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EDUCATIONAL INSIGHTS

Debt Sustainability Under Catastrophic Risk: The Case for Government Budget Insurance

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Abstract

Natural disasters are an important source of vulnerability in the Caribbean region. Despite being one of the more disaster-prone areas of the world, it has the lowest levels of insurance coverage. This article examines the vulnerability of Belize's public finance to the occurrence of hurricanes and the potential impact of insurance instruments in reducing that vulnerability. The article finds that catastrophic risk insurance significantly improves Belize's debt sustainability. In addition, the methodology employed makes it possible to estimate the appropriate level of insurance, which for the case of Belize is a maximum coverage of US$120 million per year. International organizations can play a role in assisting countries to overcome distortions in insurance markets, as well as in helping to relax internal political resistance to the purchase of insurance policies.

Introduction

This article analyzes the vulnerability of Belize's public finances to the occurrence of large natural disasters and the possible use of insurance instruments to reduce that vulnerability. Natural disasters cause an abrupt increase in government spending, both for relief activities and to restore infrastructure and facilities that have been damaged or destroyed. Although international aid usually helps to defray those costs to some

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extent, the experience of Belize and other frequently affected developing countries is that disasters result in an increase in government debt and a higher risk that debt may reach an unsustainable level. With the development of insurance and reinsurance markets for natural disasters, and the initiatives sponsored by the World Bank and other institutions to facilitate access to those markets by Caribbean economies, countries like Belize now have an opportunity to reduce their public finance vulnerability to disasters. This article attempts to evaluate the reduction in debt vulnerability that can be achieved through disaster insurance and computes the optimal level of insurance from the point of view of debt sustainability.

In two recent papers, Robert Barro (2006a, b) has shown that the occurrence of infrequent economic disasters has much larger welfare costs than continuous economic fluctuations of less amplitude. Barro estimated that for the typical advanced economy, the welfare cost associated with large economic disasters such as those experienced in the 20th century (wars, economic depressions, financial crises) amounted to about 20 percent of annual gross domestic product (GDP), whereas normal business cycle volatility only amounted to about 1.5 percent of GDP. For developing countries, which usually suffer from a larger propensity to disasters of all types, and of even larger magnitude than in advanced economies, these events have an even greater effect on the welfare of the average citizen. Of the more than 6,000 natural disasters recorded during 1970–2002, three-fourths of the events and 99 percent of the people affected were in developing countries (Rasmussen, 2004). At the macro level, Rasmussen (2004) finds that the 12 large natural disasters in the Eastern Caribbean Currency Union (ECCU) produced a median reduction in same-year GDP growth of 2.2 percentage points and a median increase in the current account deficit equal to 10.8 percent of GDP. In addition to their direct costs, large catastrophic risks pose a major challenge for public finances, and for debt sustainability in particular. And reaching a position of unsustainable public debt usually results in further financial and economic distress for the country.

In the case of case of Belize, a Central American country of 300,000 people and a GDP of approximately US$1 billion, natural disasters are the source of relatively frequent events of catastrophic proportions. For example, the last two hurricanes that hit Belize, Keith in 2000 and Iris in 2001, caused some of the worst damage ever in the country. According to available estimates, the costs amounted to 33 percent of GDP (US$280 million) and 30 percent of GDP (US$250 million), respectively.[1] The increase in government expenditures associated with these two storms reached US$50 million and spread over three fiscal cycles. As the country's fiscal position worsened, its debt dynamics became increasingly unsustainable, and Belize eventually required a restructuring operation for public debt in 2006. Although not all the fiscal imbalances that have developed since the late 1990s may be directly associated with the storms, the government argues that the spending increases that led to the large deficits and debt accumulation were necessary to pay for reconstruction in the aftermath of the hurricanes.[2]

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[1] The economic impact of a disaster usually consists of direct costs, such as damage to infrastructure, crops, and housing, and indirect economic losses, such as drops in tax revenues, unemployment, and market instability. See EM-DAT, "The OFDA/CRED International Disaster Database" (2006).

[2] See Government of Belize (2006).

Belize is a vivid example of the damage that hurricanes can cause to public finances and debt sustainability, but it is by no means an isolated case. Freeman et al. (2003) document the increased incidence of natural disasters in developing countries, particularly small island states and low-lying coastal states. Relatively poor countries are particularly vulnerable because they have a higher proportion of poor population who are often priced out of safer areas and who live in disaster-prone areas. Additionally, developing countries are typically poorly insured against catastrophic risk, in part as a consequence of the limited availability of affordable insurance options but also because the private sector probably expects a bailout from the government in the aftermath of a severe storm; governments in turn expect to receive aid from external donors. According to Freeman et al., the consequences of natural disasters go beyond the direct costs associated with physical damage. They are also typically associated with: (1) a worsening of the fiscal position as governments pay for reconstruction and sources of revenue are disrupted, (2) a worsening of the trade balance as the exporting capacity is hampered, and imports for reconstruction surge, (3) downward pressure on the exchange rate due to the worsening of the trade balance and concerns about the repayment capacity of the government by international investors, and (4) inflationary pressures. Therefore, the total impact on the budget widely exceeds the direct costs of relief and reconstruction from the disasters.

For this reason, there is broad consensus on the need to design fiscal management policies to resist the stress caused by the occurrence of disasters. Freeman et al. (2003) consider ways to create the necessary fiscal space to deal with catastrophic risk. Among various alternatives, they advocate treating natural disasters as a contingent liability for the national government (although they are skeptical about its practical feasibility, particularly in low-income countries). A more substantive initiative would be to implement an annual budgetary allocation to provide for natural disaster expenditure when needed. Mexico's FONDEN (Fondo Nacional de Desastres Naturales) provides this kind of fiscal provisioning against the risk of any type of natural disasters. But these measures, although prudent, amount to forms of self-insurance, which may be very costly in the case of an economy with substantial borrowing costs and prone to experiencing "sudden stops" in capital inflows.

In the case of emerging economies and developing countries exposed to large natural disasters, insurance—or debt contracts with insurance-like features—provides an attractive alternative to self-insurance.[3] In the case of temporary shocks, whose effect is reversed over time, and where countries do not face borrowing constraints in global markets during periods of economic distress, a strategy of borrowing and saving, such as those applied by stabilization funds, could be fully appropriate.[4] But in the case of shocks that cause large permanent losses and when countries have an unreliable access to capital markets, insurance schemes represent a superior strategy. While market imperfections may affect the cost and availability of catastrophe insurance, the levels

[3] See Borensztein et al. (2005) and Hofman and Brukkof (2006).

[4] Even in this case, there are caveats, as it all depends on the price charged for the market insurance (or whether that market exists). Ehrlich and Becker (1972) show that self-insurance and market insurance are substitutes and may coexist in equilibrium.

of risk premium that the public and private sector of emerging economies face make self-insurance a particularly expensive strategy (Caballero and Cowan, 2007).

Implementing disaster insurance in developing countries, however, faces two types of obstacles: market unavailability and political resistance. For a number of reasons, markets have traditionally been insufficiently developed or simply nonexistent. More recently, however, advances such as the development of parametric insurance policies have expanded the availability of coverage for countries and households. Instead of basing payments on an estimate of the damage suffered, parametric insurance contracts establish the payout as a function of the occurrence or intensity of certain natural phenomenon, as determined by a specialized agency such as the U.S. National Hurricane Center or the U.S. National Earthquake Information Center. In this way, the transaction costs and uncertainty associated with insurance payments are considerably reduced. There is no need to verify and estimate damages and no potential disagreement or litigation about the payouts. Moreover, the country has immediate access to the resources when the disaster takes place. Political reluctance to engage in insurance purchase derives from the fact that there is little benefit for the political leadership from entering insurance contracts. Insurance involves costs today and a possible payoff some time in the future, when the government may have changed hands. And because disasters are natural phenomena and politicians cannot be blamed for their occurrence, there are weak incentives to take relatively complex measures, such as market insurance, to offset some of the costs.

The prospects for disaster insurance in the Caribbean region have been enhanced considerably with the creation of the Caribbean Catastrophe Risk Insurance Facility (CCRIF), under the leadership of the World Bank (see World Bank, 2006). This facility will act as a financial intermediary between the participating countries and the international reinsurance market, allowing participating governments in the Caribbean region to purchase insurance that would provide them with immediate assistance after the occurrence of an earthquake or the passing of a hurricane. The proposed insurance coverage will rely on parametric techniques and coverage will be calculated such that the instrument provides business interruption insurance against budgetary losses caused by hurricanes and earthquakes. That is, the government will have available the financial means to continue to operate and start recovery activities immediately. It is expected that the aggregation of the individual risks into a large and diversified portfolio will help achieve lower costs for the reinsurance coverage. Moreover, the creation of this instrument with the support of international institutions and donors would create incentives and peer pressure to help overcome internal political resistance to the purchase of insurance policies. It is often the case that policymakers are apprehensive of purchasing insurance instruments because they are complex instruments not frequently used by their peer countries, and they may easily generate misperceptions. A joint initiative would thus look much less risky politically. Moreover, donors may not feel very generous toward countries who opted out of the insurance if a disaster does occur. Furthermore, the recent success of the Mexican government in the issuance of catastrophe bonds (as will be discussed below) may indicate that disaster insurance markets are becoming increasingly available and cheaper, which would open the door for individual countries to supplement the CCRIF facility and tailor their disaster coverage by themselves over time.

These efforts by the World Bank and other institutions respond to the extreme vulnerability of the Caribbean region to natural disasters. According to Rasmussen (2004),[5] despite being one of the more disaster-prone areas of the world, the Caribbean region has the lowest levels of insurance coverage, with less than 4 percent of disaster damage covered by insurance, compared with more than 30 percent in North America, the region with the highest coverage.

The article is organized as follows. In the next section we describe in further detail the fiscal impact of natural disasters in the experience of Belize. Then, we explore which instruments are available for governments to insure public finances against catastrophic risk. The next step is to perform a debt sustainability analysis for Belize in order to quantify the potential benefits from the different insurance scenarios. Finally, we explore some of the problems associated with insurance schemes and how to address them. We end with some concluding remarks.

DEBT DYNAMICS AND CATASTROPHIC RISK: THE CASE OF BELIZE

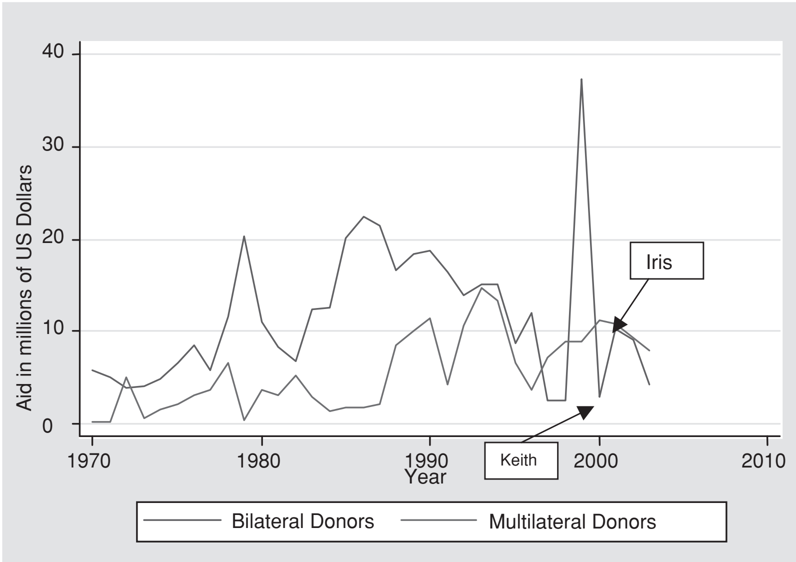
Belize is located in one of the most active hurricane areas of the world. According to EM-DAT, an online emergency disaster database sponsored by United Sates Agency for International Development (USAID) and Center for Research on the Epidemiology of Disasters (CRED), between 1931 and 2005, 11 wind storms directly hit Belize, killing an average of 168 people per event,[6] injuring 52, and causing an average annual cost of US$5.5 million (in constant US$ of 2000).[7]

The last two hurricanes that hit Belize (Keith in 2000 and Iris in 2001) caused some of the worst damage ever according to EM-DAT estimates: 33 percent and 30 percent of GDP, respectively. The direct fiscal cost of these two storms, measured as the increase in expenditures for reconstruction, was US$50 million. It is worth emphasizing that this is the *lower bound* of the total fiscal cost because it comprises only the spending for emergency reconstruction recorded in the operations of the central government over the 3 fiscal years between 2000 and 2003.[8] Therefore, this cost estimate does not include either the lost revenue as a consequence of the storms or the worsening of debt costs as a consequence of the debt increase.

The bilateral and multilateral aid received by Belize was insufficient to cover the increase in expenditures. Indeed, as shown in Figure 1, bilateral and multilateral aid flows did not increase significantly in the aftermath of the 2000 and 2001 hurricanes. Note that the spike in bilateral aid corresponds to an unusually large donation from the United Kingdom (the former colonial ruler of Belize) in the year 1999 that predated the first of the two major hurricanes that struck Belize in 2000 and 2001. Interestingly, this aid shortfall does not appear to be a unique feature of the case of Belize. Bobba and Powell (2006), using a large panel data set, find no evidence that natural disasters affect the pattern of

[5] Also see studies cited in the article.
[6] Belize's average total population is approximately 300,000 people.
[7] This is equivalent to 0.7 percent of the GDP of the year 2000, the base year for the calculations. The information is available at http://www.em-dat.net/.
[8] IMF Article IV reports, several issues.

FIGURE 1
Bilateral and Multilateral Aid Flows to Belize, 1970–2003



Source: OECD (2005).

bilateral and multilateral aid flows.[9] In other words, controlling for other determinants of aid, the occurrence of natural disasters does not have a statistically significant effect of increasing international aid. This suggests that the expectation of large aid inflows in the aftermath of natural disasters might be unwarranted.[10]

The low levels of private insurance observed in the region, along with the limited diversification of risk feasible at the domestic level in a small economy such as Belize, created a large volume of contingent liabilities for the government, which were triggered in the aftermath of the natural disasters of 2000 and 2001.

The fiscal primary deficit increased from 2.2 percent of GDP in fiscal year 1998–1999 (just before the two major storms hit the country) to 7.3 percent of GDP in 2000–2001. The overall deficit increased from 4.1 percent to 9.7 percent of GDP in the same period, whereas total debt increased from approximately 40 percent of GDP in 1998–1999 to over 100 percent of GDP in 2003–2004. Even though the fiscal accounts were in disarray

[9] While international aid does not flow as is often expected by many countries, the development banks very often accelerate disbursement through a restructuring of current operations. This has been termed "development mission risk." We thank an anonymous referee for pointing this out to us.

[10] The lack of contemporaneous correlation between natural disasters and international aid in the data is not enough to rule out a relationship between the two variables, as the (*ex ante*) level of aid flows could be determined by the likelihood of a disaster. In other words, disaster-prone areas might always receive more aid flows in anticipation of shocks.

despite the incidence of the storms (e.g., there was a public sector wage increase of up to 8 percent in each of the 3 years ending in 2005–2006, which added some 1.5 percent of GDP to government expenditures),[11] the combination of the large scale of the disasters with low levels of private insurance and limited foreign aid in the aftermath of the storms led the government to increase the deficit even more and issue external debt to pay for emergency relief and reconstruction of infrastructure. The end result was that the country's debt dynamics became increasingly unsustainable as the servicing of external debt became more and more expensive. Repeated refinancing operations led to a continuous rise in borrowing costs, with the effective weighted average interest rate on the external public debt owed to private creditors increasing from 6.4 percent in 2003 to 11.3 percent in 2006. This increase in the cost of servicing the debt also had its effect on fiscal performance, and interest expenses climbed from 2 percent of GDP in 1999–2000 to 5.9 percent of GDP in 2005–2006, with an additional expenditure of 2.7 percent of GDP on account of fees and charges for reprofiling debt and arranging external loans. By fiscal year 2005–2006, the burden of interest on public debt reached 25 percent of fiscal revenues (see Glenday and Shukla, 2006).

In light of this fragile situation, Belize formally announced in August 2006 its intention to start negotiations with private foreign creditors to restructure debt instruments and seek a relief in payment terms. The public offer was opened in December 2006, and the formal negotiations ended on January 26, 2007.

Beyond the specifics of the debt restructuring process undertaken by Belize, it is clear that the debt problems that led to that process resulted in part from natural disasters. Thus, the government's objective of achieving a sustainable debt path would require reducing the impact of future natural disasters on fiscal accounts and indebtedness. It is in this context that government fiscal insurance for natural disasters provides a promising tool to support these objectives. In this sense, insurance could play an additional positive role mitigating moral hazard as the government would not be able to use the cost of reconstruction to cover up uncontrolled fiscal spending.

Instruments for Catastrophic Insurance

Governments in countries that are vulnerable to natural disasters appear to have only a limited set of options available to insure public finances against those risks. Hofman and Brukoff (2006) survey some recent initiatives in this regard. The modalities of risk transfer for public finances, to the extent that they exist, are similar to the ones used by the private sector. For example, among the particular modalities of risk transfer that are relevant for catastrophic risk, they document the importance of *reinsurance*. The risk characteristics of catastrophe insurance claims differ from other insurance products. A company providing car insurance can achieve a good diversification if it has many clients because in that case the volume of claims would be predictable with a high level of accuracy. In contrast, natural disasters are low-probability events that cause extremely large losses when they occur and thus not easily diversifiable in the same way as car insurance. This low level of possible diversification tends to increase the cost of insurance. Primary insurers need to transfer a considerable share of their catastrophe exposure to large reinsurers, namely, companies that act as insurers of the

[11] See Glenday and Shukla (2006).

retail insurance companies. The increased reliance on reinsurers increases the cost of primary insurance, reducing its attractiveness and scope. With less available insurance for the private sector, the contingent liabilities of the government increase. In recent years, reinsurers themselves have also begun to rely more on capital markets to reduce their own exposure.

The success of the private catastrophe bond markets ("cat bonds") has prompted governments and international institutions to explore their use as a mean of shielding governmental budgets from the impact of natural disasters. A cat bond is a tradable instrument that facilitates the transfer of the risk of a catastrophic event to capital markets. A typical structure is one in which the investors purchase a safe bond, such as a U.S. Treasury bond, for the desired amount of coverage and deposit it with a special purpose vehicle (SPV) institution, which is legally distinct from the parties. The investors collect the interest on the bond plus the insurance premium that is paid by the insured party while the disaster does not occur. If the disaster strikes, however, their claim is extinguished and the SPV sells the bond and transfers the funds to the insured.

In May 2006, the Mexican government obtained earthquake insurance by means of cat bonds and a direct purchase of coverage from international reinsurers for a total coverage of US$450 million (see IDB, 2007, Box 14.2). These instruments provide parametric insurance, which means that predetermined payouts will be made in case of the occurrence of an earthquake in three at-risk areas of the country's Pacific coast and around Mexico City. This is the first catastrophe bond placed by a Latin American country and is expected to be the first step in the Mexican government's plan to secure insurance against natural disasters, including hurricanes. Mexico has been operating a disaster fund, the FONDEN, since 1996 as a saving vehicle to build up resources to be used by local governments in case of a major earthquake, but the fund had become nearly depleted, and the scheme was recognized as economically inefficient and vulnerable to political voracity.

In the Caribbean case, the CCRIF is intended to provide the financial instruments, expert advice, and donor support to encourage all countries in the region to obtain coverage against hurricanes and earthquakes. By pooling all the countries in a portfolio, the CCRIF expects to gain scale economies and diversification because the losses caused by any given event tend to be concentrated in one or two countries only, implying that the correlation of risks among the whole group of countries is low. Annual premiums for participating countries vary from US$200,000 to US$2 million for payouts from US$10 million to US$50 million. There is no cross-subsidization among the participating governments. Each government's premium is directly related to each country's specific risk profile based on models developed by specialized firms for the CCRIF. The facility was formally launched in a conference held in Washington, D.C. in February 2007, where donors pledged US$47 million to the reserve fund. Donors' financial contributions to the reserves of the facility will help all participating countries through a reduction in the amount of reinsurance that needs to be purchased. As reserves increase, the pool will become increasingly resilient and less dependent on reinsurance, with a consequent reduction in the cost of premiums. The expert assistance provided by the World Bank will further reduce costs to the participating countries, and peer pressure will encourage politicians to join the facility. CCRIF was able to secure US$110 million of claims paying capacity on the international reinsurance and capital markets. In June 2007, the facility became operational when the World Bank announced that 16 countries from the Caribbean community has subscribed.[12]

DISASTER INSURANCE AND DEBT SUSTAINABILITY

This section analyzes the potential contribution of disaster insurance to debt sustainability in Belize. The framework used for debt sustainability analysis is in line with the nascent literature that incorporates the structure of random shocks hitting the domestic economy to obtain a complete distribution of probable outcomes for the debt-to-GDP ratio rather than simply projecting one central scenario. This approach recognizes that even when the government is resolute in pursuing its fiscal targets, the outcomes are subject to significant risks, especially as the planning horizon lengthens.[13]

To focus on the case of Belize, we assume that the government issues only foreign-currency-denominated debt,[14] paying interest rate r^f, and that the country is prone to natural disasters (in this exercise, hurricanes) that, when they happen, lead to additional borrowing to pay for reconstruction. In this case, the evolution of the debt-to-GDP ratio follows the standard equation augmented by the incidence of hurricanes on primary expenditures:

$$d_t = \left(\frac{1 + r_t^f}{1 + \Delta y_t} \right) d_{t-1} - f_t + H(Category)_t, \tag{1}$$

where d_t is the debt-to-GDP ratio, Δy_t is the rate of growth of GDP, f_t is the primary surplus of the budget over GDP, and $H(Category)_t$ is the ratio of the budgetary cost of a hurricane to GDP, which is an increasing function of its category (intensity).[15] In a year without hurricanes, $H(0) = 0$.

Next, assume that the government purchases catastrophic-risk insurance through, for example, the CCRIF facility. In that case, the debt-to-GDP ratio is given by the following modified version of Equation (1):

$$d_t = \left(\frac{1 + r_t^f}{1 + \Delta y_t} \right) d_{t-1} - f_t + H(Category)_t + P(M) - I(M, Category), \tag{2}$$

where $P(M)$ is the insurance premium (as a percentage of GDP) that is a function of M, the insurance coverage limit (the prescribed payout), and $I(M, Category)$ is the insurance

[12] Participating countries in the new program are from the Caribbean Community and Common Market, or CARICOM: Anguilla, Antigua & Barbuda, Bahamas, Barbados, Belize, Bermuda, Cayman Islands, Dominica, Grenada, Haiti, Jamaica, St. Kitts & Nevis, St. Lucia, St. Vincent & the Grenadines, Trinidad & Tobago, Turks and Caicos Islands. For details, see http://www.ccrif.org/.

[13] This exercise is very similar in spirit to García and Rigobón (2004), Celasun et al. (2006), and Ferrucci and Penalver (2003).

[14] Belize has maintained a fixed exchange rate regime since 1976 and is committed to maintaining it. Therefore, there is no exchange rate risk associated with the country's debt dynamics.

[15] We assume, for simplicity, that not more than one hurricane can hit Belize per year. The assumption is not restrictive, as multiple mild hurricanes might be equivalent, in terms of total costs, to a single severe one.

TABLE 1
Forecast and Standard Deviations

Year	Δy_t	r^f	10 Years Treasury	Spread	f_t
2006	9.3	7.9	5.1	2.8	3.2
2007	5.1	7.4	5.1	2.3	3.3
2008	4.6	7.2	5.1	2.1	3.3
2009	4.7	7.8	5.2	2.6	3.3
2010	4.8	8.3	5.3	3.0	3.3
2011	5.1	7.6	5.3	2.3	3.3
2012	5.1	7.6	5.4	2.2	3.3
2013	5.1	7.6	5.4	2.2	3.3
2014	5.1	7.6	5.4	2.2	3.3
2015	5.1	7.6	5.4	2.2	3.3
2015–2020[a]	5.1	7.6	5.4	2.2	3.3
Standard deviation	2.7	1.2			4.0

Source: IMF.
[a]Projections are based on the extension of IMF forecasts year-end in 2011.

payout function as a percentage of the GDP, which depends positively on the preset limit and on the hurricane's intensity level. The insurance premium is a cost that reduces the government's primary surplus, so it enters with a positive sign on the right-hand side of Equation (2). As with any insurance policy, the premium is paid every year, but the payoffs are triggered only in the aftermath of a verifiable hurricane. If there are no hurricanes in a given year, then $I(M,0) = 0$.

To illustrate the range of likely debt-to-GDP ratios for the period between 2006 and 2020, we follow three steps. First, we generate 1,000 random realizations of the stochastic variables Δy_t, r_t^f, and f_t for each year using the IMF's forecasts for the years 2007 to 2011 as the baseline values.[16] The stochastic shocks to each series are assumed to follow a normal distribution with mean zero and standard deviations that are based on their historic volatility.[17] The forecasts and standard deviations used are shown in Table 1. Note that although we are formally treating all the variables as independent from each other in our simulations (i.e., we set the covariance of shocks equal to zero), the fact that we are using the IMF forecasts already incorporates some correlation between the variables. The projected levels of r_t^f are disaggregated into its component parts: the U.S. Treasury bond yield and the sovereign spread over U.S. Treasuries, which captures the country's credit risk.

[16] The IMF, in its latest Article IV consultation staff report (October 2006), provides forecasts for the variables of interest until the year 2011. For the years 2012 to 2020, there are no forecasts, so we simply extend the previous ones forward. Although this is not the best solution, an alternative would have been to run the simulations up to 2011 only, which would not be very informative in illustrating the effect of low-probability events such as hurricanes.

[17] For most variables we have approximately 10 years of historic information.

TABLE 2
Probability Distribution and Cost of Hurricanes by Category

Hurricane Category	1	2	3	4	5	6	7
Probability of occurrence (%)	13.0	8.0	5.0	4.0	2.0	1.0	0.4
Cost (% GDP)	2.5	5.0	7.5	10	13	22	35

Source: World Bank (2006), author's elaboration.

TABLE 3
Cost of Hurricane Insurance

Insurance Amount (US$ Millions)	Insurance Premium (US$ Millions)
0	0
30	1.6
60	3.2
120	6.4
180	9.6
240	12.8

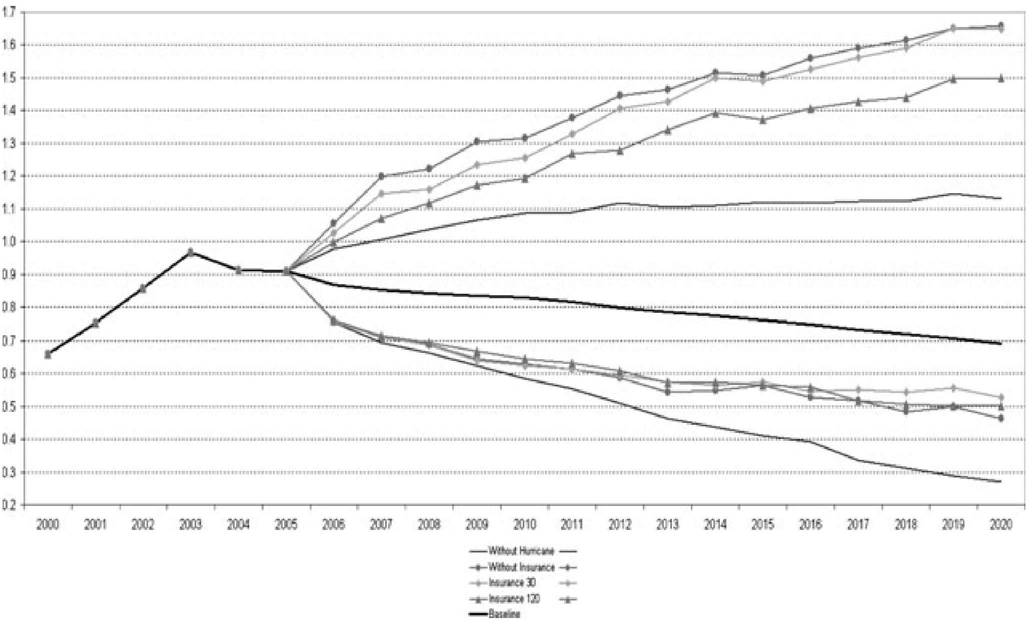
Source: World Bank (2006), author's elaboration.

Second, we generate realizations for the random variable $H(Category)_t$. In line with historical data (see World Bank, 2006), we divide the hurricanes into seven categories, with each category having a different probability of occurrence and implying a different level of cost to the economy, as shown in Table 2. Note that the probability of occurrence of a hurricane of any level of intensity in a given year is approximately 33 percent. We simulate 1,000 stochastic series of the variable $H(Category)_t$ by means of building a random sample with replacement based on the probability distribution shown in Table 2.

The values for $P(M)$ and $I\,(M, Category)$ are obtained from World Bank (2006), applying interpolation. Table 3 summarizes the different preset coverage limits M that would correspond to different premium payments, $P(M)$. The actual insurance payouts I (M, *Category*) depend on the *Category* of the hurricane and its projected associated costs, which are estimated *ex ante* based on historic data and are part of the insurance contract. In the event that there is a hurricane on a given year, payouts are automatically triggered and increase with a sliding scale, which is predetermined, based on the expected costs associated to each category of storm, up to a maximum coverage level M. Thus, there is no need to asses the *actual* costs of the event in its aftermath as payouts are based on the *ex ante* calculations of the expected costs. This is a key advantage of parametric insurance.

Finally, we simulate the path of d_t using Equations (1) and (2). The "fans" in Figure 2 represent the range of values that have 98 percent of probability of occurrence. In other words, after excluding the 2 percent of simulations that yield the most extreme values

FIGURE 2
Debt Sustainability Analysis (DSA): Fan 1 (Confidence Intervals at 98%)



for the debt-to-GDP ratio, the remaining values span the range plotted in Figure 2. The baseline scenario (i.e., the expected evolution of the debt-to-GDP ratio based on the forecasts and in the absence of any additional shocks) is also included.

Figure 2 combines four possible scenarios together with the baseline case. Each scenario represents different levels of insurance coverage, as follows: (1) Belize does not have insurance against hurricanes, (2) Belize has insurance against hurricanes with a limit of US$30 million and pays insurance premium of US$1.6 million,[18] and (3) Belize has insurance against hurricanes with a limit of US$120 million and pays an insurance premium of US$6.4 million. Finally, for comparability purposes, we include a hypothetical scenario (4) in which the country is free from the risk of hurricanes. The latter scenario is introduced in order to evaluate how the different levels of insurance allow the country to get closer to the situation that it would face if it had no risk of hurricanes. Scenario (2) is of particular interest, as it is the one that mimics the World Bank's proposal for Belize under the CCRIF. Scenario (3) quadruples the coverage limit to assess the potential benefits of a much larger coverage. Our sensitivity tests suggest that US$120 million of coverage is approximately the tipping point, whereby the costs of a higher level of insurance start to outweigh the benefits (as will be discussed further below).

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[18] Although we do not know exactly how much each country paid to the CCRIF when they subscribed in June 2007, the publicly available information in the World Bank's web site indicates that annual premiums for all countries vary from US$200,000 to US$2 million for payouts from US$10 million to US$50 million. This is consistent with the US$1.6 million premium for US$30 million coverage used for the simulations done for Belize.

In this exercise, the government starts from a vulnerable position: a debt-to-GDP ratio around 90 percent (in the year 2005, which is the start of the simulation period).[19] The baseline scenario—which illustrates the expected debt-to-GDP trajectory if the government complies with the fiscal target of a surplus of approximately 3.3 percent of GDP, the economy grows at approximately 5.1 percent on average, interest payments on debt are as projected by the IMF (see Table 1 for details), and the economy is not hit by any unexpected shocks—shows the debt-to-GDP ratio reaching a level of approximately 70 percent by 2020, with a declining tendency. If the economy is only prone to *normal* volatility (i.e., no risk of hurricanes), then with a 98 percent probability the debt-to-GDP ratio could reach by 2020 anywhere between approximately 110 percent of GDP (worst-case scenario) and under 30 percent of GDP (best-case scenario). In other words, this range is the cone of uncertainty around the baseline scenario in the hypothetical case that the economy is not under risk of natural disasters.

But Belize is prone to hurricanes and the costs of these to the economy are significant. Taking disaster risk into account and incorporating the incidence of hurricanes to the equation of the evolution of the debt-to-GDP ratio, the cone of uncertainty around the baseline scenario expands to almost 170 percent of GDP in the worst-case scenario, and to a little under 50 percent of GDP in the best-case scenario. This is evidence that hurricanes, in and on themselves, worsen the debt sustainability picture considerably by increasing the likelihood of explosive debt-to-GDP trajectories, simultaneously reducing the chances of declining trajectories.

How can catastrophic risk insurance help to improve debt sustainability? The results show that an insurance level of US$30 million (as proposed by the World Bank under the CCRIF) reduces the cone of uncertainty in the direction of the case without hurricanes but only moderately so by the year 2020. However, as expected, bigger insurance limits render bigger reductions in uncertainty over future debt-to-GDP paths. An insurance with a limit of US$120 million reduces the range of possible outcomes by approximately 20 percentage points without a significant impact on the baseline debt path. In the worst-case scenario, the debt-to-GDP ratio falls to approximately 150 percent of GDP by 2020 (still above the 110 percent level of the case without hurricanes but below the 170 percent level of the case without insurance), whereas in the best-case scenario the debt ratio stabilizes at approximately 50 percent of GDP (approximately the same level as the case without insurance but still above the 30 percent level of the case without hurricanes).

Our sensitivity tests suggest that US$120 million is approximately the optimal level of insurance for Belize in terms of debt sustainability. The calculations are summarized in Table 4. This table shows the maximum (worst-case scenario) and the minimum (best-case scenario) level of the debt-to-GDP ratio for Belize by the year 2020, as well as the range (the difference between the maximum and minimum values) under different insurance coverage limits. Note that higher insurance levels are always associated with higher premiums and, when the coverage limit exceeds US$120 million, the higher premiums are not compensated by additional gains in terms of debt sustainability, as neither the minimum nor the maximum levels of the debt-to-GDP ratio fall by the

[19] The debt restructuring process, ended in January 2007, does not include reductions in the face value of the debt (i.e., nominal haircut).

TABLE 4
Optimal Insurance

	Debt Over GDP, Year 2020		
Insurance Amount (US$ Millions)	Min	Max	Range
0	0.46	1.66	1.20
30	0.53	1.65	1.12
60	0.51	1.54	1.03
120	0.50	1.49	0.99
180	0.53	1.50	0.97
240	0.58	1.52	0.94

Source: Author's elaboration.

year 2020. Although the range of the debt-to-GDP ratio still falls slightly when the coverage limit exceeds US$120 million, this is only because the minimum possible debt-to-GDP ratio *increases* by more than the maximum, which implies a worsening of debt sustainability.

Indirect Gains From Disaster Insurance

As the occurrence of disasters worsens debt sustainability, this fact will be reflected in the country's borrowing conditions in financial markets. Natural disasters create a burden on fiscal resources that will worsen creditworthiness in the view of investors in most cases. The recent experience of Belize indicates that borrowing conditions deteriorated sharply in the aftermath of the natural disasters. Moreover, the pattern of deterioration of external financing conditions is evident in other emerging markets too. In Table 5, we report results on the determinants of the emerging markets bond index (EMBI) spread (a proxy for country's credit risk and thus its cost of international borrowing) by augmenting the baseline specification proposed by González-Rozada and Levy-Yeyati (2008) to consider the incidence of wind storms.[20] The effect of hurricanes on sovereign spreads is captured by the point estimate of a dummy variable that takes a value of 1 in the month that the corresponding country is hit by a storm.[21] Column 1 shows that, on average, wind storms increase sovereign spreads by approximately 40 percent. In addition, column 2 shows that the impact is persistent over time, lasting 6 months after the occurrence of the catastrophic event.

[20] The frequency of the data is monthly, and the sample consists of all emerging markets that are listed in the EMBI. See González and Levy-Yeyati (2008) for details.

[21] We consider wind storms that have been classified as natural disasters. According to EM-DAT, at least one of the following criteria must be fulfilled in order for an event to be classified as a natural disaster. First, 10 or more people killed. Second, 100 or more people affected/injured/homeless. Third, significant disaster (e.g., "worst disasters in the decade"). Fourth, significant damages (e.g., "most costly disaster"). Finally, declaration of a state of emergency and/or an appeal for international assistance.

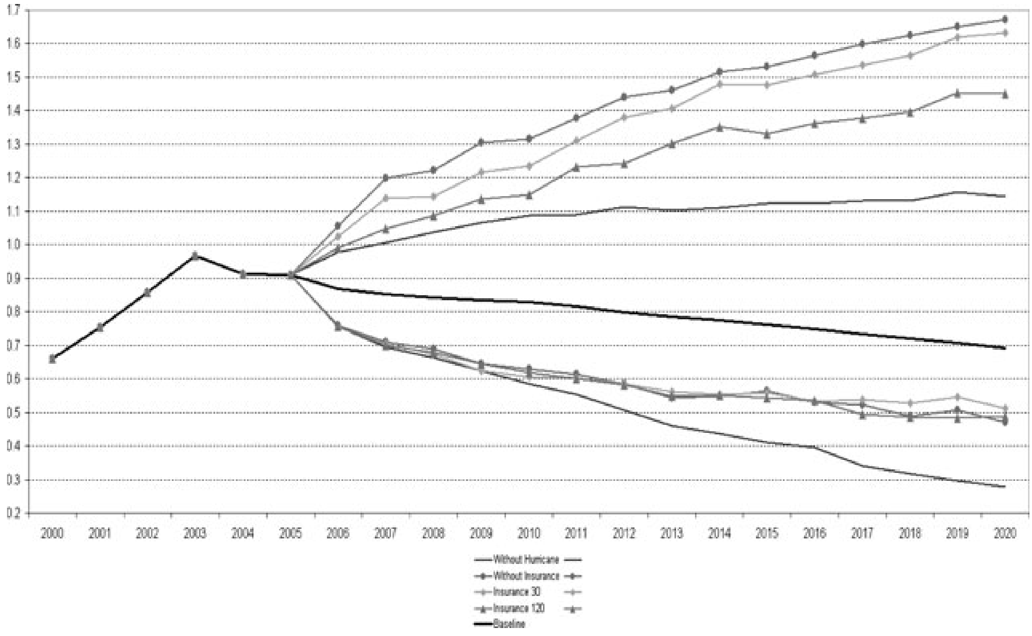
TABLE 5
Wind Storms and Emerging Market Spreads

	(1) Ln($EMBI_t$)	(2) Ln($EMBI_t$)
Ln(High $yield_t$)	0.586^{***}	0.646^{***}
	(0.132)	(0.117)
Ln(Sovereign $rating_{i,t}$)	-1.323^{***}	-1.329^{***}
	(0.120)	(0.124)
Ln($10YT_t$)	0.870^{**}	0.800^{**}
	(0.342)	(0.316)
$Storm_t$	0.420^{***}	0.325^{***}
	(0.067)	(0.058)
$Storm_{t-1}$		0.261^{***}
		(0.033)
$Storm_{t-2}$		0.211^{***}
		(0.026)
$Storm_{t-3}$		0.210^{***}
		(0.035)
$Storm_{t-4}$		0.240^{**}
		(0.074)
$Storm_{t-5}$		0.238^{***}
		(0.054)
$Storm_{t-6}$		0.221^{*}
		(0.097)
Constant	1.901^{***}	1.891^{***}
	(0.438)	(0.387)
Observations	1,890	1,743
R^2	0.628	0.640

Note: Regressions are based on the baseline specification proposed by González-Rozada and Levy-Yeyati (2008). Robust standard errors are in parentheses.
*Statistically significant at 10 percent level.
**Statistically significant at 5 percent level.
***Statistically significant at 1 percent level.

To incorporate this effect in the debt simulations, we assume that disaster insurance would facilitate a decrease in the level of Belize's sovereign spreads, as well as a simultaneous reduction in the volatility of the interest rate on sovereign debt. Thus, we assume that in the case of a US$30 million coverage limit, the existence of insurance permits a decrease in the sovereign spread of 20 percent (i.e., around 60 basis points), as well as a 20 percent decrease in the volatility of the interest rate applied to Belize's

Figure 3
Debt Sustainability Analysis (DSA): Fan 2 (Confidence Intervals at 98%)

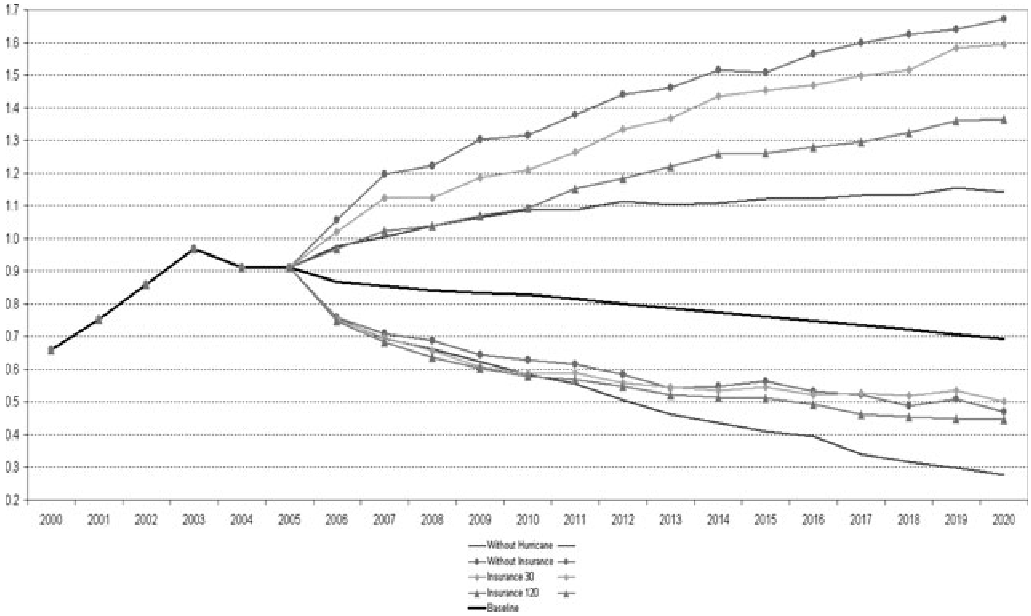


debt. In other words, we suppose that the existence of insurance improves the conditions under which the country has access to external borrowing in both the level and volatility dimensions. With more insurance, the credit enhancement effects are possibly stronger. We assume that coverage of US$120 million lowers spreads by 40 percent (i.e., around 120 basis points) and reduces volatility by 40 percent. Thus, we assume that with this amount of insurance, the incidence of storms on spreads identified in the regressions reported in Table 5 is neutralized. Although the specific assumptions are somewhat arbitrary, they are indicative of the potential benefits. In particular, note that by assuming that coverage of US$120 million lowers spreads by 40 percent, we are suggesting that this particular level of coverage (that we have identified as optimal for the case of Belize in terms of debt sustainability) effectively eliminates the contemporaneous impact of hurricanes on borrowing costs identified in the regressions reported in Table 5.

Figure 3 shows the same set of simulations as Figure 2 but under the assumption that catastrophic-risk insurance has the aforementioned additional beneficial effects in terms of market access. The results show that now even insurance with a maximum limit of US$30 million has nonnegligible beneficial effects in terms of improved debt sustainability for Belize. In the worst-case scenario, the debt-to-GDP ratio falls from 170 percent of GDP by 2020, to below 160 percent with US$30 million in insurance, and to approximately 145 percent with US$120 million insurance (recall that in the case without hurricanes the worst-case scenario has a debt-to-GDP ratio of 110 percent

FIGURE 4

Debt Sustainability Analysis (DSA): Fan 3 (Confidence Intervals at 98%)



by 2020). In the best-case scenario, the debt-to-GDP ratio stabilizes at slightly over 50 percent for both levels of insurance.

Finally, in Figure 4 we incorporate an additional stabilizing effect of catastrophic risk insurance by assuming that it also helps to mitigate the output fluctuations that are so common in the aftermath of these events. For example, if insurance reduces the debt hikes caused by the hurricanes, then credit access might be maintained, enabling a faster and smoother recovery of economic activity. Also, if the insurance contract provides a stable flow of funds that guarantees that the government is able to continue its operations, then overall economic activity might suffer a smaller disruption. The existing cross-country empirical evidence on output fluctuations suggests that less aggregate volatility might itself increase growth rates.[22]

There may also be an aggregate effect on economic growth stemming from the unavailability of disaster insurance at the individual level. Households may take actions that help them cope with the disaster risk but that are inefficient in terms of resource allocation for the aggregate economy. For example, Morduch (1995) reviews studies that have shown the use of variability-reducing input choices and diversification of economic activities as means to smooth household income in countries like India and Thailand, all of which entail significant economic cost in the aggregate. Pörtner (2006) concludes that the risk of hurricanes in Guatemala increases fertility and encourages migration. These

[22] See, for example, Ramey and Ramey (1995).

indirect effects of disasters are hard to measure but may have a large macroeconomic impact.

All in all, the idea that insurance could help to mitigate output volatility seems reasonable. Therefore, in this set of simulations we assume that insurance with a limit of US$30 million causes a decrease in the volatility of Δy_t of 10 percent and an increase in the growth rate equivalent to 0.75 percent per annum. These effects are in addition to the effects on the interest rate and interest rate volatility. Similarly, an insurance with a limit of US$120 million produces a decrease in the volatility of Δy_t of 20 percent and an increase in the level of growth equivalent to 1.5 percent per annum. Once again, although these assumptions are evidently arbitrary, they are indicative of the enhanced potential benefits of insurance. These additional stabilizing effects of insurance have the result of reducing the cone of uncertainty of the debt-to-GDP ratio even more. With insurance, the distribution of probable outcomes of the debt-to-GDP ratio approximates more closely the hypothetical case of no hurricanes.

In summary, the results suggest that catastrophic risk insurance helps to mitigate the impact of hurricanes by reducing the cone of uncertainty around the baseline debt-to-GDP trajectory. An insurance level of US$120 million goes a long way toward replicating the probable outcomes of the debt-to-GDP trajectories that would prevail in the hypothetical case of no hurricanes, especially if we assume that insurance has also stabilizing effects in terms of output and financial conditions. Our sensitivity tests suggest that US$120 million of coverage is approximately the tipping point beyond which the costs of higher level of insurance start to outweigh the benefits.[23]

THE DARK SIDE OF INSURANCE

Insurance markets are imperfect in most cases. It has been well documented in the literature that moral hazard is a big problem in insurance markets (see, e.g., Stiglitz, 1977, 1983). Moral hazard in the insurance context is a phenomenon whereby the insured takes more risks just because it is insured. Parsons (2003) defines moral hazard as "essentially an incentive problem, arising from asymmetric information of agents and the difficulty that insurers have in discriminating between the actions of the insured on the one hand, and exogenous uncertainty on the other" (p. 451). Taking this definition as a benchmark, one can ask whether catastrophic risk insurance for government budgets is susceptible to moral hazard problems.

At a first level, the answer is "no" because hurricanes are by definition exogenous events. Indeed, the background document of the CCRIF argues that "parametric insurance policies offered by the CCRIF are exempt from moral hazard because the indexes used in the calculation of the indemnity payouts (for example, wind speed, ground motion) are independent of the individual actions of the governments" (p. 57). Although this is true, it refers only to one source of moral hazard, namely the "policyholder hazard." The latter is defined in the Parsons (2003) taxonomy as the moral hazard that arises from the

[23] This estimation is based on the simulations without the additional gains. The optimal level of insurance if we include the additional gains depends on the assumptions made, so we prefer to rely on the results obtained for the benchmark case.

possibility that the policyholder, knowing that he/she is insured, will change his/her behavior in a way that increases risks.

There are, however, other sources of moral hazard that can be equally, or even potentially more, troublesome than the policyholder hazard in the context of catastrophic risk insurance for government budgets. For example, it is possible that the private sector in insured countries would choose not to take out private insurance at all, in the expectation that the government will pay for reconstruction in the event of a catastrophe, using the proceeds from its own insurance coverage. This is important because with lower levels of private insurance, the size of the government's contingent liabilities grows, rendering any level of public insurance less effective. Therefore, while with catastrophic risk the policyholder hazard might be low, the "third-party hazard" is potentially important, so the moral hazard problem is alive. Although there are no easy ways out of moral hazard problems, the government has tools to monitor and influence the behavior of the private sector. For example, appropriate regulation and enforcement could help mitigate third-party hazard. There might be other ways too. One possibility is that the government makes payouts for emergency reconstruction of private properties, based on the estimated value of the damaged property minus a deductible, so that each owner has incentives to privately insure for the amount of the deductible. In fact, deductibles and copayments are mechanisms utilized commonly to limit moral hazard problems in insurance contracts. Another possibility is the assessment of extraordinary taxes on uninsured property and the publication of a list of uninsured properties in order to elicit peer-monitoring mechanisms.[24] The bottom line is that the dangers generated by third-party hazard do not invalidate the benefits of catastrophic risk insurance in the same way that policyholder hazard does not invalidate, for example, the value of car insurance. Although policymakers should be aware of the dangers of moral hazard, and should be prepared to address them, they should not disregard insurance altogether.

Another potential problem associated with catastrophic risk insurance is that governments themselves might have few incentives to purchase insurance in the expectation that the international community will step in and provide foreign aid in the aftermath of a large-scale catastrophe. Perhaps surprisingly, the available data do not support that conjecture. As mentioned above, Bobba and Powell (2006), using a large panel data set, find no evidence that natural disasters affect the pattern of bilateral and multilateral aid flows. This means that there is no evidence that aid is an appropriate substitute for insurance. Furthermore, even when there is an increase in aid in the aftermath of a particular catastrophe, according to the background document of the World Bank's CCRIF, donors' assistance can take a long time to materialize and usually is earmarked for specific investments. For example, Yang (2006) finds evidence that although hurricanes trigger increases in official development assistance, they do so with a 1-year lag. All in all, the evidence suggests that the expectation of a large surge in aid flows in the aftermath of natural disasters is overoptimistic.

[24] See, for example, Arnott and Stiglitz (1991) on the potential importance of peer-monitoring mechanisms in mitigating moral hazard.

CONCLUSIONS

Disaster risks are of huge magnitude in the Caribbean region and in Belize in particular. This article made the case that hurricane insurance could enhance debt sustainability and economic performance more generally. Although market imperfections and political reticence have deterred the adoption of insurance, recent developments have improved the outlook on both fronts.

International institutions such as the World Bank and the Inter-American Development Bank can play a role in assisting countries to overcome the distortions in insurance markets, as well as helping to relax the internal political resistance to the purchase of insurance policies. On the one hand, the provision of adequate information on the potential benefits of insurance, as well as on the risks associated with absence of insurance, are important elements of persuasion. Furthermore, the involvement of these organizations in developing markets in which countries could purchase insurance at reasonable prices would go a long way toward reducing the barriers to entry that countries now face. That is one of the primary objectives of the CCRIF, under the leadership of the World Bank and with the support of the Inter-American Development Bank, among others. Once the process gets started and some countries sign on, peer pressure might help to bring other countries on board as well. Finally, international financial institutions, in their roles as donors, should perhaps consider making concessional loans or aid contingent on the governments having previously purchased catastrophic risk insurance. All of these actions together can help to develop the right incentives and the appropriate instruments to expand the markets for government budget insurance against natural disasters.

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