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DISASTERS AND LOSS OF LIFE: NEW EVIDENCE ON THE EFFECT OF DISASTER RISK MANAGEMENT GOVERNANCE IN LATIN AMERICA AND THE CARIBBEAN

Roberto Guerrero Compeán* and Sergio Lacambra Ayuso**

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Summary

This study provides new empirical evidence on the effect of improving the conditions in disaster risk management (DRM) governance in terms of human losses resulting from disaster events. To measure governance in disaster risk management, we use the Index of Governance and Public Policy in Disaster Risk Management (IGOPP), developed by the Inter-American Development Bank, which characterizes the development of regulatory, institutional and budgetary processes for disaster risk management at the national level. This analysis uses regression models of count data for 26 countries in Latin America and the Caribbean for the 1980-2017 period. We show that an improvement in disaster risk management governance leads to a significant reduction in the probability of human losses caused by disasters triggered by natural hazards. Specifically, an additional point in the IGOPP is associated with a 3% reduction of the fatalities caused by disasters. In addition, we find that a categorical improvement from low to good disaster risk management governance conditions yields savings, in terms of avoided human fatalities, in the order of US$ 381-670 million per year and reduces the probability of fatality occurrence in 11 percentage points. These results suggest that the creation of conditions to improve disaster risk management governance is a crucial element not only to reverse the negative impact of the underlying causes of social vulnerability, such as deficiencies in the economic system and weak institutional capacity, but also a cost-effective strategy to reduce risk.

Keywords: disaster risk management; governance; Latin America

JEL classification: Q1; Q54; Q58

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I. Introduction

The Latin American and the Caribbean (LAC) region is one of the most vulnerable in the world in terms of its susceptibility to multiple natural hazards, from volcanic eruptions and earthquakes to droughts, floods and storms of great magnitude, which have become more frequent and severe as a result of climate change. According to the Emergency Events Database (EM-DAT) of the Center for Research on the Epidemiology of Disasters (CRED) of the Public Health School of the University of Leuven (Guha-Sapir, Below and Hoyos 2019), when comparing the periods between 1979 and 1988 and 2009 and 2018, it is observed that the frequency of droughts in the region increased from 17 to 42 events (an increase of 147%), storms increased from 39 to 114 cases (192%), and floods from 118 to 265 incidents (124%). Without exception, all the countries of the LAC region have faced some of the 1,848 disasters triggered by natural hazards[1] that occurred during the last 40 years.

Considering that 75% of the LAC population lives in areas at risk of disasters (Weiss Fagen 2008), these phenomena can have highly destructive effects. We estimate that between 1980 and 2016, disasters triggered by natural hazards caused approximately 400,000 deaths and cost more than US$ 183 billion in economic losses in real terms, almost quadruple to what was reported in the previous eighty years (1900-1980) (IDB 2013). Table 1 reports the annualized frequency of disasters by country for this period, as well as the total number of deaths, injuries and people who were left homeless as a result of a disaster per million inhabitants. The figures reflect that, with some exceptions, disasters have much more severe humanitarian effects in countries with lower levels of development in the region. Additionally, it is in these countries where most of the deadliest disasters of the last quarter of the century occurred (Table 2).

As a consequence of the region's vulnerability to disasters, the LAC countries have accrued relevant experience in public policy reform processes in the last three decades, aimed at creating the conditions for disaster risk governance. Mexico's National System of Civil Protection was established in 1986 after the earthquake of September 1985, and Colombia's National System for Disaster Prevention and Management (1988), was passed after the eruption of the Nevado del Ruiz volcano in November 1985. These have been

[1] An important precision of terminology is essential in the light of the Hyogo Framework for Action (UNISDR 2005): In this paper, whenever we make use of the term *disaster*, we refer to disasters triggered by natural hazards, or, more specifically, disasters due to vulnerability to natural hazards. We refrain from the expression *natural disaster*, which implies that disasters are a natural occurrence and not the result of a socioeconomically induced process that exposes vulnerabilities, which can be mitigated if effective risk prevention measures are undertaken.

pioneering experiences worldwide in promoting risk governance to face disasters and reduce vulnerability (IDB 2014).

Table 1. Statistics on disasters in Latin America and the Caribbean, 1980-2018

		Rate per million inhabitants				Total per disaster			
Country	Disaster annual average frequency	Dead	In-jured	People left home-less	Affected	Dead	In-jured	People left home-less	Affected
Argentina	2.5	0.5	0.5	424.8	11,736.5	9	6	6,124	258,894
The Bahamas	0.5	4.0	0.0	168.2	2,915.3	3	0	106	1,919
Barbados	0.3	0.2	0.8	831.7	233.2	0	1	912	139
Belize	0.4	6.6	60.7	0.0	23,923.8	4	52	0	18,996
Bolivia	2.1	6.6	1.6	435.7	28,175.1	28	5	2,107	90,971
Brazil	4.7	1.1	1.2	179.6	13,004.9	36	54	5,101	446,085
Chile	2.3	3.3	24.2	3,014.7	9,727.2	26	258	31,961	85,918
Colombia	3.9	24.4	16.3	474.9	7,415.0	620	226	2,970	64,587
Costa Rica	1.5	2.5	74.5	446.7	12,172.7	6	152	808	27,335
Dominican Republic	1.8	5.5	2.7	439.1	16,743.3	26	21	4,031	106,131
Ecuador	1.9	20.5	11.9	690.9	8,251.4	90	67	3,704	66,606
El Salvador	1.5	21.0	241.3	1,414.4	18,250.3	88	1,001	9,243	64,741
Guatemala	2.6	10.5	28.5	136.7	14,356.1	46	131	516	65,373
Guyana	0.3	1.2	0.0	345.9	43,433.3	3	0	1,000	124,725
Honduras	1.9	67.6	51.5	256.5	20,235.0	170	127	918	77,372
Haiti	2.8	635.8	1,575.2	4,597.9	45,571.8	1,221	2,851	18,819	161,983
Jamaica	0.9	2.4	0.4	40.2	24,171.6	7	2	138	70,978
Mexico	5.7	5.1	13.2	248.7	4,670.4	280	841	5,720	110,801
Nicaragua	1.8	23.4	8.0	505.7	19,861.1	39	25	2,306	66,825
Panama	1.3	2.8	10.4	189.2	2,804.9	6	11	362	7,122
Paraguay	1.2	1.6	0.9	166.4	15,218.2	8	3	913	63,586
Peru	3.7	20.6	1,841.8	534.8	15,333.1	109	12,423	2,839	114,052
Suriname	0.1	0.3	0.0	0.0	1,635.2	2	0	0	15,744
Trinidad and Tobago	0.3	0.2	0.0	4.7	61.6	1	0	16	297
Uruguay	0.7	0.3	2.0	134.8	1,640.9	1	14	432	5,803
Venezuela	1.3	34.4	5.5	202.1	889.8	364	70	2,450	14,229
Regional	1.8	34.7	152.8	610.9	13,939.7	155	978	4,866	99,786

Source: Emergency Events Database (EM-DAT) of the Centre for Research on the Epidemiology of Disasters (CRED).

Table 2. Deadliest disasters in Latin America and the Caribbean, 1980-2018

Disaster type	Country	Year	Total number of deaths
Earthquake – January 12	Haiti	2010	222,570
Landslide – Vargas Tragedy	Venezuela	1999	30,005
Volcanic activity – Nevado del Ruiz	Colombia	1985	21,800
Storm – Hurricane Mitch	Honduras	1998	14,600
Earthquake –September 19	Mexico	1985	9,500
Earthquake –March 5	Ecuador	1987	5,000
Storm – Hurricane Mitch	Nicaragua	1998	3,332
Storm – Hurricane Jeanne	Haiti	2004	2,754
Flooding of May in Hispaniola	Haiti	2004	2,665
Storm – Hurricane Stan	Guatemala	2005	1,513
Earthquake – January 25	Colombia	1999	1,186
Storm – Hurricane Gordon	Haiti	1994	1,122
Earthquake – October 10	El Salvador	1986	1,100

Source: Emergency Events Database (EM-DAT) of the Centre for Research on the Epidemiology of Disasters (CRED).

There is no doubt that developing and consolidating DRM governance is a sine qua non condition for sustainable development, investment protection and poverty eradication (Wisner et al. 2003). While it must be recognized that disasters triggered by natural hazards are a latent threat to the survival and security of the population, the role that the State plays through the implementation of appropriate public policies is critical to counteract the potential effects caused by these threats. The experience of the national policy reform processes in the LAC region stresses that there are several aspects that must be considered within the framework of State action, including: (i) the normative, institutional and budgetary basis for the organization and coordination of risk management; (ii) identification and reduction of risks; (iii) preparation of the emergency response; (iv) recovery planning and post-disaster rehabilitation and reconstruction that avoid rebuilding or increasing vulnerability, and (v) financial protection. These aspects are directly related to the reduction of vulnerability in our societies and building the resilience of communities, particularly the poorest ones. (IDB 2014).

Unfortunately, the measurement of the effectiveness in applying these improvements in governance, in terms of reducing vulnerability to disasters has not been empirically quantified. The absence of empirical evidence can be an obstacle in making policy decisions aimed at building institutional capacity in the face of disasters, canceling the possibility of understanding the effectiveness and sustainability of disaster risk management as a development strategy. This research contributes to closing this knowledge gap, with the dual purpose of identifying whether there is indeed a relationship between governance reforms and disaster-related fatalities and, if necessary, strongly supporting these reforms for an effective risk management.

Much has been written about the relationship between institutional soundness and the damage caused by disasters resulting from natural hazards, but evidence on the relationship between vulnerability and national political reform processes in disaster risk management is limited. The introduction of specific policies and instruments on disaster risk management that has taken place in recent decades in the LAC region leads a priori to a general improvement in risk governance levels. Using unpublished information on governance conditions in 15 countries in Latin America and the Caribbean, Guerrero Compeán, Salazar and Lacambra Ayuso (2017) showed that such an improvement in risk management governance conditions leads to a significant reduction in the death toll of a disaster. We build on these research efforts and, by incorporating disaster risk governance data for 11 supplementary countries in the LAC region, we present new empirical evidence on the magnitude of the impact of public policies in terms of disaster risk reduction and eventual disaster losses. Our results show that the favorable conditions that arise as a result of the implementation of national regulatory reforms in disaster risk management have an impact on the number of victims.

II. The conceptual relationship between governance and disaster risk

Governance has become an increasingly complex notion over time, since it now incorporates precepts and criteria from multiple disciplines that certainly hinder a precise conceptualization. The 2017 World Development Report discusses the role of governance and the law, defining governance as the process through which public and private agents interact given a set of formal and informal rules that determine and are determined by rules and power (World Bank 2017). Another definition of governance refers to “the ability of societies to guide and organize their public and social institutions so that they offer people more and better opportunities to lead the kind of life they value, including them in decisions that affect them” (IDB 2014, p. 82). Ballart (2013) delves into this notion and emphasizes that this capacity is manifested in a continuous and stable management by the State and the private actors of a country. The term also emphasizes “the appropriate conditions at all levels of government to achieve performance consistent with the objectives of human development" (Moreno 2004, p. 22). By linking this concept with the dimension of vulnerability, the fact that the magnitude of a disaster depends not only on the intensity of the natural phenomenon per se, but also on political, economic and institutional dimensions, is highlighted, because such dimensions largely determine how vulnerable a society is to natural hazards (Wisner et al., 2003). In other words, the impact of disasters is not only explained by the type of natural threat that affects a specific community, but also by its different levels of vulnerability, which is determined more by governance conditions, among others, than by natural forces.

Governance also refers to the existence of institutions necessary to deal collectively with political challenges. As Barreda and Costafreda (2003) argue, the quality of the existing institutional system is a critical factor in determining the governance conditions of a country. Institutions create incentives, define and restrict the set of choices of individuals, both in terms of their economic activities in general (North 1991) and their decisions related to their protection against natural hazards. In his approach, Moreno (2004, p. 24) emphasizes that "intelligent institutions capable of fostering new leading skills of the State are required. Such institutions, along with a participatory civil society, can develop new social contracts. The instruments to accomplish this task are institutional capacity building, social capital, decentralization and networks. In this way, governance refers to an open and flexible management and leadership by the government." Boin and Lodge (2016) argue that in response to the perceived increase in the number of large-scale crises and disasters, both practitioners and academics have called for enhanced societal resilience, which often is a function of the institutional processes and mechanisms through which governments react to disasters.

In general, institutions contribute to determine how society should react to specific situations. Failure to act within the institutional framework entails sanctions and implies costs, so institutions reduce information, monitoring and enforcement costs. Institutions can be classified as formal and informal. Formal institutions follow the codified rules that constitute the legal, political, economic and social environment of a society, such as the Constitution, general laws of a country, or general governance frameworks for the implementation of public policies, among others. In contrast, informal institutions are those cultural and moral factors, codes of conduct, values and traditions that influence human behavior. In this context, institutions create tools that improve or decrease the capacity of governance to face a national or local problem (Ballart 2013). Therefore, by improving the governance capacity to deal with a specific problem (e.g. a disaster triggered by natural hazards), greater effectiveness should be observed in the policies implemented, thus reducing the negative consequences associated with this problem. This study tests this hypothesis empirically, analyzing the effect of improving the governance of a country, through national DRM policy reform processes, on humanitarian losses caused by natural phenomena.

The link between institutions and the impacts caused by disasters is typically identified using indicators that measure general aspects of institutional functioning, such as corruption, political systems, institutional capacity of the State, access to markets and regulation. Our work relates to this literature by linking the status of progress of DRM governance (being this a dimension of institutionalism) with disaster-related human losses.

Kahn (2005) and Plümper and Neumayer (2009) find that an improvement in the quality of institutions (operationalized by the level of democracy and indicators of good governance such as regulatory quality, corruption control, rule of law and accountability) mitigates the negative impact (in terms of mortality) caused by earthquakes and famines, respectively. Pelling (1999) shows that oligarchic political systems increase vulnerability to floods in urban areas. Ballart and Riba (2002) state that effective human and material resource management capacity significantly reduces the negative consequences of forest fires. Keefer, Neumayer and Plümper (2011) suggest that public policies have a direct effect on seismic mortality, since they mitigate information asymmetries in the construction process, regulate the industry, establish seismic-resistant construction standards, and encourage mechanisms to reduce vulnerability to the occurrence of low-probability events. Using synthetic controls, Barone and Mocetti (2014) conclude that the institutional context significantly affects the resilience of communities affected by telluric movements and show that in a context of limited institutional capacity, the probability of directing financial assistance to unproductive activities increases, exacerbating the deterioration of institutions. Noy (2009) provides evidence that the economic cost of disasters is lower in countries with strong institutions. The author attributes this relationship to the fact that a country with solid institutional capacity is more efficient in carrying out post-disaster recovery processes and stimulating a rapid and adequate response by the private sector to an emergency.

Several micro-econometric studies (Paxson 1992, Townsend 1994, Udry 1994) on the effect of the institutional vacuum derived from the absence of risk-reduction mechanisms and incomplete credit and financial markets, conclude that the most vulnerable groups in a society adopt inefficient and expensive risk and consumption strategies to deal with disasters. Guerrero Compeán (2013) demonstrates that when a household has access to a government program that operates as a de facto social protection network in the face of hydrometeorological shocks, welfare increases significantly by mitigating inefficient ex post behavior in agricultural economies.

Skidmore (2001) examines government regulation in the catastrophe insurance market, whose objective is to counteract the underestimation of the risk of such events as well as infra-insurance. He finds that, in terms of economic losses, institutionalized insurance regimes are more efficient than those of self-insurance through capital accumulation. Sawada (2007) identifies the existence of a credit market as a definitive risk recovery factor. Rumbach and Foley (2014) conclude that the preexistence of home-grown institutions concerning family hierarchy, social cohesion and community organization reduces disaster risk and induces community resilience. Through case studies in multiple developing countries and in the context of various types of recurring disasters triggered by natural hazards, Battista and Baas (2004) show that the implementation of risk management activities and community participation are optimized when local institutions operate and work with the central government in a coordinated fashion.

Escaleras, Anbarci and Register (2007) argue that institutional distortions generated by illegal payments made by third parties (i.e., bribes) hinder the enforcement of building codes and increase the likelihood of human losses caused by earthquakes. Besley and Burgess (2002), Garrett and Sobel (2003) and Mustafa (2003) agree that the State's *ex-post* financial assistance in the context of disasters, both in industrialized and developing countries, is inconsistent with the needs of the victims and is rather explained by political motivations, generating an inefficient distribution of public resources.

Studying the relationship between institutional outcomes and disaster losses is increasingly relevant. This paper employs the Index of Governance and Public Policy in Disaster Risk Management (IGOPP), a measure that captures the levels of governance in disaster risk management, to empirically analyze the impact of governance improvements on disaster risk in a multi-event and multi-country methodological framework.

III. The IGOPP and the operationalization of the notion of governance

We define disaster risk management as "all the processes to design, implement and evaluate strategies, policies and measures aimed at improving the understanding of disaster risk, promoting its reduction and financial protection, and promoting continuous improvement in disaster preparedness, response and recovery practices, with the explicit purpose of increasing human safety, well-being, quality of life, resilience and sustainable development" (IDB 2014, p. 10). Consequently, we hypothesize that as the capacity for governance increases in disaster risk management public policy processes, a greater effectiveness will be observed in decision-making processes, which in turn will reduce the negative impact of disasters. Recent case studies show that in Bogotá and Mexico City, disaster risk management public policy reforms at the national level resulting from disaster-induced institutional crises led to reforms to local legal frameworks, effectively implementing risk-reducing strategies both at the national and community levels (IDB 2014b). Schmidt et al. (2018) argue that there is a relationship between institutional crises and policy reform, where crises are followed by mostly positive policy change.

National DRM policy reform processes must be operationalized and become quantifiable in order to measure the impact of governance. In 2013, the Inter-American Development Bank (IDB) developed in a national indicator for the full characterization of regulatory development on disaster risk management. This indicator, called the Index of Governance and Public Policy in Disaster Risk Management (IGOPP), allows us to establish whether a country has the appropriate governance conditions to implement comprehensive public policies for disaster risk management (IDB 2014). Likewise, this indicator is able to identify specific gaps that might exist in the legal, institutional and budgetary frameworks at the national level and thus guide the design and implementation of future policies to improve risk management (Lacambra et al. 2015).

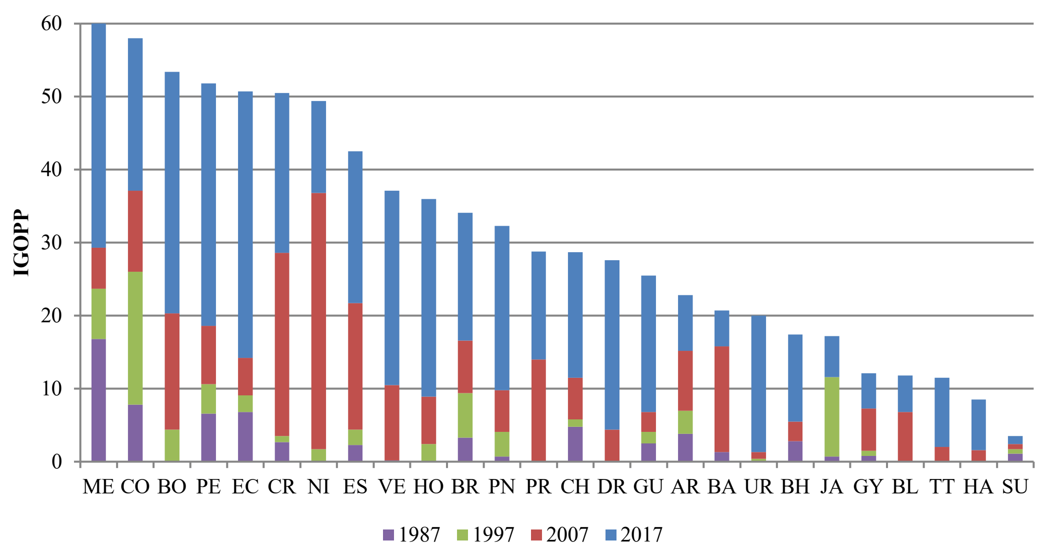
The IGOPP approaches two fundamental dimensions of DRM: the components that make up the policy reforms in disaster risk management and the public policy phases. Specifically, policy reforms in disaster risk management are generally divided into six components: (i) general framework of governance for disaster risk management, (ii) risk identification and knowledge, (iii) risk reduction, (iv) disaster preparedness, (v) recovery planning, and (vi) financial protection. In turn, each of these aspects is analyzed from the three axes or phases that lead the public policy reform process, including (i) inclusion on the government agenda and policy formulation, (ii) policy implementation, and (iii) policy evaluation (IDB 2014).[2] This analysis shows a set of 241 indicators that are distributed by risk management reform components and by public policy phases (see Table 3).

[2] The general framework of governance for DRM refers to the regulatory foundation suitable for the organization and coordination of DRM in each country. The risk identification and knowledge process of DRM focuses on the knowledge of the origins, causes, scope, frequency and possible evolution, among other aspects, of potentially dangerous phenomena, as well as of the location, causes, evolution and resistance and recovery capacity of exposed socioeconomic elements. The risk reduction process focuses on minimizing vulnerabilities and risks in a society, to avoid (i.e., prevention) or limit (i.e., mitigation) the adverse impact of hazards, within the broad context of sustainable development. The disaster preparedness process aims to plan, organize and test the society's response procedures and protocols in the event of a disaster, guaranteeing appropriate and timely assistance to affected persons, facilitating the normalization of the essential activities in the zone affected by the disaster. The recovery planning process focuses on ex ante preparation for a quick and appropriate reestablishment of acceptable and sustainable life conditions through the rehabilitation, repair or reconstruction of infrastructure, goods and services that were destroyed, interrupted or deteriorated in the affected area, and the recovery of the economic and social development at the community level under conditions of lower risk. The financial protection process seeks the optimal combination of financial mechanisms or instruments for the retention and transfer of risk in order to have ex-post access to economic resources in a timely fashion, thus improving the response capacity to disasters (smaller and recurrent events and large infrequent disasters) and protecting the fiscal balance of the State. On the other hand, the IGOPP analyzes the inclusion on government's agenda by verifying the existence of appropriate legal frameworks for DRM, or the inclusion of the subject in sectorial and territorial regulations. Similarly, the IGOPP analyzes evidence of implementation by verifying the actions taken or the availability of resources allocated to the parties responsible for implementing the DRM policy, in its different components and governmental levels. Finally, the IGOPP analyzes the public policy evaluation from the perspective of the existence of monitoring and accountability mechanisms, as well as data and citizen participation mechanisms.

Table 3. Classification and codification of the Index of Governance and Public Policy for Disaster Risk Management

Public Policy Phases / Components of public policy reform in DRM	1. Inclusion in the government agenda and policy formulation			2. Policy implementation	3. Policy evaluation
	Central policy coordination and articulation	Definition of sectoral responsibilities	Definition of territorial responsibilities	Evidence of progress in implementation	Monitoring, accountability and participation
General framework of governance for DRM (GF)	GF-1A	GF-1B	GF-1C	GF-2	GF-3
Risk identification and knowledge (RI)	RI-1A	RI-1B	RI-1C	RI-2	RI-3
Risk reduction (RR)	RR-1A	RR-1B	RR-1C	RR-2	RR-3
Disaster preparedness (DP)	DP-1A	DP-1B	DP-1C	DP-2	DP-3
Recovery planning (RC)	RC-1A	RC-1B	RC-1C	RC-2	RC-3
Financial protection (FP)	FP-1A	FP-1B	FP-1C	FP-2	FP-3

The IGOPP score ranges between 0 (nonexistent governance conditions) and 100 (outstanding governance conditions) and has been computed for Argentina, the Bahamas, Barbados, Belize, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Suriname, Trinidad and Tobago, Uruguay and Venezuela. As can be seen in Figure 1, the countries of Latin America and the Caribbean have advanced at different speeds in the creation of conditions for governance in order to implement adequate DRM public policies, although most of the reform processes have taken place during the last 10 years. It can be observed that there is room for significant improvement to achieve optimal governance conditions at the regional level. Mexico, the country with the highest IGOPP in the region, barely exceeds 60 points.



Note: ME: Mexico, CO: Colombia, BO: Bolivia, PE: Peru, EC: Ecuador, CR: Costa Rica, NI: Nicaragua, ES: El Salvador, VE: Venezuela, HO: Honduras, BR: Brazil, PN: Panama, PR: Paraguay, CH: Chile, DO: Dominican Republic, GU: Guatemala, AR: Argentina, BA: Barbados, UR: Uruguay, BH: The Bahamas, JA: Jamaica, GY: Guyana, BL: Belize, TT: Trinidad and Tobago, HA: Haiti; SU: Suriname.

Source: Authors' calculations.

Figure 1. Index of Governance and Public Policy for Disaster Risk Management, by country, 1987-2017

IV. Research design and empirical strategy

As previously mentioned, the objective of this paper is to explain the relationship between the national governance framework for disaster risk management policy reform processes and human losses caused by natural phenomena. However, these political reform processes are far from being the only mechanism that has an impact on the death toll of disasters. Thus, the number of fatalities caused by disasters in the i-th country in year *t* is a function of the national political reform process in disaster risk management, captured by the IGOPP ($IGOPP_{it}$), the country's income (Y_{it}) and income distribution ($Gini_{it}$), exposure to natural hazards, which is a function of inherent physical and geographical attributes in a country (F_i) as well as the unobservable conditions common to all countries that change over time (G_t), the number of people potentially at risk (pop_{it}) and the occurrence of natural disasters:

$$Loss_{it} = f(IGOPP_{it}, Y_{it}, Gini_{it}, \eta(F_i, G_t), pop_{it}, o_{it}, \epsilon_{it}) \quad (1)$$

Specifically, given the occurrence of a disaster, human losses are expected to increase with the population (Kahn 2005). Likewise, Anbarci, Escaleras and Register (2005) document that unequal societies have a lower capacity for collective action and, therefore, for disaster response. It is expected that human losses will increase in the case of a country with greater exposure to natural hazards and geographical vulnerabilities (Kahn 2005, Pernetta and Milliman 1995) as well as more recurrent disasters (Kellenberg and Mobarak 2007). On the other hand, the number of human losses is expected to decrease with the level of per capita income (Escaleras and Register 2008). Kahn (2005) suggests that richer governments have the capacity to provide better quality infrastructure and a more effective response to emergency events, implicitly reducing the vulnerability of their inhabitants to disasters and other shocks. Finally, with regard to governance, the consolidation of institutions is likely reduce the magnitude of losses associated with natural disasters (Escaleras, Anbarci and Register 2007, Keefer, Neumayer and Plümper 2011, Noy 2009, Raschky 2008). In particular, an improvement in the legal, institutional and budgetary conditions for the effective implementation of comprehensive disaster risk management public policies (i.e., an increase in the IGOPP score) should result in lower human and economic losses attributable to disasters.

Equation 1 can be econometrically estimated as:

$$Loss_{it} = \beta_1 IGOPP_{it} + \beta_2 \ln Y_{it} + \beta_3 Gini_{it} + \beta_4 \ln pop_{it} + \beta_5 o_{it} + \alpha_1 F_i + \alpha_2 G_t + \epsilon_{it} \quad (2)$$

Note that this empirical strategy includes fixed spatial and temporal effects or time trends to incorporate exposure to natural hazards. Also, we allow for general heteroskedasticity and use robust Eicker-Huber-White standard errors for Equation (2)[3].

The dependent variable in the empirical model is the total number of people who lost their lives as a result of a disaster in a given year. In this paper, we use EM-DAT's definition of disaster, that is any geophysical (earthquake, volcanic eruption,), meteorological (storm, severe temperature conditions, fog), hydrological (flood, landslide, storm surge) or climatic (drought, forest fire, glacial lake overflow) phenomenon where at least 10 people perished, 100 people were injured, a state of emergency was declared or humanitarian assistance from the international community was requested. The annual frequency of disasters is the total number of events within these four categories in a year. The total number of people who reported having lost their home or suffered physical injuries as a direct result of a natural disaster will be used as alternative dependent variables. These variables were obtained from the EM-DAT database (Guha-Sapir, Below and Hoyos 2019).[4]

Total exposed population data were extracted from the European Commission's Global Human Settlement Layer (Pesaresi et al. 2016). In addition, information on real per capita income (using a gross domestic product price deflator (implicit price deflator) where 2016=100) was extracted from the World Bank's DataBank (2019). Gini coefficient data were obtained from the Standardized World Income Inequality Database 8.0 (SWIID) (Solt 2019). Finally, the complete IGOPP database was used, which includes scores for the 26 IDB borrowing-member countries covering the period from 1980 to 2017. The 26 countries included in this study are Argentina, the Bahamas, Barbados, Belize, Bolivia, Brazil, Chile, Colombia, Costa Rica, the Dominican Republic, Ecuador, El Salvador, Guatemala, Guyana, Haiti, Honduras, Jamaica, Nicaragua, Mexico, Panama, Paraguay, Peru, Suriname, Trinidad and Tobago, Uruguay and Venezuela.

Exposure to natural hazards, which is a function of the inherent physical attributes of a country, such as geographical features, that can induce (or mitigate) the occurrence of certain threats, is captured by incorporating country fixed effects. In alternative specifications, regional fixed effects, which control for regional climatic effects that do not vary over time, are used. Similarly, time fixed effects are included, thus controlling for observable and unobservable environmental conditions common to all countries but that change over time.

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[3] For the logarithmic variables the transformation $\ln(var_{it} + 1)$ is used in order not to lose observations at the time of estimation.

[4] The analysis does not incorporate those disasters that are not part of the EM-DAT dataset.

The analysis of the relationship between national DRM policy reform processes and the losses caused by disasters presented below is based on data of a humanitarian nature (total deaths, injuries and victims who reported losing their home), which are strictly non-negative. Given this restriction, ordinary least squares is not appropriate for the estimation, since the assumptions of linearity and normality in the distribution of errors is violated. In general, the standard statistical procedure for analyzing count data is the Poisson regression model. However, one of the assumptions of this generalized linear model is that the response variable has the same mean and variance.

From Table 4, it is observed that the variance of the interest count variables is much higher than their mean. This overdispersion makes the Poisson model inadequate for estimation. As a result, a zero-inflated negative binomial regression model is used. This is because between 44% and 77% of the observations of the response variables of interest are zero.[5]

Table 4. Descriptive statistics

Variable	Observations	Mean	Standard deviation	Minimum	Maximum
Deaths as a direct result of a disaster	988	389.7	7,424.7	0.0	229,549.0
People injured as a direct result of a disaster	988	2,730.3	60,191.9	0.0	1,800,006.0
People whose house was destroyed or heavily damaged as a direct result of a disaster	988	7,893.6	49,898.2	0.0	835,000.0
People requiring immediate assistance during a period of emergency	988	214,106.2	1,293,458.9	0.0	27,550,600.0
Annual frequency of natural disasters	988	1.8	2.1	0.0	12.0
Total population (millions)	988	18.8	36.4	0.1	210.0
GDP per capita (Constant 2016 USD)	988	7,381.0	7,247.6	671.0	36,895.6
Gini coefficient	988	46.5	4.4	26.5	54.3
IGOPP	988	10.6	13.2	0.0	62.4
Weighted IGOPP	988	11.7	14.5	0.0	66.3

In practical terms, a zero-inflated model assumes that the result of zero is derived from two different processes. In this case, the two processes are the occurrence and absence of disasters in a given year. In the absence of natural disasters, the only possible value that the response variables can take is zero. If disasters do occur, a count process is observed. These two parts of a zero-inflated model make this a binary process: typically, a logistic regression to model which of the two processes the value of zero is associated with and a count regression (in this case a negative binomial regression) to model the count process.

[5] Note that the fact that the response variable is zero can be explained either by the absence of disasters or because the losses associated with these disasters were not reported. Likewise, the absence of losses associated to disasters may reflect different conditions of vulnerability vis-à-vis countries where disasters did occur.

A zero-inflated negative binomial model postulates that there is a probability of p_i that the i-th observation is always equal to zero and a probability of $1-p_i$ that the value of the response variable has a negative binomial distribution with a parameter μ_i, such that $\ln(\mu_i) = \ln\lambda_i + \epsilon_i$, where $\lambda = \exp\,(x_i'\beta)$ and $\exp(\epsilon_i)$ has a gamma distribution with parameters ν, whereby $\mathbb{E}(\exp(\epsilon_i)) = 1$ and $\mathrm{Var}(\exp(\epsilon_i)) = 1/\nu$, being $\nu > 0$.

Thus, the probability distribution is:

$$P(Y_i = y_i) = \begin{cases} p_i + (1-p_i)\left(\frac{\nu}{\nu+\lambda_i}\right)^{\nu} \leftarrow y_i = 0 \\ (1-p_i)\frac{\Gamma(y_i+\nu)}{\Gamma(y_i+1)\cdot\Gamma(\nu)}\cdot\left(\frac{\nu}{\nu+\lambda_i}\right)^{\nu}\left(\frac{\lambda_i}{\nu+\lambda_i}\right)^{\lambda_i} \leftarrow y_i = k > 0 \end{cases} \quad (4)$$

Where $\Gamma(\cdot)$ is the gamma function.

The estimation method is maximum likelihood, which provides consistent and asymptotically efficient estimators. In the case of a zero-inflated negative binomial model, the following likelihood logarithm function determines the estimated values of the β parameters, as well as $\tau \in \mathbb{R} : p_i = \Lambda(\tau X_i\beta)$ and the dispersion parameter $\alpha = \frac{1}{\nu}$. In this case, S is the set of observations where no one was a victim of a disaster:

$$\mathcal{L}(\beta,\alpha,\tau) = \sum_{i\notin S}\ln\left(\exp(\tau X_i\beta) + \left(\frac{\nu}{\nu+\exp\,(X_i\beta)}\right)^{\nu}\right) - \ln(1+\exp(\tau X_i\beta)) + \sum_{i\in S} y_i\ln\alpha + y_iX_i\beta - \left(y_i + \frac{1}{\alpha}\right)\ln(1+\alpha\exp(X_i\beta)) + \ln\Gamma\left(y_i + \frac{1}{\alpha}\right) - \ln(y_i!) - ln\Gamma\left(\frac{1}{\alpha}\right) \quad (5)$$

V. Results

Table 5 presents the main results derived from estimating Equation (2). The relationship of interest is between national DRM policy reform processes, captured by the IGOPP, and human losses caused by disasters. Column 1 presents the base specification, with no country, region or time fixed effects, as well as no trend line. There is ample evidence that an improvement in the conditions for disaster risk governance is *ceteris paribus* associated with a decrease in the number of fatalities caused by disasters triggered by natural hazards. This relationship is theoretically consistent with the notion that better institutional quality has a direct impact on the level of development of a country (Acemoglu, Gallego and Robinson 2014).

Empirical specifications incorporating elements that capture exposure to natural hazards (in this case through fixed effects and trend lines) are preferred to the basic specification of column 1. Statistical significance is maintained when trend lines (columns 2 and 3) and time fixed effects -which capture those unobservable environmental conditions common to all countries but that change over time- (columns 4 and 6) are included in the empirical specification. The IGOPP coefficient remains significant in the specifications in columns 3 to 6, which contain country or regional fixed effects, through which physical and geographical attributes inherent to a country or region that increase exposure to natural hazards are modeled.

Table 5. Determinants of the annual national death toll from disasters, 1980-2017

	Zero-Inflated Negative Binomial Regressions					
Independent variable	(1)	(2)	(3)	(4)	(5)	(6)
Log population	0.926***	1.001***	0.873**	0.896***	0.436	0.584***
	(0.094)	(0.094)	(0.345)	(0.088)	(0.320)	(0.050)
Log GDP per capita	-0.974***	-1.047***	-1.160**	-1.114***	-0.567	-0.946***
	(0.188)	(0.172)	(0.568)	(0.144)	(0.525)	(0.074)
Gini coefficient	-0.012	-0.043	-0.016	-0.008	0.004	0.048***
	(0.041)	(0.038)	(0.039)	(0.027)	(0.040)	(0.012)
Total count of disasters	0.037*	0.032	0.021	0.037*	0.069***	0.104***
	(0.022)	(0.020)	(0.018)	(0.022)	(0.024)	(0.021)
IGOPP	-0.060***	-0.084***	-0.068***	-0.080***	-0.028**	-0.029***
	(0.014)	(0.020)	(0.013)	(0.018)	(0.012)	(0.010)
Andean dummy				1.060**		0.481**
				(0.454)		(0.234)
Caribbean dummy				-0.178		-0.586**
				(0.507)		(0.276)
Central America dummy				-0.236		-0.379*
				(0.265)		(0.196)
	Zero-Inflated Logit Model					
Total count of disasters	-1.524***	-1.492***	-1.410***	-1.485***	-1.342***	-1.386***
	(0.192)	(0.192)	(0.206)	(0.195)	(0.194)	(0.185)
Constant	1.381***	1.328***	1.181***	1.316***	1.271***	1.378***
	(0.208)	(0.210)	(0.234)	(0.218)	(0.231)	(0.207)
Ln α	1.446***	1.408***	1.188***	1.359***	0.922***	1.025***
	(0.114)	(0.094)	(0.068)	(0.084)	(0.069)	(0.068)
Time trend	No	Yes	Yes	Yes	No	No
Country fixed effect	No	No	Yes	No	Yes	No
Region fixed effect	No	No	No	Yes	No	Yes
Year fixed effect	No	No	No	No	Yes	Yes
Observations	988	988	988	988	988	988
Non-zero observations	455	455	455	455	455	455
Wald $\chi 2$	1033.132	1678.501	3495.204	2145.413	6079.646	4628.287
Log likelihood function	-3481.643	-3464.327	-3375.277	-3444.532	-3292.995	-3334.41

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

Eicker-Huber-White robust standard errors in parentheses. The lower panel of the table reports the logit model estimates of the probability that nobody in a given nation in a given year died from a disaster. The upper panel reports the results from the negative-binomial regression. The omitted regional category is South America.

The interpretation of a zero-inflated negative binomial model requires transformations of the estimated parameters because of the log link function, which places the regression coefficients on the log scale, thus forcing the predictor variables to have a non-linear relationship with the outcome.[6] Based on the specifications incorporating spatial and time fixed effects, and on the condition that a non-zero number of deaths have occurred, an additional point in the IGOPP is associated with an average reduction of approximately 3% of the total fatalities caused by disasters triggered by natural hazards. To have a magnitude of the parsimony with which disaster risk management policy reform processes take place, the variation observed in the IGOPP scores of the 26 countries with available information is, on average, an increase of 0.8 points per year. To put the IGOPP coefficients in perspective, we predict the annual death toll from disasters as well as the probability of experiencing no deaths from a disaster for a country with low, incipient and good governance conditions for disaster risk management in Table 6. The average nation with low DRM governance conditions experiences 367-616 deaths from disasters triggered by natural hazards. If this nation reached good DRM governance conditions, the number of fatalities would fall to 97-141 per year. Drawing from Viscusi and Masterman (2017), we estimate the income-adjusted average value of a statistical life for LAC countries at US$ 1.41 million, implying that such an improvement in DRM governance conditions yields savings in the order of US$ 381-670 million. It is also worth noting that such an improvement in governance conditions decreases the probability of lethal disasters by 10 percentage points.

Table 6. Predicted annual death toll and probability of zero-fatalities, by DRM governance level

DRM governance level	Expected deaths	Probability that disaster deaths = 0
Low	367-616	0.08
Incipient	171-237	-0.11-0.12
Good	97-141	-0.18-0.19

Prediction ranges are based on the results of Table 5, specifications (5) *and* (6). *An IGOPP score lower than 20 reflects a low level of favorable governance conditions for disaster risk management; an IGOPP score between 21 and 40 indicates incipient DRM governance conditions; an IGOPP score between 41 and 70 denotes good DRM governance conditions.*

[6] To interpret the regression coefficient from the zero-inflated binomial regression as the percentage change in the expected counts, we exponentiate the product of the regression coefficient and the units of change in the predictor. Specifically, we define the percentage change in the expected counts as $100 \times [e^{\beta \cdot \delta} - 1]$, where $\delta = 1$ for one unit of change in the independent variable.

As expected, with respect to other explanatory variables, a higher frequency of disasters triggered by natural hazards implies a greater number of fatalities. As documented by Keefer, Neumayer and Plümper (2011), countries with a higher per capita income exhibit a lower death toll from disasters. Also, in line with previous empirical studies (Heatwole and Rose 2013, Kahn 2005, Kellenberg and Mubarak 2008), the specifications in Table 5 suggest that a larger exposed population is associated with a higher disaster fatality rate. In general, it is not possible to present conclusive evidence that a country's level of inequality is associated to the number of fatalities resulting from disasters. Only the empirical specification that includes regional and time fixed effects (column 6 of Table 5) shows an income inequality coefficient that is positive and statistically significant.

Improvements in disaster risk management governance are not only an important factor contributing to the reduction of mortality caused by disasters but could also influence *a priori* the number of injured or homeless. Table 7 presents the results of estimating Equation (2), with two alternative dependent variables: the total number of injured and people left homeless as a result of a disaster. The magnitude of the impact of national disaster risk management policy reform processes is greater in terms of injuries. Based on the specifications incorporating spatial and time fixed effects, and on the condition that a positive number of injured persons exists, an additional point in the IGOPP is associated with a reduction between 5 and 6% of total injuries caused by disasters triggered by natural hazards.

On the other hand, although the association is negative across all empirical specifications, it is not possible to generalize a statistically significant relationship between disaster risk management policy reform processes and the number of people left homeless as a result of a disaster. Based on the specifications incorporating spatial and time fixed effects, and on the condition that a positive number of homeless exists, an additional point in the IGOPP is associated with a reduction of up to 4% in the total number of disaster-related homeless victims.

Table 7. Determinants of annual national total injuries and homeless people from disasters, 1980-2017

	Zero-Inflated Negative Binomial Regressions					
	Injured					
Independent variable	(1)	(2)	(3)	(4)	(5)	(6)
Log exposed population	0.722***	0.759***	2.820***	0.582***	1.469**	0.374***
	(0.117)	(0.109)	(0.683)	(0.130)	(0.620)	(0.129)
Log GDP per capita	-1.333***	-1.335***	-3.529***	-1.053***	-2.081**	-0.753***
	(0.227)	(0.237)	(1.106)	(0.182)	(0.830)	(0.114)
Gini coefficient	0.145***	0.123***	-0.221***	0.099**	0.001	0.141***
	(0.039)	(0.046)	(0.068)	(0.042)	(0.099)	(0.034)
Total count of disasters	-0.102	-0.097	-0.057	-0.054	-0.053	0.052
	(0.089)	(0.069)	(0.038)	(0.042)	(0.055)	(0.048)
IGOPP	0.023	-0.01	-0.057***	-0.056**	-0.051*	-0.058***
	(0.037)	(0.035)	(0.022)	(0.022)	(0.029)	(0.018)
Andean dummy				2.582***		1.811***
				(0.855)		(0.433)
Caribbean dummy				-0.098		-2.385***
				(0.910)		(0.605)
Central America dummy				1.178**		1.061***
				(0.581)		(0.361)
	Zero-Inflated Logit Model					
Total count of disasters	-1.026***	-1.015***	-0.811***	-0.978***	-0.771***	-0.858***
	(0.149)	(0.148)	(0.142)	(0.142)	(0.158)	(0.154)
Constant	2.559***	2.559***	2.148***	2.556***	2.140***	2.362***
	(0.293)	(0.289)	(0.282)	(0.286)	(0.291)	(0.289)
Ln α	2.584***	2.570***	2.212***	2.485***	1.944***	2.104***
	(0.108)	(0.111)	(0.110)	(0.097)	(0.136)	(0.120)
Time trend	No	Yes	Yes	Yes	No	No
Country fixed effect	No	No	Yes	No	Yes	No
Region fixed effect	No	No	No	Yes	No	Yes
Year fixed effect	No	No	No	No	Yes	Yes
Observations	988	988	988	988	988	988
Non-zero observations	732	732	732	732	732	732
Wald χ2	591.9798	588.5555	26752.06	1053.478	12096.53	2576.954
Log likelihood function	-2213.032	-2211.697	-2141.42	-2198.726	-2095.73	-2127.065

**** p<0.01, ** p<0.05, * p<0.1.*
Eicker-Huber-White robust standard errors in parentheses. The lower panel of the table reports the logit model estimates of the probability that nobody in a given nation in a given year died from a disaster. The upper panel reports the results from the negative-binomial regression. The omitted regional category is South America.

Table 7. Determinants of annual national total injuries and homeless people from disasters, 1980-2017 (continued)

	Zero-Inflated Negative Binomial Regressions					
	Homeless people					
Independent variable	(1)	(2)	(3)	(4)	(5)	(6)
Log exposed population	0.407***	0.347***	-0.181	0.443***	1.806***	0.350***
	(0.067)	(0.058)	(0.413)	(0.080)	(0.583)	(0.083)
Log GDP per capita	0.109	0.226**	1.438**	0.13	-1.15	0.290***
	(0.142)	(0.098)	(0.663)	(0.087)	(0.851)	(0.101)
Gini coefficient	0.060**	0.072***	0.011	0.074***	-0.058	0.094***
	(0.027)	(0.025)	(0.069)	(0.026)	(0.060)	(0.022)
Total count of disasters	0.042	0.034	0.07	0.021	0.038	0.044
	(0.047)	(0.050)	(0.047)	(0.045)	(0.050)	(0.043)
IGOPP	-0.050***	-0.009	-0.046**	-0.001	-0.038*	0.001
	(0.015)	(0.017)	(0.021)	(0.017)	(0.021)	(0.013)
Andean dummy				-1.101**		-0.981**
				(0.529)		(0.401)
Caribbean dummy				-0.615		-0.328
				(0.512)		(0.449)
Central America dummy				-1.137**		-0.557
				(0.482)		(0.346)
	Zero-Inflated Logit Model					
Total count of disasters	-0.194***	-0.185***	-0.150***	-0.182***	-0.146***	-0.172***
	(0.048)	(0.040)	(0.026)	(0.036)	(0.024)	(0.028)
Constant	1.669***	1.661***	1.472***	1.658***	1.486***	1.660***
	(0.140)	(0.131)	(0.117)	(0.126)	(0.113)	(0.117)
Ln α	1.371***	1.283***	1.059***	1.220***	0.768***	0.930***
	(0.185)	(0.171)	(0.096)	(0.129)	(0.078)	(0.079)
Time trend	No	Yes	Yes	Yes	No	No
Country fixed effect	No	No	Yes	No	Yes	No
Region fixed effect	No	No	No	Yes	No	Yes
Year fixed effect	No	No	No	No	Yes	Yes
Observations	988	988	988	988	988	988
Non-zero observations	729	729	729	729	729	729
Wald χ2	4058.076	4773.158	52038.5	5057.788	35791.06	16539.35
Log likelihood function	-3217.25	-3210.195	-3168.85	-3201.699	-3129.12	-3166.527

**** $p<0.01$, ** $p<0.05$, * $p<0.1$.*

Eicker-Huber-White robust standard errors in parentheses. The lower panel of the table reports the logit model estimates of the probability that nobody in a given nation in a given year died from a disaster. The upper panel reports the results from the negative-binomial regression. The omitted regional category is South America.

VI. Robustness checks

Our results are robust to alternative empirical specifications of the role of national disaster risk management policy reform processes. Nonetheless, it could be argued that the usefulness of our disaster data is limited due to inconsistencies, data gaps and ambiguity of terminology resulting from multiple methodologies and definitions. Although the EM-DAT dataset employs clear definitions for disaster events and parameters, the original data suppliers may not. In addition, while we deliberately excluded observations prior to 1980 due to heterogeneity and lack of systematized information, accuracy, recording and classification issues in the earlier records in the EM-DAT database are well documented (Berz 2000, Shen and Hwang 2018).

While the EM-DAT dataset provides a generally solid statistical record on human losses for Latin America and the Caribbean region, other datasets can be employed to draw more robust conclusions on the role of disaster risk management governance. We estimate Equation (2) using disaster mortality data from NatCatSERVICE, a global natural catastrophe loss database provided by re-insurance company Munich Re (2017). We chose the NatCatSERVICE dataset because, even though it was conceived as a data repository to service client insurance companies, it has a larger number of disaster entries (3,479 events, compared to EM-DAT's 1,807 records for the period 1980-2017). This is due to the fact that NatCatSERVICE has no exclusion criteria and therefore includes all events that have incurred either property or human losses, mitigating the risk of excluding important events that should be considered in the sample. Table 8 presents the results of estimating Equation (2) using national death toll data from NatCatSERVICE. Table 11 shows that, in all cases, the estimates of the IGOPP coefficient are similar both in terms of the sign and statistical significance, although slightly larger in terms of the magnitude of the coefficient when both time and spatial fixed effects are included in the empirical specifications. On the condition that a positive non-zero number of deaths have taken place, an additional point in the IGOPP is associated with a reduction between 3 and 4% of the total fatalities caused by disasters triggered by natural hazards.

Table 8. Determinants of the annual national death toll from disasters using NatCatSERVICE data, 1980-2016

	Zero-Inflated Negative Binomial Regressions					
Independent variable	(1)	(2)	(3)	(4)	(5)	(6)
Log exposed population	0.658***	0.695***	0.37	0.678***	0.510*	0.508***
	(0.070)	(0.070)	(0.364)	(0.082)	(0.280)	(0.045)
Log GDP per capita	-0.982***	-0.996***	-0.071	-0.987***	-0.547	-0.743***
	(0.131)	(0.135)	(0.552)	(0.126)	(0.447)	(0.068)
Gini coefficient	0.053**	0.039*	-0.051	0.041*	-0.007	0.041***
	(0.026)	(0.021)	(0.044)	(0.022)	(0.043)	(0.010)
Total count of disasters	0.116***	0.110***	0.094***	0.115***	0.116***	0.144***
	(0.032)	(0.028)	(0.025)	(0.026)	(0.024)	(0.021)
IGOPP	-0.055***	-0.064***	-0.074***	-0.065***	-0.038***	-0.034***
	(0.009)	(0.016)	(0.013)	(0.013)	(0.011)	(0.009)
Andean dummy				0.345		0.209
				(0.386)		(0.214)
Caribbean dummy				0.148		-0.403
				(0.488)		(0.255)
Central America dummy				-0.174		-0.352**
				(0.285)		(0.179)
	Zero-Inflated Logit Model					
Total count of disasters	-16.605***	-17.956***	-17.500***	-17.436***	-16.244***	-16.068***
	(0.503)	(0.480)	(0.524)	(0.506)	(1.810)	(2.318)
Constant	16.503***	17.841***	17.288***	17.328***	16.096***	15.995***
	(0.347)	(0.313)	(0.358)	(0.355)	(1.645)	(2.166)
Ln α	1.098***	1.095***	0.943***	1.084***	0.672***	0.778***
	(0.080)	(0.079)	(0.060)	(0.075)	(0.054)	(0.057)
Time trend	No	Yes	Yes	Yes	No	No
Country fixed effect	No	No	Yes	No	Yes	No
Region fixed effect	No	No	No	Yes	No	Yes
Year fixed effect	No	No	No	No	Yes	Yes
Observations	962	962	962	962	962	962
Non-zero observations	386	386	386	386	386	386
Wald χ2	1205.657	1220.799	3731.554	1585.521	5858.188	5192.278
Log likelihood function	-3287.786	-3286.064	-3219.109	-3281.497	-3117.222	-3161.132

**** p<0.01, ** p<0.05, * p<0.1.*
Eicker-Huber-White robust standard errors in parentheses. The lower panel of the table reports the logit model estimates of the probability that nobody in a given nation in a given year died from a disaster. The upper panel reports the results from the nega-tive-binomial regression. The omitted regional category is South America.

Furthermore, it is plausible that certain disaster risk management public policy elements might contribute more than others to risk reduction. As mentioned earlier, the IGOPP addresses disaster risk management governance by evaluating 241 indicators distributed in six equally weighted policy reform components. An alternative is to assign different weights to each indicator, depending on their relative importance. The IDB Disaster Risk Management Group carried out an alternative application protocol of the IGOPP with a weight structure that reflects composite valuations of the indicators (IDB 2014). Table 9 shows that when the unweighted IGOPP is replaced by the weighted IGOPP as an explanatory variable, the estimate of Equation (2) yields robust, although more conservative, results in the case of disaster-related fatalities. Regressions without fixed effects have been excluded for conciseness, but these essentially lead to the same results presented in Table 5. Based on the specifications incorporating spatial and time fixed effects, and on the condition that a non-zero number of deaths have occurred, an additional point in the weighted IGOPP is associated with a reduction of approximately 3% of the total fatalities from disasters triggered by natural hazards. Similarly, an additional point in the weighted IGOPP is associated with a reduction between 3 and 6% of the total number of injured and homeless people attributable to disasters.

Table 9. Determinants of the annual national death toll, total injuries and homeless people from disasters, 1980-2017

	Zero-Inflated Negative Binomial Regressions					
	Dead		Injured		Homeless	
Independent variable	(1)	(2)	(3)	(4)	(5)	(6)
Log exposed population	0.436	0.583***	1.479**	0.369***	1.834***	0.351***
	(0.319)	(0.051)	(0.614)	(0.131)	(0.575)	(0.083)
Log GDP per capita	-0.568	-0.945***	-2.104**	-0.758***	-1.168	0.291***
	(0.522)	(0.074)	(0.823)	(0.115)	(0.841)	(0.101)
Gini coefficient	0.004	0.048***	0.002	0.145***	-0.064	0.094***
	(0.040)	(0.012)	(0.099)	(0.033)	(0.061)	(0.022)
Total count of disasters	0.068***	0.105***	-0.055	0.053	0.04	0.044
	(0.024)	(0.021)	(0.053)	(0.047)	(0.050)	(0.044)
Weighted IGOPP	-0.028**	-0.027***	-0.049*	-0.055***	-0.035*	0.001
	(0.011)	(0.009)	(0.027)	(0.016)	(0.019)	(0.012)
Andean dummy		0.480**		1.817***		-0.981**
		(0.233)		(0.422)		(0.404)
Caribbean dummy		-0.597**		-2.474***		-0.328
		(0.276)		(0.608)		(0.450)
Central America dummy		-0.381*		1.090***		-0.557
		(0.196)		(0.361)		(0.348)
	Zero-Inflated Logit Model					
Total count of disasters	-1.340***	-1.383***	-0.772***	-0.856***	-0.146***	-0.172***
	(0.193)	(0.185)	(0.157)	(0.153)	(0.024)	(0.028)
Constant	1.271***	1.379***	2.143***	2.362***	1.486***	1.660***
	(0.231)	(0.206)	(0.291)	(0.288)	(0.113)	(0.117)
Ln α	0.920***	1.023***	1.943***	2.100***	0.768***	0.930***
	(0.069)	(0.068)	(0.135)	(0.120)	(0.078)	(0.079)
Country fixed effect	Yes	No	Yes	No	Yes	No
Region fixed effect	No	Yes	No	Yes	No	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	988	988	988	988	988	988
Non-zero observations	455	455	732	732	729	729
Wald χ2	6078.453	4644.945	14234.59	2592.183	36266.36	16507.37
Log likelihood function	-3292.575	-3334.141	-2095.677	-2126.755	-3129.073	-3166.527

**** p<0.01, ** p<0.05, * p<0.1.*
Eicker-Huber-White robust standard errors in parentheses. The lower panel of the table reports the logit model estimates of the probability that nobody in a given nation in a given year died from a disaster. The upper panel reports the results from the negative-binomial regression. The omitted regional category is South America.

Finally, it might be considered more appropriate to estimate the relationship between human losses in a given year and the IGOPP score from previous periods. The use of lagged IGOPP values would recognize the fact that national disaster risk management policy reform processes take time to materialize and that the human impact of a disaster today is heavily determined by those policy reforms that took place theretofore. The implication is that the greatest impact of these processes is not immediate but takes place several years after their implementation.

Table 10 presents six different specifications of Equation (2). Specification (1) includes the contemporaneous IGOPP as an explanatory variable. Specifications (2)- (6) include the IGOPP variable with a 1-, 2-, 5-, 10-, 15- and 20-year lag, respectively. All specifications include country and time fixed effects.

These regressions show that, in fact, improvements in disaster risk management governance conditions for risk management take time to consolidate. An additional point in the contemporaneous IGOPP is associated with a reduction of approximately 2.8% of the total deaths attributable to disasters. The 1-, 5- and 10-year lagged IGOPP coefficients are 0.3 to 0.4 percentage points larger in magnitude. Beyond a 10-year lag length, however, the effects taper off and are not statistically different from zero.

Table 10. Determinants of the annual national death toll from disasters, with lagged IGOPP variables, 1980-2017

	Zero-Inflated Negative Binomial Regressions					
Independent variable	(1)	(2)	(3)	(4)	(5)	(6)
Log exposed population	0.436	0.517	0.889**	0.592	0.758	0.689
	(0.320)	(0.380)	(0.406)	(0.511)	(0.688)	(0.767)
Log GDP per capita	-0.567	-0.812	-1.094	-0.927	-1.005	-0.967
	(0.525)	(0.632)	(0.688)	(0.854)	(1.141)	(1.298)
Gini coefficient	0.004	0.017	0.032	0.03	-0.026	0.001
	(0.040)	(0.041)	(0.047)	(0.051)	(0.060)	(0.063)
Total count of disasters	0.069***	0.070***	0.069***	0.092***	0.106***	0.109***
	(0.024)	(0.024)	(0.025)	(0.027)	(0.029)	(0.030)
IGOPP	-0.028**					
	(0.012)					
IGOPP *t*-1		-0.031**				
		(0.013)				
IGOPP *t*-5			-0.032**			
			(0.016)			
IGOPP *t*-10				-0.032*		
				(0.018)		
IGOPP *t*-15					-0.032	
					(0.028)	
IGOPP *t*-20						0.035
						(0.028)
	Zero-Inflated Logit Model					
Total count of disasters	-1.342***	-1.359***	-1.300***	-1.228***	-1.001***	-1.067***
	(0.194)	(0.191)	(0.209)	(0.254)	(0.301)	(0.200)
Constant	1.271***	1.336***	1.063***	0.787***	0.626*	0.561
	(0.231)	(0.236)	(0.261)	(0.303)	(0.351)	(0.361)
Ln α	0.922***	0.917***	0.930***	0.924***	0.851***	0.626***
	(0.069)	(0.069)	(0.070)	(0.076)	(0.102)	(0.087)
Country fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	988	962	858	728	598	468
Non-zero observations	455	440	367	297	232	173
Wald χ2	6079.646	5915.269	5151.716	4323.264	3925.69	3811.818
Log likelihood function	-3292.995	-3227.118	-2997.167	-2582.961	-2148.541	-1658.497

**** $p<0.01$, ** $p<0.05$, * $p<0.1$.*

Eicker-Huber-White robust standard errors in parentheses. The lower panel of the table reports the logit model estimates of the probability that nobody in a given nation in a given year died from a disaster. The upper panel reports the results from the negative-binomial regression.

VII. Conclusion

The objective of this paper is to demonstrate that DRM governance significantly mitigates the human impact caused by natural phenomena in developing countries. The argument presented here is that the absence of governance conditions, rather than nature itself, is one of the causes of the social vulnerability that has been observed in the LAC region in recent decades: disasters are much more deadly in countries where the state exhibits weak institutional capacity. In Latin America and the Caribbean alone, disasters triggered by natural hazards have caused approximately 400,000 deaths and more than US $ 183 billion in economic losses in less than four decades.

This study used a panel of 26 LAC countries benefiting from access to data from the largest disaster risk management governance database of the region, to test the hypothesis that an improvement in governance conditions leads to a significant reduction in the probability of suffering human losses due to disasters.

This study builds on previous work by Guerrero Compeán, Salazar and Lacambra Ayuso (2017), providing new empirical evidence on the critical role of disaster risk management governance in reducing the number of fatalities caused by disasters. An additional point in the Index of Governance and Public Policy Index in Disaster Risk Management (IGOPP), which characterizes the regulatory, institutional and budgetary development of disaster risk management in LAC countries, is associated with a reduction of approximately 3% of total fatalities caused by disasters, as well as a decrease between 4 and 6% of people left homeless and injured in the aftermath of a disaster. Likewise, income, exposure levels and the frequency of events also directly influence the incidence of disaster-related fatalities. In addition, we find that a categorical improvement from low to good DRM governance conditions yields savings, in term of avoided human fatalities, in the order of US$ 381-670 million per year. These results are robust to different empirical specifications.

The main public policy implication of this study is that creating conditions to improve disaster risk management governance is a crucial element not only to reverse the negative impact of the underlying causes of social vulnerability, such as deficiencies in the economic system and weak institutional capacity, but also to cost-effectively counteract the effect of dynamic triggers of risk, such as rapid urbanization, environmental degradation and market inefficiencies.

While this empirical analysis focused on the effect of disaster risk governance on human losses, future research efforts should be directed to study the effect of such processes on the economy, in order to evaluate the extent to which improvements in disaster risk management governance also translate into reduced economic losses. Likewise, an analysis of the impact of risk governance that incorporates a greater number of countries could disaggregate its incidence by hazard type. Similarly, it is critical to have a better understanding of the specific importance of the fundamental components of medium and long-term disaster risk management reforms, particularly in the context of a changing climate and more devastating disasters.

References

Acemoglu, D., F. Gallego and J.A. Robinson. 2014. "Institutions, human capital and development." *Annual Reviews of Economics* 6: 875-912.

Anbarci, N., M. Escaleras nd C.A. Register. 2005. "Earthquake fatalities: the interaction of nature and political economy." *Journal of Public Economics* 89: 1907-1933.

Ballart, X. 2013. "Marco conceptual del índice." Washington, D.C.: Inter-American Development Bank.

Ballart, X. and C. Riba. 2002. "Forest fires: Evaluation of government measures." *Policy Sciences* 35: 361-377.

Barone, G. and S. Mocetti. 2014. "Natural disasters, growth and institutions: a tale of two earthquakes." *Journal of Urban Economics* 84: 52-66.

Barreda, M. and A. Costafreda. 2003. *Democracy matters but it is not enough for equality: institutional information and weakness in Latin America.* Paper presented at the International Conference on Democracy, Governance and Welfare in Global Societies. Barcelona: International Institute of Governance.

Battista, F. and S. Baas. 2004. "The role of local institutions in reducing vulnerability to recurrent natural disasters and in sustainable livelihoods development. Consolidated report on case studies and workshop findings and recommendations." Rural Institutions and Participation Service. Roma: FAO.

Berz, G. 2000. "Flood disasters: lessons from the past—worries for the future." *Proceedings of the Institution of Civil Engineers-Water and Maritime Engineering* 142(1): 3-8.

Besley, T. and R. Burgess. 2002. "The political economy of government responsiveness: theory and evidence from India." *The Quarterly Journal of Economics* 117: 1415-1451.

Boin, A. and M. Lodge. 2016. "Designing resilient institutions for transboundary crisis management: A time for public administration." *Public Administration* 94(2): 289-298.

Escaleras, M., N. Anbarci and C.A. Register. 2007. "Public sector corruption and major earthquakes: a potentially deadly interaction." *Public Choice* 132: 209–230.

Escaleras M. and C.A. Register. 2008. "Mitigating natural disasters through collective action: the effectiveness of tsunami early warnings." *Southern Economic Journal* 74(4): 1017–1034.

Garrett, T.A. and R.S. Sobel. 2003. "The political economy of FEMA disaster payments." *Economic Inquiry* 41: 496-509.

Guerrero Compeán, R. 2013. *Essays in Climate and Development.* PhD. Dissertation. Cambridge, MA: Massachusetts Institute of Technology.

Guerrero Compeán, R., L.P. Salazar and S. Lacambra Ayuso. 2017. "Gestionando el riesgo. Efectos de la gobernabilidad en las pérdidas humanas por desastres en América Latina y el Caribe." IDB Working Paper Series IDB-WP-819. Washington, D.C.: Inter-American Development Bank.

Guha-Sapir, D. and R. Below. 2002. "The quality and accuracy of disaster data: a comparative analysis of three global data sets." Manuscript. Disaster Management Facility. Washington, D.C.: The World Bank.

Guha-Sapir, D., R. Below and P. Hoyos. 2019. EM-DAT: International Disaster Database. Retrieved from www.emdat.be on September 1, 2019. Brussels, Belgium: Université Catholique de Louvain.

Heatwole, N. and A.Z. Rose. 2013. "A reduced-form rapid economic consequence estimating model: application to property damage from U.S. earthquakes." Paper 202. Los Angeles, CA: USC Center for Risk and Economic Analysis of Terrorism Events.

Inter-American Development Bank. 2013. "Infrastructure strategy for competitiveness." Washington, D.C.: Inter-American Development Bank.

Inter-American Development Bank. 2014. "IGOPP. Index of Governance and Public Policy in Disaster Risk Management. Main Technical Document." Technical Note IDB-TN-720. Environment, Rural Development and Disaster Risk Management Division. Washington, D.C.: Inter-American Development Bank.

Inter-American Development Bank. 2014b. "Theoretical and empirical study of the impact of the processes of political reform in DRM". Environment, Rural Development and Disaster Risk Management Division. Washington, D.C.: Inter-American Development Bank.

Kahn, M.E. 2005. "The death toll from natural disasters: The role of income, geography and institutions." *The Review of Economics and Statistics* 87(2): 271-284.

Keefer, P., E. Neumayer and T. Plümper. 2011. "Earthquake propensity and the politics of mortality prevention." *World Development* 39(9): 1530-1541.

Kellenberg, D.K. and A.M. Mobarak. 2008. "Does rising income increase or decrease damage risk from natural disasters?" *Journal of Urban Economics* 63: 788-802.

Lacambra, S., C. Rogers, G. Suárez, T. Hori, L.P. Salazar, M. Esquivel, L. Narváez, O.D. Cardona, R. Durán, A.M. Torres and E. Visconti. 2015. "Public Policy Governance Index in Disaster Risk Management(iGOPP). Application Protocol." Technical Note IDB-TN-913. Environment, Rural Development, Disaster Risk Management Division. Washington, D.C.: Inter-American Development Bank.

Moreno, M.A. 2004. "Institutions and democratic governance: keys to the virtuous circle of development" in Moreno, M.A. (ed.) *Governance, institutions and development*, pp. 16-48. Tegucigalpa: Inter-American Institute for Social Development.

Munich Re (Münchener Rückversicherungs-Gesellschaft). 2017. *NatCatSERVICE Methodology.* Munich: Münchener Rückversicherungs-Gesellschaft.

Mustafa, D. 2003. "Reinforcing vulnerability? Disaster relief, recovery and response to the 2001 flood in Rawalpindi, Pakistan." *Environmental Hazards* 5: 71-82.

North, D.C. 1991. "Institutions." *Journal of Economic Perspectives* 5(1): 97-112.

Noy, I. 2009. "The macroeconomic consequences of disasters." *Journal of Development Economics* 88(2): 221-231.

Paxson, C.H. 1992. "Using weather variability to estimate the response of savings to transitory income in Thailand." *American Economic Review* 82(1): 15-33.

Pelling, M. 1999. "The political ecology of flood hazard in urban Guyana." *Geoforum* 30: 249-261.

Pernetta, J.C. and J.D. Milliman. 1995. *Land-Ocean Interactions in the Coastal Zone: Implementation Plan.* Stockholm: International Geosphere Biosphere Programme.

Pesaresi, M., M. Melchiorri, A. Siragusa, and T. Kemper. 2016. *Atlas of the Human Planet – Mapping Human Presence on Earth with the Global Human Settlement Layer.* Brussels, Belgium: Publications Office of the European Union.

Plümper, T. and E. Neumayer. 2009. "Famine mortality and rational political inactivity." *World Development* 37(1): 50-61.

Raschky, P.A. 2008. "Institutions and the losses from natural disasters." *Natural Hazards and Earth System Sciences* 8: 627-634.

Rumbach, A. and D. Foley. 2014. "Indigenous institutions and their role in disaster risk reduction and resilience: evidence from the 2009 tsunami in American Samoa." *Ecology and Society* 19(1): 19.

Sawada, Y. 2007. "The impact of natural and manmade disasters on household welfare." *Agricultural Economics* 37(s1): 59-73.

Schmidt, A., K. Boersma, and P. Groenewegen. 2018. "Management strategies in response to an institutional crisis: The case of earthquakes in the Netherlands." *Public Administration* 96(3): 513-527.

Shen, G. and S.N. Hwang. 2018. Revealing global hot spots of technological disasters: 1900–2013. *Journal of Risk Research* 21(3): 361-393.

Skidmore, M. 2001. "Risk, natural disasters and household savings in a life cycle model." *Japan and the World Economy* 13(1): 15-34.

Solt, F. 2019. "The Standardized World Income Inequality Database, Version 8." https://doi.org/10.7910/DVN/LM4OWF, Harvard Dataverse, V2.

Townsend, R.M. 1994. "Risk and insurance in village India." *Econometrica* 62(3): 539-591.

Udry, C. 1994. "Risk and saving in Northern Nigeria." *American Economic Review* 85(5): 1287-1300.

UNISDR. 2005. "Hyogo Framework for Action 2005-2015: Building the resilience of nations and communities to disasters." International Strategy for Disaster Reduction. World Conference on Disaster Reduction. 18-22 January 2005, Kobe, Hyogo, Japan.

Viscusi, W. K., and C.J. Masterman. 2017. Income elasticities and global values of a statistical life. *Journal of Benefit-Cost Analysis* 8(2): 226-250.

Weiss Fagen, P. 2008. "Natural disasters in Latin America and the Caribbean: national, regional and international interactions. A regional case study on the role of the affected state in humanitarian action." Humanitarian Policy Group. London: Overseas Development Institute.

Wisner, B., P. Blaikie, T. Cannon and I. Davis. 2003. *At Risk. Natural Hazards, People's Vulnerability and Disasters.* London and New York, NY: Routledge.

World Bank. 2017. "The World Development Report 2017 – Governance and the Law. Concept Note." Report No. 101555-GLB. Washington, D.C.: World Bank Group.

World Bank. 2019. DataBank. Retrieved from https://databank.worldbank.org/ on September 1, 2019.