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Natural Disaster Insurance for Sovereigns: Issues, Challenges and Optimality

by Aliona Cebotari and Karim Youssef

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Natural Disaster Insurance for Sovereigns: Issues, Challenges and Optimality[1]

Prepared by Aliona Cebotari and Karim Youssef

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Abstract

Natural disasters are a source of economic risks in many countries, especially in smaller and lower-income states, and ex-ante preparedness is needed to manage the risks. The paper discusses sovereign experience with disaster insurance as a key instrument to mitigate the risks; proposes ways to judge the adequacy of insurance; and considers ways to enhance its use by vulnerable countries. The paper especially aims to inform policy decisions on disaster insurance. Through simulations of natural disasters and various insurance options, we find that sovereign decisions on optimal risk transfer involve balancing trade-offs between growth and debt, based on government risk preferences and country risk exposure. The choice of optimal insurance for smaller countries turns out to be more constrained by cost considerations due to their higher exposure, likely resulting in underinsurance; donor grants could help them achieve a more optimal protection. We also find that optimal insurance packages are those that are least costly relative to expected payouts (i.e. have the lowest insurance multiple), which are also the packages that insure less severe (more frequent) disasters.

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Keywords: natural disaster insurance; debt growth tradeoffs; optimal insurance for sovereigns.

Author's E-Mail Address: acebotari@imf.org; kyoussef@imf.org

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I. INTRODUCTION

1. Natural disasters are emerging as a macro-critical risk in many economies, especially in small, low-income and other disaster-vulnerable states. While many developed and emerging markets rightly focus on addressing climate change, most disaster-vulnerable states are faced with the immediacy of adapting to the increased strength and frequency of climate-related disasters. Therefore, their focus has increasingly been on preparedness for disasters before they materialize (see IMF, 2019). Such ex-ante efforts have focused on: (i) reducing exposure to disaster risk through more resilient infrastructure; (ii) transferring risk through insurance; or (iii) managing retained risk ex-ante through self-insurance and contingency financing.

2. This paper focuses on natural disaster insurance as one tool for managing the financial costs of disasters. Insurance against natural disasters does not reduce the physical losses following events, but it helps better manage and mitigate their financial and economic costs. Spreading the expected and potentially large one-off costs of disasters through smaller annual payment of insurance premia reduces the volatility of financial losses and can help policymakers more easily manage consequences of disasters. Disaster insurance by the private sector also helps mitigate the macroeconomic implications of major natural disasters for households and businesses. Recent estimates in the literature suggest that while uninsured losses account for the strong negative effects of disasters on economic activity, well insured disasters can be inconsequential for growth (e.g. BIS, 2012).

3. In discussing disaster risk transfer by sovereigns, one invariably faces the question of what an appropriate level of risk transfer should be. While many vulnerable states appear under-insured, one cannot infer that their choice is suboptimal without some benchmark for assessing optimality or adequacy in light of the risks they face. After examining the experience of sovereigns with disaster insurance, the paper therefore looks more in-depth at the question of assessing the adequacy of insurance, defining adequacy against government preferences over debt and growth outcomes. Finally, the paper discusses what can be done to scale up sovereign insurance**.**

4. We analyze different risk-transfer options based on their impact on debt and growth under stochastic simulations of natural disasters. We draw disaster shocks from model-based probability distributions of disasters of various strengths, as well as estimates of their economic and fiscal costs used by the insurance industry. We then compare debt and output dynamics under a scenario without insurance (where disaster costs are financed ex-post through borrowing) with debt and output paths under alternative insurance packages, using the same disaster shocks. This comparison helps us illustrate the benefits and costs of insurance. It also helps us compare various insurance packages to determine the ones that offer the most beneficial trade-offs between debt sustainability and growth for given government preferences.

5. The results of the paper help identify the trade-offs countries face in considering insurance options, and how optimal choices depend on risk exposure, country size and

government preferences. Choosing higher risk transfer would provide higher protection to growth by enabling a faster recovery but would entail fiscal costs. Therefore, prioritizing fiscal sustainability considerations may require choosing less costly insurance packages, associated with lower payouts, and thus less beneficial growth outcomes; while prioritizing higher growth outcomes may require choosing more expensive insurance packages, with higher payouts. Ultimately, each country must find the appropriate balance between the two, depending on its risk preferences and its aversion to growth declines. For example, in smaller and more vulnerable countries, natural disasters carry a higher social cost and therefore government's risk aversion and the benefits of insurance are higher; however, the cost of significant insurance coverage is higher as well, often resulting in suboptimal insurance choices. Support from the international community can help loosen the fiscal constraints countries face in choosing the optimal level of insurance protection and help increase risk transfer with enhanced growth outcomes.

6. The remainder of this paper is organized as follows. The second section discusses current sovereign exposures to disasters, practices in managing the associate risks through risk transfer, and takes an initial look at the current levels of risk transfer. The third section discusses the criteria used to benchmark optimality, and the methodology behind the stochastic simulations of natural disasters, public debt and growth outcomes under alternative insurance packages. The fourth section discusses the main findings of the simulation exercise and considerations for choosing various insurance options. The fifth section discusses options for countries to scale up disaster insurance, and the sixth section concludes.

II. The Current Landscape

A. Nature of Exposure to Natural Disasters

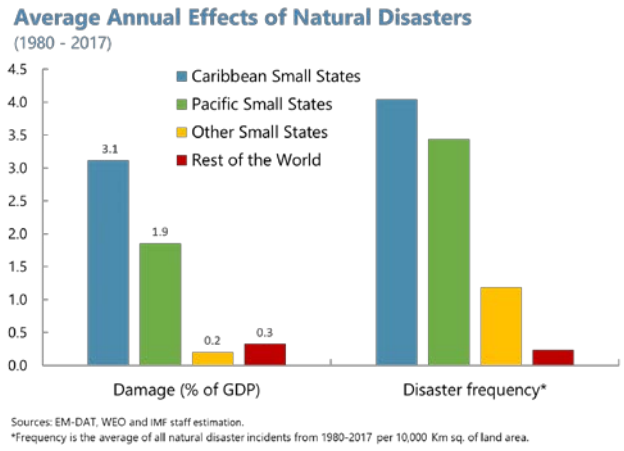
7. Natural disasters can have large and long-lasting macroeconomic effects that need to be well managed. Major disasters take a toll on near-term and often longer-term growth[2], destroy capital and increase public debt, often perpetuating the vicious cycle of high debt-low growth in which many smaller economies are trapped. They also affect social outcomes, as those most vulnerable may not have adequate mechanisms to cope in the absence of strong social safety nets. In the absence of ex-ante arrangements that would disburse immediately after disaster strikes, reconstruction and recovery is delayed, compounding effects of the disasters. The choice of such ex-ante arrangements by sovereigns depends on their exposures to risk, the cost of the various options and the available fiscal space.

8. The effects of natural disasters are more systemic and macro-relevant in smaller states. In larger states, damages from natural disasters are localized and therefore represent a relatively small share of the economy. In smaller countries, states or territories, natural disasters present a systemic risk, as the bulk of their territory could be affected at the same time. For example, small Caribbean countries face disasters most frequently and with the highest damages

[2] Acevedo (2016) for example, estimates that the average hurricane in the Caribbean region causes a cumulative decline in GDP per capita of 4.4 percent over seven years.

relative to GDP (3.1 percent of GDP a year on average from 1980 to 2017), while Pacific small states face annual damages of around 2 percent of GDP, both significantly smaller than 0.3 percent of GDP in larger states (Figure 1, left chart). For some countries, the intensity of a single natural disaster had caused economic losses of multiples of GDP (Figure 1, right chart). These costs could rise further if natural disaster frequency and intensity increase.

Figure 1. Exposures to Natural Disasters



Top Ten Natural Disasters: 1980-2017

Country	Year	Event	Damage (% of GDP)
Dominica	2017	Storm	374
Grenada	2004	Storm	184
Maldives	2004	Earthquake	179
Mongolia	1996	Wild Fire	158
Samoa	1991	Storm	157
Samoa	1990	Storm	145
St. Kitts & Nevis	1998	Storm	137
Vanuatu	1985	Earthquake	131
Haiti	2010	Earthquake	122
Cambodia	1991	Flood	106

Sources: EM-DAT and IMF staff estimates.

9. The systemic nature of the damages in smaller countries has several implications:

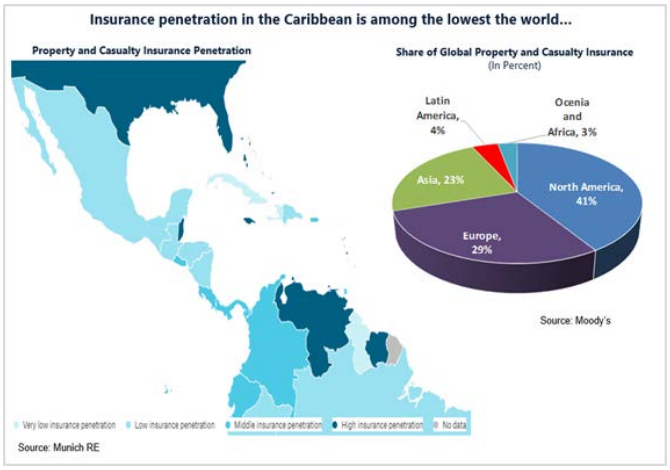
- ***Larger contingent liabilities for the sovereigns***. Natural disaster damages are both a direct cost and a contingent liability for the sovereign.[3] Implicit liabilities, stemming from the pressures to step in to help uninsured households, are generally the costliest and are also larger in smaller countries and territories, where the bulk of the population is affected by the disasters (Box 1).
- ***Higher social costs of damages imply higher sovereign risk aversion and social benefits of insurance.*** As discussed in Ghesquiere and Mahul (2007), highly correlated private sector damages result in a higher social (i.e. macroeconomic) cost from natural disasters. In jurisdictions without a high correlation of damages, sovereigns could be more risk neutral and may not need to purchase insurance given their ability to spread the costs widely across the population through taxation, whereas a high correlation of damages would induce a more risk-averse behavior due to its high social costs and inability to spread risks, making a strong case for insurance.
- ***Missing local risk markets may require regional solutions or government interventions.***

[3] The direct costs reflect damages to public property and infrastructure, including roads, hospitals, schools, and other public buildings. The contingent liabilities usually include: (i) an explicit component, when the affected assets are public property or where the liability of the sovereign vis-à-vis private losses is specified in the legislation (such as in the case of government-insured pools for private sector risk like Turkish Catastrophe Insurance Pool, California Earthquake Authority, or the New Zealand Earthquake Commission); and (ii) an implicit component, where the government steps in to provide disaster relief and recovery for uninsured households, an ubiquitous practice. Implicit liabilities are generally the costliest, although data on the cost of government relief for uninsured private properties are not readily available.

Highly exposed countries—many with shallow or weak financial and insurance systems—can also face the problem of missing natural disaster risk markets. In such cases, risks would not be underwritten at any price due to their catastrophic and correlated nature across the local economy. This has been the rationale for government intervention in insurance markets (e.g. public underwriting of private risk pools) in many larger exposed countries. In smaller countries, the missing markets problem was solved through the creation of regional insurance pools with support from the World Bank (discussed below).

Box 1. Implicit Contingent Liabilities from Natural Disasters

In addition to direct public losses from natural disasters, sovereigns often face implicit contingent liabilities from private losses, particularly from low- and lower middle-income households and small businesses. In many countries, these households have either no insurance or are significantly underinsured, reflecting high premia, lack of suitable products, unfit construction that fails to meet insurability standards, lack of social tradition of purchasing insurance, or expectation of assistance from the government after natural disasters (the so-called charity hazard). In Belize and Grenada, for example, traditional indemnity insurance of physical assets reportedly covered only 4.5 percent of the total damage in recent the large disasters (see IMF, 2016). Similarly, estimates from Munich Re suggest that less than 2 percent of the natural disaster losses were insured in Cuba and Haiti during 2010-16, less than 6 percent in El Salvador, and around 10 percent in Jamaica.[1] Inadequate insurance of the private sector, especially small businesses, delays the recovery and reduces tax revenues for governments, especially if the tax incidence is concentrated in a particular industry, such as tourism in the Caribbean region.



[1/] Based on Munich Re's NatCatSERVICE comprehensive databases for analyzing and evaluating natural catastrophes. See https://natcatservice.munichre.com/?filter=eyJ5ZWFyRnJvbSI6MjAxMCwieWVhclRvIjoyMDE2fQ%3D%3D&type=3

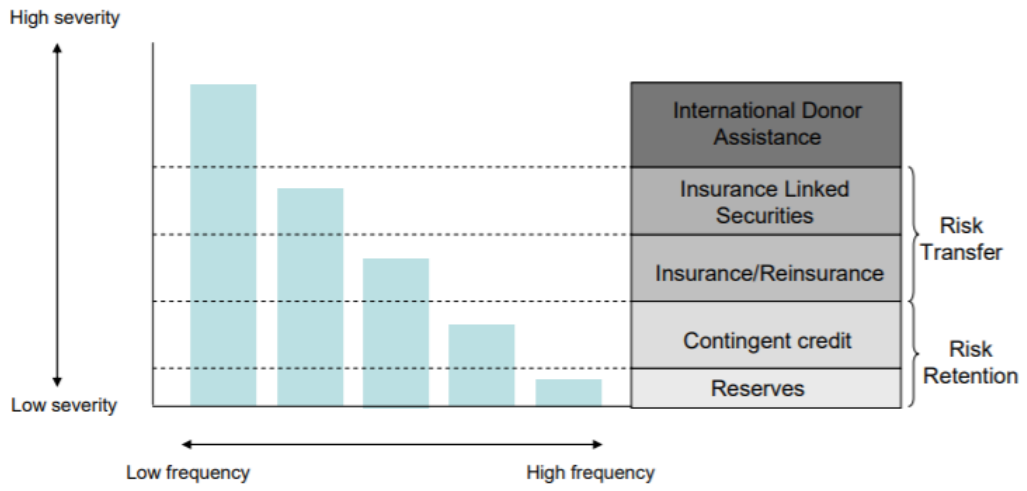
B. A Taxonomy of Risk Transfer Instruments Used by Sovereigns

10. To manage financial risks from natural disasters, sovereigns can pre-arrange a number of instruments that would disburse immediately after disasters. These include: (i) self-insurance by building fiscal buffers overtime to secure immediate access for emergency financing; (ii) risk-transfer to the insurance or to capital markets (e.g., catastrophe bonds); and (iii) pre-arranged contingent loans from international financial institutions or central banks, which would disburse immediately after disasters. Ex-post, many sovereigns deal with remaining unfinanced needs either through market or official borrowing, or reliance on grants and

humanitarian assistance if large scale borrowing is not feasible.

11. The World Bank has developed a multi-layer risk approach that determines the most cost-efficient way of combining these instruments to achieve a pre-determined level of coverage (e.g. US$100 million) (Figure 2). These instruments are prioritized in terms of cost and timeliness of disbursement, with this approach usually deploying self-insurance for smaller and more frequent disasters, followed by contingent credit lines, insurance and finally catbonds for the most infrequent/severe disasters (e.g. Ghesquiere and Mahul, 2010). Sovereigns have pursued, to various degrees, such multi-instrument strategies, combining their various advantages.

Figure 2. World Bank's Multi-Layer Risk Approach to Financing Disaster Risk



Source: Ghesquiere and Mahul (2010).

12. In this paper, we focus on risk transfer instruments, leaving aside instruments under which risk is retained (self-insurance and contingent financing). In more advanced economies or in economies were exposure to risk is localized, sovereigns can insure property directly through the local private insurance markets. Most other sovereigns have insured public assets through regional insurance pools, catastrophe bonds, and state-owned insurance companies.

Regional Risk Pooling Facilities

13. Many vulnerable countries transfer risk to regional insurance pools. There are currently three well-established regional pools: (i) the *Caribbean Catastrophe Risk Insurance Facility Segregated Portfolio Company* (CCRIF), the first multi-country risk pool established in 2007 for the Caribbean countries and extended to Central American region in 2015; (ii) the *Pacific Catastrophe Risk Assessment and Financing Initiative* (PCRAFI), whose insurance program was established in 2013 following the CCRIF model, and (iii) the *African Risk Capacity*

LTD (ARC),[4] established in 2013 as a specialized agency of the African Union (Table 1). An agreement has been signed in December 2018 to establish a fourth pool, the *Southeast Asia Disaster Risk Insurance Facility (SEADRIF)*.[5]

Table 1. Regional Sovereign Insurance Pools

	Hazards insured	Member states/territories (latest season available)	Avg. premium income/ Avg. coverage
CCRIF (2007)	Earthquake Tropical cyclone (hurricanes) Excess rainfall Drought	Insured members (21): Anguilla, Antigua & Barbuda, Bahamas, Barbados, Belize, Bermuda, British Virgin Islands, Cayman Islands, Dominica, Grenada, Haiti, Jamaica, Montserrat, Nicaragua, Panama, St. Kitts & Nevis, St. Lucia, St. Vincent and the Grenadines, Trinidad & Tobago, Turks & Caicos Islands Other eligible members (14): Aruba, Costa Rica, Curacao, Dominican Republic, El Salvador, Guadeloupe, Guatemala, Guyana, Honduras, Martinique, Puerto Rico, Saint Barthelemy, Suriname, US Virgin Islands	US$21.5m US$650m
PCRAFI (2013)	Tropical cyclone Earthquake/tsunami Excess rainfall	Insured members (5): The Cook Islands, the Marshall Islands, Samoa, Tonga, Vanuatu Other eligible members (10): Fiji, Kiribati, Federated States of Micronesia, Nauru, Niue, Palau, Papua New Guinea, Solomon Islands, Timor Leste, Tuvalu	US$2m US$45m
ARC (2013)	Drought Extreme weather (*drought, excess rainfall, heatwaves and tropical cyclones*)	Insured members (6): Burkina Faso, Mali, Mauritania, Niger, Senegal, The Gambia Other eligible members (6): Chad, Ethiopia, Madagascar, Malawi, Kenya, Zimbabwe	US$22m US$50m
SEADRIF (2018)	Mainly flood risk	Signatories to agreement: Cambodia, Indonesia, Japan, Lao, Myanmar, Singapore	TBD

Source: CCRIF, World Bank, data on premium and coverage from World Bank (2017).

14. Regional pools provide significant advantages to vulnerable sovereigns:

- They provide participating governments with parametric insurance coverage at a significantly lower cost than if they were to purchase it individually from the financial markets. Thus, regional pools facilitate access of smaller states to catastrophe insurance and re-insurance markets by increasing the size of the aggregate portfolio, offering

[4] Participation in ARC is conditional on the country's "good standing", i.e. compliance with a number of processes such as signing MOUs for in-country capacity building and defining a contingency plan for ARC payouts.

[5] All sovereign catastrophe risk pools have benefited from donor support to start operations and to remain sustainable during their first years. Donor financing has at various stages covered start-up costs, capitalization, and sometimes (partial) premium financing (World Bank, 2017).

country-specific risk models, and reducing administrative costs.

- Quick payouts following disasters, which helps members maintain essential government functions. In the case of CCRIF, payouts are made in14 days or less and the provision of flexible and rapid budget support is a key value proposition compared to conventional insurance schemes;
- Policy holders are the owners of the facility (CCRIF, PCRAFI, ARC), which allows benefits to accrue to member states either through dividend payments or lower premia. This also helps avoid conflicts of interest between increased profits and serving member states that would be present in privately held schemes.

15. Regional risk pooling also faces challenges. Since the insurance is not private, inflow of fresh capital cannot generally be relied on for maintaining adequate risk capital. Therefore, pools have to transfer risks to reinsurance markets at a cost, rely on new contributions from donors, or limit the size of overall payouts.[6] In addition, the small size of the existing pools (about US$750 million overall in terms of average annual coverage) increases the reinsurance (and hence insurance) premia for countries already facing large risks. The parametric nature of insurance also exposes countries to *basis risk* (see paragraph 20) and may require regional pooling to be combined with other, indemnity-based, risk transfer instruments.

Catastrophe Bonds

16. Catastrophe bonds (or catbonds) are an emerging risk transfer instrument for sovereigns. A catbond is a close equivalent to parametric insurance, but it is tapping capital, rather than traditional insurance, markets (see IMF, 2019, Annex IV). Sovereign uptake of catbonds has been increasing over the years but remains relatively limited, likely due to the sophisticated nature and high setup costs of the product. Only Mexico and Turkey have issued individual catbonds so far; the World Bank also issued the first joint sovereign catbond for members of the Pacific Alliance (Chile, Colombia, Mexico and Peru), delivering cost savings and record-low premium rates stemming from high investor demand for diversification.[7] Catbonds have become more affordable in recent years as their coupons have come down and as the World Bank Treasury has started offering the service with lower setup costs.

State-Owned Insurance Companies

17. Many sovereigns rely (fully or partially) on state-owned insurance companies for disaster risk transfer. These companies are often established because insuring public assets through the local private markets is not efficient due to their small scale and lack of competition among insurance companies in covering large-scale public assets, and/or due to an explicit prohibition of hiring private insurance brokers for insuring the public sector. Such state-owned

[6] Maximum payout limits are US$100 million per hazard in the case of CCRIF and US$30 million per country per season for drought events that occur with a frequency of 1 in 5 years or less in the case of ARC.

[7] The joint issuance consisted of five series of earthquake-linked notes, three of which for Chile, Colombia, and Peru each, and the remaining two for Mexico.

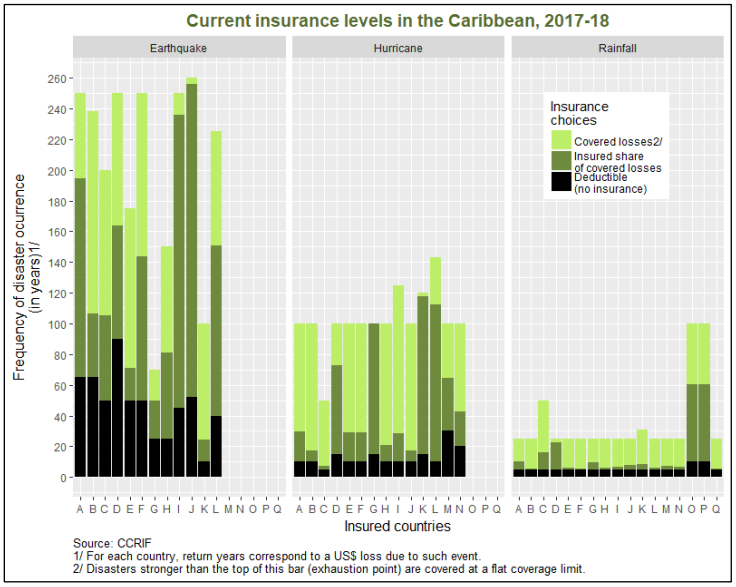
insurance companies include Sri Lanka's state-owned Insurance Corporation (SLIC), Costa Rica's *Instituto Nacional de Seguros*, the Philippine's Government Service Insurance System (GSIS) covering national government assets and local governments, among other (Box 2).

Box 2. Philippines: Catastrophe Risk Insurance Program

As part of its Disaster Reduction Financing and Insurance Strategy, the government has introduced in 2017— with support from the World Bank Group and UK's DFID—a catastrophe risk insurance program to protect government assets. Under the program, the government-owned insurance agency GSIS would provide protection against catastrophe risks to the national government and 25 participating local governments. The insurance provides coverage of up to US$206 million (in local currency) against typhoons and earthquakes, with parametric trigger for payouts. GSIS passes on the risk to a group of private international reinsurance companies through a competitive bidding process, with the World Bank Group acting as an intermediary. This program complements the government's existing natural disaster-related reserves and contingency credit lines and was developed in the context of the adoption of a Disaster Risk Finance Strategy by the Department of Finance and the preparation of the first catastrophe risk model for the country.

C. Current Levels of Risk Transfer

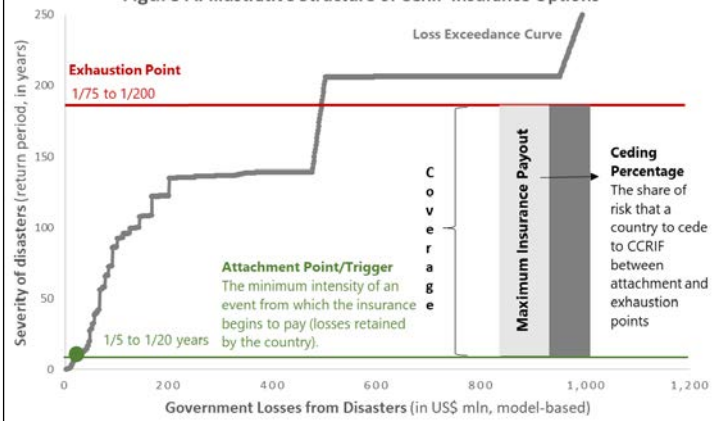
18. Many sovereigns have chosen relatively low levels of insurance. As discussed above, only few sovereigns have insured through catbonds to date and while the take-up of traditional insurance has increased over the years, the current insurance choices suggest relatively low and varying levels of coverage selected by countries. For example, in 2017-18, Caribbean countries (for which more information is available) have insured on average some 35 percent of the estimated losses to the government assets from different types of hazards: 50 percent for earthquakes, 38 percent for hurricanes, and 21 percent for excess rainfall (shown as shares of dark green in the green bars in the chart). In the case of hurricanes, countries have insured emergency losses starting with events that are expected to occur once in 5 to 30 years (trigger or *attachment* point for insurance; black bars) and capping coverage at levels estimated for once in 50-to-140-year events (the so-called *exhaustion* point; light green bars) (Box 3 explains in more detail these parameter choices in parametric insurance).



Box 3. Decisions Faced by Sovereigns in Choosing Parametric Insurance
(Based on insurance under CCRIF)

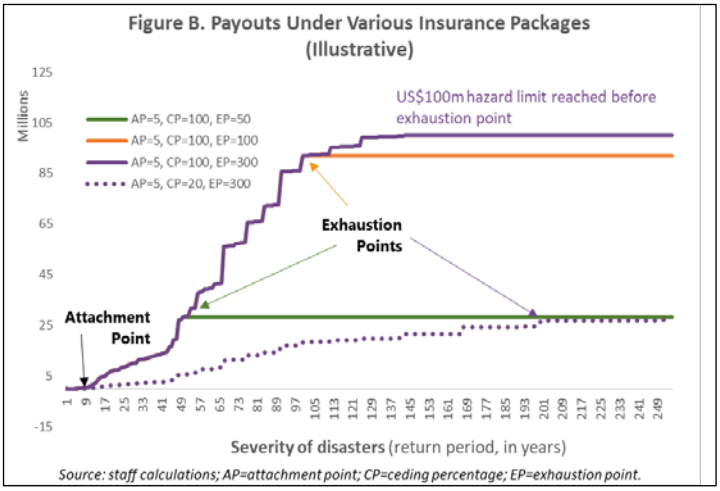
CCRIF insurance against a specific hazard (hurricane, earthquake, excess rainfall) requires countries to choose three parameters: (i) *the attachment point*: this is the severity of the disaster (and the associated model-determined losses) at which insurance coverage is triggered (akin to a deductible); (ii) *the exhaustion point*: a disaster strength threshold at or above which the insurance pays only the maximum payout; and (iii) *ceding percentage*: the share of the risk between the attachment and the exhaustion points that the country wants to cede to the insurance company (Figure A). Following a disaster that meets the parametric triggers, CCRIF payouts are made if the trigger parameters (e.g. wind speed) lie above the attachment point, with payouts based on model estimates for the disaster, rather than actual losses: this facilitates rapid disbursements as they do not require loss assessments, but it also implies that actual losses can be much larger.

Figure A. Illustrative Structure of CCRIF Insurance Options



These choice parameters then determine the amount of risks countries transfer to CCRIF, hence the payouts following disasters and the premium paid for the insurance. Figure B below illustrates how payouts for different severity disasters could differ depending on the parameters chosen. Currently, payouts under CCRIF policies are limited to US$100 million per hazard per year, and this limit could become binding before the coverage limit imposed by the chosen exhaustion point – this is likely to be the case for larger countries.

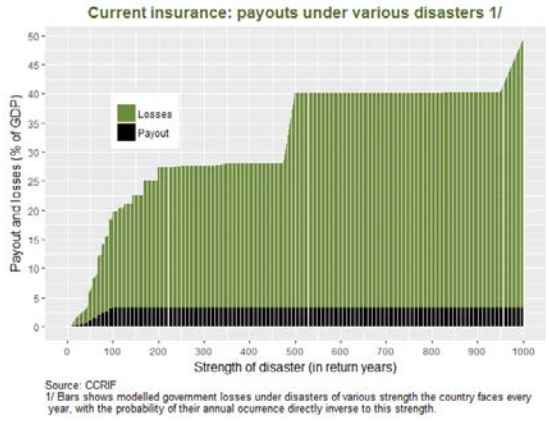
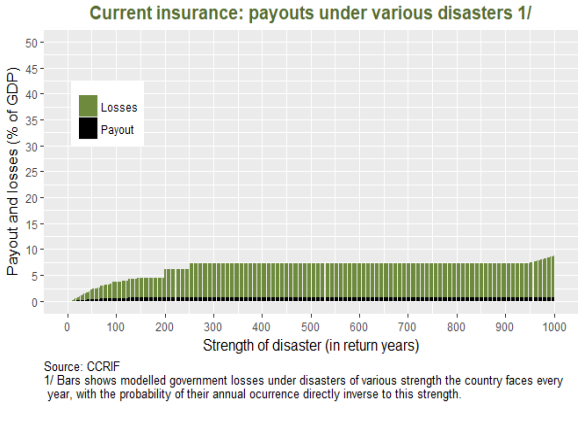
Figure B. Payouts Under Various Insurance Packages (Illustrative)



Source: staff calculations; AP=attachment point; CP=ceding percentage; EP=exhaustion point.

19. Low insurance coverage leads to low sovereign protection in case of disasters. The figures below illustrate the payouts that would be received by two countries with different risk exposure that both choose to insure close to a fifth of the government estimated losses. Under the parametric insurance structure, the payouts (black bars in Figure 3) increase proportionally to government losses (green bars) between the attachment and the exhaustion point, after which the coverage flattens at the chosen limit. The relatively low exhaustion point implies that payouts would cover a small proportion of losses under larger disasters. While parametric insurance is not meant to cover losses in full, but rather to provide emergency liquidity for recovery from disasters, the coverage levels in some countries appear inadequate – we tackle this question in the next section.

Figure 3. Illustrated payouts against public losses when close to 20% of risk is ceded

Smaller, highly exposed, country	Larger, less exposed, country
	

Source: Fund staff estimates.

20. The relatively low level of coverage chosen by many countries reflects a number of factors:

- *Low perceived vulnerability*. Catastrophic disasters are rare and therefore the perceived vulnerability is low until the disaster or a series of disasters materialize. With the increased intensity and frequency of disasters, vulnerability perception and interest in insuring against disasters is increasing.

- *Cost*. The insurance choices also reflect decisions to keep premium costs low. In many sovereigns, weak fiscal positions and competing demands on public resources typically limit their ability to buy substantial disaster insurance. For instance, the cost of parametric insurance and catbonds is estimated to be in the range of 1.2-3.2 times the expected annual payout, which reflects a mix of factors, including large tail risks facing vulnerable countries and geographical correlation of risks across potential buyers (embedded chart). Nevertheless, ex-post the insurance payout by far exceeds the annual premium in most disasters, and proportionately more so under larger disasters (Figure 4). While the probability of these larger disasters is small, the fast and potentially large insurance payouts are all the more valuable in mitigating their effects on output and growth. Given the higher frequency of smaller disasters, however, many sovereigns witness smaller or no payouts under these disasters, which are largely predetermined by sovereign's own choice of insurance parameters.

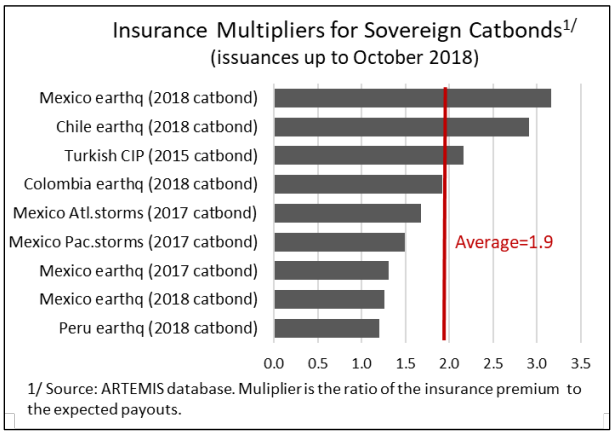
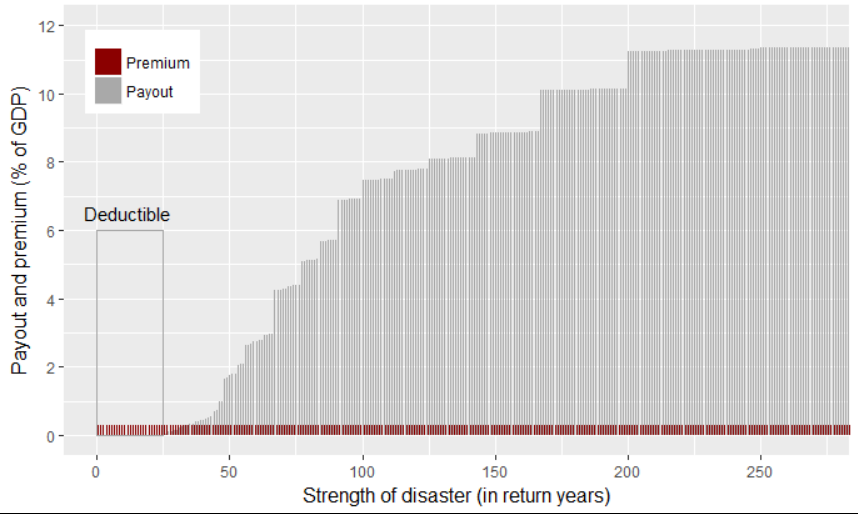


Figure 4. Payoff from Insurance: cost vs benefit 1/
(example based on package: AP=25, EP=200, CP=50; highly exposed small country)



Source: Fund staff estimates based on CCRIF data.
1/ Bars shows modelled payout under disasters of various strength the country can face, with the probability of their annual occurrence directly inverse to this strength.

- *Basis risk.* The parametric nature of insurance also exposes countries to *basis risk*, i.e. the risk that insurance will not be triggered (e.g. because the strength of disaster is measured in a different location from its main impact) and/or the risk that actual losses may exceed modelled losses and the associated payouts.
- *Political economy factors*—related to both costs and basis risk—may also play a role, given the difficult trade-off between paying insurance premia and financing other pressing developmental needs, as well as the risk that an event causing significant damages would not trigger a payout.

III. Optimal Risk Transfer: Considerations

21. The adequacy of country's insurance levels is hard to judge simply by looking at their insurance choices. Countries may choose limited insurance because higher risk transfer may imply a higher premium cost and therefore higher debt levels.[8] Nevertheless, countries could benefit from payouts when disasters are large, and these payouts could be significantly higher than the premia in the case of catastrophic disasters. It is clear, therefore, that countries face a tradeoff between the cost and benefits of risk transfer instruments. This section discusses the trade-offs, their drivers, and how policymakers can organize their approach when making decisions on the desirable or optimal level of insurance to fit their circumstances.

[8] Given the multitude of possible fiscal responses to financing disaster costs and/or the insurance premium (reducing spending, increasing taxes, accumulating debt), we assume— for ease of tractability and to be in a position to identify the net effects of insurance—that all disaster spending is financed by debt, while underlying fiscal policies remain unchanged.

22. What is an adequate level of insurance coverage against natural disasters? The answer depends on the criterion used. BIS (2012), for instance, judges coverage as adequate if it produces no output loss (given their finding that insurance reduces the output cost of disasters).[9] Countries might think of the fiscal space they have for annual premium payments as a criterion to choose between more expensive and less expensive insurance coverage. The criterion used in this paper to judge the adequacy of insurance coverage is that expected payouts (minus paid premiums) will help countries avoid significant deterioration in debt dynamics while offering some protection for growth. This assessment takes into account the specifics of a country's exposure to risk, government risk preferences, and the actual insurance options countries face.

A. Methodology

23. To identify debt and output implications of risk transfer options we rely on stochastic simulations of disaster incidence and the ensuing debt and output dynamics. Specifications of the data and approach taken for this exercise are as follows:

- *Data and simulated shocks:* Current insurance choices, costs and payouts are based on information from the Caribbean Catastrophe Risk Insurance Facility (CCRIF). The shocks are simulated based on the probability distribution of disaster strength and the associated fiscal costs derived from catastrophe risk models by CCRIF. We simulate a large number of possible natural disasters paths over a 10-year horizon.
- *Range of insurance packages:* We parse out the cost and payouts of about 550 insurance packages (using a wide range of parametric assumptions) under all simulated disasters and estimate the impact on the debt and output dynamics for each insurance package.
- *Country coverage:* We do these simulations for two countries: (i) one smaller country that is heavily exposed to natural disasters (hereinafter "smaller country") and (ii) a somewhat larger country that is less exposed to disasters, given the larger geographical and economic size (hereinafter "larger country").

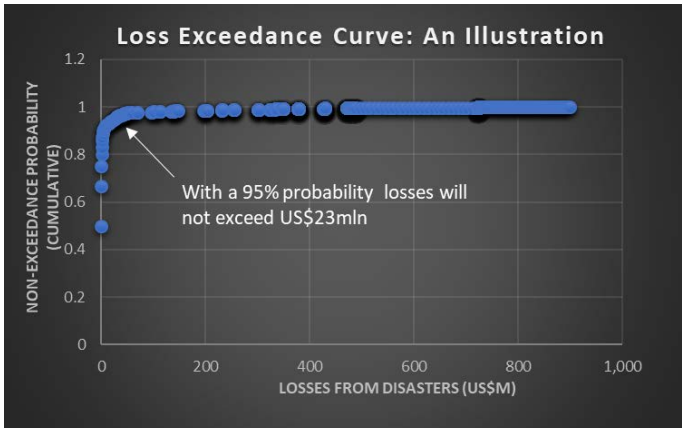
24. The simulation algorithm is built along the following steps:

- **Step 1: natural disaster simulations**. We simulate a 10-year string of natural disasters (hurricanes). For this, we use two different methods for drawing the probabilities of being hit by various strength disasters. Under the first method, we sample the disasters from the Loss Exceedance (LE) curves, which show the probability that a certain level of loss will be surpassed in a given time period (see illustration in chart).[10] We do this by (i) first drawing randomly from a uniform distribution between 0 and 1, then (ii) mapping the draw into the cumulative probability distribution of the losses in the LE curve and from there to the non-

[9] Their estimates suggest that, at 91 percent insurance coverage, the average projected output path is not expected to show loss, and at 60 percent coverage the expected loss turns statistically insignificant.

[10] The loss exceedance curves are simulations derived from catastrophe models, which combine historical probabilities of disasters occurring in a specific location with information about the replacement value of the affected infrastructure.

exceedance probability associated with a specific size disaster from the curve; and (iii) finding the losses that correspond to this size disaster; this is then our draw for that particular year. Under the second method, a smooth and continuous distribution of exceedance probabilities is derived using the available LE data and a non-parametric kernel density estimation approach. First, a kernel function that is non-negative and which integrates to one, with a mean of zero is defined to approximate the available data. Second, a smoothing parameter is chosen based on a minimizing the mean integrated square error of the approximated data. Finally, annual damages are drawn based on this distribution. The qualitative results from the two methods are similar, and we report here the results from the first method only. The result of the simulation is a string of annual public sector losses during our 10-year simulation period.



- **Step 2: insurance cost and payouts.** We limit the number of insurance choices to 550 packages, reflecting a combination of (i) five *attachment points*, ranging from return periods of 5 to 25; (ii) eleven *exhaustion points*, ranging from return periods 50 to 300; and (iii) ten *ceding percentage* options, ranging from 10 to 100 percent. Each insurance package (i.e. each combination of these three parameters) has an ex-ante known payout for any size disasters, with the probability-weighted payouts affecting the premium for this package. For each natural disaster that occurs on the 10-year path, we calculate the insurance payouts that would be received under each insurance packages.

- **Step 3: output path simulation**. Based on literature estimates about the effect of insured and uninsured natural disaster damages on growth (e.g. BIS (2012)), we assume that growth is affected by the losses *not* financed by insurance payouts. Namely, we assume the following growth dynamic:

$$\boldsymbol{g_{t,i}} = \boldsymbol{g_{t,i}^{MT}} - \boldsymbol{a} * \left(\frac{(\boldsymbol{GLoss - payout_i})}{\boldsymbol{GDP}}\right)_{\boldsymbol{t}} + \boldsymbol{b} * \left(\frac{(\boldsymbol{GLoss - payout_i})}{\boldsymbol{GDP}}\right)_{\boldsymbol{t-1}}, \text{ where}$$

$\boldsymbol{g_{t,i}^{MT}}$ is the country's potential growth under package $\boldsymbol{i}$, $\boldsymbol{GLoss_t}$ is the government loss derived from the disaster simulation step 1 above, and $\boldsymbol{payout_{t,i}}$ is the payout by package $\boldsymbol{i}$ for the realization of the disaster at time $\boldsymbol{t}$, as derived from step 2 above. Coefficients *a* and *b* are assumed as *a* = -0.3 (negative contemporaneous effects due to disruptions in production) and *b* = 0.1 (positive lagged effects, due to a transitory pickup in reconstruction activities). The estimates for the short-run effects are drawn on BIS (2012), whereas the medium-term growth effects discussed below are consistent with the estimates for tropical cyclones of Hsiang and Jina (2014).

Potential growth, $g_{t,i}^{MT}$, in turn, can be affected by natural disaster if damages remain unfinanced to recover destroyed capital. Therefore, potential growth is assumed to decline somewhat if insurance payouts and ex-post borrowing by the government do not fully cover losses from disasters:

$$g_{t,i}^{MT} = g^{WEO} - 0.1 * \left(\frac{(GLoss - payout_i) - borrowing}{GDP}\right)_t, \text{ where}$$

$borrowing_t$ is ex-post borrowing by the government to finance natural disaster losses, and g^{WEO} is the potential growth projection based on IMF's WEO projection as of 2023. We assume that the government is able to smoothly finance the baseline (pre-disaster) overall balance and the insurance premium but would face constraints on the financing of the losses caused by natural disasters, as these could easily exceed sovereign's borrowing capacity. We have set this limit on post-disaster loss financing at 5 percent of GDP for both smaller and larger country and discuss the sensitivity of the results to this assumption below.

$$borrowing_{t,i} = 5\% \text{ of GDP}$$

- **Step 4: debt paths simulations**. For each 10-year path of natural disasters, we calculate the debt to GDP path under the 550 accompanying insurance packages using the conventional debt dynamic equation:

$$d_{t,i} \equiv (1 + g_{t,i})^{-1}(1 + r_{t,i})d_{t-1,i} - p_{t,i}, \text{ where}$$

$d_{t,i}$ is the public sector debt to GDP ratio, $g_{t,i}$ is growth as defined above, *r* is the real effective interest rate on total public debt, and $p_{t,i}$ is the primary balance in percent of GDP.[11]

The latter is calculated as

$$p_{t,i} \equiv p^{MT} - premium_i - \min[(GLoss - payout_i)_t, borrowing_{t,i}] \text{ where}$$

p^{MT} is the steady-state (baseline) primary balance, based on the WEO projection for 2023, $premium_{t,i}$ is the annual insurance cost of package *i*, and the "min" term reflects the net disaster-related expenditures the government is able to finance in the markets within its access limits. By adding the premium, payouts, and disaster-related expenditures to the baseline primary balance we are able to more clearly measure the effects of insurance and natural disasters on debt dynamics. We assume, for simplicity, that the natural disaster losses affect only the current primary balance rather than being spread through the years.

We also assume that the real interest rate is affected by large increases in debt, as follows:

$$r_{t,i} = r_{t-1,i} + 0.04 * (d_{t-1,i} - d_{t-2,i})$$

[11] We abstract from the effects of the exchange rate dynamics, and therefore do not differentiate between domestic and foreign currency debt.

- **We repeat the four steps above 1000 times** (any arbitrary large number would do) to find the distribution of disasters, debt and growth under various potential states of the world, and determine which package is more likely—on average over 1000 simulations—to produce the most benign debt and output dynamics.

- **Government utility.** As a basis for deciding which packages are more desirable than others, we look at the packages that maximize government's objective function (utility hereinafter for short). We assume that government is risk averse with regard to growth outcomes (featured in typical utility functions that maximize social welfare) and risk neutral relative to financial outcomes (reflecting practical concerns about the impact of various decisions on debt dynamics) and use an additive constant risk aversion utility function for the government from insurance package ***i***:

$$\boldsymbol{U_i = (1 - z)\frac{\Delta g_i^{(1-\rho)}}{(1-\rho)} + z * \Delta d_i}$$

  where $\boldsymbol{\rho}$ is the coefficient of constant risk aversion (assumed equal to 1.2, but sensitivity of results to this coefficient is discussed below); $\boldsymbol{z}$ is the weight in the utility function given to debt sustainability considerations (assumed at 0.5 in the baseline simulations, but sensitivity to this discussed below); $\boldsymbol{\Delta g_i}$ is growth outcomes under insurance package ***i*** compared to a no-insurance scenario, measured as difference —averaged over 1000 simulations—between (i) average growth over the 10-year strings under insurance package *i*; (ii) average growth over the same 10-year strings under a no insurance scenario; and $\boldsymbol{\Delta d_i}$ is the outcome for the debt-to-GDP ratio under insurance package ***i*** compared to a no-insurance scenario, measured as difference between (i) debt ratio in year 10 under insurance package ***i***, and (ii) debt ratio in year 10 under no insurance, averaged over 1000 simulations.

  Thus, all the results reported from here on measure growth and debt outcomes produced by a given insurance package relative to a no-insurance scenario under the same disaster strings.[12]

B. Results

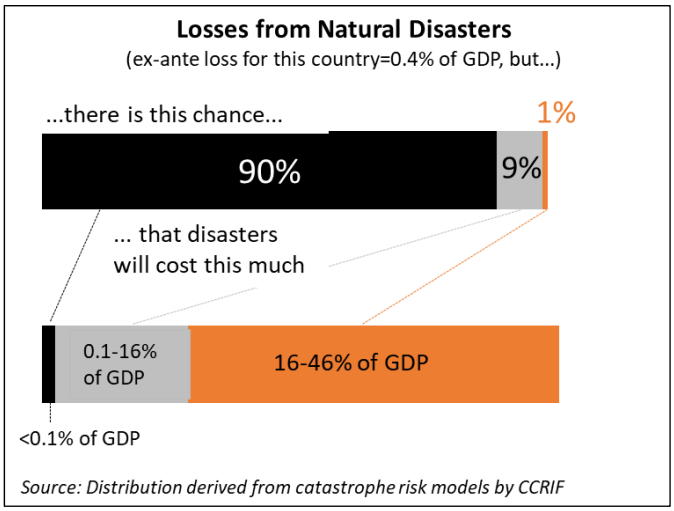
The solutions to the maximization problem simulated above are illustrated in this section by highlighting the insurance packages that maximize government utility (with each package represented in most figures by its impact on growth and debt outcomes). Rather than focusing on one specific utility-maximizing package, we look at the top 50 packages to help us parse out the characteristics of these packages.

25. In choosing how much natural disaster risk to transfer to insurance, countries face a trade-off between the implications of this insurance for debt and for growth. The nature of this trade-off and the optimal risk transfer will vary amongst countries depending on size, exposure to disaster, fiscal space, and its risk aversion to growth losses. Therefore, risk transfer

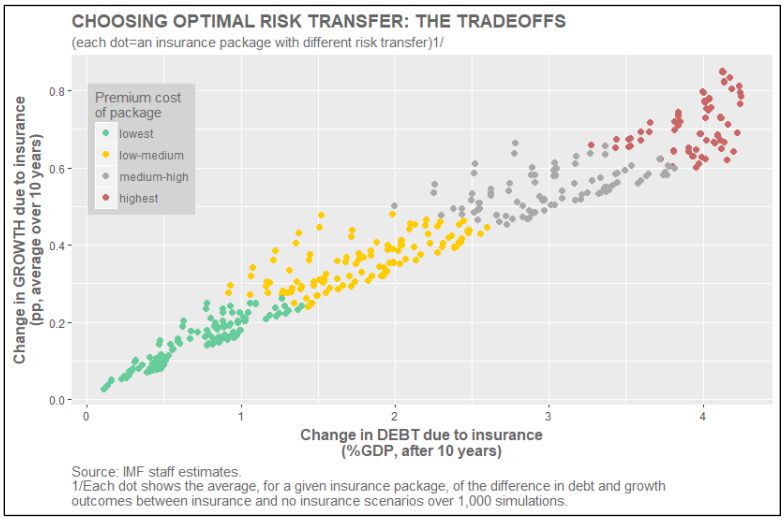
[12] The no-insurance scenario is simulated following the steps above, but with zero premia or payouts.

decisions faced by larger (less exposed) countries are different in many respects from those of smaller and more exposed ones. These results are discussed below.

26. Result 1. **In countries where a large share of output and capital are at risk from low frequency events—i.e. where natural disaster effects could be systemic—governments should guard against tail risks and not just expected average loss** (in other words, they cannot be risk-neutral relative to non-financial outcomes such as economic growth). In fact, any insurance decision based on the expected value of loss may lead to suboptimal investment in financial protection, as ex-post disaster realizations could be catastrophic and derail economic development. While ex-ante government losses from natural disasters can appear manageable, at an average of 0.1-0.4 percent of GDP in the case of Caribbean states, actual losses could be significantly higher. For instance, in the inserted chart, the government's expected losses are 0.4 percent of GDP a year on an ex-ante basis. While this seems manageable, the government alone could face actual losses of 16-46 percent of GDP, with considerably larger financial and economic development implications. Thus, considering only ex-ante loss expectations could significantly underestimate actual outcomes.



27. Result 2. **In deciding on the appropriate amount of risk transfer, countries face a tradeoff between the impact of purchasing insurance protection on fiscal costs and economic growth.** More insurance coverage supports growth by allowing faster rebuilding but comes at a cost of a higher premium which needs to be paid for by more borrowing (gray and red packages in the chart). Less insurance coverage would add less to debt because of a lower insurance premium but would also provide little protection in terms of debt (green and yellow packages). While this "result" may seem trivial, it quickly becomes clear that it is central to thinking about optimal financial protection, with these trade-offs different for each country depending on its preferences over fiscal costs and growth, risk aversion over negative growth outcomes, size and limit on insurance payouts.

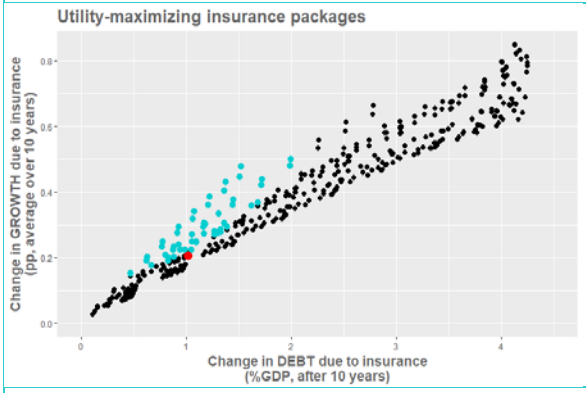


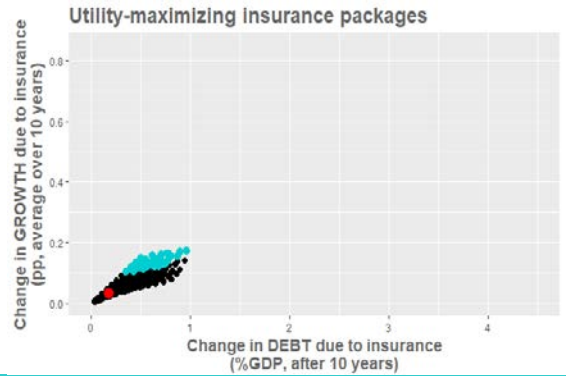
28. Result 3. Risk transfer decisions faced by larger (less exposed) countries are different from those of smaller and more exposed ones in several respects:

- *Insurance can have a significantly larger impact in more exposed countries*. For smaller and more exposed countries, a set of insurance choices would be more costly than for larger countries because disaster losses and therefore insurance premia are larger as a share of GDP, adding more to debt. At the same time, the payouts and the benefits in terms of mitigating the disaster effects on growth are also higher. The different sets of trade-offs faced by two countries between growth and debt can be seen in the charts below, where results are shown under the same scale.

Optimal insurance packages depending on COUNTRY SIZE[1/]
(green dots=top 50 utility maximizing packages; red dots=actual insurance package)

Small exposed country	Larger less exposed country (same scale, no insurance limit)



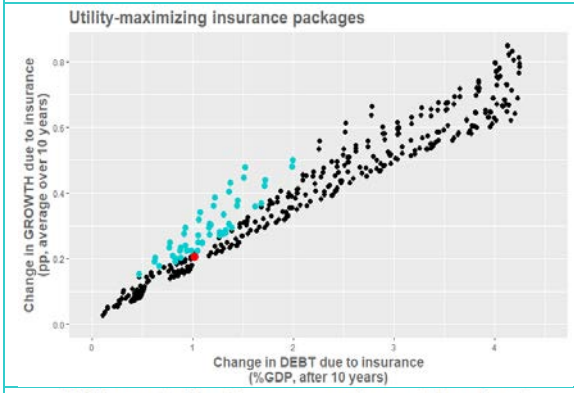
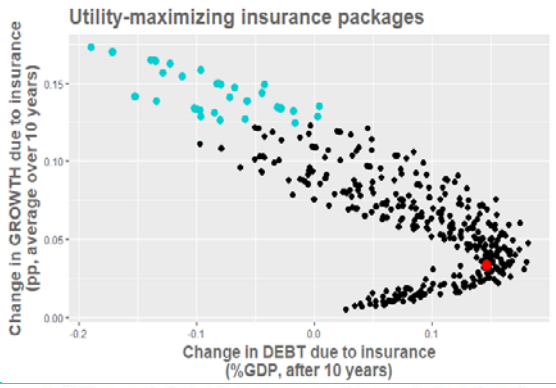
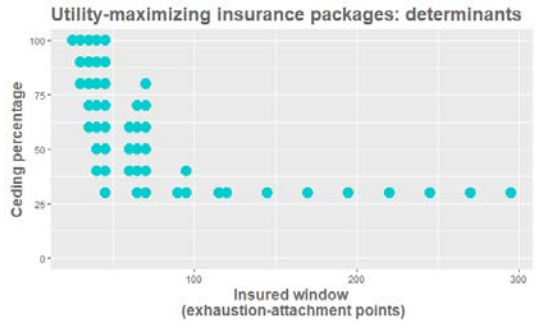
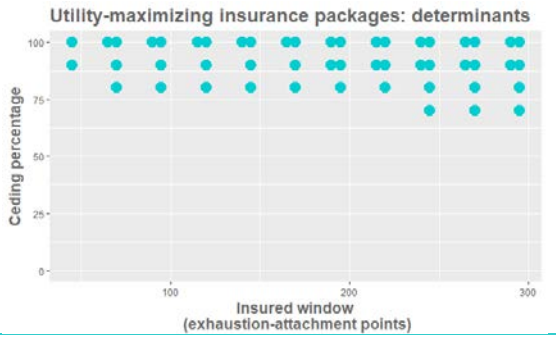


1/ Each dot represents an insurance package with different risk transfer. For each package, the axes show the average difference in debt and growth outcomes between insurance and no insurance scenarios over 1,000 simulations.
Source: Fund staff estimates.

- *Optimal risk transfer can be different as well…*. When both countries have the same preferences over growth and debt outcomes, the optimal risk transfer for a small and more exposed country (green packages in the left chart above) is likely to be biased towards less expensive/less coverage packages, whereas the larger countries would choose packages with larger coverage (more expensive and more protective of growth). This could be due to differences in the distribution of the trade-offs faced by the two countries in the absence of binding limits on insurance payouts (charts above), but also to a large extent …

- *…due to different tradeoffs imposed by payout limits*. Larger countries may face binding constraints on insurance payouts (e.g., US$100 million in the case of CCRIF), which also limit its premium payments, creating the boomerang shape in the top right chart below. For larger countries, therefore, the limit may de facto eliminate the tradeoffs between debt and growth and shift their optimal risk transfer toward packages that provide maximum growth protection.

Optimal insurance packages depending on COUNTRY SIZE[1/]
(green dots=top 50 utility maximizing packages; red dots=actual insurance package)

Small exposed country	Larger less exposed country (own scale, with insurance limit)
	
	

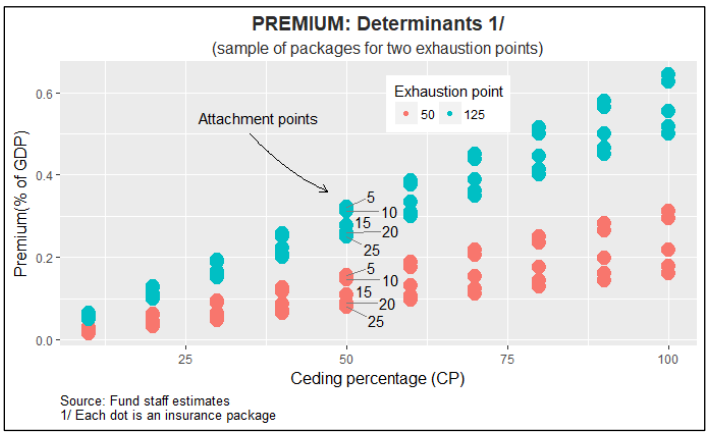
1/ Each dot represents an insurance package with different risk transfer. For each package, the axes show the average difference in debt and growth outcomes between insurance and no insurance scenarios over 1,000 simulations.
Source: Fund staff estimates.

- *Within optimal packages, there is generally a tradeoff between insured range and ceded risk, and they are also different for smaller vs larger countries* (bottom charts above). Among the top utility-maximizing insurance packages, smaller countries can choose the packages that either (i) insure against a narrower window of disasters (the different between exhaustion and attachment points) but cede a larger share of risks to the insurer, or (ii) insure against a wider window of disasters but limit the shared of ceded risk (left bottom chart above). For larger countries, were optimal insurance may mean maximum risk transfer, there are alo trade-offs between insured window and degree of risk transfer, but these are less pronouced and generally among the highest ranges of insurance ranges and risk transfer (right bottom chart above).

29. **Result 4**. **The best growth-debt tradeoff is offered by packages that have the lowest insurance multiple, i.e. cost less relative to the expected payout**. These provide the best value for money from the sovereign's perspective.

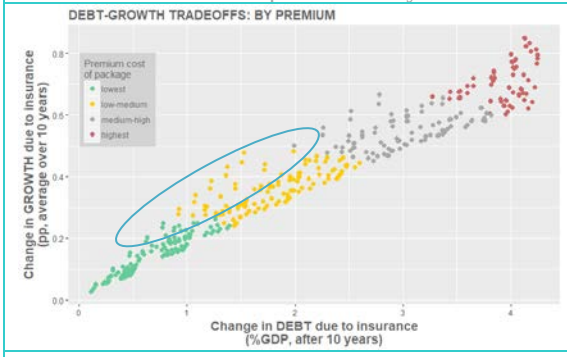
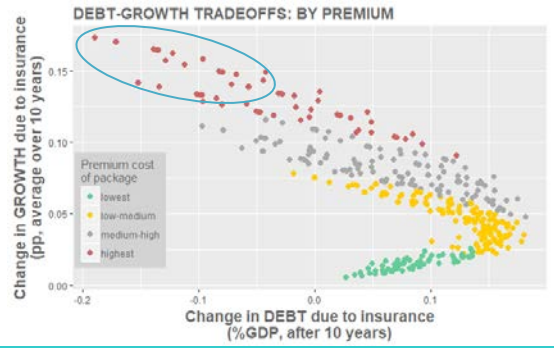
- Every insurance package is associated with a fiscal cost (premium) and a fiscal benefit (expected payout, which is the predetermined payout for each state of the world times the probability of that state of the world).

- If countries were to choose insurance based on the cost criterion alone, they would choose packages that have the lowest premium (green and yellow packages in result 2). As discussed, these are packages that have—all else constant—either a higher deductible (attachment point), a lower maximum payout (exhaustion point), or a lower risk transfer (ceding percentage). The embedded chart shows the marginal effects of these insurance choices on the cost of the insurance.



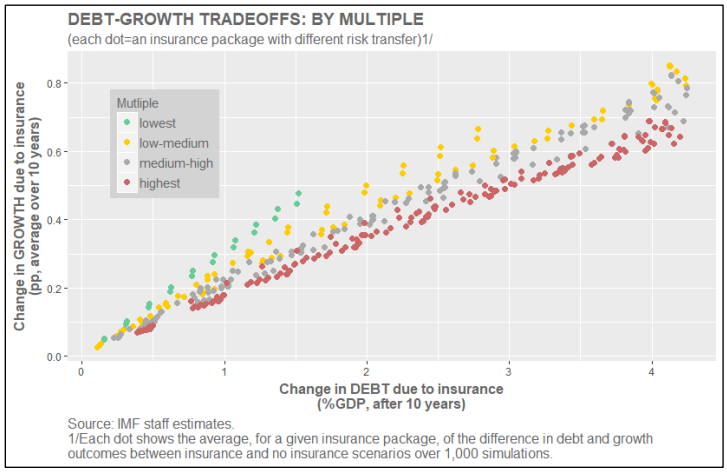
- Once countries consider not just the costs, but also the benefits offered by insurance in terms of payouts (and growth protection), the set of insurance packages that offer the best trade-offs is different from the cheapest packages. The charts below compare the cost of various packages (from result 2) and with the set of "optimal" packages from result 3, proxied by ellipses. The optimal packages for neither country are necessarily the cheapest ones, and in fact are the most expensive in the case of the larger country.

Optimal insurance packages depending on PREMIUM[1/]
(optimal packages are proxied by the ellipses)

Small exposed country	Larger less exposed country
	

1/ Each dot represents an insurance package with different risk transfer. For each package, the axes show the average difference in debt and growth outcomes between insurance and no insurance scenarios over 1,000 simulations.
Source: Fund staff estimates.

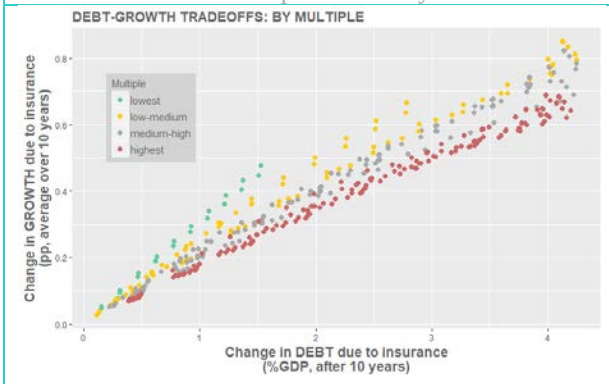
- If not cost, what then characterizes these "optimal" packages? Parsing out their various features, we find that these turn out to be packages that offer the lowest "insurance multiple" (see Box 4). In the inserted figure, one can see that for any given debt outcome associated with insurance packages there are packages that can be expected to produce the best growth outcomes – these are the ones that are on the top of the trade-off curve (green and yellow dots). These, it turns out, are the packages that have the lowest insurance multiple. As discussed in Box 4, these packages cost the least relative to the expected payout, or—another way to look at it— can be expected to have the highest payout on average for a given cost (premium) and therefore provide the best value for money from the point of view of the sovereign.



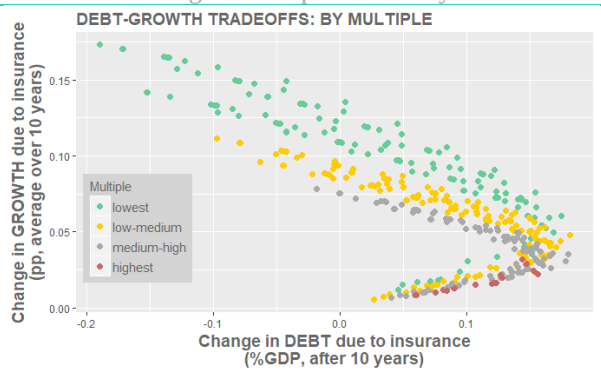
- The optimality provided by lower multiple packages holds regardless of the tradeoffs relating to country size. The chart below shows the tradeoffs faced by smaller more exposed country and by the larger less exposed country – in both cases, the packages with smaller multipliers lie on top of the tradeoff curves, whichever direction the curve is bent, i.e. on a sort of "efficient frontier".

Efficient Frontiers: Tradeoffs by the Insurance MULTIPLE[1/]

Small exposed country



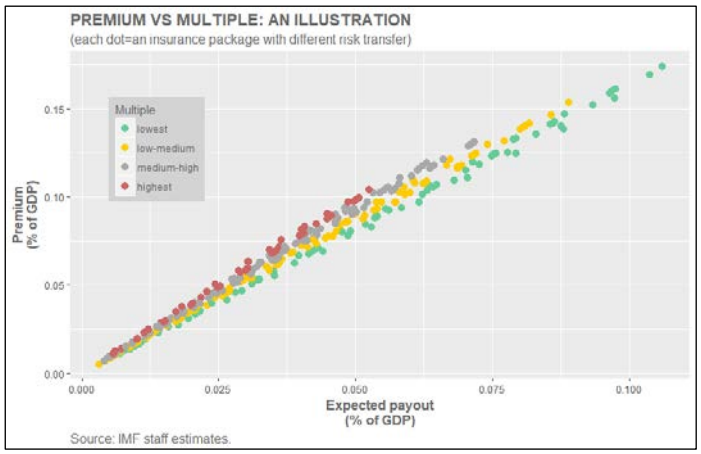
Larger less exposed country



1/ Each dot represents an insurance package with different risk transfer. For each package, the axes show the average difference in debt and growth outcomes between insurance and no insurance scenarios over 1,000 simulations.
Source: Fund staff estimates.

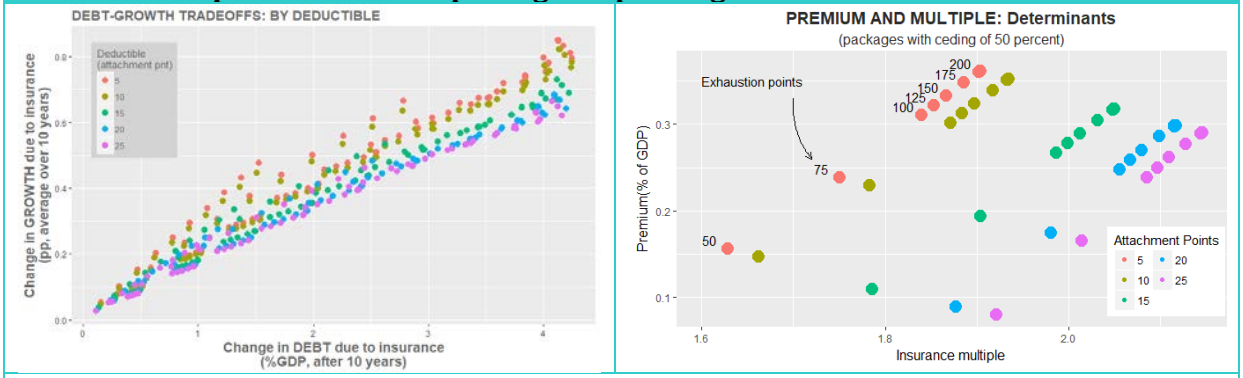
Box 4. The Insurance Multiple

The insurance multiple is the ratio of the premium to the expected payout, in other words how much one pays for every dollar of expected payouts (i.e. payouts to be received under various disaster sizes weighted by the probability of those disasters). The inserted figure provides an illustrative relationship between the premium, expected payout and insurance multiple: premium increases with the expected payout, but for a given premium there are packages that provide the highest payout: these are packages with the lowest multiple (green, followed by yellow).



30. **Result 5. Under the existing insurance options, insuring smaller disasters can improve the debt-growth tradeoffs.** In staff's analysis, the packages with the lowest insurance multiples (best growth-debt tradeoffs) are also the ones that trigger the insurance at more frequent disasters (i.e. have the lowest deductible)**.** This might seem counter-intuitive. The conventional view of insurance against natural disasters is that countries should use insurance against medium-to-large disasters because they are cheaper and more cost-efficient, while financing losses from smaller disaster from own resources (in line with our discussion of result 4). Our result is not inconsistent with this view: packages with lowest deductible are not necessarily the cheapest packages (lowering the attachment point increases the price of insurance because it widens the insured window, for a given choice of other insurance parameters – see right chart below). However, given a price range, the packages that would give the most value for money in that range will be the packages with the lowest deductible (left chart below). Another way to look at it is that for a chosen insurance window, it is more cost-efficient to choose an insurance window that starts with lower frequency disasters (right chart below).

Optimal insurance packages depending on the DEDUCTIBLE[1/]

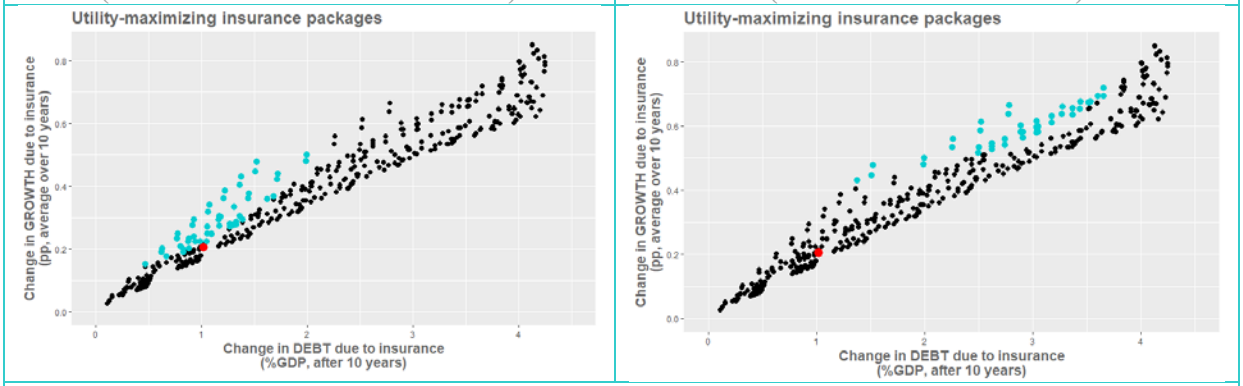


1/ Each dot represents an insurance package with different risk transfer, based on the small country simulations. For each package, the axes of the left chart show the average difference in debt and growth outcomes between insurance and no insurance scenarios over 1,000 simulations.
Source: Fund staff estimates.

31. Result 6. **A higher risk aversion to negative growth outcomes may imply the need for a more growth-biased (but prohibitive) optimal risk transfer.** Smaller countries with large exposure are likely to be more risk averse to growth losses, in line with the findings in Ghesquiere and Mahul (2007). This means that they would be seeking higher insurance coverage with more growth protection as an optimal strategy (green dots in right-hand chart below), compared to countries with a relatively lower risk aversion to growth declines (green dots in left-hand chart below).[13] However, these are packages that cede a large share of the losses to insurance and can have wide insured windows, which means they can carry a prohibitive cost with large debt implications. Actual small country coverage is thus often less than optimal (red dot, based on one country example).

Optimal insurance packages depending on RISK AVERSION[1/]

(risk aversion coefficient 1.2: baseline) | (risk aversion coefficient 3.5)



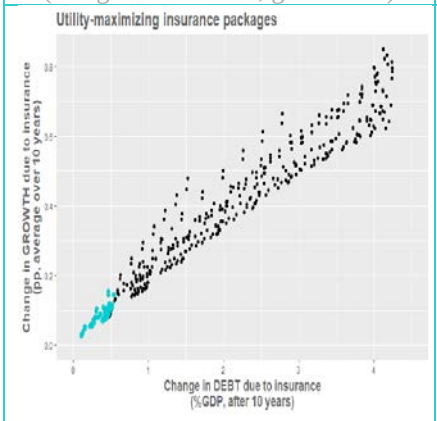
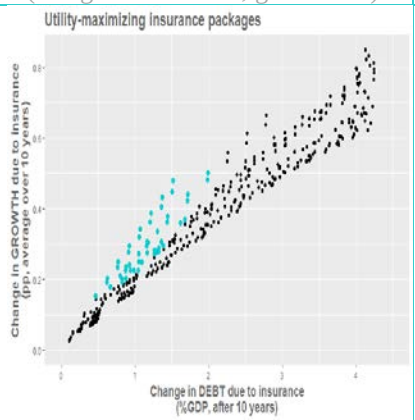
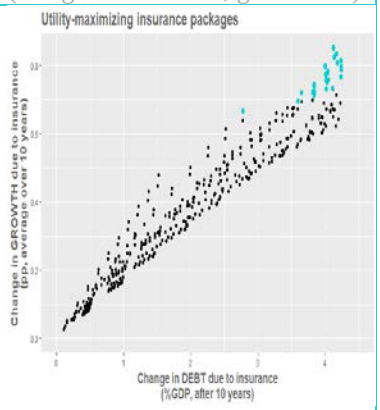
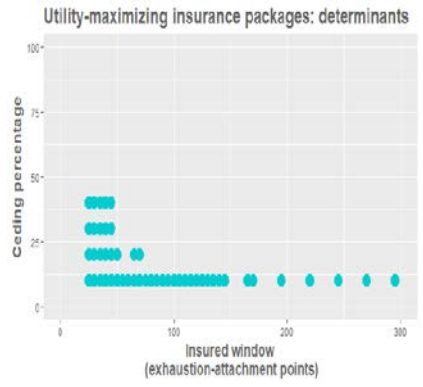
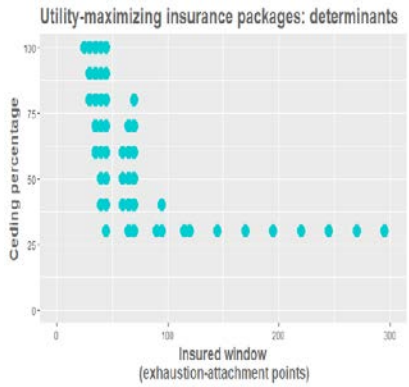
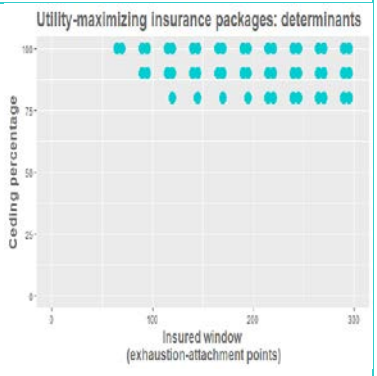
1/ Each dot represents an insurance package with different risk transfer, based on the small country simulations. For each package, the axes show the average difference in debt and growth outcomes between insurance and no insurance scenarios over 1,000 simulations.
Source: Fund staff estimates.

32. Result 7. **Similarly, smaller or more exposed countries may have—in addition to higher risk aversion—a stronger preference for protecting growth rather than reducing debt, which would again bias their optimal insurance choices towards higher risk transfer.**

- Countries that prioritizing fiscal sustainability considerations would optimally choose less costly insurance packages, associated with lower payouts, and thus less beneficial growth outcomes (green packages in the left chart, top). These are the packages that have a relatively limited coverage: ceding percentages generally low or very low if the insured window is wide (left chart, bottom).
- Countries that prioritizing higher growth outcomes (e.g., for more systemically exposed countries) would choose more expensive insurance packages, with higher payouts (right chart, top). These are the packages that have the highest ceding percentages and generally wide insured windows.

[13] Note that our simulation does not have a feedback channel from debt to growth, whereby higher debt and the associated interest burden can slowdown growth. If this channel was operating, the results might be somewhat different.

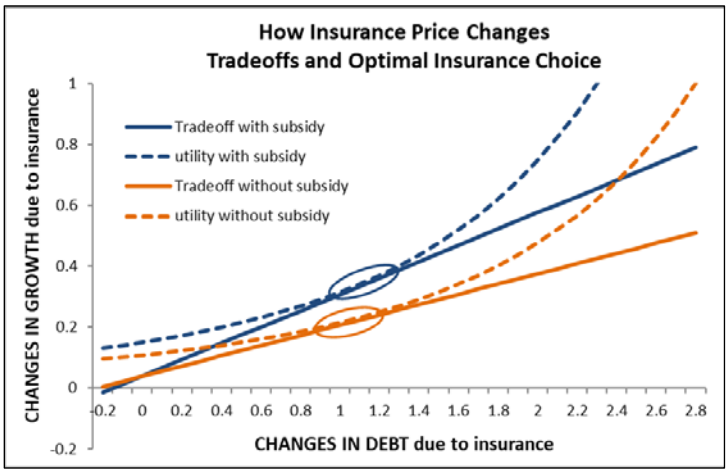
Optimal insurance packages depending on PREFERENCES over debt and growth[1/]
(green dots=top 50 utility maximizing packages)

(Weights *z*: debt 0.9, growth 0.1)	(Weights *z*: debt 0.5, growth 0.5)	(Weights *z*: debt 0.1, growth 0.9)
		
		

1/ Each dot represents an insurance package with different risk transfer, based on the small country simulations. For each package, the axes in top row charts show the average difference in debt and growth outcomes between insurance and no insurance scenarios over 1,000 simulations.
Source: Fund staff estimates.

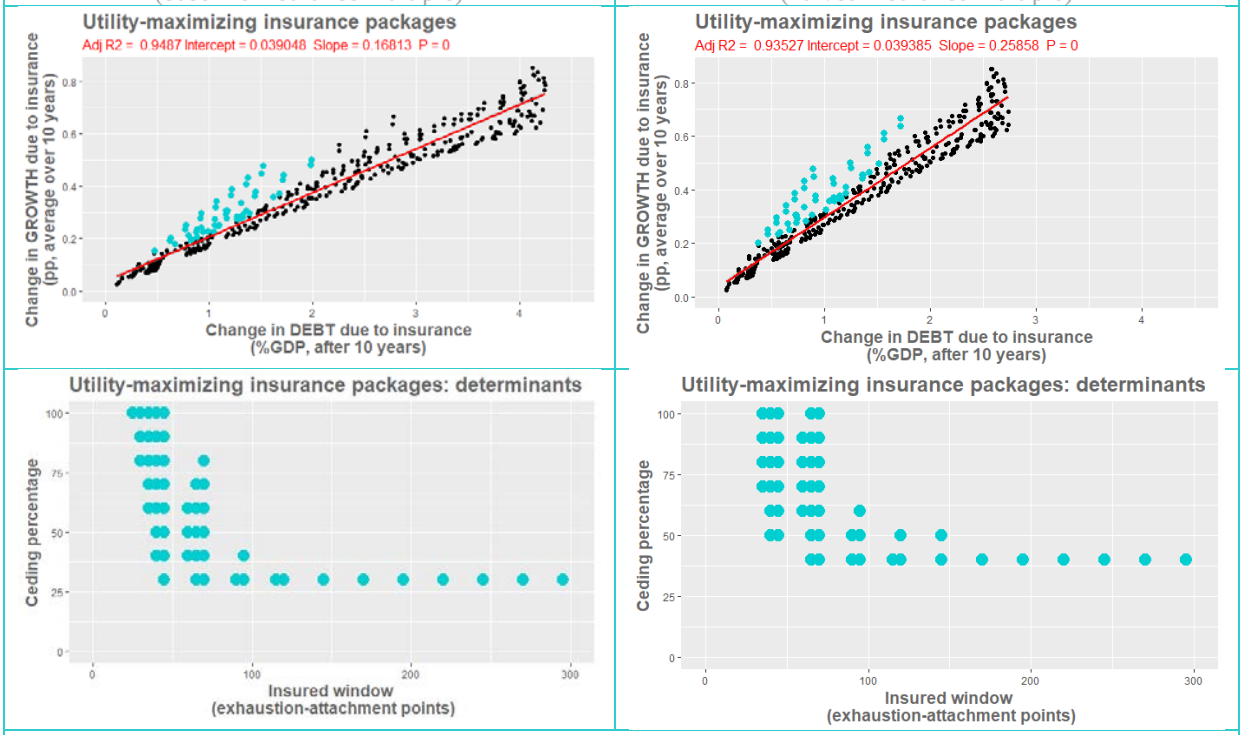
33. Result 8. A discount on the insurance premium (e.g., through donor support) would allow countries to choose more expensive packages that provide better coverage and hence growth protection. Reducing the cost of insurance not only directly affects the impact of insurance on debt and growth, but also changes the tradeoffs countries face in choosing the optimal insurance. We have proxied the lower cost of insurance by halving the insurance multiple for each package, which has three effects on trade-offs: (i) the increases in debt as a result of insurance are of course more limited when insurance is funded (see the debt ranges in the top row charts below); (ii) the trade-offs improve, as the same increase in public debt is now associated with larger gains in terms of growth, i.e. the "sacrifice ratio" is smaller (see the lines in the imbedded chart, which correspond to the red "tradeoff" regression lines in the top row charts below); and (iii) as a result, the optimal choices of insurance packages shift towards those

that are more growth-biased (in the imbedded chart, these are the points where the trade-off lines are tangential to our assumed government utility function). Thus, facing a lower price allows sovereigns to choose more expensive packages that provide better coverage and hence growth protection. Again, these are the packages that cede higher risk and generally have higher insured windows that normally priced packages (bottom charts below).



Optimal insurance packages depending on PRICE[1/]

(baseline insurance multiple) | (halved insurance multiple)

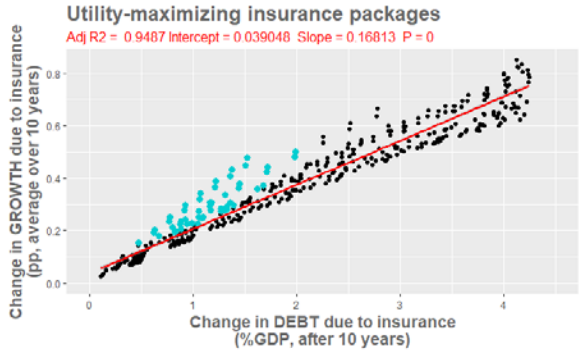
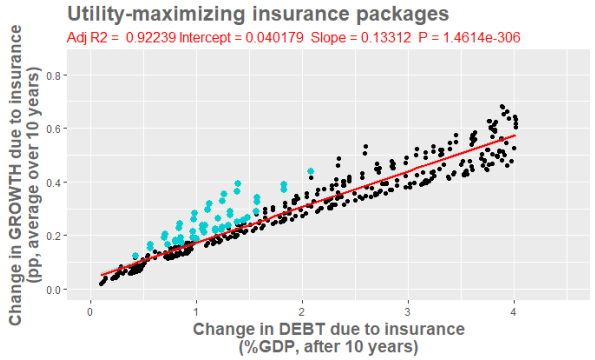


1/ Each dot represents an insurance package with different risk transfer, based on the small country simulations. For each package, the axes in top row charts show the average difference in debt and growth outcomes between insurance and no insurance scenarios over 1,000 simulations.
Source: Fund staff estimates.

34. Result 9. **Countries that face larger borrowing constraints would benefit more from disaster insurance.** Tighter constraints on post-disaster borrowing (left chart) improves the tradeoffs between growth and debt outcomes offered by disaster insurance (the slope of the red regression line is higher than in the case of a looser borrowing constraint). Insurance, in other words, is more likely to relieve the constraint on financing disaster losses, therefore providing larger growth benefits relative to countries were borrowing constraints are less binding (right

chart).[14] An alternative way of interpreting this is that if countries anticipate assistance following disasters (akin to a non-binding borrowing constraint), they may opt for lower insurance coverage due to the perceived smaller benefits (the "charity hazard").

Optimal insurance packages depending on CAPACITY TO BORROW

Capacity to borrow more limited *("borrowing"=5% of GDP)*	Capacity to borrow larger *("borrowing"=10% of GDP)*
	

1/ Each dot represents an insurance package with different risk transfer, based on the small country simulations. For each package, the axes show the average difference in debt and growth outcomes between insurance and no insurance scenarios over 1,000 simulations.
Source: Fund staff estimates.

IV. Options to Strengthen Financing of Disaster Risks

35. This section discusses options for expanding insurance coverage for sovereigns, especially in smaller states. Most of these options hinge on making insurance decisions within a comprehensive risk management strategy and making insurance more affordable, by donor participation, risk pooling and improved design.

- **Making risk transfer decisions in the context of a more comprehensive Disaster Resilience Strategy (DRS).** To ensure an optimal allocation of resources between (i) risk transfer and risk retention (discussed in the previous section) and between (ii) risk mitigation and risk reduction through resilient investment (not tackled in this paper), decisions should be made in the context of a comprehensive DRS. Such a strategy would help ensure that the policy response to disaster is developed optimally by considering the risk exposure of a country, the costs and benefits of different allocation of resources between financial management of the costs of disaster and risk reduction efforts, as well as policy consistency with government's longer-term macro-fiscal objectives (for a broader discussion of such a strategy see IMF, 2019). Many countries are developing disaster risk management or disaster risk financing strategies with assistance from the World Bank, although some of these strategies may not take a comprehensive and quantified approach to resilience building.
- **Scaling up existing regional insurance pools through diversification of membership**

[14] At the same time, since larger capacity to borrow would provide an overall better protection to growth, it would also reduce the debt ratios, helping offset more the increases in debt due to insurance premia.

and perils. The larger the risk pools, ceteris paribus, the lower the operational costs and the cost of reinsurance in the global capital markets, which could in turn be passed on the member states through lower premia. While regional pools are already working to diversify risks by expanding memberships and insured perils, pools could also share risks among themselves to reduce costs.[15]

- **Scaling up insurance coverage through direct donor support for insurance premium cost and fiscal effort.** Making insurance more affordable by direct donor support of premiums could help increase country insurance coverage and may also encourage the remaining eligible countries and territories to join the regional pools, in turn helping to further reduce the premia. To guard against the risk of creating dependency on donor funding that may dry up in the future, donor-financed support for insurance premia could be temporary and made conditional on:
  - *Countries entering or having an IMF program, or already pursuing sound macroeconomic policies.* This would allow countries higher access to post-disaster payouts to protect the reforms and the macro adjustment during the program period or may provide a marginal incentive for countries to embark on the needed structural adjustment.
  - *Countries purchasing own insurance, while donors match the premium for a higher payout.* This will both maintain the incentive for the country to purchase a higher level of insurance and could be used to increase the amount paid out under each insured event.
  - *Countries committing to invest in climate-resilient infrastructure and risk reduction.* This could be operationalized through a donor-supported program within the regional pools, with an ex-ante agreement on what resilience-related spending will be undertaken and how compliance would be monitored. There are several challenges associated with this form of conditionality: (i) enforcement may be difficult, as a setup may be required to assess plans and verify investments in these areas; and (ii) it may involve countries scaling up spending, which may or may not add to resilience building when enforcement is weak. This option would have to include more frequent updates of regional pools' cat risk models to factor in the more resilient infrastructure, and ultimately reducing premia.
- **Reducing risk premia or increasing coverage through indirect insurance premium**

[15] In an extreme, pools could also merge to enhance the benefits of diversification, although this is not strictly necessary if risks can be shared. The political economy considerations of such a geographical diversification within a combined pool can be mitigated by the segregation of the insurance portfolios of various regions (as currently done for the Caribbean and Central America under CCRIF) in order to prevent the cross-subsidization of risk from one region to another. While risks are not pooled across the Caribbean and Central America, the joint management of the two risks portfolios provides the opportunity to share operational functions and costs and to maximize the benefits of diversified portfolio when accessing the reinsurance markets. Logistical issues of such a merged pool are unlikely to present a challenge, as CCRIF is a currently a virtual office that works smoothly with consultants across various time zones.

subsidization (recapitalization of regional pools). Increasing the capital of the regional pools would help reduce costs and scale up insurance through different channels, including *lowering reinsurance costs* or *increasing the current coverage limit*. Such an increase in capital is already made possible through the recently established—with assistance from the World Bank, UK and Germany—Global Risk Financing Facility (GRiF), whose aim is to strengthen financial resilience of vulnerable countries.

- *Lowering costs.* Regional pools are ceding the bulk of the risk they hold to reinsurance companies or to capital markets through catbonds. Reinsurance costs are the largest contributor to their costs and hence the insurance premia paid by countries. To reduce these reinsurance costs, pools would have to hold more risk, which is only possible if they increase their capital. Currently, capital is built largely from donor contributions to a trust fund and from country insurance premia.[16]
- *Increasing availability of insurance*. The amount of coverage currently available under existing policies (e.g. up to US$100 million per hazard per year in the case of CCRIF) is insufficient to meet larger countries' disaster risk transfer and financing needs if a truly major disaster struck.

- **Increasing penetration of private property insurance to reduce government contingent liabilities.** Reducing this contingent liability requires incentivizing a broader use of private insurance by households. Some of the options include: (i) developing the local insurance markets, which in many smaller countries are weak and poorly regulated or supervised; (ii) regional pooling of private insurance risk to overcome local market failures; (iii) government-sponsored pools for natural disasters, akin to the *Turkish Catastrophe Insurance Pool*;[17] (iv) incentives to private providers of risk transfer instruments if market failures exist.

  An option for smaller states that would capture alternatives (ii) and (iii) above would be introducing mandatory property insurance, alongside with targeted subsidies to assist poorest households. Risks from these additional insurance contracts could be pooled at the national level – potentially with government support— and re-insured internationally. Existing regional pools could be used, in turn, as platforms to pool regionally risks from these national pools, which could help achieve additional gains in costs through further diversification of the aggregate portfolio before transferring the risk through re-insurance

[16] In the case of CCRIF, capital from donors is placed in a multi-donor trust fund that is used by CCRIF to make payouts and cover reinsurance costs until the trust fund is exhausted. In parallel, country premium payments go to build the capital of the segregated cells (Caribbean and Central American, which are separate pools), so that they are fully self-sustaining once the trust fund is finished. Part of the trust fund resources is earmarked for technical assistance to enable countries to make effective use of payouts as well as integrate this insurance solution into comprehensive country frameworks for financial and disaster risk management.

[17] TCIP was established in 2000 with assistance from the World Bank and it manages the compulsory earthquake insurance in the country, aiming to limit the fiscal contingent liability, focus government relief funds on low-income households, and access international reinsurance markets.

or capital market instruments.[18] Several considerations would need to be taken into account in developing such options, including appetite and ability by local insurance companies to expand and support higher risk, need for enhanced insurance supervision, and additional financial costs to support the capital of the national or regional pools.

- **Expanding coverage through better trigger measurement and design**. Since a contributing factor to underinsurance could be failure to trigger payouts in moderate events that cause significant damage, the design of the triggers could be refined to make them less complex/uncertain and ensure a more granular geographical measurement to avoid non-triggering events outside the geographic areas covered by the trigger.
- **Expanding the range of insurance instruments.** The parametric insurance against catastrophic risk could be complemented with a number of other insurance options, some of which are discussed below.
    - *Issuing catbonds*. As discussed above, catbonds have become more affordable in recent years and are offering a good, albeit still costly, alternative to traditional insurance, especially if also done at a regional level.
    - *Introducing hurricane clauses in new sovereign bond issuances.* A debt repayment stand-still following disasters —akin to the "hurricane clause" introduced in the bonds issued during Grenada's recent debt restructuring—would be similar to insurance and would automatically provide the necessary financial resources immediately following disaster. Such hurricane clauses can be structured to be NPV-neutral for investors and therefore not require a premium, although additional risks may still add to costs, e.g. risks from reprofiling of debt service payments at lower rates that will prevail in the future (see IMF, 2019, for a discussion of these options).
    - *Complementing the parametric trigger with an indemnity-type reimbursement*. The latter would make payouts not against actual losses, which would take a long time, but against some easier benchmarks approximating these losses. For example, catbonds or other insurance policies could be issued with an "industry loss" triggers—linked for instance to aggregate losses reported by insurance companies following an event. While such an option would delay access to funds relative to parametric insurance, they could help mitigate basis risk and allow countries to achieve higher disaster coverage without risking receiving no payouts under one policy.

V. Conclusions and Policy Implications

36. The possibility of disasters with large economy-wide implications makes pre-arranged financing, including through insurance, compelling. Considering insurance choices ex-ante, insurance would be expected to add to debt because the low probability of catastrophic

[18] Alternatively, such a regional pool could be created through an entity separate from the existing regional pools, but there would be little advantage of doing so given the existing logistical and risk modelling platform already in place.

events would keep expected payouts below the yearly paid premia. The ex-ante financial impact of the insurance, however may not be the most adequate criterion to judge its benefits. Ex-post, natural disasters could be significantly costlier than suggested by ex-ante expectations, and they can have a macroeconomic and social effect beyond their pure fiscal or financial cost. That is why, while sovereigns can be risk neutral with respect to financial costs, risk aversion to potentially catastrophic effects of disasters on the economy make insurance compelling despite its costs. Moreover, the binding financial constraints a country is likely to face after catastrophic disasters would be significantly alleviated by the immediate availability of insurance payouts.

37. Decisions about the (optimal) level of insurance therefore need a benchmark that would take into account both the financial and the economic effects of disasters. In this paper, we use such a benchmark in the form of a government utility function that explicitly internalizes the macroeconomic trade-offs between the costs of the insurance (impact on debt) and its benefits (impact on growth). Insurance choices that maximize such an utility provide the best trade-offs for country authorities, given their risk exposure and preferences. Certainly, other benchmarks and utility forms can be developed, but this has provided a useful initial framework for considering sovereign insurance choices and for integrating such choices in country macro-fiscal decisions. It is also worth noting that the proposed framework is different from the approach currently used by many governments (e.g. deciding on a nominal amount for the premium or coverage), especially because it provides an organized approach to understand and weigh trade-offs and optimality considerations.

38. Countries that face a more systemic exposure to natural disasters would benefit more from protecting against such risks, but they also are more likely to be underinsured. In these countries, the social and macroeconomic costs of disasters are so high that sovereigns are more likely to have a stronger preference for protecting growth. Results in this paper suggest that such preferences would require higher risk transfer as an optimal choice. Our results also suggest that when countries face tighter borrowing constraints—and smaller or low-income states often have limited access to markets or have already borrowed heavily from financial institutions—the benefits of insurance are higher. Despite the optimality of higher risk transfer, insurance is often prohibitive for smaller or more vulnerable states because of lack of fiscal space and high public debt, some of it due to recoveries from past disasters. These sovereigns, therefore, are more likely to be underinsured.

39. Support from the international donor community can help more vulnerable states protect growth by alleviating the constraints they face when choosing disaster insurance coverage. The paper showed that direct or indirect donor support for insurance costs would not only alleviate the financial constraints and help countries scale up financial resilience without creating notable debt sustainability risks but would improve the growth-debt tradeoffs countries face and allow them to achieve better growth outcomes. If conditioned on an existing track record of efforts to create fiscal space or strong macroeconomic policies (e.g. Jamaica after the successful implementation of successive Fund supported programs), such support would be desirable for donors as well, as it could reinforce beneficial macroeconomic externalities and

properly align incentives. In addition, such ex-ante assistance could also reduce the costs of ex-post support from donors (IMF, 2019).

40. In practice, decisions about appropriate risk transfer also need to be anchored on three key elements.

- *Understanding and quantifying the exposure to natural disasters*. Whether this is done in the context of purchasing insurance or with assistance from the IFIs, identifying and quantifying disaster risks will be critical in finding an appropriate balance between insurance costs and benefits.
- *Clarity over government preferences over growth protection and fiscal sustainability*, to enable it to rank options and pin down the options along the trade-offs that best meet these preferences. Across preferences, however, results show that keeping the insurance multiples low and insuring smaller disasters can improve the debt-growth tradeoff for a given cost range.
- *Taking optimal risk transfer decisions in the broader context of disaster resilience strategies.* Such strategies would involve concomitant decisions about (i) the optimal choice between investing in financial resilience vs structural resilience (infrastructure), and (ii) the optimal choice of investing in risk transfer vs risk retention (discussed in this paper). The broader framework for decisions offered by such a resilience strategy and the additional aspects it brings into play may affect the trade-offs we discussed in this paper.

41. There are several areas for further analytical work. One is considering the risk transfer optimality in the broader context discussed above: namely, how to allocate a certain fiscal space between building financial resilience (purchasing insurance) and building structural resilience (investing in resilient infrastructure). Another is look more carefully at the tradeoffs between purchasing insurance and self-insuring against disasters (which in this paper has been treated as market borrowing). A third line of research could expand the analysis to a broader range of countries to identify how optimal risk transfer choices depend on country-specific characteristics, such as size and risk exposure.

REFERENCES

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

Ghesquiere, Francis; Mahul, Olivier, 2007, "Sovereign Natural Disaster Insurance for Developing Countries: A Paradigm Shift in Catastrophe Risk Financing", Policy Research Working Paper; No. 4345, World Bank, Washington, DC. © World Bank. https://openknowledge.worldbank.org/handle/10986/7331 License: CC BY 3.0 IGO

Ghesquiere F., and O. Mahul, 2010, "Financial Protection of the State Against Natural Disasters: A Primer," World Bank Policy Research Working Papers No. 5429 (Washington: World Bank)

Gurenko, E., 2004, "Catastrophe Risk and Reinsurance: A Country Risk Management Perspective," (London: Risk Books)

Hsiang, Solomon M. and Jina, Amir S., 2014. "The Causal Effect of Environmental Catastrophe on Long-Run Economic Growth: Evidence From 6,700 Cyclones," NBER Working Papers 20352

International Monetary Fund, 2016, "Small States' Resilience to Natural Disasters and Climate Change—Role for the IMF," IMF Policy Paper (Washington)

International Monetary Fund, 2019, "Building Resilience in Developing Countries Vulnerable to Large Natural Disasters", IMF Policy Paper (Washington)

Mahul, O. and E. Gurenko (2006). The Macro Financing of Natural Hazards in developing Countries, World Bank Policy Research Working Paper 4075

G.Von Peter, S. von Dahlen, S. Saxena, 2012, "Unmitigated disasters? New evidence on the macroeconomic cost of natural catastrophes", BIS Working Paper No 394