

## SECTOR IN-DEPTH

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## Global Credit Strategy - Environmental Risks

# Understanding the Impact of Natural Disasters: Exposure to Direct Damages Across Countries

## Summary

Natural disasters can have a large negative impact on government finances and economic growth in affected countries and according to the IMF are the second-leading cause of materialization of contingent liabilities for emerging market sovereigns, after banking crises. On occasion, natural disasters have been the direct cause of sovereign defaults. Using data from the Emergency Events Database (EM-DAT) during 1980-2015, we analyze the vulnerability to natural disasters across 125 Moody's-rated sovereigns, compare how the susceptibility to natural disasters in emerging economies differs from the developed world, and identify the most exposed regions and countries. We find the following:

- » **The incidence of natural disasters has increased over the past 35 years**, primarily driven by a higher occurrence of floods and storms globally. Floods represented the most common type of natural disaster, and overall, about 80% of natural disasters were weather-related. The most destruction globally was caused by tropical storms and earthquakes. In dollar terms, the annual average loss globally has increased by a factor of 2.6 in the new millennium compared to prior to 2000; however, the trend disappears after controlling for GDP.
- » **Emerging economies are significantly more exposed than developed countries.** The average annual damage from natural disasters over 1980-2015 was 1.5% of GDP in emerging markets vs. 0.3% of GDP in developed economies. The average share of affected population over the same period was 3.0% in emerging markets vs. 0.4% in developed economies.
- » **The two most exposed regions globally are Emerging Asia and the Caribbean.** Due to its geographic features, Asia has been affected the most in terms of total natural hazards occurrence and affected population, while the Caribbean region has experienced the highest damages globally as a share of GDP. Over the 1980-2015 period, the five countries with the highest annual loss in percent of GDP globally were Mongolia (20.1%), Maldives (18.5%), Belize (9.3%), El Salvador (8.5%) and the Solomon Islands (8.0%).

- » **In addition to being more exposed to natural disasters, emerging economies are also less insured against them.** Data from SwissRe show that over 40% of the direct losses from natural disasters are insured in developed countries, while less than 10% of losses are covered by insurance in middle-income countries and less than 5% in low-income countries. Private sector (re)insurance plays an important role in mitigating the adverse impacts of natural disasters in advanced economies. In contrast, developing countries rely on their governments for post-disaster relief, which places a heavy burden on public finances and gives rise to sovereign contingent liabilities.
- » **Natural disasters have severe macroeconomic impact and can affect sovereign creditworthiness through several channels, including directly impacting a country's economic strength, government fiscal strength and external vulnerability.**<sup>1</sup> Natural disasters are frequently associated with: (i) contracting economic output, potentially followed by a short-term boost to growth from reconstruction efforts; (ii) increasing poverty, as natural disasters have a disproportionate impact on the poorer segments of the population; (iii) worsening external balances, as imports of reconstruction materials increase and exports tend to suffer; (iv) downward pressure on the exchange rate and upward pressure on prices; (v) deteriorating fiscal balances, as tax revenues shrink due to the decline in economic activity but government expenditures rise due to emergency assistance and reconstruction efforts; and (vi) increasing debt-to-GDP levels, which results from both the decrease in GDP and from an increase in borrowing to finance the recovery and reconstruction activity.

Natural disasters can affect a sovereign's debt repayment capacity by affecting a country's economic resilience, fiscal strength and susceptibility to event risk. Sovereigns that are more susceptible to natural disaster risks generally have weaker creditworthiness, reflected in lower government bond ratings. Our recent report, "[How Moody's Assesses the Physical Effects of Climate Change on Sovereign Issuers](#)", reviews in more detail Moody's approach to assessing the sovereign credit impact of climate change risks.

This report is organized as follows. Section I analyzes the global trends in the intensity and direct damages of natural disasters over time. Section II provides a regional and country comparison of the impact of natural disasters. Section III discusses the role of disaster relief mechanisms in the public as well as private sectors, and section IV summarizes the implications of natural catastrophes for sovereign creditworthiness.

## I. The Incidence of Natural Disasters Globally Has Increased since 1980

### Introduction and data coverage

We review the manifestation of natural disasters for 125 Moody's-rated countries over the 1980-2015 period, using the EM-DAT database compiled by the Center for Research on the Epidemiology of Disasters (CERD), which represents the most comprehensive publicly-available database on natural disasters. The database is compiled from a number of sources, including UN agencies, non-governmental organizations, research institutes, insurance companies, and press agencies.

Natural disasters included in the database are those which led to at least 10 fatalities, or at least 100 people affected, or resulted in a declaration of state of emergency or a call for international assistance. The database reports the number of people killed, the number of people affected, and the dollar amount of damages for each disaster. The amount of damages refers to 'direct damages' or the destruction of capital stock, including damages to roads, other infrastructure, buildings, housing and crops.

Natural disasters fall into the following main groups, namely:

1. **Geophysical events ("Earthquakes")** - earthquake, tsunami, volcanic activity;
2. **Weather-related:**
  - a. **Meteorological events ("Storms")** - tropical storm, extra-tropical storm, convective storm, local storm;
  - b. **Hydrological events ("Floods")** - flood, mass movement;

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- c. **Climatological events ("Droughts")** - extreme temperatures, drought, wildfire;
3. And the least common type, **biological events ("Epidemics")** - animal accident, epidemic, insect infestation, - some of which were also related to changes in weather patterns.<sup>2</sup>

In general, as there is no standard methodology for reporting disaster damages across countries, there is significant evidence that the physical damages from natural disasters tend to be underreported. For example, CRED (2015) notes that information on the economic damage from natural disasters is only available for 36% of disasters reported since 1994. Records are particularly partial for Africa, where losses were reported for only 13% of events, compared to about 40% in the Americas, Asia and Europe and 50% in Oceania. Further, Acevedo (2016) presents evidence that capital stock damages in the Caribbean region could be underestimated between 38% and 72%, and that the average annual damages in the Caribbean could be as high as 5.7% of GDP on average, instead of the recorded 1.6% of GDP. FAO (2015) also notes that disaster damages in the agriculture sector are not systematically collected or reported. Finally, as the EM-DAT database started to record disasters in 1988, post-1988 coverage is likely more complete than coverage in earlier periods.

Our sample includes 125 Moody's-rated countries, comprising of 26 developed and 99 emerging markets across all regions globally. Appendix I details the country coverage by region. We also use the World Development Indicators (WDI) database and Moody's sovereign database for data on population and GDP.

### The incidence of floods and storms has risen over time

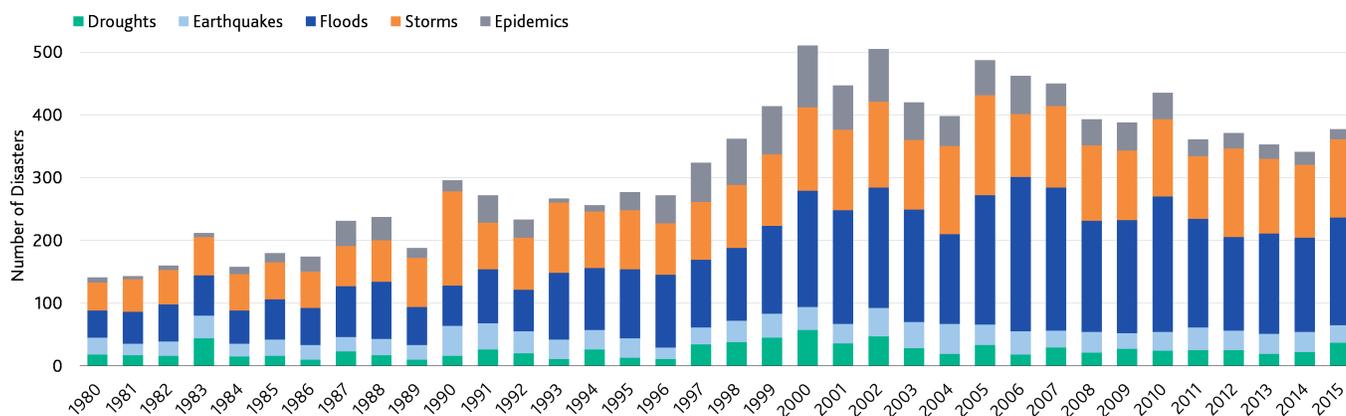
Total occurrence of reported natural disasters increased steadily from 141 events in 1980 to a all time high of 527 events in 2000. Despite a decline in frequency since then, a continuous increase in the intensity of floods and storms resulted in a total of 377 disasters in 2015, which is 1.2 times higher than the 35-year average (of 314 events per year). As noted above, reporting of events in the early 1980s is likely incomplete and the increased frequency of disasters reflects to some extent better reporting of milder events.

Of the total 11,512 natural catastrophes over the 1980-2015 period, 79% took the form of weather-related extreme events, such as storms, floods and droughts. Of the remaining, 12% represented biological events, and 9% fell into the category of geophysical events such as earthquakes, tsunamis and volcanic activities.

Among weather-related events, hydrological events were the most common type of natural disasters, with the highest average occurrence probability of 38.5% over the past 35 years. There was also an increasing occurrence of hydrological events compared to other disasters: floods and mass movement represented 34% of all events in the 1980s and the 1990s, 43% in the 2000s and 46% since 2010.

Exhibit 1

#### Global Natural Disasters by Type, 1980-2015

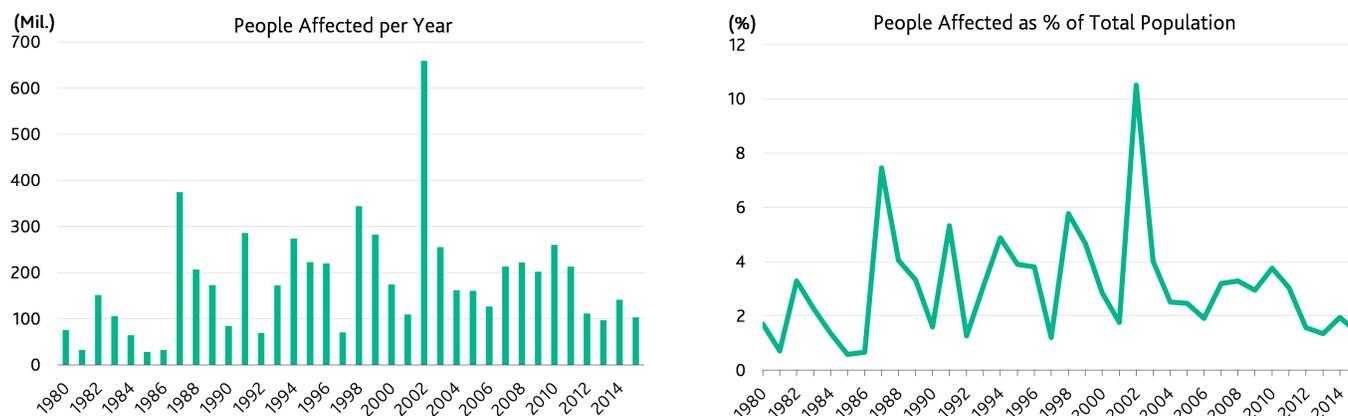


Note: 221 countries globally.  
Source: EM-DAT

### The number of people affected by natural disasters globally has fallen post-2003

Further, during the 1980-2015 period, natural disasters on average claimed 50 thousand lives annually and additionally affected 169 million people per year. The average number of people affected each year was 119 million during the 1980s, 191 million in the 1990s, 217 million in the 2000s and 136 million post-2010. Thanks to the deployment of disaster risks prevention systems and more accurate forecasting mechanisms, the number of people affected by natural disasters has fallen from its peak reached in 2003 – when severe floods and about 30 earthquakes above 5.0 on the Richter scale hit China and affected a population of 219 million.

Exhibit 2  
**Total Population Affected by Natural Disasters Globally, 1980-2015**

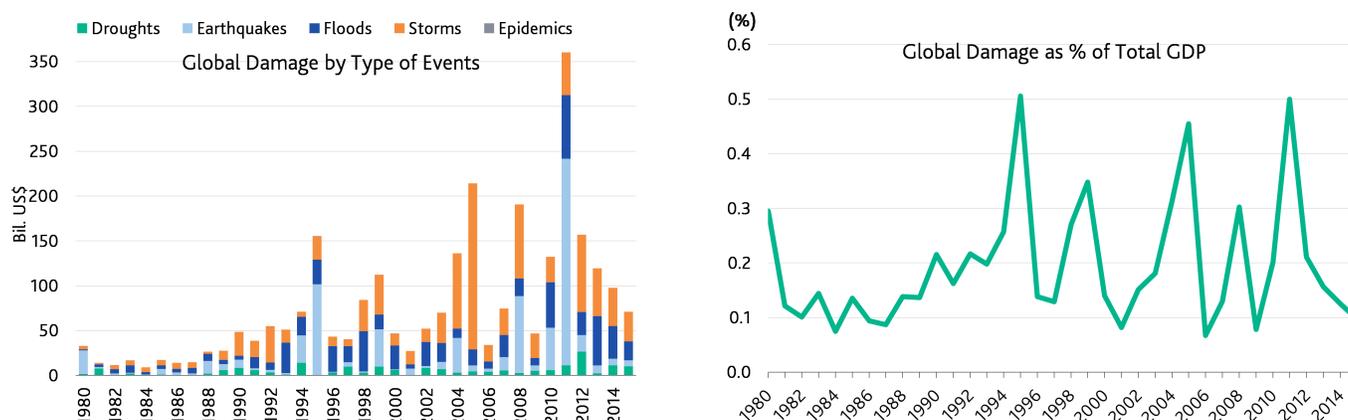


Note: 221 countries globally.  
 Source: EM-DAT, World Development Indicators (WDI)

### Direct damage from natural disasters has jumped up in dollar terms, but the trend disappears after controlling for GDP

In dollar terms, total damage from natural disasters has increased over time. For the 1980-2015 period, estimated direct losses from natural disasters amounted to over US\$2.6 trillion worldwide and on average US\$71.8 billion per year. The direct damage has increased from an average of US\$15.1 billion per year in the 1980s, to US\$64.7 billion per year in the 1990s, to US\$86.7 billion per year in the 2000s, and US\$153.6 billion per year post-2010. Nevertheless, after controlling for GDP the trend disappears.

Exhibit 3  
**Global Direct Damage per Year in Dollar Terms and as a Share of GDP, 1980-2015**



Note: 221 countries globally.  
 Source: EM-DAT

Despite hydrological events (i.e., floods) being the most common type of natural disaster, the most destruction globally was caused by meteorological and geophysical events, including tropical storms and earthquakes.

Overall, 39.8% of damages globally were due to storms, 27.8% were caused by earthquakes and tsunamis, 25.3% by floods, 7.1% by droughts and wildfire, and only 0.01% by epidemics.

Exhibit 4

#### Top 10 Natural Disasters Ordered by Overall Losses, 1980-2015

Date	Event	Affected Area	Overall Losses in Mil. US\$	Overall Losses as % of GDP	Fatalities
11.3.2011	Earthquake, tsunami	Japan: Aomori, Chiba, Fukushima, Ibaraki, Iwate, Miyagi, Tochigi, Tokyo, Yamagata	210000	3.6	15880
25-30.8.2005	Hurricane Katrina, storm surge	United States: LA, MS, AL, FL	125000	1.0	1720
17.1.1995	Earthquake	Japan: Hyogo, Kobe, Osaka, Kyoto	100000	1.9	6430
12.5.2008	Earthquake	China: Sichuan, Mianyang, Beichuan, Wenchuan, Shifang, Chengdu, Guangyuan, Ngawa, Ya'an	85000	1.9	84000
23-31.10.2012	Hurricane Sandy, storm surge	Bahamas, Cuba, Dominican Republic, Haiti, Jamaica, Puerto Rico, United States, Canada	68500	N/A	210
17.1.1994	Earthquake	United States: Northridge, Los Angeles, San Fernando Valley, Ventura	44000	0.6	61
1.8-15.11.2011	Floods, landslides	Thailand: Phichit, Nakhon Sawan, Phra Nakhon Si Ayuttaya, Phthumthani, Nonthaburi, Bangkok	43000	11.6	813
6-14.9.2008	Hurricane Ike	United States, Cuba, Haiti, Dominican Republic, Turks and Caicos Islands, Bahamas	38000	N/A	170
27.2.2010	Earthquake, tsunami	Chile: Concepción, Metropolitana, Rancagua, Talca, Temuco, Valparaiso	30000	13.8	520
23./24./27.10.2004	Earthquake	Japan: Honshu, Niigata, Ojiya, Tokyo, Nagaoka, Yamakoshi	28000	0.6	46

Source: Munich Re, NatCatSERVICE, 2016

The disaster management literature commonly distinguishes the “rapid on-set” disasters, such as storm surges and earthquakes, which cause immediate loss and disruption, from the “slow on-set” events such as droughts. From an economic point of view, it is also useful to distinguish “low-frequency, high-severity” events, such as geophysical hazards, which cause large one-time losses from “high-frequency, low-severity” events, such as many of the climate-related hazards, which have a recurrent long-term impact on the economy. The recurrent nature of hazards more frequently leads to adaptation in economic and social activity, such as agriculture, housing and water supply.

Further, unlike other natural disasters, droughts could have especially harmful economic effects which materialize over the long run. As droughts can last for several years, they can result in food insecurity, persistent malnutrition, water supply shortages, outbreaks of epidemic diseases, and the displacement of large sections of the affected population. Thus, droughts can have indirect effects in terms of increased hunger, poverty and underdevelopment, in addition to the reported immediate loss of life, that are often poorly documented. For example, CRED (2015) notes that the figures for reported drought-related deaths globally are misleading as they exclude the vast majority of indirect deaths caused by drought-related malnutrition, disease and displacement. In a related study, FAO (2015) also estimates that the indirect losses experienced by the agricultural sector in developing countries in the seasons after a disaster are twice as high as the direct damage to agricultural assets.

The sectoral impact of natural disasters is still a subject that requires further research. The same 2015 FAO report estimates that in developing countries the agricultural sector absorbs on average 22% of the total damage and losses caused by natural disasters. The remaining losses occur to housing, health, education, transport and communication, electricity, water and sanitation, commerce, industry, tourism and the environment, among other sectors. The relationship between droughts and agriculture is particularly important as 84% of the damage from droughts occur to the agricultural sector.

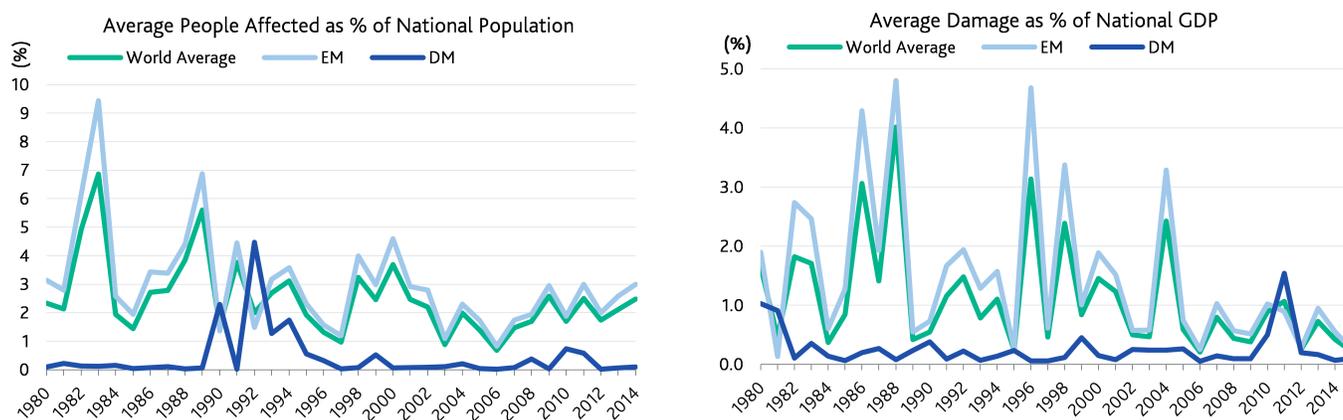
## II. Compared to Developed Economies, Emerging Markets Are Significantly More Vulnerable to Natural Hazards

Overall, US\$1.6 trillion of damage occurred in the developed world during the past 35 years, compared to less than US\$0.9 trillion damage in emerging and developing countries. However, developing countries, especially small island states, are significantly more exposed than developed countries in terms of damage as a percent of GDP.

Comparing the number of people affected by natural disasters as a percentage of national total population and the direct damage from natural disasters as a proportion of national GDP across countries, we find that emerging markets suffer eight times more in terms of the average share of population affected, and five times more in terms of direct damage as a share of GDP, compared to developed markets. Over the 1980-2015 period, the average annual damage from natural disasters was 1.5% of GDP in emerging markets vs. 0.3% of GDP in developed economies. The average share of affected population over the same period was 3.0% in emerging markets vs. 0.4% in developed economies.

Exhibit 5

### Vulnerability to Natural Disasters in Emerging Countries vs. Developed Countries, 1980-2015



Note: 125 Moody's-rated countries globally.  
Source: Moody's Investors Service (MIS), EM-DAT

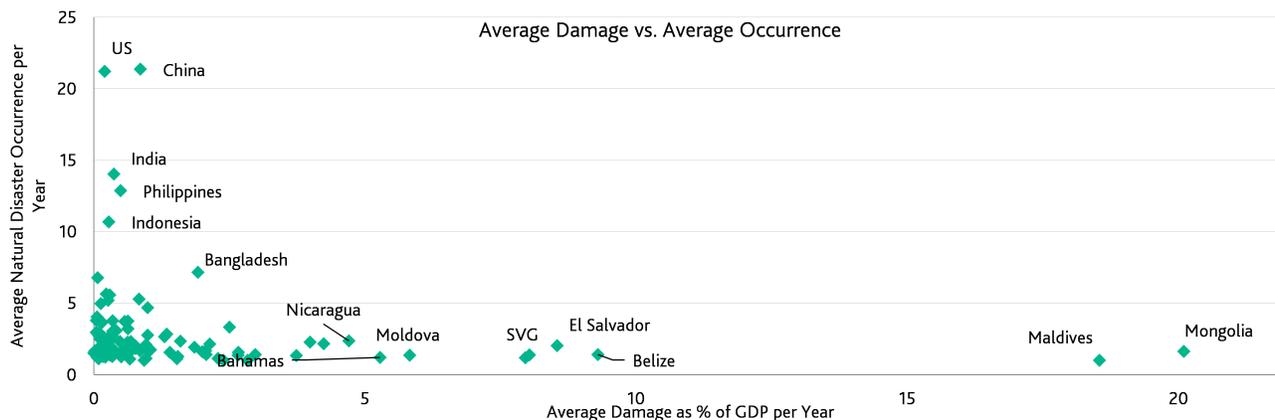
Naturally, there is a large variation across countries among emerging markets group, as small islands are much more vulnerable to natural catastrophes. For example, the average cost of natural disasters in the five largest countries by land area from 1980 to 2015 is 0.4% of GDP per year, compared to 7.7% of GDP per year for the five smallest countries.

The literature on the economic costs of natural disasters (see, for example, the summary by Cavallo and Noy (2010)) suggests several factors that impact a country's susceptibility to disasters. Geography and geographical location are critical determinants of the physical vulnerability of certain countries or regions to different types of natural disasters. For example, the presence of multiple river basins and large floodplains increases susceptibility to floods. Location in a hurricane-prone area increases susceptibility to storm damage. The small islands in the Caribbean and Pacific regions, for example, are particularly vulnerable on this dimension.

Country size is another factor that affects vulnerability to natural disasters. Larger countries in terms of land area or population size have more assets or people exposed to direct damages from natural disasters. However, larger countries may also be more diversified and better able to enact inter-sectoral or inter-regional transfers that help mitigate the economic impact of natural disasters. Therefore, while direct losses may be high in large countries because of assets exposure, the greater capacity to absorb shocks would imply lower indirect losses, and/or that the size of the damage may be lower relative to the size of the country.

Exhibit 6

## Small Island Economies Are Much More Impacted Than Large Economies, 1980-2015



Note: 125 Moody's-rated countries globally.  
Source: MIS, EM-DAT

In addition, the level of economic development seems to have a more nuanced, nonlinear relationship to the susceptibility to natural disasters. Risk initially increases with higher incomes as a result of changing people behaviors, such as residents locating to more desirable but more dangerous sites near coasts and floodplains. Moreover, as economies develop, industrialization and urbanization increase population densities. When this development occurs in areas at high risk of natural disasters, the frequency of disasters increases because more people are in harm's way. Similarly, risks emanating from geophysical hazards could increase with urbanization and growth of industrial and service sectors. Further, as Benson and Clay (2004) point out, an economy at an intermediate stage of development is typically more integrated, both between sectors and between regions, which increases spillovers and multiplier effects of adverse performance in one sector or region. For example, climate-related disasters may impact manufacturing as well as the agricultural and livestock sectors, especially where the initial development of the manufacturing sector is based on agroprocessing, as is commonly the case. Thus, a natural disaster shock that affects the agriculture sector would spread more broadly in the economy through these inter-sectoral linkages. In the later stages of economic development, the relative scale of the economic impact of disasters declines again, reflecting the smaller share of the particularly hazard-vulnerable agricultural sector in GDP, but also typically higher investment in risk reduction, improved environmental management, lower levels of poverty, and higher levels of insurance.

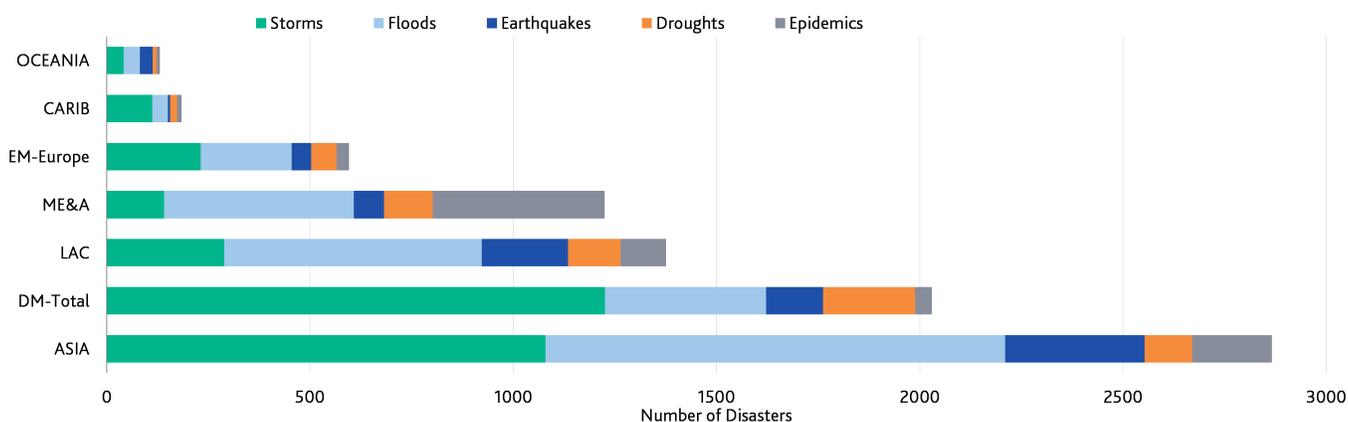
Finally, institutional and political factors also affect the impact of natural disasters. Better institutions which result in greater resources being spent on disaster prevention and legal enforcement of mitigation rules (for example, building codes and land-use planning), or higher accountability of policymakers, tend to result in reduced disaster impact. Further, in many disaster-affected countries, just one type of disaster is the cause of the large majority of recorded economic damage. Thus policy adaptation can significantly limit a country's susceptibility to natural disaster risks. For example, Benson and Clay (2004) find declining sensitivity to tropical storms and floods and increased resiliency over time in the Caribbean and Bangladesh, resulting from both economic transformation and public actions for disaster reduction. CRED (2015) also note that India, China, Indonesia and Myanmar have made noticeable progress towards reducing disaster losses by acting on the priorities of the Hyogo Framework for action. Better flood control has been identified by the international community as one of the "low-hanging fruit" in disaster prevention since affordable and effective technologies already exist - such as dams, dykes, mobile dykes and better early warning systems. In the case of Australia, Deloitte Access Economics (2016) estimates that investment in resilience measures could reduce the costs of disaster relief and recovery by more than 50% by 2050.

### III. The Two Most Exposed Regions Globally Are Emerging Asia and the Caribbean

While the reporting of disasters in the 1980s is likely incomplete, the frequency of disasters increased from the 1990s into the 2000s, and then fell into the 2010s across all regions. The type of disasters varied somewhat across regions. While storms were relatively more frequent in developed markets and in the Caribbean region, floods were relatively more frequent in Latin and Central America compared to other disasters. Further, the largest number of epidemics occurred in the Middle East and Africa region, and the largest number of droughts occurred in developed economies.

Exhibit 7

#### Global Natural Disasters by Type across Regions



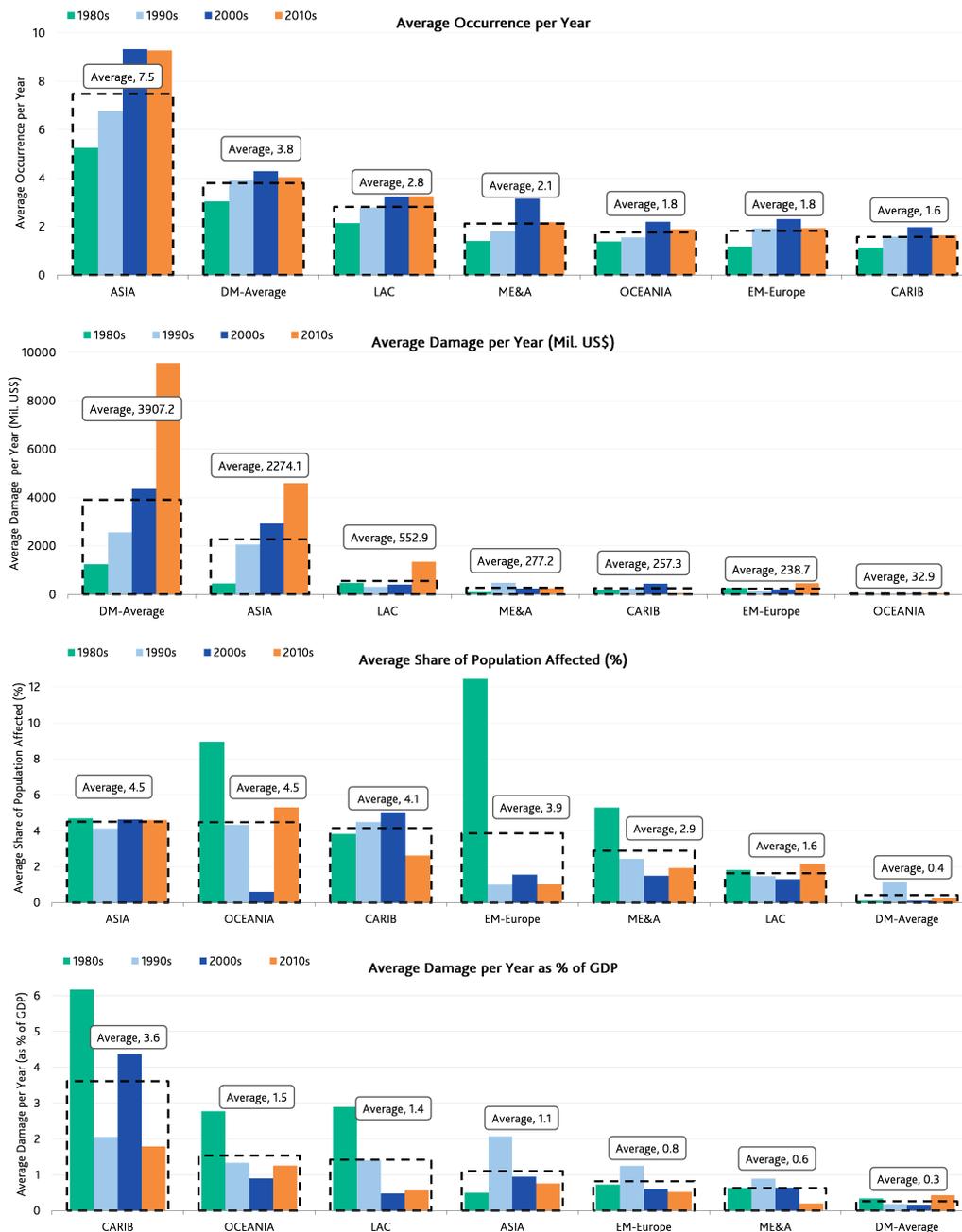
Note: 125 Moody's-rated countries globally.  
Source: EM-DAT

Among the developed countries, the US experienced the highest number of natural catastrophes due to its large landmass and population. The US also bore the largest average damage of US\$21.7 billion per year, with a greater number of people affected than any other country in the developed group. Windstorms were responsible for 70% of the damage to private property in the US.

Among emerging markets, Asia has been hit the hardest by natural catastrophes, with more frequent events and a greater number of people killed and affected than in the other regions. This is due mainly to its geographic characteristics, including large and varied landmass, multiple river basins, and flood plains, combined with a high density of urbanized populations in some disaster-prone zones. Further, growing concentration of populations in hazard-prone regions and fragile infrastructure have been some of the main causes of the increased economic costs of natural catastrophic events.

Nevertheless, the proportion of the population affected by natural disasters has generally fallen over time, in part reflecting increased deployment of early warning systems and improved accuracy of modern weather forecasting. In EM-Europe and Oceania, in particular, the number of people affected has dramatically fallen from its peak in the early 1980s when a number of extreme events hit those regions.

Exhibit 8  
**Frequency and Direct Damage of Natural Disasters across Regions, 1980-2015**



Note: 125 Moody's-rated countries globally; list of countries by region is in Appendix I.  
 Source: MIS, EM-DAT

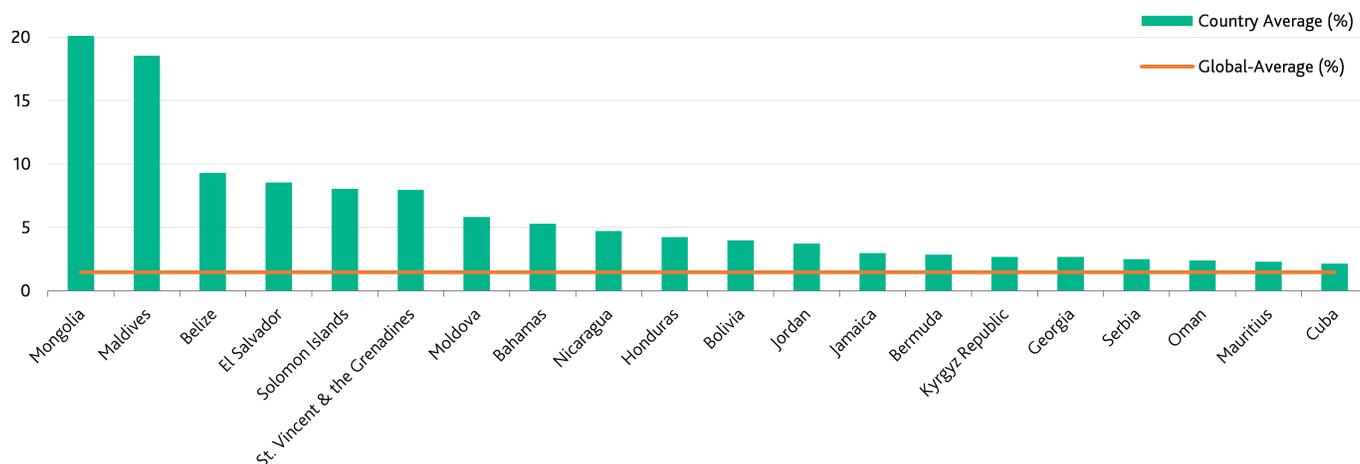
The Caribbean region is one of the most disaster-prone regions in the world. During 1980-2015, the Caribbean countries suffered from 390 (documented) natural disasters, most of them tropical cyclones and hurricanes, and floods. Similarly, another 366 natural disasters occurred in the Central American region.

Consequently, the Caribbean region suffered average annual damage of 3.6% of GDP, the highest globally, followed by Latin and Central America at 1.4% of GDP and developing Asia and Oceania at 0.8% of GDP.

Among the 20 most vulnerable countries globally, more than half represent small island states across the Caribbean and Pacific regions.<sup>3</sup> These 20 countries bear average losses between 20.1% and 2.1% of their respective GDP every year.

Exhibit 9

**Most Vulnerable Countries to Natural Disaster Risks**  
Average Annual Loss as % of GDP, 1980-2015



Note: 125 Moody's-rated countries globally. The data on Mongolia in the chart reflects EM-DAT data, while government reports seem to suggest smaller damages.  
Source: MIS, EM-DAT

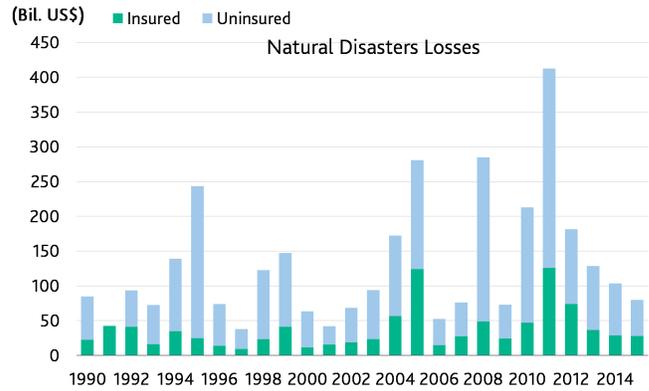
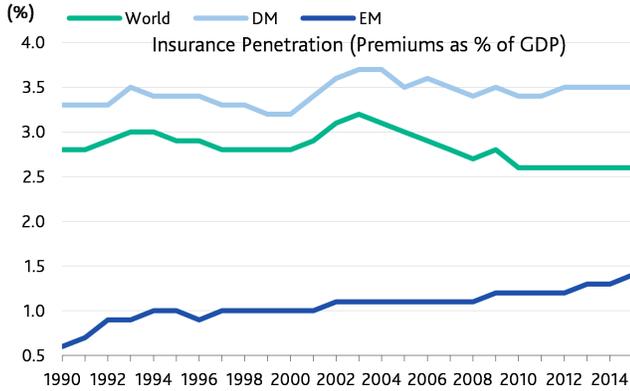
#### IV. Mitigating the Risk: In Addition to Being More Exposed to Natural Disasters, Emerging Economies Are Also Less Insured Against Them

In developed countries, insurance and capital markets are widely used in order to hedge the immediate adverse impacts of natural disasters. According to MunichRe, more than 40% of the direct losses from natural disasters are insured in developed countries, usually through compulsory insurance.

At the same time, MunichRe estimates that less than 10% of losses are covered by insurance in middle-income countries and less than 5% are covered in low-income countries. Private insurance mechanisms are not well developed or are absent in many emerging countries, some of which are both the worst hit by natural disasters and the least prepared. For example, the Latin America and the Caribbean region have the lowest levels of insurance coverage, despite the fact that they suffer some of the largest direct damages globally, partly because risk pooling is not possible.

There are a number of factors that contribute to the gap between economic loss and insured loss. Low insurance penetration is one of the reasons, while unaffordability of insurance is also commonly identified as a cause of low coverage. For example, insurance penetration, measured as a percentage of GDP, is only 1.4% in Latin America and Africa, compared to 3% in Europe and almost 5% in North America.

Exhibit 10  
**Insurance Plays Much More Important Role in Mitigating Risk in Developed Markets**

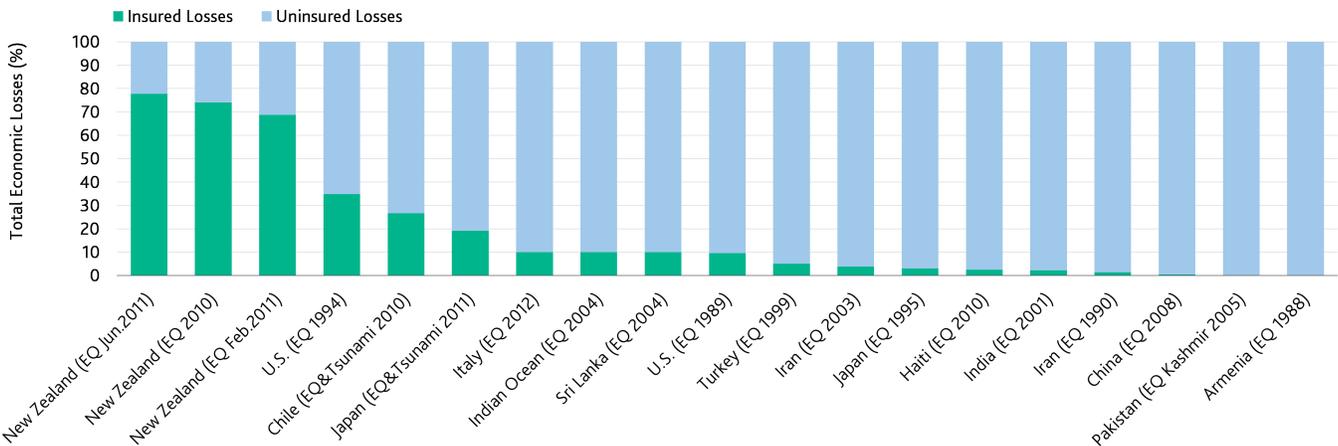


Source: Munich Re, World Bank

Further, even for advanced countries, private insurers are reluctant to cover large catastrophe risks. Data from Munich Re suggests that, on average, only about 26% of the losses from the world's largest natural catastrophes (in terms of total losses) occurring during 1980-2015 had been insured, while only 50% of the largest storm events had been insured.<sup>4</sup>

In some cases, there is no private insurance solution for catastrophe risks, or even if insurance were to exist, the premium would be too high for it to be affordable as a private sector solution. Therefore, governments around the world have participated in several insurance programs in order to make insurance more available and accessible. Examples include the US National Flood Insurance Program, the French Catastrophe Naturelles, the Turkish Catastrophe Insurance Pool, and the California Earthquake Authority.

Exhibit 11  
**Insured Loss versus Uninsured Loss of Selected Events, 1980- 2015**



Note: Based on property losses including, if applicable, agricultural, offshore, marine, aviation and National Flood Insurance Program losses in the United States and may differ from data shown elsewhere.  
 Source: 2016 Munich Re, Geo Risks Research, NatCatSERVICE

### Developing Countries Rely Heavily on Government and International Organizations for Post-Disaster Relief

Due to the lower level of private-sector catastrophe risk insurance in developing economies, the provision of post-disaster relief, reconstruction and rehabilitation remain largely a government responsibility, which often results in significant fiscal burden for the government.

To supplement the government's central role in natural disaster emergency relief, recovery, and reconstruction in developing countries, international organizations have played an important role in providing post-disaster reconstruction financing. For instance, the World Bank launched the Caribbean Catastrophic Risk Insurance Facility (CCRIF) in 2007, which helps countries finance early rehabilitation activities and public sector costs following natural catastrophic events. The objective of the insurance facility is to enable the governments of the participating countries and territories to receive an injection of liquidity in the wake of a hurricane or earthquake that meets specific parameters. Nevertheless, the payouts have only covered a small portion of the overall damages in the Caribbean countries.

Exhibit 12

#### CCRIF: An Example of International Organization Assistance in Disaster Relief

	Total damage (Mil. US\$)	CCRIF payouts to date (Mil. US\$)	CCRIF payouts as % of total damage
Haiti (2010)	8000	7.8	0.1
Turks & Caicos Islands (2008)	500	6.3	1.3
Dominica (2015)	483	2.4	0.5
St. Lucia (2007)	40	0.4	1.1
St. Vincent & the Grenadines (2010)	25	1.1	4.4
Dominica (2007)	20	0.5	2.6

Source: CCRIF SPC Annual Report 2014-2015

Further, the amount of funds available for all development assistance has remained constant for the past decade. Disaster assistance from the World Bank now accounts for 12% of all overseas development assistance from all sources, and this percentage has increased as the cost of disasters has escalated over time, putting pressure on development spending for other needs.

Besides the aid from multinational organizations, governments in countries that are vulnerable to natural disasters appear to have only a limited set of options (e.g., catastrophe bonds being another option currently under discussion by the international community) available to insure public finances against those risks.

## V. Natural Disasters Can Have Severe Macroeconomic Impact

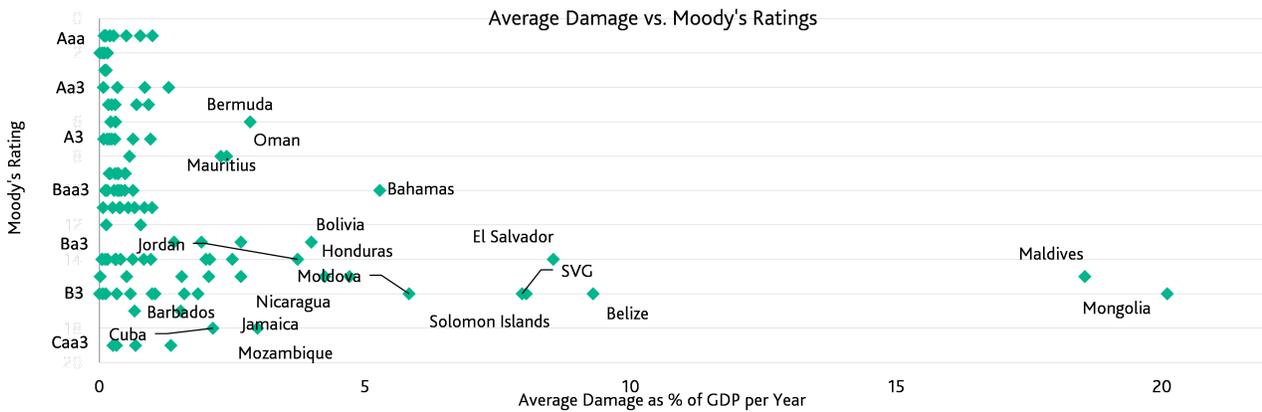
Natural disasters can have a severe impact on the economy and on sovereign creditworthiness, directly impacting a country's economic strength, government fiscal strength and external vulnerability as they are frequently associated with:

1. Contraction in economic output as a result of physical damages and loss of life, potentially followed by a short-term boost to growth from reconstruction effort;
2. Increasing poverty, as natural disasters have a disproportionate impact on the poorer segments of the population;
3. Worsening external balances, as imports of reconstruction materials increase and exports tend to suffer;
4. Downward pressure on the exchange rate and upward pressure on prices;
5. Deteriorating fiscal balances, as tax revenues shrink due to the decline in economic activity but government expenditures rise due to emergency assistance and reconstruction efforts;
6. Increasing debt-to-GDP levels, which results from both the decrease in GDP and from increase in borrowing to finance the recovery and reconstruction activity.

The macroeconomic costs of natural disasters, including the immediate decline in GDP and then potentially the cumulative, permanent GDP loss during the years following a major disaster, can also have a second-round effect on the government's budget. In addition, natural disasters can escalate government borrowing costs, especially for already highly indebted nations.

Through the above channels, natural disasters can affect a sovereign's debt repayment capacity by affecting a country's economic resilience, fiscal strength and susceptibility to event risk. Sovereigns more susceptible to natural disaster risks generally have weaker creditworthiness, reflected in lower government bond ratings. Our recent report, "[How Moody's Assesses the Physical Effects of Climate Change on Sovereign Issuers](#)", reviews in more detail Moody's approach to assessing the sovereign credit impact of climate change risks.

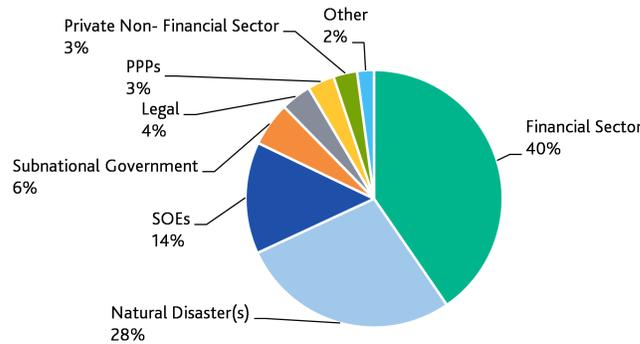
Exhibit 13  
**Sovereigns More Susceptible to Natural Disaster Risks Generally Have Weaker Debt Repayment Capacity**



Note: 125 Moody's-rated countries globally. Ratings are as of September 16, 2016.  
 Source: MIS, EM-DAT

As discussed in detail in our report "[Caribbean Sovereigns: The Silent Debt Crisis](#)", natural disasters have contributed significantly to the wave of sovereign defaults experienced in the Caribbean region over the last two decades. Several extreme events were the direct cause of recent sovereign defaults. For example, Hurricane Ivan in 2004, which resulted in damages of over 200% of GDP, was the direct cause of Grenada's subsequent debt restructuring. Further, hurricanes in 2003 and 2004, which damaged the agricultural sector, were contributing factors in the Dominican Republic's debt restructuring in 2005.

Exhibit 14  
**Contingent Liabilities Materialization Episodes by Category**

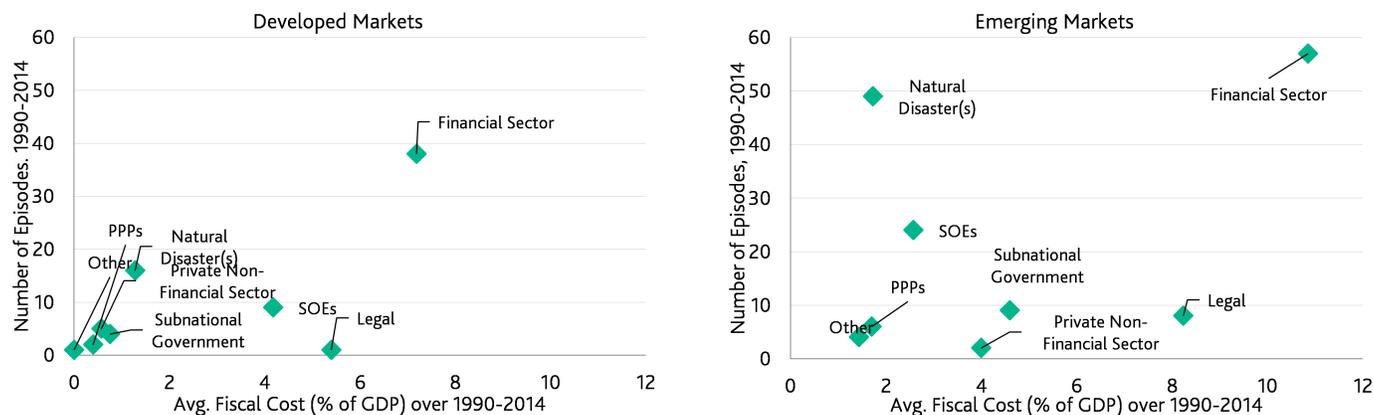


Note: Sample includes 235 contingent liability realizations in 75 countries over the period 1990-2014.  
 Source: IMF, *The Fiscal Costs of Contingent Liabilities: A New Dataset*, WP/16/14

Further, according to a recent study of contingent liabilities by the IMF, natural disasters have been the second-leading cause of materialization of contingent liabilities for emerging market sovereigns – after banking crises, - as the government has typically acted as a (re)insurer of last resort, without knowing precisely its disaster risk exposure.<sup>5</sup> Contingent liabilities may include losses incurred on government assets and emergency response and recovery. Occasionally, political and social pressure may also lead the government to accept additional liabilities after a major disaster, despite initial limited government responsibility.

Exhibit 15

**Natural Disasters Represent the Second-Most Frequent Source of Contingent Liabilities (CL) in Emerging Markets**



Note: Sample includes 235 contingent liability realizations in 75 countries over the period 1990-2014. Fiscal cost is considered as gross fiscal outlays and immediate changes in the government financial position directly due to the CL realization.

Source: IMF, *The Fiscal Costs of Contingent Liabilities: A New Dataset*, WP/16/14

## Appendix I: Country Sample Coverage

Our sample includes the following 125 Moody's-rated developed and emerging market countries. We note that a number of emerging market economies are "high-income" economies as per current World Bank classification.

### Emerging Markets:

- » **19 countries in Asia (Asia):** Bangladesh, Cambodia, China, India, Indonesia, Macao, Malaysia, Mongolia, Pakistan, Philippines, Sri Lanka, Taiwan, Thailand, Vietnam;
- » **11 countries in the Caribbean (CARIB):** Bahamas, Barbados, Belize, Bermuda, Cayman Islands, Cuba, Dominican Republic, Jamaica, St. Vincent and the Grenadines, Suriname, Trinidad and Tobago;
- » **24 countries in Emerging Europe (EM-Europe):** Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Russia, Ukraine, Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Montenegro, Poland, Romania, Serbia, Slovakia, Slovenia;
- » **17 countries in Latin and Central America (LAC):** Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Uruguay, Venezuela;
- » **29 countries in the Middle East and Africa (ME&A):** Cameroon, Cyprus, Egypt, Israel, Jordan, Kuwait, Lebanon, Morocco, Oman, Saudi Arabia, Tunisia, Turkey, Angola, Botswana, Côte d'Ivoire, Democratic Republic of the Congo, Ethiopia, Gabon, Ghana, Kenya, Mauritius, Mozambique, Namibia, Nigeria, Republic of the Congo, Senegal, South Africa, Uganda, Zambia.
- » **3 countries in Oceania (Oceania):** Fiji, Papua New Guinea, Solomon Islands.

### Developed Markets:

- » **26 developed markets (DM):** Australia; Austria; Belgium; Canada; Denmark; Finland; France; Germany; Greece; Hong Kong; Iceland; Ireland; Italy; Japan; Korea; Luxembourg; Netherlands; New Zealand; Norway; Portugal; Singapore; Spain; Sweden; Switzerland; United Kingdom; United States of America.

## References

Acevedo, Sebastian, 2016, Gone with the Wind: Estimating Hurricane and Climate Change Costs in the Caribbean, IMF Working Paper WP/16/199, October.

Benson, Charlotte and Edward Clay, 2004, Understanding the Economic and Financial Impacts of Natural Disasters, Disaster Risk Management Series No. 4, The World Bank

Bova, Elva, Marta Ruiz-Arranz, Frederik Toscani, and H. Elif Ture, 2016, The Fiscal Costs of Contingent Liabilities: A New Dataset, IMF Working Paper WP/16/14.

Cavallo, Eduardo and Ilan Nov, 2010, The Economics of Natural Disasters: A Survey, IDB Working Paper Series No. IDB-WP-124, May.

Centre for Research on the Epidemiology of Disasters (CRED), 2015, The Human Cost of Natural Disasters.

Climate Change 2013: The Physical Science Basis, Working Group I Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change

Deloitte Access Economics, 2016, The economic cost of the social impact of natural disasters, Australian Business Roundtable for Disaster Resilience & Safer Communities, March.

Food and Agriculture Organization (FAO) of the United Nations, 2015, The impact of disasters on agriculture and food security.

Freeman, Paul K., Michael Keen, and Muthukumara Mani, 2003, Dealing with Increased Risk of Natural Disasters: Challenges and Options, IMF Working Paper WP/03/197, October

GFDRR, Financial Protection against Natural Disasters, an Operational Framework for Disaster Risk Financing and Insurance, GFDRR, World Bank Group.

Rasmussen, T., 2004, Macroeconomic Implications of Natural Disasters in the Caribbean, IMF Working Paper WP/04/224, December.

Stern, Nicholas, 2007, The Economics of Climate Change: The Stern Review, Cambridge and New York: Cambridge University Press.

The Intergovernmental Panel on Climate Change (IPCC), 2014, Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland.

## Moody's Related Research

### Rating Methodology:

- » [Sovereign Bond Ratings, December 2015](#)

### Sector In-Depth:

- » [How Moody's Assesses the Physical Effects of Climate Change on Sovereign Issuers, November 2016](#)
- » [Sovereign Defaults Series: Caribbean Sovereigns: The Silent Debt Crisis, February 2016](#)
- » [Heat Map Shows Wide Variations in Credit Impact Across Sectors, November 2015](#)
- » [Moody's Approach to Assessing the Credit Impacts of Environmental Risks, November 2015](#)
- » [Mexico: Exposure to Natural Disasters Highlights Sector Vulnerabilities, November 2015](#)
- » [US State and Local Government: US Federal Disaster Aid Is Critical for State and Local Governments, May 2015](#)

### Sector Comment:

- » [State and Local Governments and P&C Insurance—US: Hurricane Joaquin Highlights Importance of Federal Disaster Assistance, October 2015](#)
- » [Insurance: Storm Niklas has a moderate negative impact on German P&C insurers, April 2015](#)

### Issuer Comment:

- » [Flood Damage in Bosnia and Herzegovina Will Hurt the Government's Balance Sheet, a Credit Negative, July 2014](#)

### Special Comment:

- » [Impact of Japan's Disasters: Risks to the Downside Have Increased, March 2011](#)
- » [Catastrophe Bonds Represent Less Than 15% of Hedge Protection; Reinsurance Still the Dominant Tool Used by Insurers to Hedge U.S. Natural Disasters, January 2011](#)

For more related Moody's research, see [Environmental Risks and Developments](#)

To access any of these reports, click on the entry above. Note that these references are current as of the date of publication of this report and that more recent reports may be available. All research may not be available to all clients.

## Endnotes

- <sup>1</sup> Moody's Investors Service, [Sovereign Bond Ratings Methodology, December 2015](#)
- <sup>2</sup> The database contains information on 14,535 episodes of natural disasters since 1900, including an estimation of the number of people killed and affected, and the direct economic loss. For more details, see EM-DAT the [International Disaster Database Criteria](#) and EM-DAT the [International Disaster Database General Classification](#). The EM-DAT data has limitations as information used to compile the list from natural disasters comes from a variety of sources and hence may create some inconsistencies across countries and time. In addition, reporting of events in the earlier years is likely incomplete.
- <sup>3</sup> The six Eastern Caribbean Currency Union (ECCU) members experienced damages equivalent to 1.9% of GDP per year and affecting 6.8% of the population each year since 1980. Based on the experience since 1980, a large natural disaster (inflicting damage equivalent to more the 2% of GDP) can be expected to hit the ECCU roughly once every 11 months. For such large disasters in the ECCU, the median damage was 13.7% of country's annual GDP and a median 2.8% of the population was affected. In the extreme, some events have affected the entire population and caused damage exceeding 100% of GDP.
- <sup>4</sup> The same data shows that among weather-related natural disasters, hurricanes in North America led to the largest losses, while losses from floods and winter storms in Europe were considerably lower.
- <sup>5</sup> Bova, Elva, Marta Ruiz-Arranz, Frederik Toscani, and H. Elif Ture, 2016, The Fiscal Costs of Contingent Liabilities: A New Dataset, IMF Working Paper WP/16/14

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