DAT).

3. METHODOLOGY

In order to analyse the macroeconomic impact of disasters on the growth rate of the real per capita Gross Domestic Product (GDP) and on the rate of spending growth in general per capita real government consumption (fiscal policy measure) in the five groups of countries in Latin America and the Caribbean,[18] two approaches are used. The first approach refers to the use of *Structural Vector Autoregressive* models (SVAR) through the analysis and interpretation of the impulse-response functions (IRF) derived from those models, which are widely used in this type of studies.[19] The second analytic approach consists in the estimation of a series of uni-equational models (multi-variable regressions) for each group of countries, which alternatively allows for obtaining another measure of the impact of disasters on the growth rate of the real per capita GDP.[20] Following is a brief explanation of the variables considered, the specification and identification of the SVAR and the empirical strategy adopted for this study.

3.1. Data

For this study, annual data for 19 countries of Latin America and the Caribbean during the period 1960-2014 were used. The data come from different sources such as: *Penn World Table 9.0* (Feenstra, Inklaar and Timmer, 2015), the World Bank (WB), specifically from the World Development Indicators (2016) (WDI), the International Monetary Fund (IMF), and the International Disaster Database (EM-DAT), of the Centre for Research on the Epidemiology of Disasters (CRED) of the Louvain Catholic University, in Brussels.

The data on disasters come from the EM-DAT database, developed by CRED. This database contains information on the incidence and effect of natural disasters from the year 1900 to the present date.

The database compiles information on natural disasters from different sources, such as United Nations agencies, non-governmental organizations, insurance companies, press agencies and research institutes. The centre was established in 1973 at the Public Health School of the Catholic University of Louvain (UCL), in Brussels. Since 1980, it became a collaborating centre of the World Health Organization (WHO). Since then, it has worked along with the United Nations Department of Humanitarian Affairs (UN-DHA), the European Union's Office for Humanitarian Aid and Civil Protection (ECHO), and some non-governmental agencies on a global scale.

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[18] The groups of countries are grouped into the following integration mechanisms plus the South American subregion: 1) the Pacific Alliance, 2) the Andean Community (CAN), 3) the Central American Integration System (SICA), 4) the Common Market of the South (MERCOSUR), and 5) South America.

[19] Studies using a variant of these types of models (VAR) to analyse the macroeconomic impact of disasters in different regions of the world include: Acevedo (2014), Cabezón et al, (2015), Raddatz (2009), Fomby et al, (2013), and Bello (2017), among others, which used a variant of the conventional VAR models, called in the literature on econometrics as models of Panel Vector Autoregressive (PVAR) models.

[20] This second methodological strategy is not used for estimating the impact of disasters on the real per capita consumption spending, because from the theoretical standpoint its behaviour is determined by a series of explanatory variables that escape from the purpose of this document.

Its reports are limited to those disasters that have relevance on a global scale. Specifically, it defines a natural disaster as a natural situation that overwhelms local capacity and/or requires the provision of external assistance. The criteria to enter a disaster into the database are as follows:

- 10 or more persons dead due to the disaster.
- 100 or more people affected.
- Declaration of a state of emergency.
- Request for international aid.

This database contains information about the number of dead people, the total population affected and the economic cost associated with the disaster due the occurrence of a natural event, disaggregated by countries, subregions and continents.[21] The majority of the consulted empirical studies assessing the macroeconomic impact of disasters have used this database as a source of information.

However, with respect to measuring the intensity of disasters, there are several alternatives that have been employed in various empirical studies.[22] For this study, and taking into account the selected empirical methodology, we chose to use a measure of disasters similar to that seen in Fomby et al. (2013), Cabezón et al. (2015), and Parker (2016), which approximates the intensity of disasters through the ratio of deaths and the total of affected people reported by event (or disaster) as a proportion of the total population:

$$Intensidad_{i,t} = \left(\frac{Número\ de\ muertes_{i,t} + 0{,}3 * Total\ Afectados_{i,t}}{Población\ total_{i,t}}\right) * 100 \quad (1)$$

This formula defines the subgroups of events as *k* (*k* = 1, 2, 3, 4 and 5, which correspond, respectively, to hydrological, meteorological, climatological, geological and biological events), in the country (or group of countries) *"i"*, during the year *"t"*. The construction of the variable, or measurement of the intensity of disasters, can be summarized in the following steps: First, an addition is made of the total number of deaths and the total number of people affected by the *k* subgroups of disasters recorded by country (and groups of countries) (k = 1, 2, 3, 4 and 5). Secondly, once total values for these two variables in each year are obtained, we proceed to apply equation (1), considering the total population of each country (or group of countries) *"i"*, during the year *"t"*.

In equation (1), the affected population is defined as a weighted average of deaths (with a weight of 1) and the total of affected people (with a relative weight of 0.3) divided by the total population, since, as Acevedo (2014) points out, it is reasonable to express that disasters with deaths are considered to be more severe (with a higher weight) than those in which there were not registered

[21] For further details on the contents, description, characteristics and different levels of disaggregation of this database, please consult: http://www.emdat.be/explanatory-notes.

[22] In order to learn about the different forms to measure disasters on the basis of the EM-DAT database that have been used in empirical studies on the impacts of disasters, please consult: Acevedo (2014), Cabezón et al., (2015), Raddatz (2009), Fomby et al., (2013), Parker (2016) and Bello (2017).

deaths.[23] The rest of the variables used in the various estimations of the study (both in SVAR models and in uni-equational models) are summarized in Table 4.

TABLE 4
Description of the variables used in the study

Variables	Definition	Source
Growth rate of real per capita GDP	First difference of the natural logarithm of the real per capita GDP	Penn World Table 9.0
Growth rate of real per capita government consumption spending	First difference of the natural logarithm of the real per capita government consumption spending	World Bank (WDI), Penn World Table 9.0 and International Monetary Fund (IMF)
Growth rate of real per capita GDP in high income countries	First difference of the natural logarithm of the real per capita GDP in high income countries	Penn World Table 9.0
International interest rate	Interest rate of the US government bonds, as a percentage	International Monetary Fund (IMF)
Growth rate of terms of exchange	First difference of the natural logarithm of the terms of exchange (px/pm), approximated by the ratio between the price indices for exports (px) and for imports (pm)	Penn World Table 9.0
Intensity of disasters	As defined in the text	EM-DAT
Growth rate of capital stock per inhabitant in real terms	First difference of the natural logarithm of the real per capita capital stock.	Penn World Table 9.0
Population	Number of inhabitants, in millions of people	Penn World Table 9.0

Source: Prepared by the author, based on the aforementioned sources (2017). Annex 3 provides a detailed definition of each variable.

[23] This intensity measure of disasters is quite similar to that used by Cabezón et al., (2015).

3.2. SVAR Models: Specification and identification

3.2.1. Specification

Since the work pioneered by Sims (1980), SVAR models have become a natural way to summarize the information contained in data and to conduct crucial economic experiments such as the evaluation of the impact of one variable on others. Starting with a structural representation of the data, a SVAR (q) can be expressed as:

$$B^{-1}y_t = \Gamma_0 + \Gamma_1 y_{t-p} + u_t \qquad u_t \sim (0, \Sigma_u) \qquad (2)$$

Where y_t is a vector of order *n x 1* of n endogenous variables,[24] and u_t is the vector of structural errors with a diagonal covariance matrix. Because of their orthogonal nature, these errors are usually known as shocks that are interpretable economically, which affect various endogenous variables at one time through a matrix of B^{-1} coefficients. Since reduced VARs are easier to estimate than the SVARs, we can always restate the previous model into a VAR (q):

$$y_t = A_0 + A_1 y_{t-p} + e_t \qquad e_t \sim (0, \Sigma_e) \qquad (3)$$

Where e_t are the errors in a reduced form, which are linear combinations of structural errors $u_t = Be_t$, so that, $\Sigma_e = B\Sigma_u B'$. Also note that $A_0 = B\Gamma_p$, which implies that for given values of the parameters in a reduced form ($A_1 \dots A_q$ y Σ_e), a conjecture or calculation of B automatically allows for estimating a set of values for the structural parameters of the model.[25]

There are several ways to retrieve the parameters of the structural equation from the parameter estimates of the reduced equation. A traditional way to exactly identify a SVAR is by imposing restrictions of exclusion (equal to zero) to the coefficients of matrix B, i.e., to the contemporary associations between structural shocks (of the endogenous variables). The necessary order condition that must be met is that, at least the parameters $n(n-1)/2$ of B are considered equal to zero or, more generally, equal to a constant. The most common factoring method restrictions of exclusion used in the literature is the Cholesky breakdown, which rewrites the matrix of co-variance of the reduced residuals, such as $\Sigma_e = PP'$, where P is a lower triangular matrix. In this case, P contains the information about $B\Sigma_u{}^{1/2}$, which also allows for retrieving the values corresponding to the matrices Γ. Note that a specific ordering of the variables in the system facilitates locating the "zero" imposed restrictions. Therefore, this method assumes a recursive structure, and for this reason the model is very sensitive to the ordering of the variables in the VAR.

In order to identify the empirical model, this study is based on the studies carried out by Sims (1986), Kim and Roubini (2000) and Parrado (2001). These authors recommend to use a general method that allows for non-recursive structures, and that restricts only the contemporary structural parameters (structural VAR). In this way, in order to recover the structural errors (of the primitive VAR) of the reduced form, we start from the following linear relationship:

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[24] The model also allows for including predetermined or exogenous variables.

[25] As pointed out by Pagliacci et al. (2011), it is generally assumed that all the values of the diagonal for *B* are equal to one (1).

$$u_t = Be_t \qquad (4)$$

By using the Cholesky factorization, in which it is supposed that B is a lower triangular matrix, we can obtain an exactly identified model. However, if we have sufficient restrictions, $n(n-1)/2$, the modelling of B, by using SVAR, can take any structure.[26]

3.2.2. Identification of shocks of disasters[27]

The model's vector of variables is:

$$yt = [i_d \; y^* \; i^* \; ti \; gp \; y_i] \qquad (5)$$

Where:

i_d = Measure of the intensity of disasters.
y^*= Real per capita GDP of high-income countries.
i^* = International interest rate (approximate according to the US government bonds).
ti = Terms of exchange (ratio between the index of export prices and the index of import prices (px/pm))
gp = Real per capita government consumption spending for the group of countries *"i"*.
y_i = Real per capita GDP for the group of countries *"i"*.

The characterization of the model based on the equation (4) is as follows:

$$\begin{bmatrix} u_{i_d} \\ u_{y^*} \\ u_{i^*} \\ u_{ti} \\ u_{gp} \\ u_{y_i} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & a_{42} & 0 & 1 & 0 & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & 1 & 0 \\ a_{61} & a_{62} & a_{63} & a_{64} & a_{65} & 1 \end{bmatrix} \begin{bmatrix} e_{i_d} \\ e_{y^*} \\ e_{i^*} \\ e_{ti} \\ e_{gp} \\ e_{y_i} \end{bmatrix} \qquad (6)$$

[26] For a detailed and rigorous analysis on the VAR and SVAR models, please consult: Sims (1980), Sims (1986), Enders (1995), and Hamilton (1994).
[27] As far as the variables used, the model is based on the specifications made by Bello (2017).

Where u_{i_d}, u_{y^*}, u_{i^*}, u_{ti}, u_{gp} and u_{y_i} are the structural shocks, i.e., the shocks stemming from disasters, the real per capita GDP in high income countries (external shock), the international interest rate (external shock), the terms of exchange in the group of countries *"i"*, the real per capita government consumption spending in the group of countries *"i"*, and real per capita GDP in the group of countries *"i"*; whereas e_{i_d}, e_{y^*}, e_{i^*}, e_{ti}, e_{gp} and e_{y_i} are those corresponding to residual innovations of the VAR in a reduced form.[28]

It is important to note that this system represents solely contemporary restrictions on the parameters.[29] No additional restrictions have been imposed on the lagging structural parameters. The particularities of the restriction scheme are as follows:

- Disasters are the most exogenous variable of the system, because they do not depend on any other internal or external variables. For this reason, the measure of disaster intensity is the first variable of the system and it is not supposed to be affected by any other variable.
- The growth rate of real per capita GDP in high-income countries (external) is not affected by disasters or any other variable of the system.
- The international interest rate (external) is not affected by contemporary restrictions of any other variable.
- The terms of exchange are affected only in a contemporary way by the growth rate of real per capita GDP in high-income countries, so as to consider in a certain way that the pressure of demand for raw materials from those countries may affect the relative price in each group of countries *"i"*.
- The growth rate of real per capita government consumption spending (gp) does not depend in a contemporary way on the growth rate of real per capita GDP for the group of countries *"i"* (y_i); however, it is affected by the rest of the variables of the system in a contemporary way.
- Finally, the growth rate of real per capita GDP for the group of countries *"i"* (y_i) depends of all the variables of the system in a contemporary way.

3.3 Empirical strategy

Two alternative strategies to measure or analyse the impact of disasters on the growth rate of real per capita GDP and real per capita government consumption spending (fiscal policy tool) are used in this study. The first one consists in estimating a set of SVAR models for different groups of countries and subregions in Latin America and the Caribbean. As a matter of fact, estimates for five SVARs (in first differences)[30] with a relatively homogeneous structure in terms of the variables used, period of study, selected lags, and short term contemporary restrictions (see equation 6) were carried out.

[28] In SVAR models, the international interest rate is expressed in first difference and the measure of intensity of disasters is expressed in levels (original series); the rest of the variables are expressed in growth rates (or variation) approximated by the first difference of the natural logarithm of each variable.

[29] The set of restrictions are short-term, since there is evidence that supports the hypothesis that it is unlikely that natural disasters affect growth in the long term. (Cavallo et al. 2010 and Acemoglu et al. 2000).

[30] Conventional tests for unit roots for this and all models of the study are presented in Annex 4.

These SVAR totalize the variables (series) for the countries that integrate each group (classified according to the integration mechanism to which they belong and for South America), namely: a) The Central American Integration System (SICA), b) the Andean Community (CAN), c) The Pacific Alliance (PA), d) the Common Market of the South (MERCOSUR) and e) the South American subregion.[31] [32]

Based on the estimates of these SVAR models, we can derive Impulse-Response Functions (IRFs), which constitute the main tool for this study to measure and analyse the impacts of disasters on the growth rate of real per capita GDP and real per capita government consumer spending for the groups of countries in Latin America and the Caribbean.

The second strategy consists in estimating a set of uni-equational regressions for each group of countries and for South America, through Ordinary Least Squares (OLS), which employs the aggregation of variables for each group of countries used in the SVAR models, with generic specifications of relatively homogeneous models for the purposes of comparability between groups of countries.

4. RESULTS

This section is divided into two subsections. The first one presents the impacts of disasters, measured by the intensity of disasters, through the Impulse-Response Functions (IRFs) derived from the SVARs, by analysing the responses of the growth rates of the real per capita GDP and the of real per capita government consumption expenses (fiscal policy measure) of the groups of countries and the South American subregion, vis-à-vis a shock or structural disturbance in one standard deviation from disasters.[33] The second subsection presents the results from the uni-equational regressions by OLS, so as to determine the effect of disasters on the growth rate of real per capita GDP for the groups of selected countries and for South America.

[31] Measurement of intensity of disasters for each group of countries is obtained by adding, first of all, the number of deaths and the total affected people by each disaster subgroup, considering the total population of the nations that make up the group of countries *"i"* (SICA, CAN, PA, MERCOSUR and South America), and then applying equation (1). The terms of exchange are obtained through an arithmetic mean of the terms of trade of countries belonging to the group of countries *"i"*, while real per capita government consumer spending and real per capita GDP for group "I" countries is obtained through the sum of the levels of all of the countries that integrate it divided among their respective populations. Finally, the growth rate of real per capita GDP of high-income countries and the international interest rate are the same variables (or series) for the five SVAR models.

[32] In the case of CARICOM countries, the data required were not available, therefore it was not possible to develop the specified models for this subregion.

[33] From the econometric standpoint, all SVARs were dynamically stable. In general, no serious autocorrelation problems became apparent, on average, until backlog 7, according to the LM test, neither problems of heteroscedasticity in the residuals, according to White's test. The length of the lags were two for all models of the study, which were selected first of all by using the information criteria of Schwarz and Hannan-Quinn and adding an additional lag in those cases that needed it because they presented serial correlation problems, until they reached two lags. However, it should be mentioned that we could not accept the null hypothesis that the errors (or residuals) are distributed according to the multivariate normal probability density function. In addition, for the five SVARs identification restrictions are not rejected at conventional significance levels, according to the tests of verisimilitude ratios.

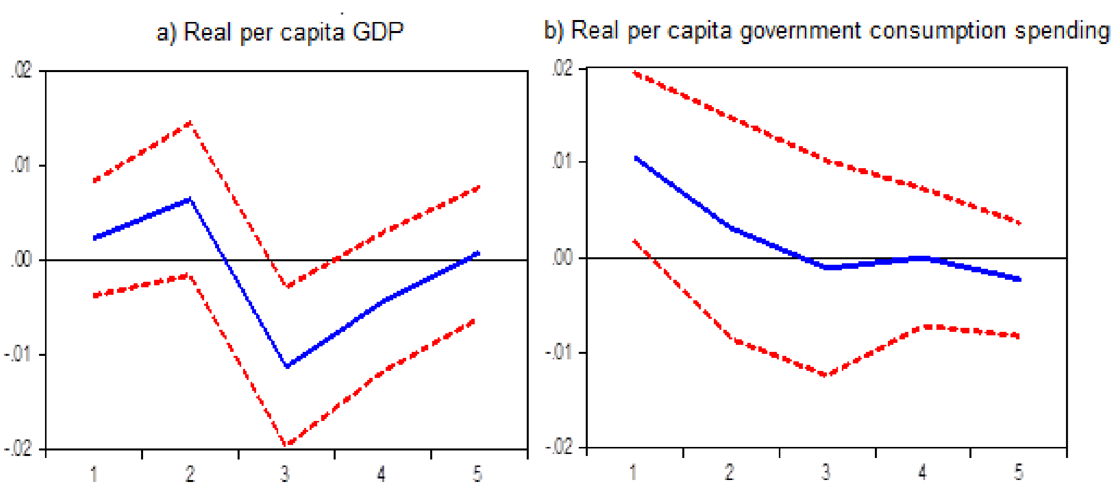
4.1. Macroeconomic impact of disasters: Evidence derived from the impulse-response function (IRF) of SVAR models

With respect to the Central American Integration System (SICA), Chart 8 shows the IRFs for the growth rate of real per capita GDP (panel a) and for the growth rate of real per capita government consumption expenses (panel b), vis-à-vis a shock or a disruption stemming from disasters, measured by the intensity of the disaster for a period of five years. This, and the rest of the charts are presented following the order and identification restrictions expressed in equation (6), highlighting also that the IRFs are adjusted to a confidence interval at 95%.[34]

Panel (a) of said graph shows that, during the period 1970-2014,[35] available evidence suggests that the variable intensity of disasters has a negative and statistically significant impact of about 1.0% in the third year on the variation rate of the real per capita GDP, while on the variation rate of the cost of per capita real government consumption spending (panel b) it generates a positive and statistically significant impact close to 1.0% in the first year of the shock (disaster), which then fades in the following years.

CHART 8

Impulse-Response Functions of the growth rates of real per capita GDP and real per capita government consumption spending vis-à-vis a structural shock from disasters for SICA (First differences of the natural logarithm and years)



Source: Prepared by the author.

Estimates for countries of the Pacific Alliance (AP) (Figure 9) show, according to the evidence available during the period 1960-2014, a positive and statistically significant effect on the annual variation rate of real per capita GDP of approximately 0.8 percentage points in the first year (panel

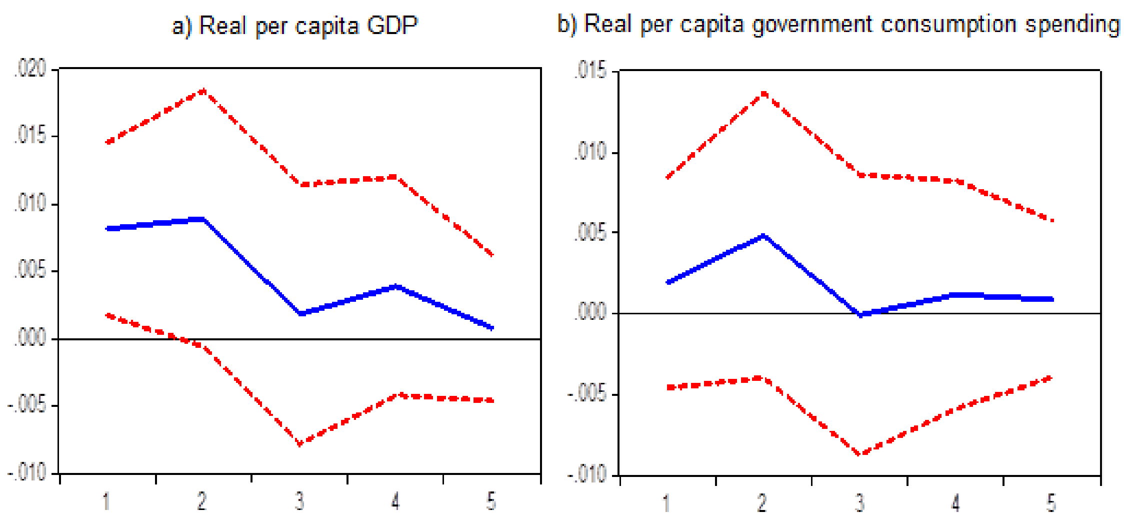
[34] In the estimation of the SVARs in first differences, all the FIRs presented in this study for the annual variation rates of the real per capita GDP and the government per capita real consumption spending are expressed in first differences of the natural logarithm of the variables, as an approximation to the measurement of their annual growth rate (or variation) by one. For the purposes of interpretation, when the values and the IRF scale are multiplied by one hundred (100), they can be used as an approximation of the growth rate in percentage terms.

[35] The period under study for SICA starts in the year 1970 because in the case of Belize data for most of the variables are available as of that year.

a). The real per capita government consumption spending does not present a statistically significant response to disasters during the five years (panel b).

In this case, the response of the real GDP per capita growth rate is contrary to what theoretically would be expected in the short term, supported by empirical evidence obtained for other groups of countries in different studies[36] (negative response to disasters). These results could be linked, probably, to the incidence of other factors not considered in the specification of the model and that have an impact on economic growth, as for example, institutions, a variable that empirical evidence has shown that is one of the main determinants of growth and the economic development of countries (Acemoglu et al., 2000;) Rodrik et al., 2003 and Cavallo et al., 2010).

CHART 9
Impulse-Response Functions of the growth rates of real per capita GDP and real per capita government consumption spending vis-à-vis a structural shock from disasters for the PA (First differences of the natural logarithm and years)



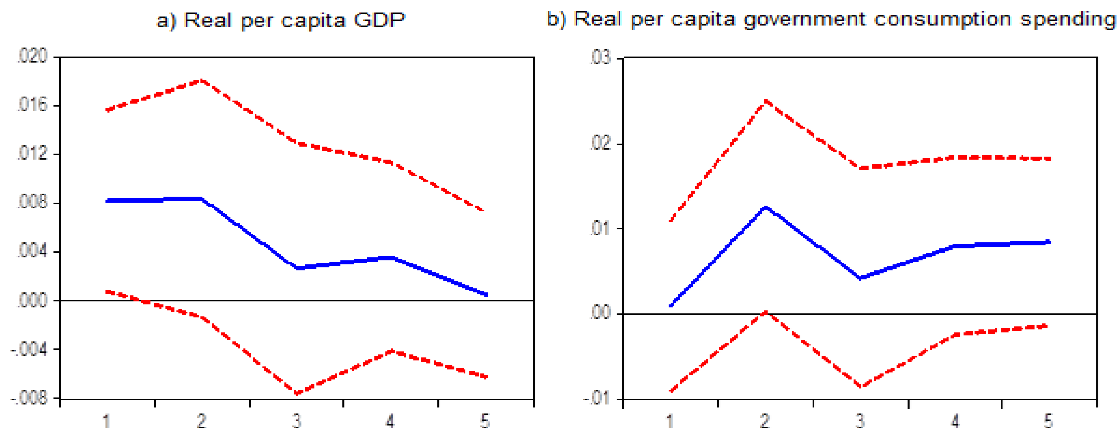
Source: Prepared by the author.

In the case of the Andean Community (CAN), during the period 1960-2014, the IRFs of Chart 10 show that a disturbance in the disasters variable generates a statistically significant increase in the rate of annual variation of real per capita GDP close to 0.8 percentage points in the first year (panel a). Furthermore, in relation to the rate of change in real per capita government consumption spending (panel b) this records a statistically significant increase of around 1.3 percentage points in the second year after the shock of the disaster. As in the case of the AP, and in relation to the response of the real per capita GDP growth rate, vis-à-vis a shock from the disaster was a result opposite to what one would theoretically expect, based on empirical evidence reported in other studies (negative response to disasters).

[36] Such as Cabezón et al., (2015), Raddatz (2010), and Bello (2017), among others.

CHART 10

Impulse-Response Functions of the growth rates of real per capita GDP and real per capita government consumption spending vis-à-vis a structural shock from disasters for the CAN (First differences of the natural logarithm and years)



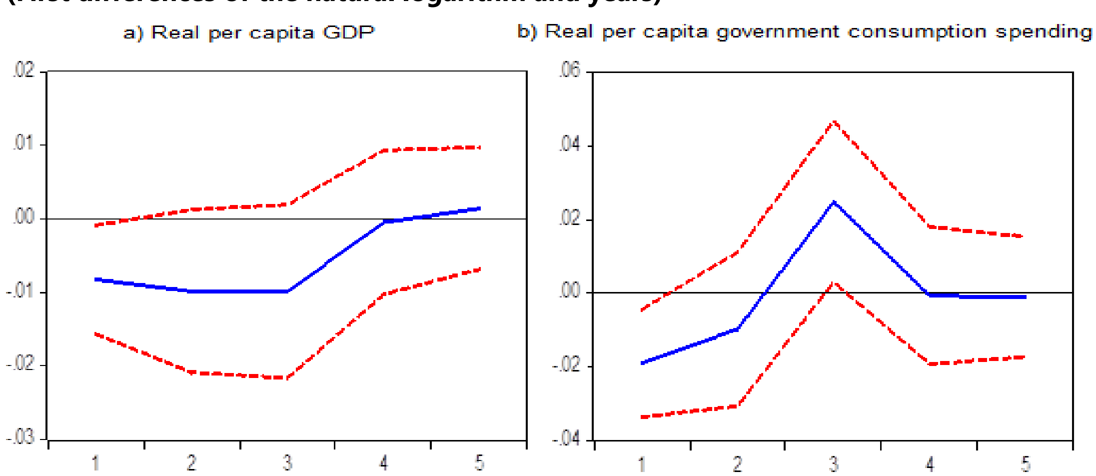
Source: Prepared by the author.

In the estimates for the Common Market of the South (MERCOSUR) shown in Chart 11, it can be seen that, during the period 1960-2014, available evidence through the IRFs suggests that the rate of annual variation of real per capita GDP registered a negative response, statistically significant, close to 0.8 percentage points to a perturbation of the variable of disasters in the first year, disappearing immediately as of the second year (panel a). In relation to the rate of variation of the government per capita real consumption spending (panel b) it was observed, first of all, a negative and statistically significant response in the first year of the disturbance from the disaster of about 1.9 percentage points, and subsequently, a positive and statistically significant response in the third year after the disturbance in the variable intensity of disasters of about 2.5 percentage points.

CHART 11

Impulse-Response Functions of the growth rates of real per capita GDP and real per capita government consumption spending vis-à-vis a structural shock from disasters for MERCOSUR

(First differences of the natural logarithm and years)



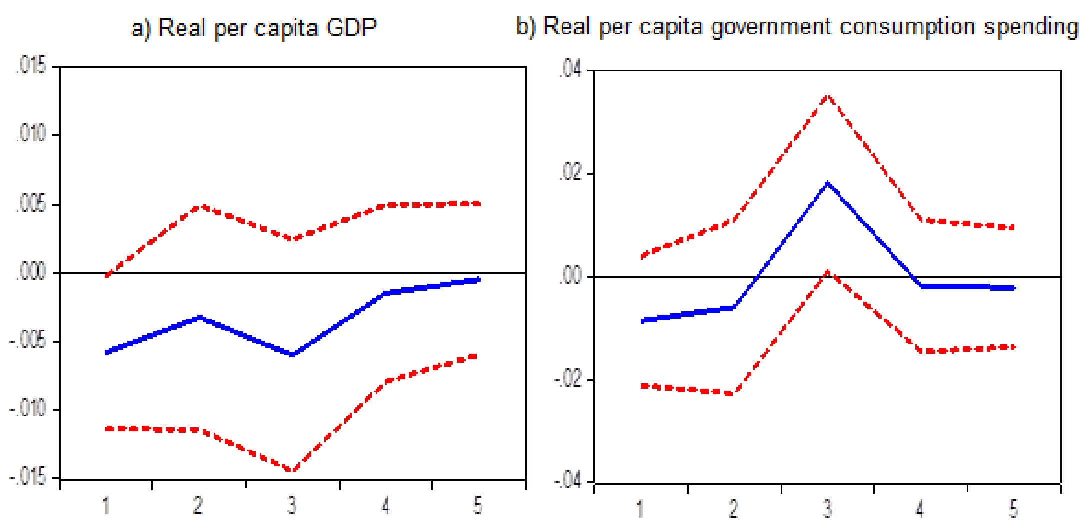
Source: Prepared by the author.

Finally, Chart 12 presents the IRFs of estimates during the period 1960-2014 for South America. It can be seen that, in the presence of a disturbance in the variable of disasters, the rate of annual variation of real per capita GDP registered a negative and statistically significant response of 0.6 percentage points in the first year. While the rate of variation of the government per capita real consumption spending records a statistically significant and positive response in the third year after the shock of the disaster, close to 1.8 percentage points.

CHART 12

Impulse-Response Functions of the growth rates of real per capita GDP and real per capita government consumption spending vis-à-vis a structural shock from disasters for South America

(First differences of the natural logarithm and years)



Source: Prepared by the author.

4.2. Impact of disasters on the growth rate of the real per capita GDP: Evidence derived from the uni-equational models

This section presents, as mentioned above, the results of the uni-equational estimates via OLS, in order to analyse, alternatively, the impact of disasters (measured by the variable intensity of disasters) on the rate of variation of the real per capita GDP for the groups of countries (SICA, AP, CAN, MERCOSUR) and for South America. For the specification of these uni-equational models the rate of variation of the per capita capital stock is incorporated into the set of explanatory variables contained in the previous SVAR, since this is one of the variables that explains much of the economic growth in the countries (Romer, 2006).[37]

[37] The capital variable is often included, by levels, in the estimates of production functions of the economies in order to analyse the determinants or explanatory factors of economic growth. Given the methodology used and the object of study in this work, it was decided to incorporate this variable in first differences of the natural logarithm as an approximate measure to its growth rate (or variation). It would have been ideal to incorporate the capital growth rate per worker (or employee), however, this measure was not possible to use due to the lack of availability of data related to the number of workers for all countries during the period under study. For this reason, it was decided to include it as a proportion of the population.

Table 5 shows the estimates carried out, highlighting the coefficient (sign and estimated value) that accompanies the variable measuring disasters, namely the intensity of disasters (row highlighted in green).

With regard to the Central American Integration System (SICA), the coefficient of the variable of disasters was statistically significant at 14%, with an average negative value of -0.003, which is equivalent to 0.3 percentage points. In this regard, this result expresses that, according to the evidence available and the methodology employed during the period 1970-2014, in the face of a unitary increase in the variable intensity of disasters, the rate of annual variation of real per capita GDP in SICA is reduced, on average, around 0.3 percentage points.

In turn, for the Pacific Alliance (AP) and the Andean Community (CAN) this coefficient (disasters) was statistically significant at conventional levels of significance (10% and 5%, respectively) but with positive signs (0,013 and 0.006, respectively), such as the sign of the responses found in the IRFs of the SVARs for these groups of countries, which, as discussed above, is contrary to what is theoretically expected.

Additionally, for MERCOSUR, the coefficient of disasters during the period 1960-2014 was negative and statistically significant with an average value of -0.008 (-0.8 percentage points), similar to the response reported in the IRFs of the SVAR models. Finally, according to the estimation made for South America through OLS during the period 1960-2014, the coefficient measure of intensity of disasters was -0.009, on average (-0.9 percentage points), which is relatively higher than that reported in the IRFs of the SVAR models (-0.6 percentage points).

With these results, it can be seen that, while measuring the impact of disasters on the annual variation rate of the real per capita GDP for the groups of countries and the South American subregion differs between both methodologies (SVAR models and uni-equational regressions), the sign of the responses regarding the economic growth rate (variation of the real per capita GDP) in the face of a perturbation stemming from a disaster is the same under both approaches.

TABLE 5
Estimation of the impact of disaster on the annual variation rate of real per capita GDP (Estimation by Ordinary Least Squares (OLS))

Notation	Variables	Dependent Variable: First difference of the natural logarithm for real per capita GDP				
		Groups of countries and subregion				
		SICA (1970-2014)	AP (1960-2014)	CAN (1960-2014)	Mercosur (1960-2014)	América del Sur (1960-2014)
Constante	c	-0.013	-0.034	-0.020	0.001	0.000
		(0.005)	(0.013)	(0.011)	(0.01)	(0.008)
dlog(rkna_pc)	dlog(kpc)	1.119	1.914	1.257	0.466	0.478
		(0.191)	(0.503)	(0.448)	(0.21)	(0.174)
dlog(pib_pc_ai)	dlog(y*)	0.229	0.613	0.085	0.203	0.256
		(0.068)	(0.143)	(0.03)	(0.154)	(0.128)
dlog(term_inter)	dlog(ti)	0.058	0.011	0.421	0.004	0.057
		(0.027)	(0.039)	(0.137)	(0.029)	(0.029)
d(tasa_int(-1))	d(i*(-1))	-0.004	-0.006	-0.001	-0.002	-0.002
		(0.002)	(0.004)	(0.003)	(0.005)	(0.003)
dlog(gasto_pc_ppa)	dlog(gpi)	0.094	-0.142	0.203	0.110	0.096
		(0.058)	(0.163)	(0.058)	(0.083)	(0.061)
intensidad_1	id	**-0.003******	**0.013*****	**0.006****	**-0.008*****	**-0.009*****
		(0.002)	(0.007)	(0.003)	(0.004)	(0.005)
AR(1)	ar(1)	0.488	0.439	0.490		
		(0.155)	(0.111)	(0.144)		
R^2		0.689	0.552	0.554	0.231	0.271
R^2 ajustado		0.630	0.481	0.483	0.131	0.176
Estadístico Durbin-Watson		1.934	1.947	2.143	1.115	1.014
Observaciones		45	52	52	53	53
Newey-West HAC Standard Errors & Covariance		No	No	Si	Si	Si
White Heteroskedasticity-Consistent Standard Errors & Covariance		Si	Si	No	No	No
Prueba de LM (Autocorrelación). Prob. Chi-Square		0.999	0.934	0.344	0.001	0.001
Prueba de Heterocedasticidad de White. Prob. Chi-Square		0.442	0.847	0.706	0.821	0.749
Prueba de Jarque-Bera para Normalidad. Probabilidad		0.335	0.050	0.598	0.865	0.963
Prueba de estabilidad estructural (CUSUM of Squares Test)		-	-	-	Estable	Estable

The log preceding the variable represents the natural logarithm of said variable. A "d" before a variable means the first difference of said variable, and when "dlog" preceds a variable it means the first difference of thew natural logarithm of said variable (as an approximation of its growth rate).
The residuals of the estimated models were stationary, I(0), according to the ADF and PP tests.
* Significant coefficient at 1%, ** Significant coefficient at 5%, *** Significant coefficient at 10% **** Significant coefficient at 14%.
Standard errors in parentheses ().

Source: Prepared by the author.

5. FINAL CONSIDERATIONS

This work analyses the macroeconomic impact of disasters due to the occurrence of natural events on various integration mechanisms in Latin America and the Caribbean and on the South American subregion, through two types of econometric estimations, namely, the SVAR multi-equational model and the uni-equational estimates through OLS (multi-variable regressions). These estimates are focused on the responses of the economic activity and the government spending in the face of the occurrence of disasters due to this type of events.

Based on the Impulse-Response Functions (IRFs) derived from the SVAR models, different results were obtained in relation to the sign, magnitude and delay in the responses seen in the growth rates of the real per capita GDP and the real per capita consumption expenses of the government (fiscal policy variable) vis-à-vis a perturbation stemming from disasters for the different subregional integration mechanisms and for South America.

As a matter of fact, for the Central American Integration System (SICA), evidence available for the period 1970-2014, conditioned by the methodology, suggests that, in the face of a perturbation from disasters, the annual variation rate of the real per capita GDP registers a negative response close to 1.0 percentage points, on average, being statistically significant in the third year after the disturbance. Furthermore, in relation to the evolution of the fiscal policy variable, measured by the variation rate of the general real per capita expenditure on consumption of the government, it reported a positive and statistically significant response in the first year after the disturbance close to 1.0 percentage point.

In the cases of the Pacific Alliance (PA) and the Andean Community (CAN), during the period 1960-2014, the estimated IRFs from the SVAR models reported an increase of their economic activity in real and per capita terms during the first year after the disaster, contrary to what was theoretically and empirically expected, as supported by the evidence shown in other studies worldwide (negative response from the product in the face of a shock from disasters). This result could probably be affected by factors that were not considered in the generic and common specification of the SVAR models which could be fundamental determinants for economic growth, such as the institutional framework or the characteristics of the institutions, which may allow for offsetting or minimizing the short-term effects of certain types of disasters or other adverse situations (Rodrik et al., 2003). In the case of the response of the variation rate of the real per capita government expenditure for the AP, it was not statistically significant, whereas for the Andean Community this policy variable recorded a positive and statistically significant response in the second year after the disaster.

In the case of MERCOSUR, the results of the IRFs suggest that, during the period 1960-2014, the annual variation rate of the real per capita GDP recorded a negative and statistically significant response, on average, of approximately 0.8 percentage points in the first year, which disappears as of the second year. In turn, the variation rate in the government's real per capita consumption expenditure reported a positive (incremental) and statistically significant response, which was close to 2.5 percentage points in the third year, after a statistically significant drop in the first year of the disaster.

Finally, for the South American subregion, IRF estimates, during the period under study, show a negative and statistically significant response in the first year in the annual variation rate of real per capita GDP of about 0.6 points, on average, in the face of a disturbance from a disaster. On the other hand, the response of the variation rate of the real per capita government expenditure recorded a positive and statistically significant result of approximately 1.8 percentage points in the third year after the disturbance.

These results are complemented by those obtained from the uni-equational regressions for the growth rate of the real per capita GDP, which contain a specification similar to that used in the SVAR models. While it is true that the coefficients accompanying the variables used in this study are different in some cases, in terms of magnitude to the responses obtained in the FIRs derived from the SVAR, the signs or the sense of the response of the rate of variation of the per capita GDP in the face of disasters for the groups of countries and subregions selected for this study, they do coincide.

As a consequence of the diversity of results among the different integration mechanisms and for South America, in terms of magnitude, direction (or sign) and delays in the responses in the annual variation rates of real per capita GDP and the general real per capita consumption spending of the government (fiscal policy variable) in the face of disasters, in this study, it is not possible to obtain a general or common result about the macroeconomic impact of disasters due to the occurrence of natural events, in these variables and for the selected groups of countries.

For this reason, it is necessary to continue to study this issue more deeply, with the use of models or specifications that consider particular elements for each country or group of countries, and that can provide more evidence on the macroeconomic impact of disasters in order to optimize the policy formulation process for disaster risk reduction in the countries and subregional integration mechanisms in Latin America and the Caribbean.

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A N N E X I

OCCURRENCE OF NATURAL EVENTS BY SUBGROUPS AND CONTINENTS, PERIOD 1960-2016

Continent/Decade	Natural events by subgroups						
	Biological	Climate	Extra-terrestrial	Geophysical	Hydrological	Meteorological	Total
Africa							
1960-1969	11	23	-	10	27	5	76
1970-1979	22	29	-	4	42	17	114
1980-1989	117	69	-	16	68	37	307
1990-1999	202	61	-	19	157	43	482
2000-2009	410	84	-	32	428	99	1.053
2010-2016	119	53	-	7	255	58	492
Total	**881**	**319**	**-**	**88**	**977**	**259**	**2.524**
Total (%)	**35%**	**13%**	**0%**	**3%**	**39%**	**10%**	**100%**
America							
1960-1969	12	11	-	24	52	87	186
1970-1979	7	13	-	34	100	69	223
1980-1989	7	33	-	62	191	175	468
1990-1999	70	76	-	85	243	326	800
2000-2009	36	92	-	67	391	363	949
2010-2016	33	68	-	43	251	234	629
Total	**165**	**293**	**-**	**315**	**1.228**	**1.254**	**3.255**
Total (%)	**5%**	**9%**	**0%**	**10%**	**38%**	**39%**	**100%**
Asia							
1960-1969	14	19	-	39	85	100	257
1970-1979	33	39	-	62	126	154	414
1980-1989	45	43	-	116	270	250	724
1990-1999	103	51	-	167	449	374	1.144
2000-2009	131	68	-	210	797	482	1.688
2010-2016	22	30	-	148	530	351	1.081
Total	**348**	**250**	**-**	**742**	**2.257**	**1.711**	**5.308**
Total (%)	**7%**	**5%**	**0%**	**14%**	**43%**	**32%**	**100%**
Europe							
1960-1969	-	1	-	13	15	10	39
1970-1979	1	1	-	19	32	24	77
1980-1989	2	32	-	40	66	74	214
1990-1999	17	36	-	45	134	184	416
2000-2009	27	59	-	25	247	260	618
2010-2016	-	12	1	13	140	139	305
Total	**47**	**141**	**1**	**155**	**634**	**691**	**1.669**
Total (%)	**3%**	**8%**	**0%**	**9%**	**38%**	**41%**	**100%**
Oceania							
1960-1969	-	3	-	3	1	19	26
1970-1979	1	9	-	7	16	42	75
1980-1989	1	9	-	11	31	60	112
1990-1999	4	16	-	19	28	64	131
2000-2009	14	12	-	23	54	68	171
2010-2016	4	19	-	9	26	43	101
Total	**24**	**68**	**-**	**72**	**156**	**296**	**616**
Total (%)	**4%**	**11%**	**0%**	**12%**	**25%**	**48%**	**100%**
Total world	**1.465**	**1.071**	**1**	**1.372**	**5.252**	**4.211**	**13.372**
Total world (%)	**11%**	**8%**	**0%**	**10%**	**39%**	**31%**	**100%**

Source: Prepared by the author, based on data from the International Disaster Database (EM-DAT).

A N N E X I I

OCCURRENCE OF NATURAL EVENTS BY SUBGROUPS AND SUBREGIONS IN THE AMERICAN CONTINENT, PERIOD 1960-2016

Subregion/Decade	Disasters by subgroups					
	Biological	Climate	Geophysical	Hydrological	Meteorological	Total
North America						
1960-1969	-	1	4	3	36	44
1970-1979	-	2	2	13	32	49
1980-1989	-	8	10	27	103	148
1990-1999	4	29	9	58	183	283
2000-2009	6	44	5	75	148	278
2010-2016	-	27	3	34	120	184
Total	**10**	**111**	**33**	**210**	**622**	**986**
Total (%)	**1%**	**11%**	**3%**	**21%**	**63%**	**100%**
Mexico						
1960-1969	-	-	2	3	7	12
1970-1979	-	1	4	6	6	17
1980-1989	-	2	8	10	9	29
1990-1999	2	4	14	14	33	67
2000-2009	1	2	4	28	31	66
2010-2016	-	2	5	14	27	48
Total	**3**	**11**	**37**	**75**	**113**	**239**
Total (%)	**1%**	**5%**	**15%**	**31%**	**47%**	**100%**
Central America						
1960-1969	7	1	4	5	6	23
1970-1979	-	3	7	14	6	30
1980-1989	-	4	15	18	6	43
1990-1999	23	12	23	29	22	109
2000-2009	9	15	17	70	40	151
2010-2016	8	9	10	43	22	92
Total	**47**	**44**	**76**	**179**	**102**	**448**
Total (%)	**10%**	**10%**	**17%**	**40%**	**23%**	**100%**
The Caribbean						
1960-1969	1	4	-	2	32	39
1970-1979	2	2	4	9	15	32
1980-1989	-	7	-	33	41	81
1990-1999	6	6	6	25	67	110
2000-2009	3	5	7	41	94	150
2010-2016	11	9	1	38	35	94
Total	**23**	**33**	**18**	**148**	**284**	**506**
Total (%)	**5%**	**7%**	**4%**	**29%**	**56%**	**100%**
South America						
1960-1969	4	5	14	39	6	68
1970-1979	5	5	17	58	10	95
1980-1989	7	12	29	103	16	167
1990-1999	35	25	33	117	21	231
2000-2009	17	26	34	177	50	304
2010-2016	14	21	24	122	30	211
Total	**82**	**94**	**151**	**616**	**133**	**1.076**
Total (%)	**18%**	**21%**	**34%**	**138%**	**30%**	**240%**
Total America	**165**	**293**	**315**	**1.228**	**1.254**	**3.255**
Total (%)	**5%**	**9%**	**10%**	**38%**	**39%**	**100%**

Source: Prepared by the author, based on data from the International Disaster Database (EM-DAT).

ANNEX III

DETAILED DESCRIPTION OF THE VARIABLES OF THE STUDY

Variables	Description	Source
Real per capita GDP (pib_pc_ppa)	Real GDP in US$ millions for the year 2011 (adjusted according to Parity Purchasing Power (PPP)) divided by the population	Penn World Table 9.0
General real per capita government consumption spending (gasto_const_pc)	General final consumption expenditure of the government (constant US$ for the year 2010) divided by the population.	World Bank (WDI), Penn World Table 9.0 and International Monetary Fund (IMF), and calculations by the author, based on already mentioned sources
Real per capita GDP of high income countries (pib_pc_ai)	Annual arithmetic average of the real per capita GDP (adjusted according to PPP) for those countries that have a per capita GDP equal or higher than 60.0% of the United States GDP. Methodology applied by Im and Rosenblatt (2015)	Penn World Table 9.0
International interest rate (tasa_int)	Interest rate based on the US government bonds, average	International Monetary Fund (IMF)
Terms of exchange (term_int)	Ratio between price indices of exports (px) and imports (pm). Base for 2011 = 1	Penn World Table 9.0
Intensity of disasters (intensidad_1)	As defined in the text	EM-DAT
Capital stock per inhabitant in real terms (rkna/pop)	Capital stock at constant prices for the year 2011 (national prices), expressed in US$ millions for the year 2011	Penn World Table 9.0
Population (pop)	Number of inhabitants (in millions of people)	Penn World Table 9.0

Source: Prepared by the author, based on data from previously mentioned sources (2017).

A N N E X I V

EVIDENCE OF UNIT ROOTS OF THE VARIABLES OF THE STUDY

Group of countries/ subregion	Description of the variable	Levels								First differences							
		ADF[a]			PP[b]			KPSS[d]		ADF[a]			PP[b]			KPSS[d]	
		P-valor[c]			P-valor[c]			LM-Stat[e]		P-valor[c]			P-valor[c]			LM-Stat[e]	
		CCST	CCCT	SCST	CCST	CCCT	SCST	CCST	CCCT	CCST	CCCT	SCST	CCST	CCCT	SCST	CCST	CCCT
Ap	intensidad_1	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0868	0,0822	0,0000	0,0000	0,0000	0,0001	0,0001	0,0000	0,2247	0,1997
Ap	log(pib_pc_ai)	0,6764	0,5780	1,0000	0,4502	0,5914	1,0000	0,8900	0,0885	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,1935	0,1628
Ap	tasa_int	0,7513	0,8196	0,4560	0,6903	0,7959	0,4429	0,3186	0,2293	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,3284	0,0623
Ap	log(term_int)	0,0295	0,0510	0,0085	0,0431	0,0450	0,0133	0,4528	0,1566	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,5000	0,5000
Ap	log(gasto_const_pc)	0,0098	0,0851	0,9958	0,0020	0,2058	0,9998	0,9212	0,2236	0,0021	0,0013	0,0036	0,0019	0,0011	0,0062	0,5273	0,1685
Ap	log(pib_pc_ppa)	0,9387	0,7870	0,9991	0,9783	0,9106	1,0000	0,9595	0,1505	0,0001	0,0010	0,0004	0,0001	0,0009	0,0005	0,1809	0,1413
Ap	log(pib_pc_rgdpna)	0,9703	0,6220	0,9998	0,9639	0,8015	1,0000	0,8833	0,1498	0,0000	0,0002	0,0003	0,0000	0,0002	0,0004	0,1297	0,1080
Ap	log(rkna/pop)	0,9182	0,6242	0,9999	0,9787	0,7926	1,0000	0,8894	0,1232	0,0028	0,0168	0,3958	0,0652	0,2218	0,4938	0,1132	0,1066
Can	intensidad_1	0,0000	0,0000	0,0003	0,0000	0,0000	0,0000	0,0491	0,0495	0,0000	0,0000	0,0000	0,0001	0,0001	0,0000	0,5000	0,5000
Can	log(pib_pc_ai)	0,6764	0,5780	1,0000	0,4502	0,5914	1,0000	0,8900	0,0885	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,1935	0,1628
Can	tasa_int	0,7513	0,8196	0,4560	0,6903	0,7959	0,4429	0,3186	0,2293	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,3284	0,0623
Can	log(term_int)	0,6049	0,0812	0,0838	0,4515	0,0722	0,0772	0,7437	0,1284	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0520	0,0682
Can	log(gasto_const_pc)	0,9738	0,9272	1,0000	0,9534	0,7702	0,9999	0,8473	0,1103	0,0000	0,0000	0,0085	0,0000	0,0000	0,0000	0,1210	0,1036
Can	log(pib_pc_ppa)	0,9796	0,9196	0,9981	0,9856	0,9420	0,9999	0,9226	0,1291	0,0007	0,0036	0,0012	0,0005	0,0030	0,0013	0,1897	0,1477
Can	log(pib_pc_rgdpna)	0,9590	0,8465	0,9961	0,9621	0,8964	0,9998	0,9174	0,1235	0,0010	0,0055	0,0009	0,0011	0,0058	0,0011	0,1772	0,1553
Can	log(rkna/pop)	0,9991	0,8064	0,9921	1,0000	0,9899	1,0000	0,8861	0,1150	0,2615	0,2726	0,6295	0,4724	0,4487	0,6668	0,4171	0,1246
Mercosur	intensidad_1	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0780	0,0774	0,0000	0,0000	0,0000	0,0001	0,0001	0,0000	0,2739	0,1783
Mercosur	log(pib_pc_ai)	0,6764	0,5780	1,0000	0,4502	0,5914	1,0000	0,8900	0,0885	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,1935	0,1628
Mercosur	tasa_int	0,7513	0,8196	0,4560	0,6903	0,7959	0,4429	0,3186	0,2293	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,3284	0,0623
Mercosur	log(term_int)	0,0028	0,0210	0,0002	0,0031	0,0224	0,0002	0,2237	0,2158	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,3221	0,1524
Mercosur	log(gasto_const_pc)	0,7725	0,4156	0,9945	0,7724	0,4156	0,9948	0,8534	0,1455	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0590	0,0421
Mercosur	log(pib_pc_ppa)	0,9643	0,4422	0,9934	0,9882	0,7191	0,9993	0,8587	0,1391	0,0005	0,0025	0,0002	0,0005	0,0025	0,0003	0,1600	0,0490
Mercosur	log(pib_pc_rgdpna)	0,7679	0,3979	0,9811	0,8510	0,6959	0,9974	0,8822	0,1120	0,0010	0,0066	0,0002	0,0011	0,0069	0,0002	0,1043	0,1044
Mercosur	log(rkna/pop)	0,1563	0,0195	0,9675	0,6829	0,9025	0,9998	0,8116	0,1939	0,4498	0,6471	0,4278	0,3012	0,5080	0,2892	0,2002	0,1070
Sica	intensidad_1	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,1292	0,0657	0,0000	0,0000	0,0000	0,0001	0,0001	0,0000	0,0842	0,0819
Sica	log(pib_pc_ai)	0,6764	0,5780	1,0000	0,4502	0,5914	1,0000	0,8900	0,0885	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,1935	0,1628
Sica	tasa_int	0,7513	0,8196	0,4560	0,6903	0,7959	0,4429	0,3186	0,2293	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,3284	0,0623
Sica	log(term_int)	0,0098	0,0199	0,0051	0,0075	0,0182	0,0050	0,1752	0,0603	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0692	0,0338
Sica	log(gasto_const_pc)	0,2663	0,6440	1,0000	0,3581	0,5655	0,9988	0,8303	0,1512	0,0093	0,0451	0,0028	0,0000	0,0002	0,0000	0,2579	0,1727
Sica	log(pib_pc_ppa)	0,9874	0,8713	0,9820	0,9945	0,9759	1,0000	0,8314	0,1818	0,1560	0,2866	0,1193	0,0001	0,0003	0,0005	0,2808	0,1644
Sica	log(pib_pc_rgdpna)	0,8702	0,7654	0,9989	0,9203	0,8310	1,0000	0,9244	0,1293	0,0011	0,0069	0,0038	0,0008	0,0053	0,0071	0,1674	0,1615
Sica	log(rkna/pop)	0,9369	0,2706	0,9945	0,9948	0,7597	1,0000	0,8692	0,1126	0,1310	0,3667	0,3048	0,1014	0,2932	0,2825	0,1842	0,0780
Suramérica	intensidad_1	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0762	0,0703	0,0000	0,0000	0,0000	0,0001	0,0001	0,0000	0,2803	0,1678
Suramérica	log(pib_pc_ai)	0,6764	0,5780	1,0000	0,4502	0,5914	1,0000	0,8900	0,0885	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,1935	0,1628
Suramérica	tasa_int	0,7513	0,8196	0,4560	0,6903	0,7959	0,4429	0,3186	0,2293	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,3284	0,0623
Suramérica	log(term_int)	0,6764	0,5780	1,0000	0,4502	0,5914	1,0000	0,8900	0,0885	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,1935	0,1628
Suramérica	log(gasto_const_pc)	0,8207	0,3606	0,9984	0,8196	0,3606	0,9984	0,8638	0,1313	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0483	0,0397
Suramérica	log(pib_pc_ppa)	0,9728	0,6981	0,9964	0,9936	0,8964	0,9999	0,8552	0,1602	0,0009	0,0044	0,0008	0,0009	0,0044	0,0011	0,1907	0,0716
Suramérica	log(pib_pc_rgdpna)	0,9167	0,5438	0,9941	0,9505	0,8110	0,9998	0,9473	0,1144	0,0013	0,0077	0,0009	0,0013	0,0077	0,0009	0,1297	0,1131
Suramérica	log(rkna/pop)	0,3289	0,0160	0,9739	0,7919	0,8719	1,0000	0,8343	0,1853	0,4359	0,6935	0,4909	0,2857	0,5415	0,3476	0,1552	0,1077

CCST: With constant, without tendency.
CCCT: With constant, with tendency.
SCST: Without constant, without tendency.
a: Dickey-Fuller on the rise, the selection of the length of the backlogs was made in accordance with the Schwarz information criterion.
b: Phillips Perron, with the special estimation method Bartlett Kernel, and with Newey-West bandwith.
c: P-values of a string, according to McKinnon (1996).
d: Kwiatkowski-Phillips-Schmidt-Shin, with the special estimation method Bartlett Kernel, and with Newey-West bandwith.
e: Test statistics. Unlike previous tests, this test proposes as null hypothesis that the variable is stationary. The null hypothesis is rejected when the test statistics (LM-Stat) is above the critical KPSS values (1992). For the specification CCST, they are: 0.7390 (at the level of 1%), 0.4630 (at the level of 5%), and 0.3470 (at the level of 10%), whereas for the specification CCCT they are: 0.2160 (at the level of 1%), 0.1460 (at the level of 5%), and 0.1190 (at the level of 10%).
The term “log” preceding a variable refers to the natural logarithm.

Source: Prepared by the author