Payouts for Perils: Why Disaster Aid Is Broken, and How Catastrophe Insurance Can Help to Fix It

Theodore Talbot and Owen Barder

Abstract

Disaster aid is often too little, too late. Pressure on aid budgets is prompting donors to find ways to handle more crises with less funding. But the current model of discretionary, ex-post disaster aid is increasingly insufficient for these growing needs, and does little to create incentives for governments in affected countries and donors to invest in risk reduction and resilience. This framing paper sets out how the global community can do better. It proposes combining novel insurance contracts that provide fast payouts based on 'parametric' triggers with clear incentives to manage risks and invest in reducing losses. Pilot programmes show that the model can work. The challenge is to provide coverage for a broader range of risks, explicitly align incentives in managing risks and reducing losses, and determine the appropriate role for governments and donors. Properly implemented, an insurance paradigm for disaster aid will save many more lives for much less money.

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Introduction

Natural and man-made hazards cause death, hardship and poverty for millions of people. Those losses are concentrated in poor countries. There is an implicit offer of assistance from the international community in the event of these disasters, through aid provided by donors, NGOs and multilateral agencies– the ecosystem of actors that we call here the *global public sector*.

That mutual assistance goes some way towards protecting people from devastating losses. But because it is provided at the discretion of donors, often after the hazard has become an emergency, assistance is usually too unpredictable, too little, or too late. And because there is no clarity about who will bear the costs of a disaster, insufficient incentives are created to reduce risks and limit losses.

This framing paper argues that innovative insurance contracts can save lives, money, and time. We set out the weaknesses of the dominant paradigm of an *ex-post*, discretionary financing model for emergencies. Because late and unpredictable financing inflicts such large costs on those affected and limit the effectiveness of governments and front-line organisations, we argue that insurance contracts in general – and the financial innovation of index-linked securities such as catastrophe bonds in particular – are a much better way to pay for our response to hazards.

Of course, more and better insurance cannot solve every problem that forms part of the humanitarian caseload. It will be harder to structure these contracts for some perils like armed conflict, especially where the risks involved are not exogenous. But insurance financing is useful for a very large range of hazards currently handled using overstretched *ex-post* emergency aid, including rapid-onset hazards like cyclones and disease outbreaks, and slow-onset hazards like drought.

Developing insurance solutions based on data like the wind-speed of cyclones or the violence of earthquakes would tackle these problems much more effectively, and it would preserve scarce humanitarian funds for those emergencies that cannot be insured. Such so-called parametric insurance provides fast payouts by contracting on risks that are strictly beyond the control of both insurers and the insured. But– precisely because the risks are exogenous– these contracts will not, on their own, create healthy incentives to reduce future losses and so lower premiums, in the way that that market pricing of a home insurance policy might provide you with financial incentives improve your home security.

We therefore propose that, in addition to scaling up access to parametric insurance, a key innovation might be novel contracts that link parametric payouts to incentives for risk management and financing for investments in resilience. The paper concludes by setting out how the right kind of innovative insurance contract will provide a 'win-win-win' of access to fast payouts that save lives, useful incentives to lower the costs of future hazards, and a lower overall financial cost to the global public sector.

Emile and Erika: Two Images of Disaster Response

The dominant model is for international aid to arrive after hazards are realised. In principle, this might be as good as a more formal insurance contract. In practice, relying on aid has substantial disadvantages. Two cases help set out the differences between the 'aid' and 'insurance' models of disaster assistance, and motivate our argument for innovation.

Ebola in West Africa

Emile Ouamouno was a six year-old boy who lived in the southern *Nzérékoré* region of Guinea. On December 2nd, 2013, he was either bitten by a bat, or perhaps ate fruit that a bat had already eaten. He was seriously ill a few days later. Taken to hospital, he was misdiagnosed with Lassa fever, a haemorrhagic fever endemic to West Africa. Despite getting rudimentary treatment, he died on December 6th. His mother and sister died soon afterwards, and the viral infection we now know to be Ebola began its exponential spread through the region (Fink, 2014).

By March, 2014, the outbreak had been correctly identified by testing at a facility in Dakar. Fears about the economic consequences of declaring a public health emergency caused senior World Health Organisation (WHO) leaders to dither. On March 23rd, the WHO finally announced the discovery with a "two-sentence update on its website" (AP, 2015).

Médecins Sans Frontières staff had described the outbreak as "out of control" on June 24th, yet the WHO did not set out a joint response plan for resources and staff to tackle the outbreak until July 31st (The Lancet, 2014). Finally, on August 8th, the WHO described the outbreak as a "public health emergency of international concern" after a two-day meeting, triggering international deployments of troops and medical corps by donors. Between March and the time of writing, the epidemic has killed an estimated 11,287 people and cost three affected countries over $2 billion in lost national income.

Two Hurricane Seasons in the Caribbean

The official hurricane season lasts from June through November in the Atlantic. "Named storms" batter the small island countries of the Caribbean, which are also vulnerable to landslides and earthquakes. Amongst the most deadly storm seasons on record was 2004, when Hurricane Ivan made landfall on several of the Caribbean's Windward Islands.

On Tuesday, September 7th, 2004, a tropical storm had picked up speed as it travelled across the Atlantic. By early afternoon, roofs were reportedly blown off houses in St. Vincent, Tobago, and Barbados. By late afternoon, the storm passed through Grenada, destroying more than three-fourths of housing stock and infrastructure. The storm accelerated as it moved toward Jamaica. It made landfall there and in the Cayman Islands on September 11th, leaving

> thousands without shelter– more than 19,000 in Jamaica alone– and causing more than a billion dollars in damage (The Economist, 2004).
>
> The global public sector's response was generous, but torturously slow. During their annual meetings in October– over a month after Ivan had hit– the World Bank and International Monetary Fund organised a presentation of the official damage assessment to secure donor interest (World Bank, 2009). This ultimately mobilised $150 million in loans for reconstruction, and $10 million for a structured program covering essential imports like petrol and rehabilitation of core infrastructure like schools and hospitals.
>
> Over a decade later, the 2015 hurricane season also resulted in devastating storms to some vulnerable Caribbean islands, the most severe of which was Hurricane Erika's passage 90km south of Dominica on August 27th. The storm caused heavy rains, flooding, and landslides that killed at least 20 people and destruction valued at up to 90% of the country's GDP (World Bank, 2015). Once again, the global public sector was called upon to respond by providing subsidised credit- and grant financing.
>
> But Dominica's most immediate post-disaster financing needs were paid less than two weeks after Erika struck. This insurance payout came from a region-wide insurance pool, the Caribbean Catastrophe Risk Insurance Facility. On September 10th, CCRIF announced that it had transferred $2.4 million to the government, the maximum payout available under an excess rainfall insurance policy it had introduced in 2012 to supplement its other policies covering hurricanes and earthquakes. Since the insurance facility began operating in 2007 with World Bank support, it has made 13 payments worth $38 million to its eight regional members, all within two weeks or less of a hazard.

The differences between the experiences of Guinea and Dominica illustrate how quickly financing could be brought to bear, and on what terms. We argue that faster payouts are crucial, but are not the whole story. Investments in storm-resistant infrastructure and tougher building codes are costly, but save lives; as we discuss below, frontline disease monitoring is the reason an Ebola outbreak in Uganda infected only 425 people (killing 224) before being contained, while in Guinea it evolved into a regional epidemic. Though neither the government of Guinea nor that of Dominica could have reduced their exposure to the underlying *risks* of these hazards, they could have greatly reduced their *losses* when these hazards struck.

Disaster Financing: Overstretched, Mismatched, Distortionary

The costs of disasters and humanitarian emergencies are growing faster than the available funding. Worse, the current system of providing aid *ex-post* distorts incentives to do better, or to invest in lowering losses. There are three reasons that our existing *ex-post* financing arrangements are not fit for purpose:

- **Overstretched:** There is not enough money to cover rising needs.

- **Mismatched:** The vast majority of funding arrives after hazards hit, often with a considerable delay that imposes financial and human costs. When it does arrive, funding cycles are often annual, a bad match for many disasters that inhibits longer-term planning that might save lives, money, and time.

- **Distortionary:** Donors provide funding at their discretion, reducing incentives to manage risk, invest in resilience, or accurately price the costs of tackling disasters.

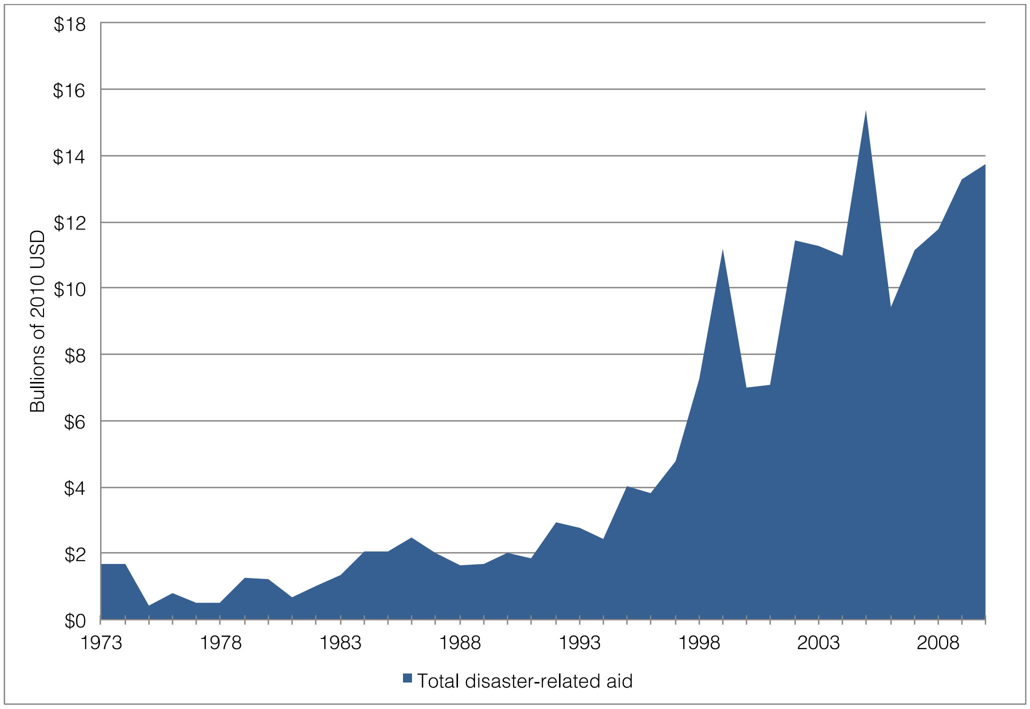
For these three reasons, we argue that a large expansion of insurance-based financing for disasters to governments, frontline agencies, and other actors would make a significant difference. It would save money and lives, by paying out more quickly and reliably, and by creating stronger incentives for investment in prevention and resilience.

Our recommendation has an important implication: scaling up insurance is *efficient* from the perspective of the global public sector, since the failure to provide reliable, fast financing (or incentives to reduce losses) makes it more likely that hazards will evolve into disasters. Because donors implicitly bear part of the risk from under-insurance, they will also benefit to some extent from these lower costs, and from investments in risk reduction and risk management overseas.

Overstretched

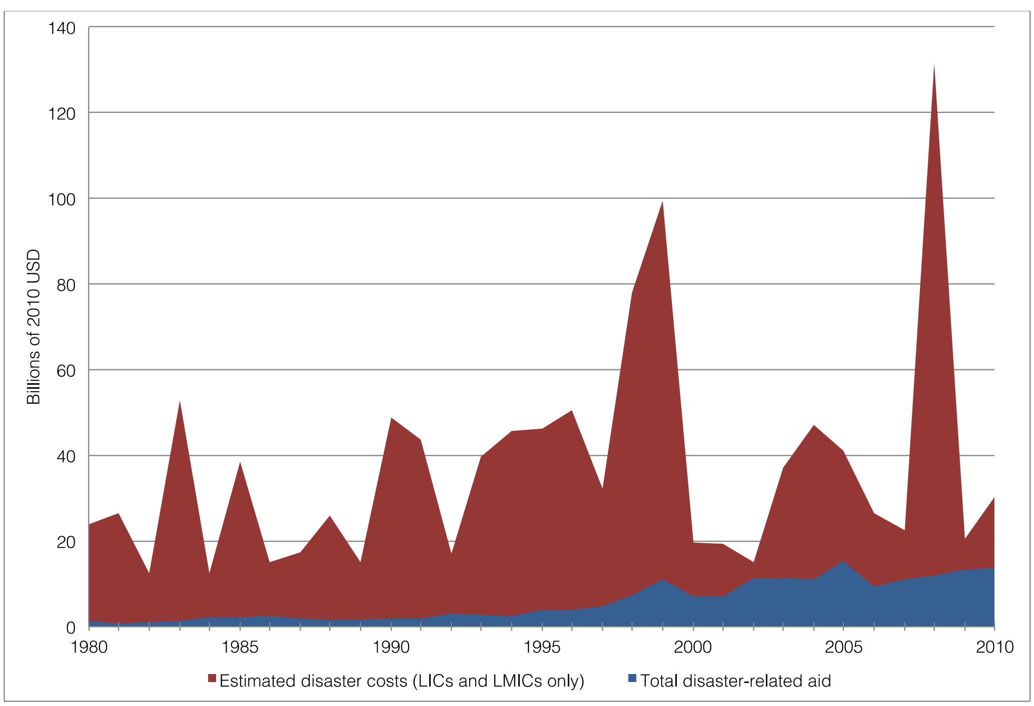
Though the global public sector's spending disasters has increased in real terms, it has not kept pace with damage caused by disasters. Donors have developed a small number of ways of paying for tackling emergencies when they happen, and supporting countries in rebuilding after they hit. The OECD's creditor reporting system provides a useful taxonomy: *humanitarian aid*, *emergency response,* funding for *prevention and preparedness*, and *reconstruction and relief* are collectively called disaster-related aid. Focusing on the damage to physical and human capital only in low- and lower-middle income countries– the places that receive the majority of post-disaster assistance– global spending on disaster-related aid lags behind needs.

Aid Spending on Disasters is Rising Quickly



Notes: Data from AidData (Tierney et al., 2011). Subset of all aid flows using coalesced purpose codes 70000, 74010, 72000–72050, 73010, corresponding to humanitarian, emergency, reconstruction and prevention / preparedness. CGD analysis.

Aid for Disasters Has Not Matched the Cost of Disasters



Notes: Data on total disaster-related aid from AidData (Tierney et al., 2011). Subset of all aid flows using coalesced purpose codes 70000, 74010, 72000–72050, 73010, corresponding to humanitarian, emergency, reconstruction and prevention / preparedness. Estimated damage is the estimated damage and estimated human capital losses for low- and lower middle-income countries. CGD analysis.

Humanitarian aid deserves special comment.[1] Response to humanitarian crises has two components: what is needed, and how it will be spent. The first is set out in a document called the humanitarian needs overview, which is used to build the humanitarian response plan,[2] a budgeting tool that earmarks areas of the response for various UN agencies and NGOs and sets out financial needs.

Response plans only specify requirements. Donors provide resources by either pooling their funds, or by paying into multi-donor pools that can respond to a range of response plans and which are controlled by the UN aid architecture[3] rather than the donors themselves (these include the Central Emergency Response Fund,[4] the Common Humanitarian Funds, the Emergency Response Funds, and Country-based Pooled Funds.)

Analysing the recent history of appeals to donors and the funding provided paints a stark picture of a rising humanitarian deficit: relying on discretionary, *ex-post* funding is increasingly insufficient compared to the needs estimated in response plans. Though contributions to response plans have increased, funding requirements have increased more than available aid. (As we discuss below, because response plans are normally only part-funded, there is an incentive for humanitarian actors to inflate their estimates of need in the hope of minimizing the gap between needs and funding.) Like other areas of disaster-related aid, these needs are set to increase further. The UN's Office for the Coordination of Humanitarian Assistance estimates that in 2016 humanitarian agencies need more than $20 billion to assist over 87 million people in nearly forty countries (OCHA, 2016).

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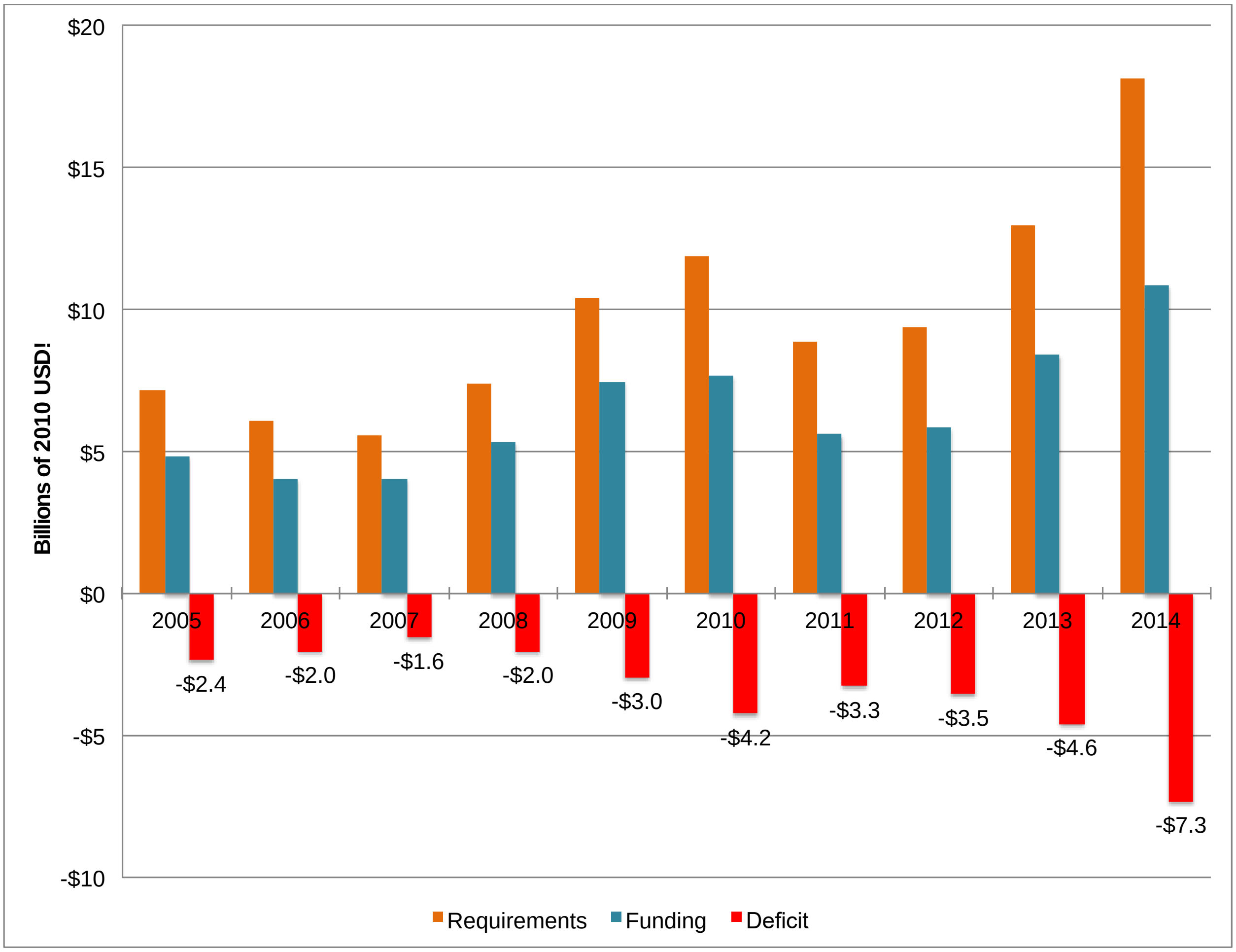
1 There are two aspects humanitarian financing: appeals mechanisms and funding mechanisms. Following a change in 2013, the so-called consolidated appeals process (CAP) has been replaced with a humanitarian programme cycle, setting out the steps in-country teams take to determine the financial and resource needs for an engagement.

2 The multi-country version, for example in use in the Middle East, is the regional response plan. Flash appeals supplement these plans, and are made for urgent funding needs.

3 The distinctions between these financing instruments lie in where the funds can flow and who contributes funds. Though response plans and country-based pools both earmark their funding for a particular engagement, donors and other external actors pay into the former, while the latter are a platform for external and national government funds to be brought together.

4 The UN General Assembly established the modern CERF in 2005, replacing the Central Emergency Revolving Fund.

The Humanitarian Financing Deficit is Growing Quickly



Notes: Data from UN OCHA Financial Tracking Service (FTS), 2015. CGD Analysis.

Mismatched

Financing in response to hazards creates at least four important mismatches between the way disaster-related aid is provided and how it should be used. By its nature, financing after the fact means funding arrives slowly; it is often a poor fit for needs; it may shoehorn multi-year problems into perpetual annual funding cycles; and it means that the pattern of disbursement does not fit the pattern of needs. Like trying to buy a house on a credit card instead of applying for a mortgage, each of these mismatches is a costly friction.

First, donor financing is typically slow to arrive. Faster financing enables a faster response, which would save lives and money. "When a fire breaks out in a city, there needs to be a prompt fire fighting response to contain the fire and prevent it from spreading," writes Dr. Gordon Woo of Risk Management Solutions, a firm which builds mathematical models of the paths and costs of catastrophes. "The outbreak of a major fire is the wrong time to hold discussions on the pay of firefighters, to raise money for the fire service, or to consider fire insurance. It is too late." (Woo, 2015).

Like fighting fires, tackling a communicable disease outbreak requires large, immediate expenditure to roll out early assistance for those affected and to try to stop the outbreak from spreading. Since the caseload for viral infections increases exponentially, at least at first, each additional future case averted earlier on saves an exponentially larger amount of money later on. A month after Ebola was detected in Guinea it would have cost a modest $5 million to contain it. By October the cost of control had reached $1 billion.

Disease outbreaks are more common than most people realise, but thankfully remain relatively rare (though expensive). In fact, famines have been much more deadly and frequent in recent history, having killed up to 10 million people since 1970.[5] Financing for these so-called slow-onset emergencies clarifies the problems with our current model. As Bailey (2012) has set out in a detailed study of the 2011 famine in Somalia, slow donor responses meant that what might have been a situation of deprivation descended into mass starvation. As he points out, this happened even though early-warning systems repeatedly notified the global public sector about the emergency: "[b]etween August 2010 and the declaration [of famine], the Famine Early Warning Systems Network...and the Somalia-focused Food Security and Nutrition Analysis Unit...produced 78 bulletins and undertook over 50 briefings to agencies and donors." As a result of this failure to act with sufficient urgency, tens of thousands of people died and millions of livelihoods were damaged, increasing poverty and vulnerability far into the future.

In addition to slow disbursement, a second mismatch occurs between what donors provide and what countries need in order to tackle a hazard effectively. For example, food aid is often the default mechanism donors use to address food shortages, even though it would often be cheaper, faster, and much more effective to provide cash to governments or directly to households, enabling markets to react (see ODI & CGD, 2015, for a detailed study on the value of shifting humanitarian assistance to cash transfers rather than in-kind aid). The only thing as bad as tardy, *ex-post* assistance is consistently mistimed assistance. Barrett (2001) and Diven (2001) both find that aid flows are *negatively* associated with needs: food aid arrives when it is not needed, and does not arrive when it is. Kuhlgatz et al. (2010) conclude that this type of aid is at best not associated with needs and at worst fails to respond to slow-onset disasters, like drought, that lead to famine.

The third mismatch is time horizons. The financing architecture remains fundamentally mismatched for long-term engagements and tackling multi-year crises. Only a minority of response plans (and so a minority of financing) set out multi-year engagements: in 2015, 13 out of 35 had horizons over a year, even though over half the countries with a response plan in 2015 had plans for at least five years, and nearly a quarter for at least 10 years (Swithern, 2016). Even in the minority of cases[6] for which planning is done with a multi-year horizon, funding is only disbursed annually, which makes it risky or expensive for agencies to undertake multi-year investments. The cumulative effect of a growing number of protracted crises and a static set of funding instruments anchored around annual planning and disbursement cycles has been a growing mismatch between needs and financing.

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5 Of course, this has not always been true: the 1918 worldwide outbreak of influenza is estimated to have killed over 50 million people.

6 It is still a minority whether we calculate this as either a share of the total plans seeking financing, or as a share of the 'humanitarian caseload', the number of people these plans ostensibly target.

The final misalignment between tools and needs arises from the very different nature of crises. In 2015, for example, UN OCHA's financial tracking system lists appeals or response plans for dealing with, amongst others, the effects of Cyclone Pam in Vanuatu, armed violence in the Central African Republic, and a cholera outbreak in Haiti: natural hazard, conflict, and disease, respectively. Tackling a disease outbreak requires mobilising a large amount of funding for immediate upfront costs because an exponential rate of growth of a pandemic implies exponentially high savings from containment. This is a different pattern of spending– and therefore financing model– than post-cyclone recovery, which combines an immediate need for medical care and shelter with much longer-term rebuilding and integration with national development plans. In place of diverse funding models tailored to specific needs, frontline agencies or governments rely only on *ex-post* appeals with fixed time horizons.

Distortionary

Providing discretionary funding after a hazard has hit distorts incentives in three important ways:

- It reduces incentives to invest ahead of time in reducing those costs,
- It reduces incentives accurately to price the costs of response, and
- It creates incentives for donors to free-ride on one another's contributions.

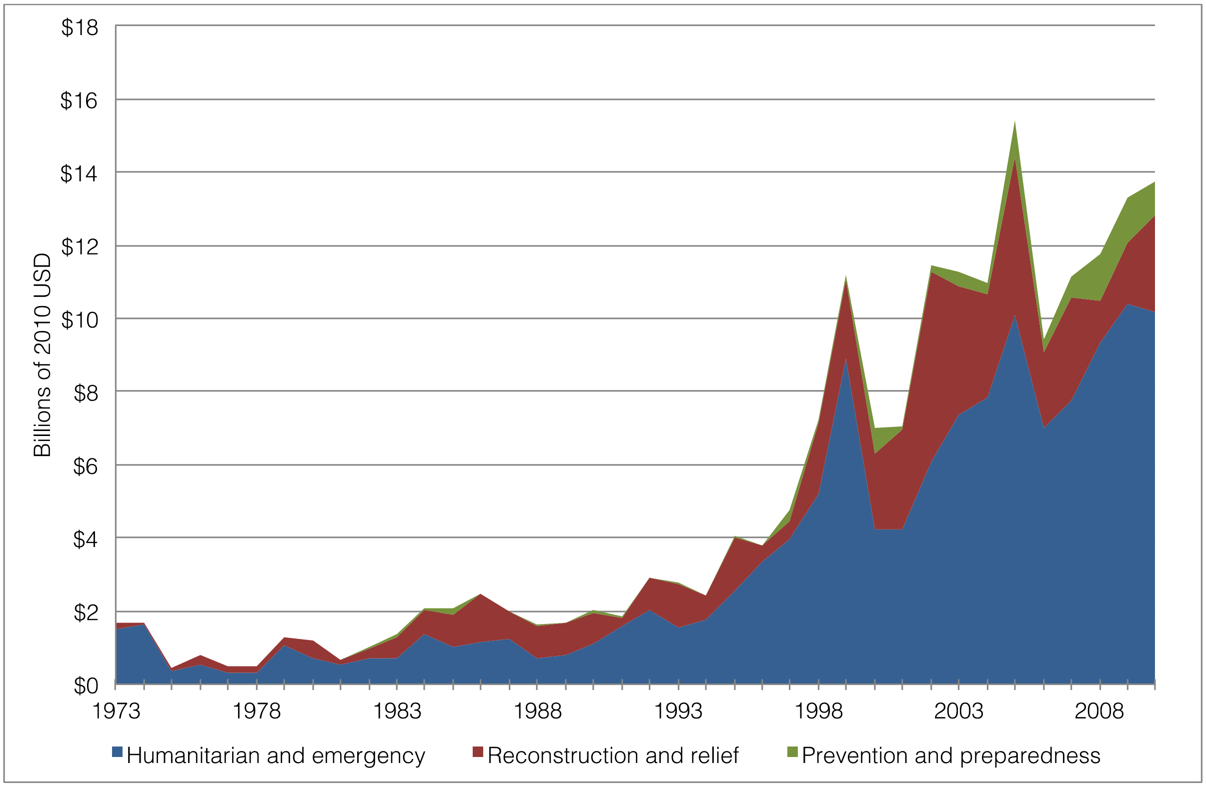
In the appendix, we set out a simple economic model of the relationship between the demand for insurance and the level of insurance cover available. A standard result in the economics of information is that the level of cover the insured gets reflects the price she pays– in a competitive market for insurance, she can fully cover herself against loss. The effect of an expected transfer of resources from overseas– *ex-post* aid– is to reduce the demand for cover, because it substitutes for insurance. If we believe that insurance is particularly useful for tackling hazards because it pays out quickly and under unambiguous conditions, and can create incentives to invest in resilience, then the prospect of aid could be crowding out a far better financing instrument.

This would still true even when the government is budget-constrained. With many calls on fiscal and bureaucratic resources, we may imagine that governments ration the amount they spend on protecting themselves from "bad" states of the world, like a cyclone making landfall– they are "underinsured." Yet providing ex-post aid does not reduce this gap in protection, precisely because it substitutes for insurance.

Because financing arrives after disaster strikes, the prevailing mechanisms also limit incentives to invest in reducing the costs of disasters in advance, both by reducing the amount donors are able and willing to spend on mitigating risks, and by providing a backstop– however imperfect– for when things go wrong. Raschky and Schwindt (2009) find that a 10% increase in the ratio of aid to a country's GDP increases the likelihood that a hazard causes sufficiently severe losses for it to be classed as a disaster[7] by 62%: aid crowds out vulnerable countries' incentives to invest in damage prevention that could otherwise keep hazards from tipping into disasters.

This is not to say that those investments would not pay off, since the same study finds a large payoff to aid flows that are earmarked for reducing the costs of hazards. Yet examining data on aid flows from 1973 to 2010 reported to the OECD by donors indicates that less than half a cent of the average dollar– just 0.43% – of disaster-related aid has been labelled as earmarked for reducing the costs future hazards ("prevention and preparedness", which we refer to elsewhere using the standard label "disaster risk reduction"). Put differently, the vast majority of our funding is devoted to delivering assistance when hazards have struck, not reducing the losses from hazards or preventing them from evolving into disasters. (Of course, this figure is problematic, because donors assert that much more has been spent on prevention and preparedness than is labelled as such in aid flows. Yet even if this figure were off by a factor of ten, it would imply spending on disaster risk reduction on the order of just $4.30 in every $100 of aid– much, much lower than what should be spent, given the extremely high returns in terms of lower costs when hazards hit).

Aid for Reducing Losses Is a Small Fraction of Disaster-Related Aid



Notes: Data on total disaster-related aid from AidData (Tierney et al., 2011). Subset of all aid flows using coalesced purpose codes 70000, 74010, 72000–72050, 73010, corresponding to humanitarian, emergency, reconstruction and prevention / preparedness. CGD analysis.

7 As we have above, they use CRED's definition of disasters: "10 or more people reported killed, 100 people reported affected, declaration of a state of emergency, call for international assistance."

The second distortion created by *ex-post* financing, as mentioned above, is the incentive to inflate estimates of loss. Humanitarian response plans are a useful example: donors react to plans without a commitment to meet the full financing needs. Because agencies know that they are likely to be underfunded, it is in their interests to inflate their budget lines; because donors know they these budgets are inflated, they have an incentive to underinvest in meeting them. In the language of game theory, this is a stable Nash equilibrium analogous to the outcome of the canonical Prisoner's Dilemma– donors and implementing agencies are each individually acting in their best interests, yet the cumulative outcome is bad for everyone involved, and for those depending on them: donors either pay too much, crowding out support for other crises, or too little, increasing harm through inadequate support.

The final distortion created by providing aid after hazards strike is that donors have an incentive to *free-ride* by shirking responsibility and hoping that others will step in instead. UN data confirms enormous differences in the level of support different donors provide for disasters or humanitarian assistance– in 2015, for example, the US gave more than three times as much as the next largest donor, the European Commission, and more than the EC, the UK and Germany combined (UN OCHA, 2015). Though all these actors give generously through other channels– the UK, in particular, meets its international commitment of spending 0.7% of GNI in foreign aid– these differences make it clear that burden sharing for *ex-post* disaster aid is far from equal.[8]

Disasters: Deadly, Expensive, Regressive, and Getting Worse

The pressure on *ex-post* financing arrangements will only increase. Examining data on disasters indicates that the costs they impose are infrequent but expensive, but they are expected to both become more frequent due to climate change and more expensive because of urbanisation that exposes an increasing number of people to high-impact hazards. The resulting costs affect rich and poor countries, but death tolls are heavily concentrated in the poorest countries while the value of property and capital lost are concentrated in richer countries. This means that without better solutions to reduce their impact– both by bringing financing to bear quickly and creating stronger incentives to invest in reducing risk– the costs of disasters are highly *regressive* because they are disproportionately felt by the poorest and most vulnerable economies.

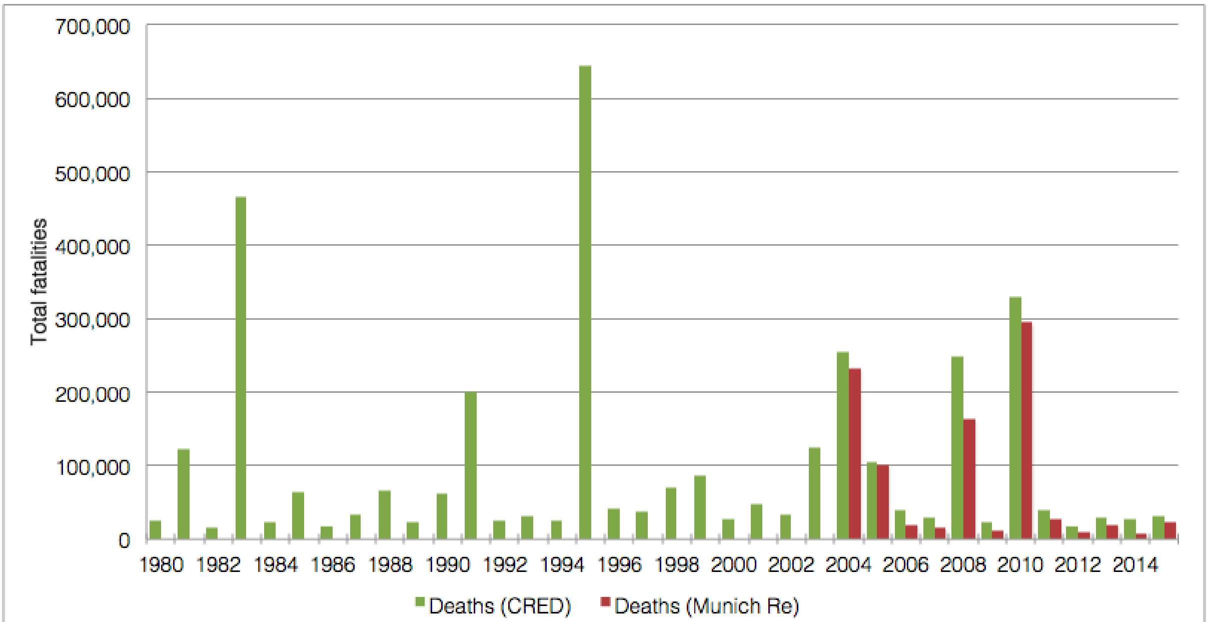
Deadly

Two standard sources for information about the incidence of damage and loss following disasters are data provided by Munich Re, a large insurance firm, and a public-access dataset on the epidemiology of hazards maintained by researchers based at Centre for Research on the Epidemiology of Disasters

8 We might expect that some countries have a lower opportunity cost to providing aid and so their higher contributions do not reflect free-riding. For example, a large logistics industry in the US might make providing in-kind aid requiring shipping 'cheaper'. However this would not prevent other countries from providing financial assistance.

(CRED) at the Catholic University of Louvain. The data sets are related but not strictly comparable.[9] Using these data to examine the human cost of hazards in historical perspective suggests that large losses have been infrequent, but deadly.

Deaths from Natural Hazards



Notes: Data from EM-DAT (Guha-Sapir et al.) and Munch Re (2015). CGD analysis.

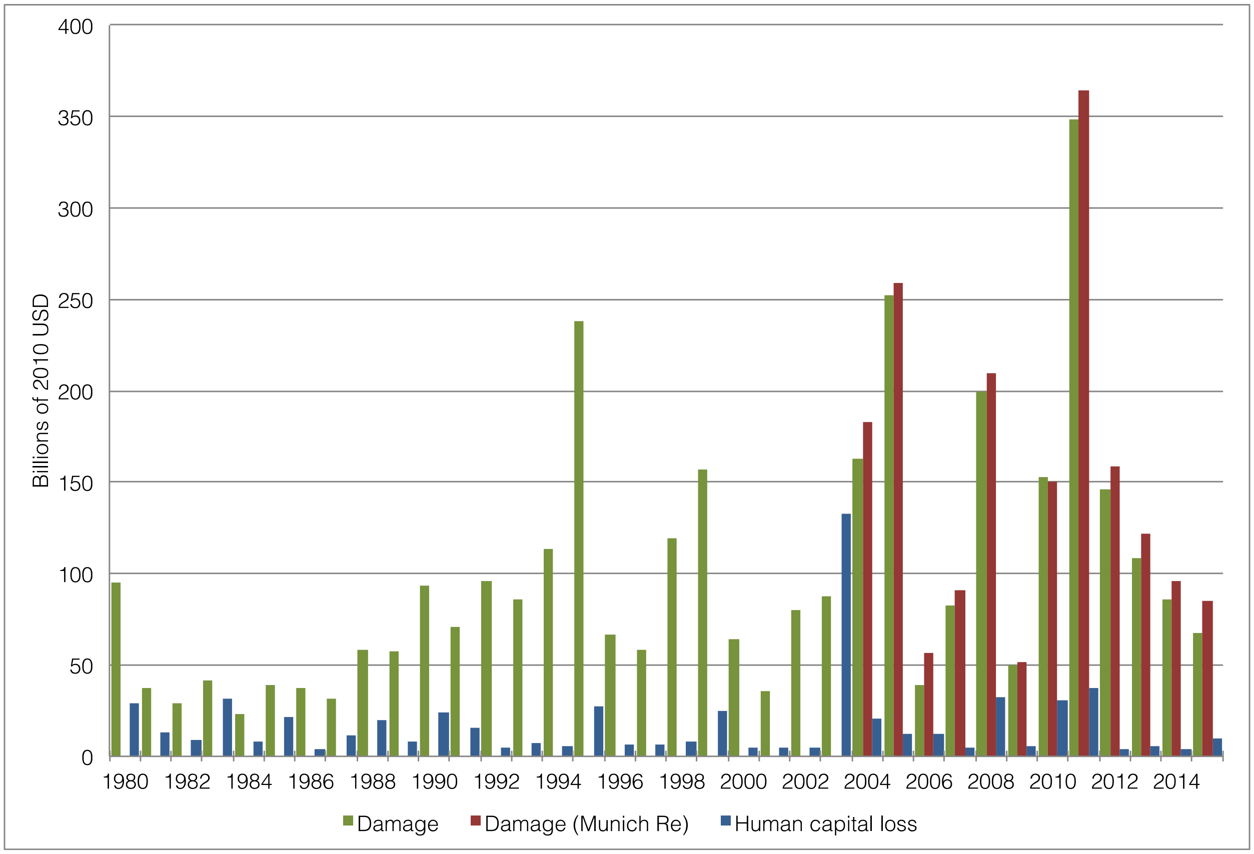
Expensive

When hazards hit, they also destroy housing and infrastructure, compounding the human cost with a financial one. As with the number fatalities, the cost of hazards has increased over time. The immediate or short-run impact of disasters disguises serious longer-term costs, because losses can make households *permanently* poorer by undermining their capacity to recover.

Dercon (2004) sets out a classic example of this, studying Ethiopian households forced to sell livestock during a deadly drought and famine. Because they are forced to sell their most valuable and productive assets, these households are made permanently worse off, even after the disaster "ends." The larger lesson is that vulnerable communities can be pushed into a new normal of persistently lower welfare or economic growth when emergency response and disaster-related aid fail.

9 EM-DAT is the name of the dataset that Center for Research on the Epidemiology of Disasters (CRED) has provided since 1988, with disaster data dating back to 1900. It provides estimates of deaths, injuries, and damage for earthquakes, hurricanes, floods, and other disasters (including man-made disasters) that killed 10 or more people, affected at least 100, or resulted in a "state of emergency" or a request for international assistance. Munich Reinsurance Company maintains NatCat, which includes data at the event-, rather than the country year-, level and has different inclusion criteria.

Damages from Natural Hazards



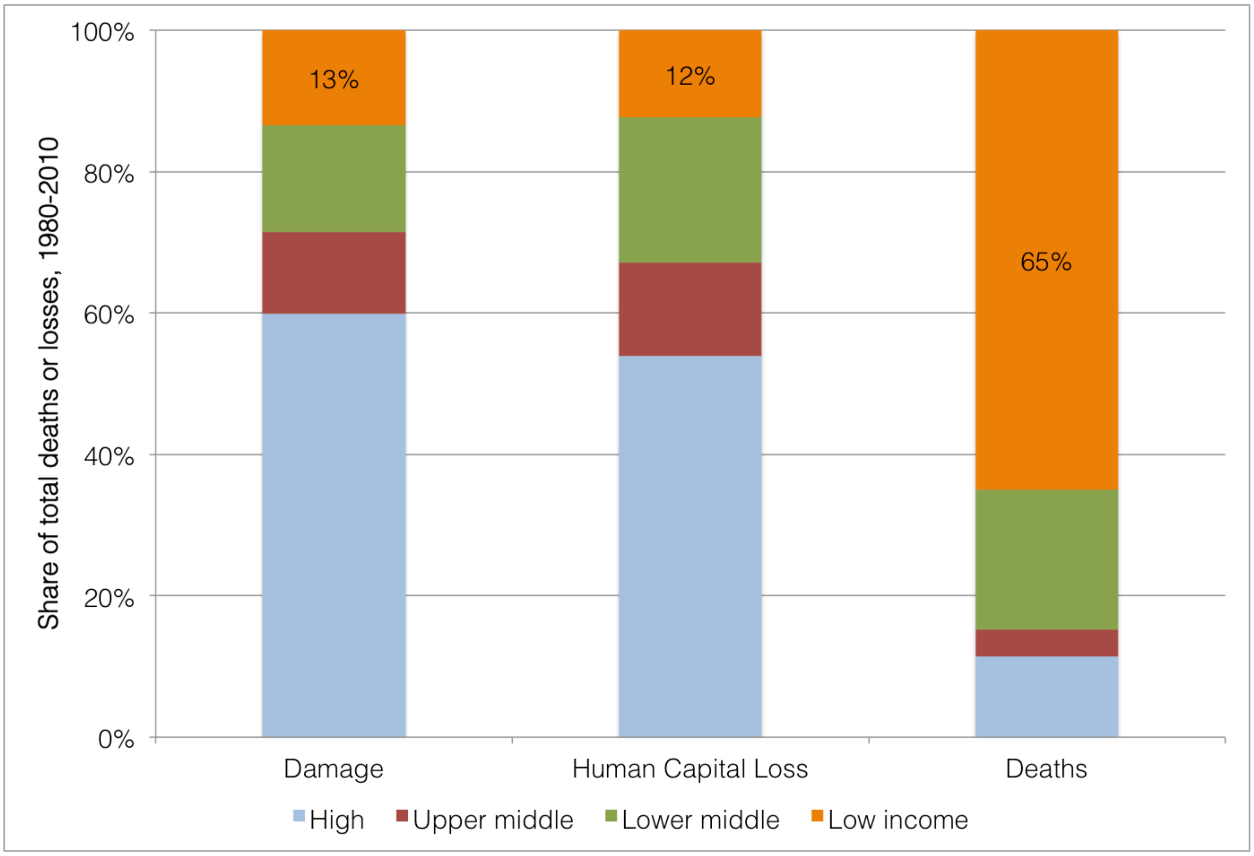
Notes: Data from EM-DAT (Guha-Sapir et al.) and Munch Re (2015). 'Human capital loss' estimated as number of deaths from Em-Dat times difference between life expectancy and median age in country times real income per capita. Median age from median-variant projection from United Nations (2012), income per capita and life expectancy from World Bank (2015b). CGD analysis.

For sufficiently violent hazards and vulnerable countries, this effect operates at the level of national growth rates. Febelmeyer and Gröschl (2014) use geophysical data on the intensity of hazards such as earthquakes, storms, and droughts to show that these shocks translate into lower national economic growth rates, in effect permanently impoverishing countries compared to an alternate history in which the hazard did not hit, the affected country were better prepared for it, or post-disaster aid were more effective. The top one per cent of the most violent events cause a drop in the growth rate of GDP per person of more than 6%. (This growth penalty increases more than proportionally as the hazard becomes more violent: disasters that are twice as violent more than double the cost in terms of economic growth).

Regressive

Because poorer countries have less capital and infrastructure per person, focusing on "damage" might make us think that they "lose less". A crude way to compensate for this bias of undervaluing losses in poor countries is to estimate the present value of income per-capita lost due to lives taken. Yet even with this adjustment, the lower incomes earned in developing countries mean that damage to physical and human capital appears to dominate the estimated costs. If we consider lives everywhere to be equally valuable, though, the data comprehensively show the opposite. Data on deaths and damage from natural disasters from 1980 through 2015 confirm that most of the lives lost have been in poor countries; most of the damage has been in rich countries, whether we measure this as loss of either physical or human capital. In this sense, the human toll of disasters is highly regressive, in that it falls disproportionately on the poor.

Damages Mainly in Rich Countries, Deaths in Poor Ones



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More broadly, studies suggest that the acceleration in the scale and damage of natural hazards and disasters creates a burden that falls disproportionately on the poor. Based on a study of country-level data for 208 countries over forty years, Namsuk (2012) shows that a poor person is twice as likely as another person to be affected by disaster. Even when we account for factors like urbanisation that increase the number of people affected by hazards, death tolls are systematically higher in poor countries, and inequalities– in political power and financial resources– are the reasons some hazards affects specific groups within countries more gravely than others (Adaman, 2012).

Similarly, Kahn (2005) studies disasters in more than 70 countries and finds that higher-income countries are not less likely to be affected by a hazard, it is simply that the same hazards do not evolve into disasters: better institutions, higher incomes, and more accountability (through democracy) all break the link between hazards and disasters. (The analysis is not new: as Amartya Sen, 1999, observed, famines do not happen in democracies with a free press, with the implication political power and voice of those affected determines whether hazards like droughts evolve into disasters like famines.)

Getting Worse

Unless the global public sector innovates, there are two reasons to expect an increase in the costs of hazards that are allowed to become disasters. First, the global population is rapidly urbanising. The share of global population living in urban areas will double in a century, from roughly a third in 1950 to more than two thirds by the middle of the 21st century (UN, 2014). This trend is already driving the development of megacities, urban agglomerations with 10 million people or more: we are projected to have 41 megacities by 2030, which have already tripled in number since 1990. Higher population densities mean that hazards with the same footprints will affect a much larger number of people and productive assets. Though rising incomes suggest that some of these newly urbanised communities will be more resilient to hazards, a far greater share of urban communities will be in developing countries, and therefore both densely packed and vulnerable.

Second, climate change is expected to cause changing weather, with more violent weather and a mismatch between construction and the weather patterns they face. (Despite pledges to tackle climate change made in Paris at the end of 2015, momentum in climate systems means that the stock of carbon emitted will inevitably cause warming during the 21st century. The preponderance of estimates put this at 2.0˚C to 4.5˚C). The consequences will include heavier rains in some latitudes and increased risk of drought in subtropical and mid-latitude areas, flooding due to higher sea levels, and larger and more violent storms.

Both these trends will directly impact the disaster caseload, and the cost curve for tackling these will not bend on its own. For example, in Bangladesh, a 2.0˚C rise in temperatures is predicted to cause flooding that lowers usable land by fifth in a country that is already one of the world's most densely populated due seasonal flooding (Karim and Mimura, 2008). Droughts that previously affected Ethiopia every decade or less now occur every two years or less, exacerbating food insecurity and the risk of famine, notably including during the 2015 harvest due to shifts in the El Niño climatic pattern, itself due to global warming (Cai, 2014). Similarly, the Zambezi river's flooding pattern has shifted from roughly once every five years to annually (Chagutah, 2006).

Bad Financing Models Exacerbate The Problem

Insufficient and uncertain funding makes planning difficult. As a result, a large amount of disaster-related aid is *fragmented*, characterised by many small programmes or projects. A study of two decades of donor spending on disasters concludes that more than 85% of projects accounted for less than 6% of funding (Kellett and Caravani, 2013). This multiplicity of programmes is costly to administer and coordinate and often deprives any single programme of the resources to make a difference.

Such ineffective planning and fractured responses help to turn hazards into disasters. The global response to the Haitian earthquake of 2008 is now a tragic example of these effects. Ramachandran and Walz (2015) analyse post-disaster aid flows to Haiti and find that funding was slow to mobilise and was badly coordinated, with very little national ownership. Though almost $6 billion has been spent in Haiti since 2010, the country's government is estimated to have received just 1% of the humanitarian aid and 15% of spending on longer-term relief.

Broken financing also imposes invisible costs, in the form of savings we could have made if the public sector could respond effectively and on-time. Estimating the returns on resilience or preparedness is difficult: without a clear counterfactual, it is challenging to estimate the difference between what happened and what would have happened,[10] and estimates are likely to vary substantially according to the context and the nature of the disaster.

Reliable estimates based on models and scenario analysis that do exist point to extremely high returns. For disease outbreaks, for example, according to one cost-benefit calculation spending $3.4 billion a year in better disease surveillance and response would save $37 billion a year in future pandemics averted (World Bank, 2012). Returns from *ex-ante* investments in the kinds of sovereign insurance programmes we discuss below are also estimated to be very high: de Janvry et al. (2016) show that Mexican municipalities that receive payouts from *Fonden*, a natural disaster insurance programme, grow 2-4% faster than those that also experience a hazard but did not benefit from insurance cover, ultimately generating benefit to cost ratios in the range of 1.52 to 2.89. Large returns are not limited to large investments. For humanitarian response, a study funded by DFID, the UK aid agency, evaluated $5.6 million-worth of preparedness investments in three countries– such as building an airstrip in Chad for $680,000 to save $5.2 million by not having to charter helicopters in the rainy season– and concluded that the overall portfolio of investments had an ROI of 2.1, with time savings in faster responses ranging from 2 to 50 days (Unicef and WFP, 2015).

Insurance for Humanitarian and Emergency Financing

The fundamental observation here is that **the constraint is design, not funding**. Putting more money through the existing system and spending more of it through flexible or longer-term facilities would be positive steps. Yet neither change could fundamentally realign incentives to invest money in reducing losses from disasters or facilitate better planning by contracting for clear payouts.

For example, the CERF is a distinct humanitarian financing facility in the aid ecosystem, pooling money from any contributor– bilateral donors, foundations, charities, or individuals– to respond immediately to response plans (while donors decide whether and how much to pay into them) and to meet the costs of underfunded crises. The facility's annual resource target is $450 million and its 'rapid response grants' are available within two days. Yet the CERF is a responsive facility, so increasing support for it and other pooled funds would enable us to "respond badly better", rather than fundamentally re-aligning incentives by securing guaranteed payouts when hazards hit, matching funding to response plans, and augmenting incentives to save lives and money by investing in DRR.

10 The pure 'treatment effect' of these investments would also be lowered by investments against hazards that do not arise

In contrast to *ex-post* aid for disasters, an insurance financing model for tackling humanitarian crises and natural disasters would provide three key features. It would:

- **spread the costs of disasters** lifting the burden from the poorest people and countries;
- **provide predictable payouts**, thereby enabling faster disaster responses which limit the overall losses; and
- **align incentives** to invest today to reduce risks (where possible) and limit losses tomorrow.

Insurance is fundamentally the trade of resources for risk.[11] A contract is an agreement between an insurance provider and a counterparty to pay an agreed amount in response to an agreed risk or a predetermined loss. By buying insurance, we can pass risk and the cost of loss to the insurer– at a price. Because insurance providers will only operate if they expect to make a profit, the price for insurance, at any point in time, exceeds or is just equal to the expected value of any payout we are likely to get. As a result, we typically only buy contracts for those risks that we cannot afford to bear at once, like being sick or losing our homes to floods or fires. Meanwhile, insurers lower their risk by offering contracts simultaneously to many counterparties, because people are likely to pay their premiums together but are unlikely to be affected by losses at the same time.

In short, we cannot reduce the *risk* of many hazards, since we cannot control hurricanes or earthquakes. But we can dramatically reduce the *losses* inflicted by a large number of such hazards. We can reduce losses in two ways: **first**, by investing in resilience (e.g. investments in flood defences, earthquake-resilient buildings, irrigation to reduce reliance on rainfall); and **second**, by acting quickly and effectively in the event of a hazard (for example, to prevent a drought from becoming a famine, or a disease outbreak from becoming an epidemic). And insurance contracts can help to ensure that money is provided when and where it is needed, and not caught up in the collective action problems and geopolitics of donors.

Under a formal insurance contract, the insurer and the insured both know the terms under which a policy will pay out. To reduce the cost of the premium, the insured may have had to accept more of the loss (a higher *deductible*), or make an investment to reduce the loss (such as installing a tracking system on her car or improving the quality of her home's foundations). She is able to plan for what she will do if the loss is realised and, because of deductibles or contractual requirements imposed by the insurance company, has an incentive to invest to reduce the risk of a bad event happening and to reduce the losses if it does.

It is true that some "hazards" are difficult to insure against because they involve a complicated interaction of natural shocks and human violence. Only some aspects of complex humanitarian

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11 The essential features of modern insurance contracts date back thousands of years, at least to 1590 BC: the Code of Hammurabi enabled merchants to take loans in exchange for an interest payment to finance their shipments and annul the loans if their assets were lost to thieves or natural hazards, a simple type of risk transfer. And as early as 3000 BC, Chinese merchants dispersed their goods jointly amongst numerous ships– a simple form of risk pooling (Trenery, 1926).

engagements can be tackled with insurance financing of the kind we discuss here.[12] However, the vast majority of disasters continue to be caused by hazards that are insurable: a report by the United Nations Office for Disaster Risk Reduction finds that nine out of ten disasters were caused by natural hazards including floods, storms, heat waves, or droughts (UNISDR, 2015). And because complex emergencies can arise as a result of natural hazards, a large number of complex emergencies have a significant insurable component.

Insurance in Practice

The insurance financing model dovetails with three key needs:

- **Size:** The combination of insurers' balance sheets and index-linked securities (like catastrophe bonds), which we discuss in detail below, enables insurance to cover very large risks, including billions in coverage for humanitarian actors or governments in developing countries.

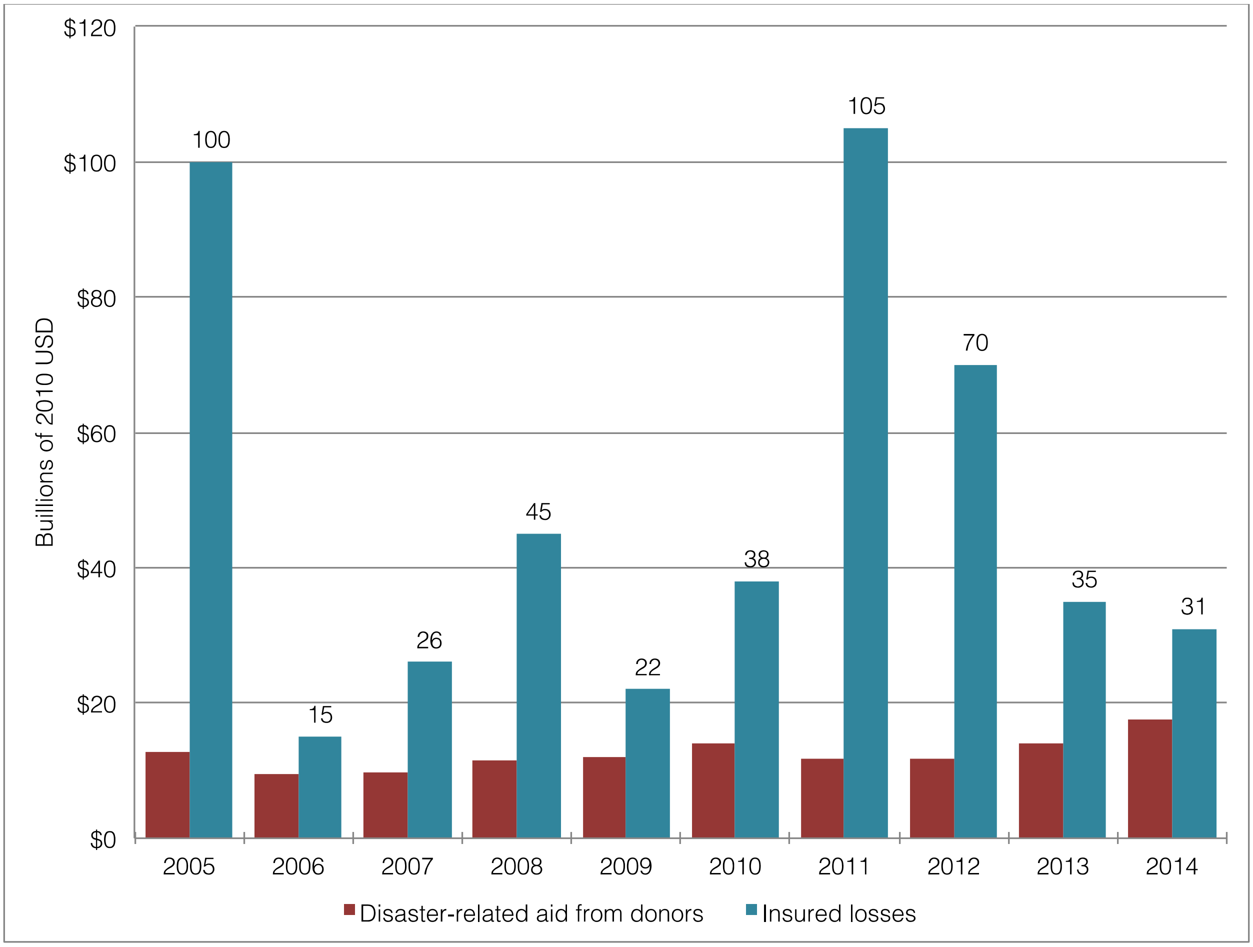
- **Predictability:** Those contracts pay out under unambiguous conditions and in response to specific hazards, so insurance fits financing needs, in contrast to the fractured, one-size-fits all model of funding reliant on donors.

- **Incentives:** The price paid for transferring risks reflects investments made in reducing them, thereby aligning, rather than distorting, incentives to reduce hazards and losses.

To help meet increasing costs of disasters, the potential value of connecting insurance needs in emerging markets with capital in industrialised countries is enormous. Analysis of donor aid presented earlier shows that $13.8 billion was earmarked for dealing with disasters in 2010, a small share of which included spending on risk reduction. According to analysis of global catastrophe costs and insurance losses by Munich Re (2012), that same year the insurance industry covered insured losses of $38 billion. The following year, it covered losses of $105 billion, certainly an expensive year mainly due to flooding in Thailand, but one that the industry was able to absorb. Put differently, the insurance industry can underwrite a scale of loss that the global public sector cannot.

12 A useful definition of so-called "complex emergencies" is "relatively acute situations affecting large civilian populations, usually involving a combination of war or civil strife, food shortages and population displacement, resulting in significant excess mortality…" (Toole, 1995).

Insurance Payouts Are Much Larger Than Disaster Aid



Notes: Data on disaster-related aid (only available until 2010) is from AidData (Tierney et al., 2011) and OECD. Subset of all aid flows using coalesced purpose codes 70000, 74010, 72000–72050, 73010, corresponding to humanitarian, emergency, reconstruction and prevention / preparedness. Data on insurance payouts is from Munich Re (2015).

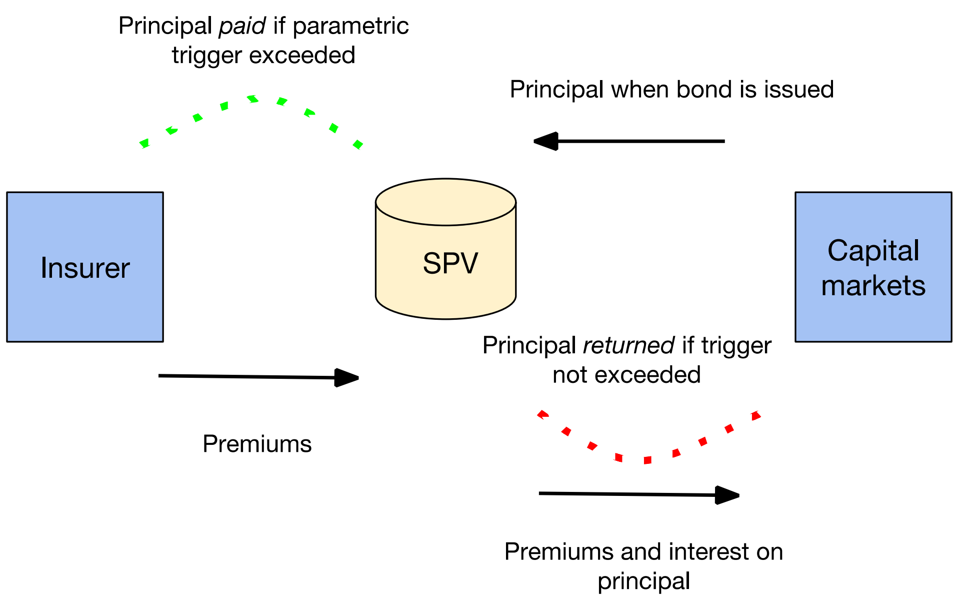
Unlike perils that affect individuals, households, and families, natural hazards are a distinct challenge in risk management for two reasons. First, they happen rarely and are disproportionately expensive. Second, because a lot of property is affected all at once, risk moves together (covaries): automobile insurers would be overwhelmed– and risk pooling would fail– if a single car crashing made a hundred other car crashes much more likely. Catastrophe insurance exists to cover situations analogous to this, but more severe: every car crashing at once.

The key actors in modern markets are insurance companies, reinsurance companies, and the global capital markets. Insurance companies offer contracts to customers, pricing the cost of those contracts using actuarial models. When the potential loss from a risk transferred from a customer to an insurance company becomes too great, the firm can transfer the risk to a second tier of insurance, the global re-insurance industry. Today, re-insurance shoulders 55%-65% of the costs of large natural disasters (Dahlen and Peter, 2012).

According to analysis by Munich Re, nearly 1,000 catastrophe events happened in 2014, causing direct losses of $110 billion. Average annual losses have been $190 billion since 2005, and the modern insurance industry has evolved to cover $300 billion in catastrophe risks globally (McKinsey, 2013). The potential costs of some of these risks would overrun even the reinsurance industry's capacity. Index-linked securities (ILS), including so-called catastrophe bonds, are a relatively recent innovation that enables those risks to be transferred from the insurance industry to the global capital markets, an effectively bottomless pool of capital with over $280 trillion in assets (IMF, 2013).

There is a rich jargon around how index-linked securities operate, but the principle is simple: rather than transferring risk to a re-insurer, an insurance firm creates a single company (a "special purpose vehicle", or SPV) whose sole purpose is to hold this risk. The SPV sells bonds to investors. The investors lose the face value of those bonds if the hazard specified in the bond contracts hits, but earn a stream of payments (the insurance premiums) until it does, or the bond's term expires. This gives any actor – insurer, re-insurer, or sovereign risk pool like schemes in the Pacific, Caribbean and Sub-Saharan Africa, which we discuss below – a way to transfer risks from their balance sheets to investors.

Flow of Funds for an Index-Linked Security



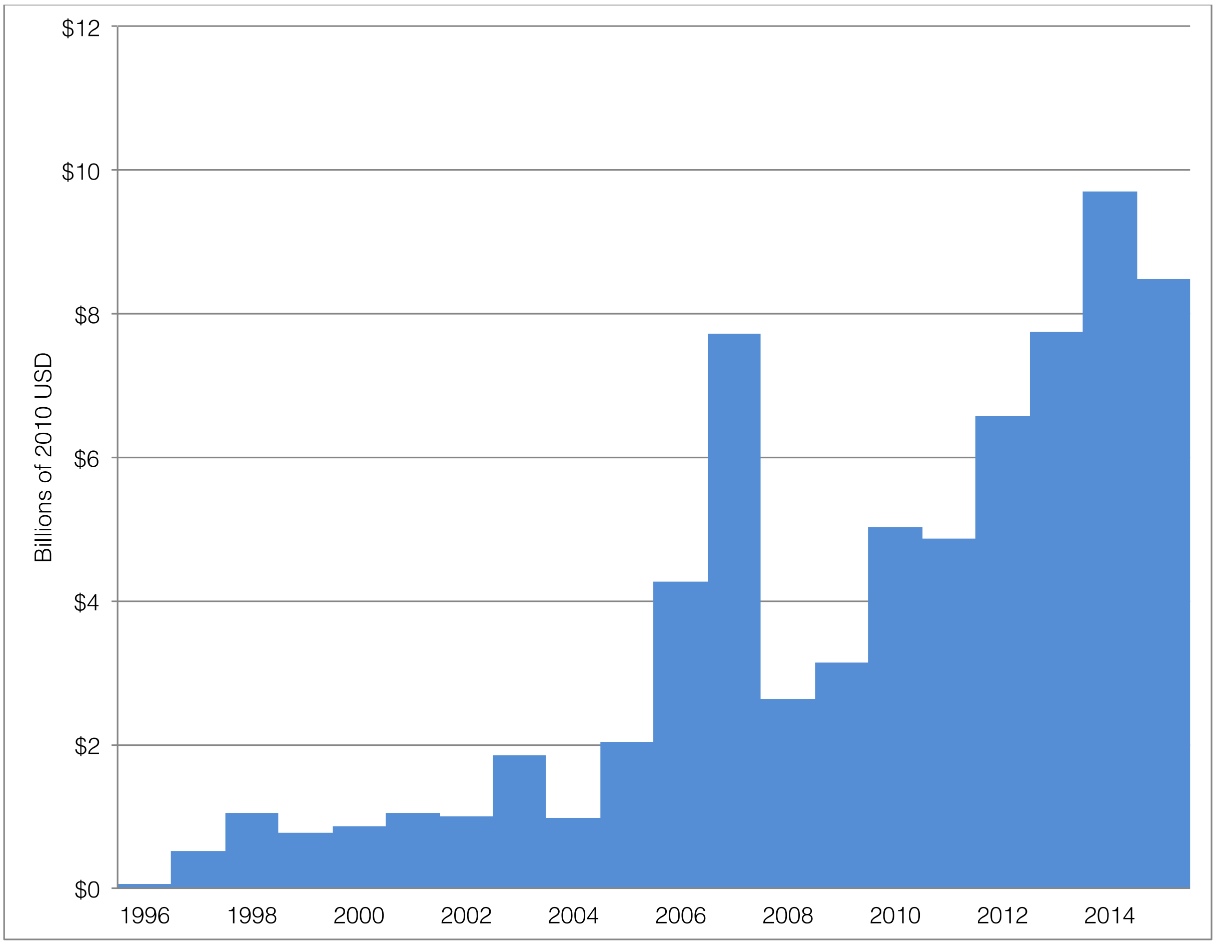
Notes: Adapted from Willis Towers Watson, 2014.

Bermuda has been the centre of the index-linked securities market because it has laws that enable insurance firms to create easily independent "cells" housing the SPVs that underlie index-linked securities transactions (In 2014, 60% of outstanding index-linked contracts globally were domiciled in there.)[13] The combination of low yields in traditional assets like stocks and bonds (due to historically

13 London is another leading centre. Its insurance market share was £30.5 ($45.89) billion, "...nearly four times bigger than Bermuda (£8.5bn), 11 times bigger than Zurich (£2.7bn) and 15 times bigger than Singapore (£2.1bn)", with 65 insurers and reinsurers and more than two hundred brokers. The UK is considering developing enabling legislation to boost the number of underlying holding companies or SPVs that are domiciled there, taking advantage a capacious insurance and reinsurance sector (HMT, 2016).

low interest rates) and the insurance features of index-linked securities have contributed to fast growth in the instrument. According to deal tracking of the catastrophe bond and index-linked security markets, demand is healthy, and global issuance has grown quickly. The graph below shows catastrophe bonds issued each year, not total cover provided by the bonds: in early 2016, cover stood at over $26 billion (Artemis, 2016).

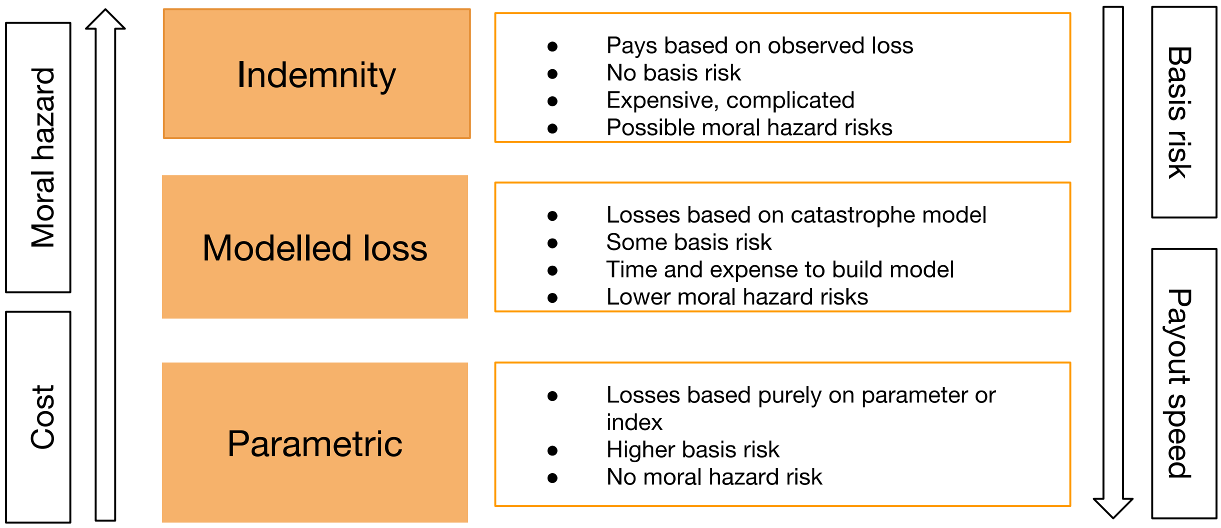
Catastrophe Bond Issuance Is Large and Growing



Notes: Data from Artemis.bm live deal tracking. CGD analysis.

In contrast to the implicit contract between aid recipients and the global public sector, insurance contracts set out explicitly when they will (and will not) pay out. As a result, defining a "trigger" has been a major area of innovation in the development of index-linked securities. Tying contracts to external, observable phenomena such as Richter-scale readings for the extent of earthquakes or median surface temperature for droughts means that risk transfer can be specifically tailored to the situation.

There are three varieties of triggers: parametric, modelled-loss, and indemnity. Parametric triggers are the easiest to calculate based on natural science data– satellite data reporting a hurricane's wind speed is transparent, publicly available, and cannot be affected by the actions of the insured or the insurer. When a variable exceeds an agreed threshold, the contract's clauses to payout are invoked. Because neither the insured nor the insurer can affect the parameter, there is no cost of moral hazard, since the *risks*– the probabilities of bad events happening– cannot be changed. Modelled losses provide estimates of damage based on economic models. Indemnity coverage is based on the insurance claims and loss-adjustment and are the most expensive to operate and take the most time to pay out (or not).



Notes: Adapted from Willis Towers Watson, 2014.

Guidon and Soulsby (2008) use the example of Hurricane Katrina making landfall in New Orleans. A contract based on a parametric trigger of wind speeds above 209–251 km/h (a category 4 hurricane) would pay out immediately based on publicly-available satellite and other meteorological data. Modelled losses would take longer to pay out, on the order of days or weeks, as third-party firms calculate the model. But indemnity triggers could be associated with delays on the order of years, for two reasons. First, because models are fallible. In Katrina's case, they failed to account for levees tragically breaking. Second, because the combination of flooding, evacuation, surging demand for rebuilding and bottlenecks in the legal system mean that an indemnity trigger based on final actual losses may not be known for many years. Therefore, though there are index-linked securities that pay out based indemnity triggers, these are largely inappropriate for developing country risks, and are generally falling in popularity: by the fourth quarter of 2014, fewer than 30% of ILS contracts featured this type of trigger (Artemis, 2015).

One important consequence of designing contracts against parametric triggers is that claims are paid out quickly– fast enough for the budgets of affected governments to begin paying for the costs of the emergency and, depending on the value of the insurance, rebuilding. Indeed, Haiti's experience with insurance is very rarely discussed, but makes a useful counterpoint to its experience of donor-led *ex-post* financing detailed above. As Roodman (2010) relates, in 2007 the World Bank set up a common insurance pool for Caribbean countries (discussed further below), combining core capital from the Bank with subsidised premium payments from donors. Haiti's $8 million payout was available just 19 hours after the earthquake struck, a faster reaction than the IMF, the US Government, or the World Bank itself.

Finally, insurance, unlike *ex-post* aid, can be calibrated to reward investments in resilience and preparedness that reduce losses when hazards hit. Roberts (2005) details a nice example of this in the Mauritius, where a quasi-government programme covers the island's sugar farmers against losses.

Farms are given a score that determines the premium they pay for insurance and the amount of loss covered if crops are lost. Farmers can improve their score (and so pay lower premiums) based on their history of claims, effectively rewarding investments in lowering the risk of disease, fire, and other threats.

There is much to like about parametric insurance contracts, because these pay out quickly and, if contracts are designed properly, when money is most needed. There are two important caveats, though. First, conditioning on a variable like wind speed can create *basis risk*, the difference between actual losses and the trigger. For example, a low-intensity storm might not trigger a parametric payout, but may damage a weakened sea wall, causing flooding: though losses are high, they are not covered by insurance. Thoughtful design for triggers and contracts can limit but ultimately cannot eliminate basis risk.

The second caveat is more subtle but very important. As we show formally in the appendix, contacting on "exogenous" parameter does not create any additional incentives to lower losses when hazards strike, precisely because the contract is based on a risk that neither the insured nor the insurer can affect. Though it is possible to include efforts for loss reduction in a contract, parametric insurance contracts do not, on their own, create these incentives. Because of this, we argue that combining parametric payouts with incentives to reduce losses is the key innovation for building the missing market in disaster insurance for vulnerable countries.

Three Examples of Sovereign-scale Insurance

A variety of pilot programmes have been set up to transfer risks from countries to insurance markets. These programmes are not individually perfect, but they collectively demonstrate that sovereign-level risk transfer works, and that there is mutual appetite for insurance models from at-risk developing countries on the demand side and the insurance industry on the supply side.

PCRAFI in the Pacific

On March 13th, 2015, the Pacific island nation of Vanuatu suffered its worst natural disaster in living memory. Cyclone Pam made landfall on some of the most populated islands that make up the nation of islands in the South Pacific, including Efate, where the capital Port Vila is located. Winds reached 300 kilometres an hour– as violent as Hurricane Katrina. As well as a conventional disaster response by donors, Cyclone Pam triggered a $1.9 million insurance payout from the Pacific Catastrophe Risk Insurance Pilot directly to the government's own bank account. The payout was based on a modelled loss calculated by a third-party analysis firm, AIR Worldwide, which was triggered by parameters that included Cyclone Pam's wind speed as it made landfall. Vanuatu's exposure to hazards reflects a regional risk: since 1950, natural hazards have affected 9.2 million people in the Pacific and cost countries.

The programme– now operating as the Pacific Catastrophe Risk Assessment and Financing Initiative, having graduated from a pilot phase– is a mutual insurance vehicle established with technical assistance from the World Bank and donor support primarily from Japan. It collects premiums from the region's island countries and pays out in response to severe earthquakes or extreme weather events. Tonga and Vanuatu both received payouts of roughly $2 million in 2015– small in absolute terms, but large relative to their small government budgets (Vanuatu's 2014 budget was about $130 million) and valuable because the money is paid when tax receipts are likely to contract the most.

Vanuatu, Tonga, Marshall Islands, the Cook Islands, and Samoa pay an average of 16% of the premium– Japan co-pays the balance– for cover against cyclones and, in some cases, earthquakes. Retaining participation in the face of basis risk has been a challenge: the Solomon Islands exited the scheme after two storms made landfall without triggering the contract. In contrast, in 2015 the Cook Islands paid its premium without any donor support.

For each of the insured countries, coverage is multiples of their national contingency budget (Mahul et al., 2015). Though the value of the payout is much less than the cost of recovery from a very violent hazard, it points the way ahead for vulnerable countries to protect themselves without relying on uncertain payouts from donors.

CCRIF in the Caribbean

What began life as Caribbean Catastrophe Risk Insurance Facility has since been institutionalised as CCRIF SPC, a "segregated portfolio company". Like the Pacific scheme that it inspired, the Caribbean facility pools risk from sixteen countries. The central innovation underlying CCRIF is risk pooling, which enables it to charge roughly half the premium countries would pay if they insured themselves individually (Ghesquiere et al., 2006). CCRIF has paid out nine times for the risks it covers– hurricanes, earthquakes, and heavy rains– for a collective payment value of over $37 million.

Though the scheme began as a purely parametric insurance contract based on satellite and related data, it has evolved into a modelled loss insurance. This reduces basis risk– payouts more closely match damage– but increases the lag between hazards striking and payouts. Nevertheless, every payout so far has been made two weeks or less after a sufficiently violent hazard was recorded.

Because the economies it covers are much larger than the participants in the Pacific pilot programme, the annual premiums and levels of coverage are much greater. Unlike the Pacific programme, members of CCRIF pay a larger share of higher premiums – $200,000 to $4 million a year for coverage of up to $50 million– and historically have relied on some form of donor support or subsidised financing from the Caribbean Development Bank.

ARC in Sub-Saharan Africa

The African Risk Capacity was established to create a risk pool to protect its members from relatively frequent droughts. ARC is two distinct entities: a secretariat and technical assistance facility and a legally-separate insurance company that offers the underlying contracts to countries and is domiciled in Bermuda (the main domicile index-linked insurance). Though

ARC was originally capitalised by donors, including the UK and Germany, it remains wholly owned by its members.

Like the risk pools in the Pacific and the Caribbean, ARC's underlying financial engineering is to collect premiums from all its members but only paying out to some of them, thereby reducing the cost of insurance for each. Also like those regional risk pools, payouts are based on modelled losses. Where the facility innovates is in requiring new members to set up a preparedness plan for how payouts will be used. The plans are vetted by an independent body (neither ARC's secretariat nor the insurance company) and coverage is only extended if the plan passes muster (African Risk Capacity, 2016).

In its first year, ARC insured Niger, Senegal, Mauritania and Kenya for coverage varying by deductible ("attachment point") and limit, up to $30 million per season. This initial risk pool was covered for $129 million in total losses, and ARC paid out more than $26 million in claims to three participants (which had paid a total of $8 million for this coverage) in response to the 2015 drought in the Sahel (ARC, 2016). The reason for this high ratio of claims to cover is that ARC insures countries against relatively frequent hazards: droughts that actuarial models predict to arrive on average once every five years.

These three models point to two levels of risk transfer. By mutually insuring one another, individual countries participating in PCRAFI, CCRIF, or ARC transfer specific risks to their respective insurance pools. In addition, programmes in the Caribbean and Africa have taken the next step of transferring a portion of those pooled risks directly to capital markets through index-linked securities, which we discuss above.

There are many more programmes to transfer risk than we discuss here, including national risk pools that have transferred risk to capital markets, like Mexico's MultiCat facility and the Turkey Catastrophe Insurance Pool to offset earthquake risk. Margulescu and Margulescu (2013) provide a nice survey, drawing on risk transfer programmes based on parametric triggers operating in Central America, the US state of Alabama, Malawi, China, and Vietnam. More broadly, the difference between estimated losses from hazards and the relatively low levels of insurance coverage represents an important opportunity to scale these models up and across.

Existing Programmes Pay Out Quickly, But Do Not Align Incentives

A large number of the insurance programmes that have been implemented or are being considered (including the World Bank's emerging framework for a Pandemic Emergency Facility, which we discuss below) prioritise the problem of swift payouts by relying on parametric contracts. They do not– or only weakly– tackle the incentive problems that lead to long-term underinvestment in disaster risk reduction. We can see this by looking at the three sovereign risk pools discussed above.

	Predictability?	Aligned incentives?
PCRAFI	Modelled loss	• Premiums have been heavily supported by donors (except the Cook Islands) • No preparedness or risk reduction incentives
CCRIF	Initially purely parametric, subsequently switched to modelled loss	• Initial subsidies for premiums have given way to subsidised financing • No preparedness or risk reduction incentives
ARC	Modelled loss	• Currently not subsidised but likely underpriced coverage; strategic plan calls for additional donor support for subsidised premiums that will be phased out • Coverage requires an externally-vetted preparedness plan, but not investments in reducing losses

Suggesting that sovereigns need better incentives to manage risk may sound uncharitable: we may often assume that governments have the best interests of the electorate to heart and do not need any external motivation to, for example, develop and actively enforce construction codes. But governments face a large number of pressures: faced with a choice between distributing bed nets to combat malaria for a well-identified cost per life saved compared to investing in better surveillance to the catch the next zoonotic disease like Ebola, even a benevolent and well-resourced government may underinvest in reducing future losses from the pandemic.[14]

As we have described above, even if a government would like to act in the interests of the electorate, it may not always be politically desirable or feasible to do so. For example, Keefer et al. (2011) consider the case of earthquake risk: governments can reduce deaths from earthquakes by enforcing construction codes, so on average higher propensity for earthquakes is associated with lower mortality from them because the rewards for risk-reduction are high. Two country-level characteristics interrupt this gradient: poverty and autocracy. Poor countries underinvest in mitigation because the opportunity cost of spending money today to avoid pain tomorrow is high– in short, they underinvest because they are poor. Autocracies and less free countries underinvest because the state is less accountable to the electorate, and therefore invests less in protecting them.

14 There is also an efficiency argument: when there are productive ways to spend money immediately, for example on education and health care, allocating a large share of the national budget for disasters is much less efficient than buying insurance.

The Missing Market in Disaster Insurance

In some contexts, an insurance contract's key feature is its guarantee of fast, reliable payouts. In other contexts, the key value of insurance is to align incentives to invest in reducing the losses from hazards that strike, such as building seawalls to protect against storm surges or continuous enforcement of building regulations and codes. And in some cases, it is an important global public good to make these investments and for governments continuously to manage these risks. For example, outbreaks of zoonotic disease like Ebola happen when people live in (increasingly close) proximity to animal populations, and spread more quickly when early warning systems either fail or do not exist. Since fast-spreading pandemics are a global risk, investing in early-warning and containment is a global public good.

These qualities – a facility that pays out quickly and predictably, or does not, and a contract that creates incentives for investment in mitigation, or does not – imply a simple framework for the market for insurance for emergencies.

	Aligns incentives	Doesn't align incentives
Pays quickly & predictably	**Missing market**	Parametric insurance
Doesn't pay quickly and predictably	Self-insurance	Donor financing

Donor financing is not predictable because it is delivered after hazards strike and at donors' discretion. It does not create incentives to invest in resilience because there is too much uncertainty about who will ultimately bear losses.

Purely parametric insurance products payout based on a parameter like wind speed or rainfall (or an index of such external parameters), and so reflect only the probability of a hazard and the coverage required. By definition, no action can be taken to reduce the risk of such hazards, and such contracts do not automatically create incentives to reduce the losses that might occur. Even ARC, which requires countries to put in place preparedness plans, does not require them to engage in prior risk mitigation and loss reduction.

Self-insurance does not involve risk transfer to insurance companies. Yet these programmes are challenging for developing countries to set up and institutionalise because there are other, pressing investments and scarce funds, there are political economy challenges to maintaining a large contingency fund, and it is rarely efficient to build up a large enough fund to cover rare-but-costly disasters. For all these reasons, self-insurance is not a strategy for 'predictable' payouts. (And as Bailey, 2012, points out, this is not only difficult for governments or sub-sovereigns: frontline agencies are under pressure to spend money today rather than save for a larger crisis later).

The **missing market** in catastrophe insurance is therefore a range of products that *both*

- Provide reliable payouts in response to clear triggers, and
- Create incentives to invest in reducing losses.

What does this look like? Kunreuther (2015) gives an example of the underlying financial maths from the US that would be applicable in many developing country settings: using insurance premiums to create an incentive to invest in flood protection. Imagine it cost $25k to elevate a property so that it is less susceptible to flooding. If a subsidised 3%, 15-year loan were available, this flood-resistance would cost $2,000 a year– still a net loss to the homeowner. But if investing in the elevation reduced her annual flood insurance premium from $4,000 a year to $500 a year, taking the loan and making the investment would "pay off" ($4,000 - $500) - $2,000 = $1,500 a year.

Flood insurance in Coastal Connecticut is not a priority use case for disaster insurance for developing country sovereigns. Yet this sets out how disaster insurance could work in frontier markets. Scaled up to national levels, this cost effectiveness algebra shows that there can be a substantial incentive to lower future losses.

The solution might have three key features:

> **Parametric payouts** A contract that indemnifies the insured for their actual losses requires a claims adjustment, to assess the loss incurred and to ensure that the insured has not contributed to their loss through negligence or foul play. But, as we argue above, claims adjustment may be impractical, expensive, dangerous or slow in the context of a disaster. Hence parametric contracts are normally preferred, because they do not require claims adjustment. This enables payouts to be made almost immediately, based on transparent data such as the wind speed of cyclones, temperature and rainfall for droughts, and seismic data for earthquakes. But it means that payouts are not related to the actual losses. A modelled loss framework closes the gap between payouts and losses, but does not eliminate this basis risk.
>
> **Premiums that create incentives for smart investments** Parametric contracts charge prices that reflect the probability of a hazard and the level of payout provided, but they do not charge lower premiums for lower losses – only for lower coverage, precisely because the risks they contract on cannot be changed by the insurer or the insured.
>
> Because losses are linked to investments that save money and lives when hazards hit, and since premiums for most insurance schemes involving developing countries include subsidised premiums, it is reasonable and feasible to calibrate the cost of the premium to the investments and actions of the insured government.
>
> **Financing (and technical assistance) to reduce losses** A developing country facing a hard budget constraint and limited ability to borrow is not able to prioritise investments that lower the costs of rare but expensive perils, even if its insurance premiums create incentives to do so. Therefore access to subsidised financing and technical assistance is a key element of any

disaster insurance scheme. This financing will ensure that governments capture the savings of lower premiums, enable them to invest in the right types of mitigation, and encourage stable commitment to an insurance programme (witness the Solomon Islands, which exited a mutual insurance programme in the Pacific, which we discuss above, after two cyclones made landfall but did not trigger a pay out).

More broadly, there is a persuasive literature arguing for the importance in clear planning for hazards and disasters. Dercon and Clarke (2016), for example, provide a compelling, book-length study of how these investments dramatically improve outcomes. Integrating the elements of this planning or investments in preparedness into insurance contracts is one way in which novel contracts could reward– and therefore incentivise– smart, forward-looking investments by governments.

There is some parallel with existing schemes like ARC, which illustrate a simple version of creating incentives alongside parametric insurance, by requiring countries to develop an externally-vetted preparedness plan in order to join the insurance pool. But– crucially– ARC has not taken the further step of creating incentives for risk mitigation and loss reduction. Moreover, there is an intuitive reason for ARC's requirement of pre-approved plans: CCRIF and PCRAFI insure against rapid-onset perils like cyclones, while ARC protects mainly against drought. Slow-onset perils have a longer lag between financing being triggered and being distributed, increasing the risk that money is misspent, which is less likely when the hazard has large, immediate, and visible consequences.

Predictable Payouts and Aligned Incentives

When designing insurance, we are concerned about *moral hazard*, the possibility that having protection against losses alters our appetite for risk. Properly designed, insurance can reward us for managing our risks more effectively (car insurance premiums may be lower for vehicles fitted with a speed limiter, for example). Parametric insurance contracts pay quickly and predictably because they are based on purely external data, like Richter scale readings. Yet because the underlying risks cannot be changed, these contracts do not create *additional* incentives to reduce losses by investing in resilience or managing risks.

We set out a more formal economic model in the appendix, but the intuition is simple. There are two types of risk: those that the insured can shift (*endogenous* risk) and those, like the velocity of wind speed, that neither the insured nor the insurer can affect (*exogenous* risk). An insight from the economics of information is the finding that when the insured can undertake costly effort to reduce the risk of a 'bad event', the resulting contract includes a deductible: that is, when there is a risk of moral hazard, insurance does not cover us completely from loss.[15] (This result obtains even under perfect competition– it is not an artefact of a too-high price for buying cover).

15 Insurers typically have two ways of combating moral hazard. First, by sharing downside risk: deductibles are losses that the insured has to bear before insurance "kicks in"– the higher the deductible, the lower the share of the risk that is transferred to the insurer. Second, by charging different amounts to different counterparties for the same risk: a smoker pays more for health insurance than a non-smoker, creating an incentive to quit.

This has interesting implications. First, when payouts are parametrically triggered, the optimal insurance contract need not include a deductible (because there is no moral hazard, since there is no way for the insured to affect the *risk* of a hazard).[16] Second, parametric contracts also do not create any additional incentives to invest in reducing losses from hazards.

A specific case can help to fix this intuition. The African Risk Capacity, which we discuss in the previous section, has recently announced Replica, a 'side contract' insurance facility through which international organisations like the WFP can buy the same parametric cover as that offered to governments (ARC, 2106). Getting a contract under Replica is conditional on having an approved disaster-preparedness plan setting out how the organisation would spend the insurance premium if the contract were triggered. Conceptually, this is like casinos offering the same games to all customers: because the risks are exogenous (beyond the control of both the casino and the customer), the characteristics of individual customers do not matter. As a result, the existence of Replica confirms that any level of parametric insurance is available at a set price: yet coverage through parametric insurance does not link that price (or the deductible) to investments in reducing future *losses*. Equivalently, Dominica, as a member of CCRIF, could not change the likelihood that hurricane Erika made landfall in 2015.

In this narrow but fundamental sense, parametric insurance separates the risk from loss, so that the price of the insurance *only* reflects the risk of bad events happening and the level of cover the insurance provides. A central innovation in building the missing market in disaster insurance therefore lies in contracts that combine parametric payouts with requirements or incentives for counterparties to reduce the costs of losses when they arrive. Purely scaling up parametric insurance will solve the problem of faster, more predictable financing. But it will not—and cannot—solve the problem of creating healthy incentives to invest in mitigation and manage risks.

The Challenge of Parametric Insurance for Pandemics

There is wide recognition that the global public sector's key failing during the Ebola outbreak of 2014 was delaying the declaration of an emergency, and, when an emergency was declared, a six-month delay before resources reached the affected countries (Grépin, 2014). According to the WHO's own estimates, it would have cost $5 million to contain Ebola in April, a month after it was initially detected, and $100 million if an emergency were declared in July. By October, 2014, the cost of control reached $1 billion (Woo, 2015). A timely response would have saved many lives by reducing new transmissions and providing better medical care for those affected. (As Frieden, 2014, points out, when the closely-related Marburg virus appeared in Germany, the fatality rate was much lower– around 23%).

As a result, the promise of fast payouts under unambiguous terms has created interest in examining how insurance contracts could provide rapid-fire financing for disease outbreaks. In particular, the World Bank has been considering the structure of a Pandemic Emergency Facility to focus on

16 As Borzenstein et al. (2009) point out in a discussion of CCRIF, this is slightly generous: parametric insurance provided to a government might be immune from "policyholder moral hazard" but still encourage more risk-taking behaviour amongst the electorate, like building closer to the shoreline, thereby inducing "third party moral hazard."

containment while "...preventing the human and financial costs from escalating with contagion" (World Bank, 2016). In May, 2016, it announced the creation of a $500 million pandemic facility with core funding from donors and additional funds provided through reinsurance and catastrophe bonds (Donnan, 2016).

The key design decision is whether insurance is the right model for a rapid payout facility. Parametric contracts are well suited for a large number of hazards, but the PEF faces two key challenges in adapting them to the problem of pandemic response. First, it is difficult to find a measure of an outbreak in a developing country that cannot be affected by insurers or the insured– in short, there is no cheaply-obtained, objective, and transparent trigger equivalent to wind intensity or seismic data. Several index-linked insurance contracts have been created to cover disease outbreak risks in OECD countries, including the US, the UK, Germany, and Canada based on catastrophe models (Woo, 2015), but these models depend on reliable frontline data– precisely the monitoring technology that developing countries do not have. Ruling out a parametric payout would mean slower disbursement, and therefore miss the key benefit of this kind of insurance financing for outbreaks.

Second, the reason that there is no strictly external trigger is that– unlike periods of high heat and low rain that cause droughts– pandemics are more likely when a country does not allocate time and money to disease surveillance, rapid testing, and early containment. As a global study of infection disease risks points out, Uganda, a low-income country, was the site of the previous Ebola outbreak in 2000, with 425 confirmed cases. Unlike Guinea, the site of the 2014 epidemic, the outcome was not an epidemic because Uganda had rolled out "...an essential health services package that included disease surveillance and control, and a decentralized health delivery system" (GHRF Commission, 2016). Because investing in these loss reduction strategies reduces the probability of an outbreak, there is a high likelihood of moral hazard. To prevent this, the optimal insurance policy would include a deductible, a higher premium, or both: the risk is not fully *exogenous*. (We discuss this point further in the appendix.)

This is troubling, because providing the full value of resources for tackling pandemics more quickly creates exponential savings and saves lives. There is a wide recognition that the global public sector should invest more in health systems. But those investments do not tackle the underlying failures: a clear trigger for funding for an effective and comprehensive response, and incentives to invest in reducing future losses and manage current risks. As two senior *Médecins Sans Frontières* staffers put it, "we caution against confusing the need for improved long-term health systems with the urgent need for a large-scale, immediate humanitarian response" (Philips and Markham, 2015).

It is possible to design a financing solution that can both pay out quickly and create incentives to invest in reducing losses. However, this facility would need to include clauses on loss reduction in addition to insurance, because a "pure parametric insurance" contract would not provide either feature. (The PEF looks set to implicitly feature the second of these: as the World Bank's own material on the facility notes, the facility "would also create an incentive for countries to be better prepared by making the development of a disease risk management plan a prerequisite for eligibility.")

This underscores a broader point that insurance financing models, including the innovative contracts we set out here, require thoughtful design. They should be scaled up dramatically for cases that feature strictly exogenous risks and where the value of fast payouts is high. Epidemics certainly satisfy the second of these conditions. Measuring the first remains an important, open challenge.

Scaling Disaster Insurance Up and Across

For those hazards where insurance financing is appropriate, fixing the market failure in the provision of disaster insurance will require two large increases:

- First, in the volume of insurance contracts agreed between governments and sub-sovereigns in developing countries and the global insurance sector (including re-insurers and, through index-linked securities, the capital markets).

- Second, an increase in the volume of contracts between insurers and sovereigns in which the global public sector (particularly multilateral institutions like the World Bank) are involved to facilitate access to cheap financing and provide a schedule of subsidised premiums.

There are three aspects to building this missing market: parametric insurance can protect low-income countries against losses and enabling better disaster preparedness and planning; linking the premiums for these contracts to investments in disaster management and preparedness can create healthy incentives for these governments to manage risk; and donor funding and technical support can enable them to do so.

Design a Flexible, Incentive-Compatible Contract

Current programmes and pilots have focused on individual support programmes either for specific transactions (for example, to facilitate a catastrophe bond issuance for Mexican public infrastructure) or building insurance pools (such as PCRAFI in the Pacific). Scaling up insurance for vulnerable economies requires designing a flexible contract that sets out a

- Trigger,

- Subsidy regime,

- Link between the premium and investments in risk mitigation, and

- Donors' provision of grant and concessional finance to meet initial build-out costs.

The contract could be scaled up (by increasing the amount covered) and across (by increasing the number of risks covered). The innovation lies in the *combination* of parametric measures of exogenous risks with conditions on endogenous effort.

As an example, a purely notional contract for Bangladesh might insure the country against significant losses from flooding– a risk exacerbated by anthropogenic climate change. The Bangladeshi government, possibly with technical assistance delivered through GFDRR and paid for by donors, might identify the level of coverage it required, and the priority investments required to limit losses.

The contract would be signed tri-laterally between a donor or multilateral agency, the Bangladeshi government, and an insurance provider. It would set out the level of coverage, the parametric trigger, and the donor's level of subsidy for the insurance premiums. Crucially, it would connect the cost of subsidies and the level of cover (and so payouts) to the Bangladeshi government's own actions and investments in mitigating the risk of flooding. Finally, it would set out the amount and degree of concessionality of any donor funding for the fixed costs of Bangladesh's investments in resilience.

Leverage Existing Programmes, Institutions, and Clubs

Multilateral institutions (particularly the World Bank and UNDP) and donors (Japan heavily subsidised PCRAFI, for example) have already established formal programmes and groupings to tackle aspects of the market failure, with various linkages to the two key actors: the insurance industry and emergency economy governments.

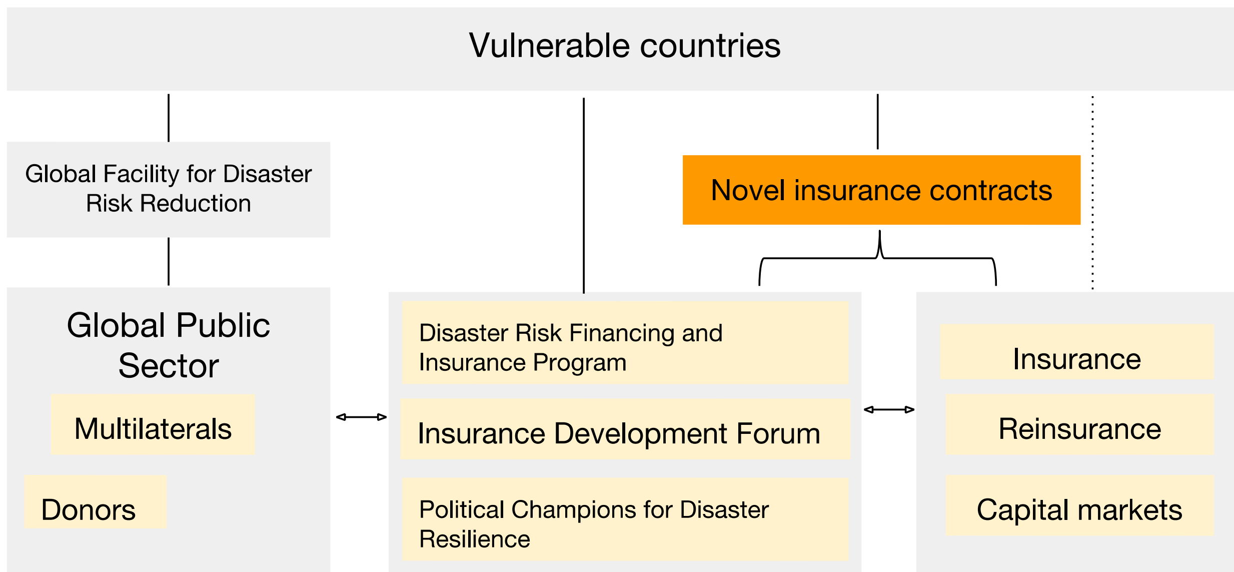
The World Bank's Global Facility for Disaster Risk Reduction works with governments and sub-sovereigns in developing countries to 'mainstream' disaster preparedness planning into government operations and budgets. At the time of writing, it has a portfolio of technical assistance contracts in and at end-2013 had provided more than 140 grants worth nearly $100 million. Cumulatively, the GFDRR is an investment in tackling the political and planning constraints on scaling up disaster insurance.

The Disaster Risk Finance and Insurance Program operates within GFDRR as an advisor that helps bridge the gap between insurers and the governments who are the World Bank's clients. It has played a role in transactions across more than forty countries. Put differently, the DRFIP helps tackle the information asymmetries that limit scale-up,[17] and maintains its reputation as a neutral advisory through an ethical wall between the programme and other teams at the World Bank that sell insurance contracts to clients.

Political leaders and senior donor officials have coalesced in semi-official clubs to promote scaling up disaster insurance. The Political Champions for Disaster Resilience initiative was launched in April, 2013, providing an informal platform for high-level donor representatives (including Justine Greening, the UK's Secretary of State for International Development and Ministerial-level representatives from Haiti, Senegal, and Bangladesh). The PCDR catalysed the Insurance Development Forum, bringing together donors, representatives from the insurance industry, and representatives from at-risk countries to work towards building pilot examples of this insurance in practice. And there is wider political recognition of the importance of broadening and deepening insurance coverage: the Group of Seven

17 In addition to public sector institutions, some insurance solutions are public-private partnerships. For example, GlobalAgRisk is a private-sector insurance advisor and broker that has advised the UK's DFID and Germany's KfW on the creation of Global Parametrics, a facility to scale up access to index-based insurance for developing countries.

(G-7) announced the joint *InsuResilience* initiative in May, 2015, setting the goal of "enabling" coverage for an additional 400 million people in developing countries by 2020.



These groupings are valuable areas of political consensus that can be leveraged to scale up novel contracts: donors will be eager to subsidise insurance payments if they recognise it will lower their implicit liability for future emergency aid; the insurance sector will benefit from access to new markets which include risks that are different than the ones already on their books (an earthquake that hits Haiti is unlikely to also affect Los Angeles); developing countries will benefit from risk transfer.

Get Out Of The Way

Finally, a large part of the potential market for disaster insurance does not require donor subsidies. For example, urbanisation and the rise of Asian megacities implies an overlap of government resources and demand for insurance against infrequent but costly perils. As a result, donors should not seek to be involved in every transaction, but disintermediate themselves, facilitating a direct market between the insurance industry and emerging economy sovereigns (the dashed line in the figure above).

Challenges for Scaling Up Disaster Insurance

Insurance financing is a compelling proposition. However, there are at least eight further political economy challenges to increasing the number of countries and range of perils covered:

Cost

Insurance firms will provide any level of cover– for a price. For emerging market sovereigns, that price is often too high, particularly given the opportunity cost in terms of other investments that the government would forego to buy cover (Mechler, 2004). Even if sovereigns could afford insurance, the bulk of evidence suggests that the programs on offer are too expensive. Looking at 30 years of data from 1970 onwards, Auffret (2003) concludes that (non-pooled) insurance has been historically overpriced, with payouts of about 0.5% of GDP compared to accumulated premia payments of 1.5% of GDP. In more competitive markets, insurance is *actuarially fairly priced*, closing the wedge between these figures.

Collective action problems

Based on estimates from CCRIF and PCRAFI, pooling risks means countries' premiums cost half what it would do to insure themselves. Yet because the benefits these savings are shared across the pool, any one country's incentive to establish a risk pool is low compared to the collective value of pooling risk. This, combined with the technical, communication, and political hurdles inherent in setting up a multi-country risk pool, mean that inertia often wins.

Information asymmetries

Governments and frontline agencies lack time, bureaucratic bandwidth, and human resources. Engaging with and negotiating effectively with sophisticated insurance firms is not a trivial allocation of any of these scarce resources. From the insurance industry's perspective, negotiating with developing country sovereigns or humanitarian agencies is challenging and unfamiliar.

Moral hazard

Purely parametric insurance contracts are immune from moral hazard because they are triggered based on measurements, like Richter scale data, that are beyond the control of the insurer and the insured. The corollary is that such contracts do not, in themselves, create incentives to invest in lowering losses. Non-parametric products, however, are not immune from the risk that, once covered, the insured will behave more riskily. Though insurers could differentiate between contracts to combat moral hazard using the usual tools of deductibles and different prices (premiums), this requires monitoring and negotiation, which can be expensive. Failing to pay out after a disaster also subjects the insurer to reputational risk. It may not be worth it to insurers to face these transaction costs and reputational risks for relatively small contracts with developing country sovereigns.

Basis risk

In 2014, the Solomon Islands was hit by two cyclones, neither of which triggered a pay out from the Pacific mutual insurance scheme it had paid premiums into (albeit heavily subsidised by donors). The country did not get a pay out because its contract was based on modelled losses crossing a trigger point, which neither storm did. As a result, the Solomon Islands' government dropped its cover under PCRAFI.

More generally, because parametric contracts are based on external models together with information about geophysical data like temperature and rainfall, they are subject to basis risk that penalises either the insurer (the index is triggered by the underlying losses are actually small) or the insured (the index is not triggered but the underlying losses are large). Though contracts based on assessed losses eliminate basis risk by bringing payouts into line with losses, these are expensive and unattractive for most kinds of catastrophe risk. The cumulative effect of basis risk and expensive alternatives both contribute to low levels of insurance cover for developing countries.

Politics

Defending persistent premium payments for an insurance policy that does not pay out for long periods is politically unsustainable for many developing country sovereigns.

In November, 2008, Andrès Velasco, then Chile's Minister of Finance, was burned in effigy by government workers in Santiago. The government Velasco served in, led by President Michele Bachelet, was wildly unpopular because it committed to saving a large share of record-high earnings from copper sales, Chile's main commodity export, rather than use them to expand social spending. Chile's rainy day fund was nearly a third of GDP at its peak– in effect, a self-insurance policy.

Following the beginning of the financial crises in 2008, international copper prices collapsed, bringing Chile's economy down with them– unemployment shot past 10%. Bachelet's government was able to use the saved export receipts to run countercyclical policy, increasing government spending to offset the worst effects of the financial crisis. As a result, by the end of Bachelet's term, she and Velasco enjoyed the highest approval ratings of any leader and minister since Chile's return to democracy.

Velasco and Bachelet are now feted for their implementation of textbook macroeconomic policy, but fought a difficult political battle to protect the national savings fund. If the crisis had not hit, their political careers may easily have been ended and Bachelet's party voted out office. (Dercon and Clarke, 2016, point out that insurance contracts– rather than self-insurance– alleviate this political pressure because they create a stream of payments to a third-party rather than a large, accessible contingency fund. Yet premium payments may themselves be politically contentious for governments faced with other priorities for spending).

Heuristics

One reason for underinsuring ourselves against disasters is that we underestimate the losses they cause. A vast number of real-world phenomena have a normal (bell-shaped) distribution, ranging from human heights to test scores to measurement error in scientific experiments.

But losses from natural disasters are not distributed this way: the losses from earthquakes, landslides, and wildfires all have a so-called power law distribution. These loss distributions have much "thicker tails", meaning that the probability of a very large loss is significantly greater than that predicted by a normal distribution, and so greater than our naïve estimates might suggest.

For example, the deadliest earthquake recorded between 1990 and 2005 registered 9.0 on the Richter scale and struck off the coast of Sumatra in 2004, killing 283,100 people. The *second* deadliest was a 7.6-magnitude quake in Pakistan in 2005, which killed 80,300 people. So the deadliest earthquake killed more than 3.5 times the second deadliest (Berger et al., 2006). Because disasters cause losses that are rarer but much worse than what we expect, we under-protect ourselves against them, reducing the demand for insurance at any price (Helbing, 2005).

Charity hazard or "Samaritan's Dilemma"

In the absence of any type of insurance, the global public sector still has an implicit commitment and moral obligation to intercede and offer assistance. By offering assistance after hazards have hit, donors and NGOs undermine incentives to self-insure, but cannot commit to 'do nothing'– the Samaritan's Dilemma.

In reality, it is impossible to estimate how much countries would self-insure or invest in resilience if donors were not expected to step in when rare but expensive hazards strike. However, one reason that the market for insurance is not as broad as it might be is the misalignment of incentives due the dominant model of *ex-post* response.

Though existing programmes like ARC, PCRAFI, and CCRIF are not perfect, and the scale of these programmes is not yet commensurate with the opportunities, their existence demonstrates that eight constraints are not binding. Appropriate donor support can help to pay for costs, as well as overcome information asymmetries and collective action problems. Though relying on parametric contracts creates basis risk, it tackles problems of moral hazard, and basis risk can be reduced through more closely tailoring the parametric trigger to the underlying loss. Insurance may be more politically attractive than other ways of saving for hazards because premiums are spent today, while contingency funds stay on-budget tomorrow– a tempting target for populists. While heuristics about the incidence of rare-but-expensive disasters leads to underinsurance, appetite amongst developing countries for insurance programmes demonstrates that leaders and line ministries are cognisant of the risks they face. Finally, using insurance to solve the Samaritan's Dilemma precisely tackles charity hazard, so donors are themselves in a unique position to reduce the reliance on *ex-post* and discretionary financing– and the poor planning and preparation that comes with it.

Conclusions and Next Steps

International assistance for large-scale costs created by hazards is rooted in our best impulses. It recognises our mutual interest in providing help when disaster strikes, and it socialises losses so that cost and responsibility transcend national boundaries. This collective effort is admirable.

Unfortunately, the way it has been done is a poor fit for the demands of modern emergencies. Because disaster aid is discretionary, there is no guarantee that the cover we provide actually matches needs. This mode of response empowers donors but compromises those affected by hazards: the response to critiques of "too little, too late" is "too bad." Because there is no explicit agreement that the burden of financing be shared equally, contributions to humanitarian aid vary greatly across donors, recipients, and time. And because aid allocations are decided *ex-post*, after hazards hit, aid has the crucial unintended consequence of distorting incentives to lower losses and manage risks.

The global public sector can do better. All the elements of the solution are available: parametric measurement for insurance contracts which pay out much more quickly and reliably than *ex-post* aid, and feasible investments in technologies that limit the losses arising from hazards. Innovative contracts that combine both these features carry the promise of preventing a far greater number of hazards from becoming disasters; of saving many more lives at lower cost.

Programmes in sub-Saharan Africa, the Pacific, and the Caribbean have all demonstrated appetite amongst developing country governments for insurance to supplement their national contingency plans. Combining the risk pooling underlying these programmes with risk transfer to capital markets will make getting cover cheaper. Most importantly, combining parametric insurance mechanisms that encourage countries to invest in lowering future losses can deliver the key features absent from our existing *ex-post* aid paradigm: fast payouts alongside aligned incentives.

Appendix

It is useful to study some implications of simple expected utility theory for which contracts are optimal given risks that can be changed with some effort ("I can drive more slowly") and those that cannot ("I can build my home to code, but not eliminate the risk an earthquake happens"). The following is based on a simplification of standard models, and in particular draws the presentation in Rees and Wambach (2008).

The simplest possible setup to demonstrate our main aims is an insured party who wants cover C in exchange for paying a premium P. She has wealth W that is subject to a binary risk of some loss L with probability π and no loss with its complement $(1-\pi)$. We assume that her utility function is concave in its argument(s) and, equivalently, that she has some level of risk aversion.

Optimal Contracts When the Insured Can Affect Risks

In the typical case, the insured can influence the probability of a loss by exerting some effort *e* with a cost $c(e) > 0$. The simplest case is a binary choice of effort, $e \in (\underline{e}, \bar{e})$ with $\bar{e} > \underline{e}$ corresponding to "greater effort". The effect of this effort is to shift the probability of experiencing the "bad" state, $\pi(e)$ with $\pi(\underline{e}) = \pi_1$, $\pi(\bar{e}) = \pi_2$, $\pi_2 < \pi_1$.

The insurer is only going to accept the risk transfer if she earns an expected profit G, so her constraint on the set of solutions—the participation constraint—is a minimum profit condition

$$(1-\pi_2)P + \pi(C-P) \geq G$$

where P is the premium payment she earns for the risk transfer and C is the amount of cover she provides. Expressing the premium as a function of total cover using $P = p \cdot C$, this is $p = \frac{G}{C} + \pi_2$. Under perfect competition G would be driven to zero, so that $p = \pi_2$.

To motivate the insured to take the costly action, it must be valuable to her relative to the low-effort choice e_1. This implies the incentive compatibility constraint

$$(1-\pi_2)u(W-\pi_2 C)+\pi_2 u(W-L+C)-c(e_2)-(1-\pi_1)u(W-\pi_2 C)-\pi_1 u(W-L+C-\pi_2 C) \geq 0$$

Which requires that the expected value of consumption in the "effortful" probability set $\{\pi_2, (1-\pi_2)\}$ is larger, net of costs $c(e_2)$, than her outside option.

The insured's problem is to choose the level of cover, C, according to the solution to the Lagrangian

$$\max_{C}(1-\pi_2)u_1(\cdot)+\pi_2 u_2(\cdot)+\lambda[(1-\pi_2 u_1(\cdot)+\pi_2 u_2(\cdot)-c(e_2)-(1-\pi_2)u_1(\cdot)-\pi_1 u_2(\cdot)]$$

Where we have used that the participation constraint binds with equality and the definitions $u_1(\cdot) = u_1(W - \pi_2 C)$ and $u_2(\cdot) = u_1(W - L + C - \pi_2 C)$ for neatness. Differentiating with respect to consumption shows that at the optimal choice C^*,

$$\frac{u_1'(W - \pi_2 C^*)}{u_2'(W - L + (1 - \pi_2)C^*)} = \frac{k - \lambda\pi_1}{k - \lambda\pi_2}$$

Where $C^* - L < 0 \Leftrightarrow C^* < L$and k is a positive constant term that is larger than λ. Since we know that effort reduces the loss probability, $\pi_2 < \pi_1$, and therefore $u_2'(\cdot) > u_1'(\cdot)$. Given that the utility function is concave in its arguments– equivalently, the insured is risk averse– this implies $C^* - L < 0 \Leftrightarrow C^* < L$. Therefore, when the insured can influence the level of risk, even when insurance is actuarially fairly priced the insured does to receive full cover under the optimal contract.

Implications for Parametric Pandemic Insurance

This suggests a useful insight for pandemic insurance. Because the risk of pandemics is not strictly exogenous, the probability of the loss state reflects (costly) effort, for example allocating fiscal and political resources to containment, preparedness, and frontline disease monitoring.

Because of the high returns to marginal investments in frontline response, we may also believe that the outbreak risks are steeply non-linear, so that $\pi'(e) < 0$ and $\pi''(e) > 0$. That, in turn, implies that the probability of the bad event under higher effort $\pi(e_2)$ is small even for modest choices of costly effort. Put differently, pandemic risk is priced as if it were highly within the control of the insured.

Given the analysis of the level of cover when effort is costly and not contracted on, this implies a low level of cover, relative to loss, and so a high deductible (in the language of catastrophe bonds, a high 'attachment point').

This is troubling, because of the public good nature of responding early to an outbreak. If the value of the deductible represents the value of unmet response needs and unmet needs generate higher subsequent costs, then there is a case for allowing additional resources at the time of the outbreak. However, no optimal contract that reflects the control of the insured over the risk of outbreak will provide full cover, even if it were available from perfectly competitive suppliers.

Contracting on Exogenous Risk

When risk is exogenous, then the insured or the insurer cannot lower or increase risk through their actions, so that $\pi$is not a function of effort e. This simplifies the insured's choice problem significantly, because there is not incentive compatibility constraint constraining the set of feasible contracts. Her problem is now

$$\max_{C\geq 0}(1-\pi)u(W-P)+\pi u(W-L-P+C)$$

Subject to the definition of the total premium, as a function of cover and the premium rate, $P = pC$. Inserting the constraint and solving the optimisation problem (differentiating with respect to C), then the optimal choice of C^* will be given by

$$\frac{u_1'(\cdot)}{u_2'(\cdot)} = \frac{\pi}{1-\pi}\frac{(1-p)}{p}$$

where, as before, we define $u_1'(\cdot) = u(W-pC)$ and $u_2'(\cdot) = u(W-L+(1-p)C)$. If we set $p = \pi$ for the case of actuarially fairly priced cover, then it must be that $C^* = L$. If the premium were lower than the probability of the hazard, optimal cover would exceed loss, $C^* > L$, and the opposite would be true if $p > \pi$.

We can easily extend this framework to show the distortionary effect of anticipated donor transfers– ex-post aid– in the case that the bad event happens. Assuming the expected value of aid in the loss state is some positive amount A, then the optimality condition is simply

$$\frac{u_1'(W-P)}{u_2'(W-L-pC+C+A)} = \frac{\pi}{1-\pi}\frac{(1-p)}{p}$$

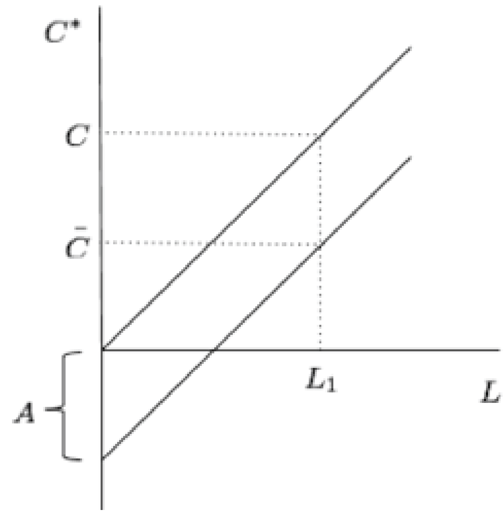
Now, even if insurance were fairly priced, the choice of cover is distorted

$$C^* - L + A = 0 \Leftrightarrow C^* = L - A$$

This is the Samaritan's Dilemma: for any positive expectation of ex-post aid, the optimal choice of cover goes down. Since the global public sector cannot commit to $A = 0$, cover will always be low, compared to loss, even when insurance is fairly priced.

Ex-post aid will not recover the optimal choice of cover in the absence of aid even if the insured is budget constrained. In practice, lower-income countries face budget rationing, so that their feasible choices of C^* may be further limited by a rationing constraint, such as $C^* < \bar{C}$. For any amount of loss, a budget rationing constraint creates a kink in the demand schedule such that cover is flat in loss, limiting cover to a lower level of loss.

Any ex-post transfer shifts is a vertical shift down in the choice of cover for all levels of loss, which has the effect of crowding out cover: even if the insured were not rationing her budget, for some loss L_1, ex-post aid would lower her demand for cover from C to $\bar{C}$.



Though it is true that an appropriate choice of A can give the same fiscal level of transfer, this simple example demonstrates the crowding out effect of aid: even perfectly targeted aid will not increase *insurance* cover for a given level of loss. If we consider that insurance has valuable incentive-aligning effects and is valuable because it pays out quickly and unambiguously, this crowding out has welfare consequences.

Contracts On Risk Do Not Incent Loss Reduction

Catastrophe bonds and other index linked securities facilitate fast payouts after hazards hit, which they achieve by contracting on strictly exogenous risks such as wind speed. Because of this, insurance cannot be priced to incent higher (unobserved) effort, as we showed above. However, the optimal contract also does not create *increased* incentives for loss reduction.

To see this, we include a costly way for the insured to reduce losses in the bad state, when a hazard has hit, the parameter $R(e)$. Choosing higher effort incurs larger reduction costs, $R'(e) > 0$ but simultaneously reduces losses, $L'(e) > 0$. Including these terms delivers the insured's problem, which is to maximise cover under costly loss reduction

$$\max_C E(U) = (1-\pi)u_1(W - R(e) - P) + \pi u_2(W - R(e) - L(e) - P + C)$$

subject to the same 'premium definition' constraint $P = pC$. The derivatives of this function with respect to effort, e, and cover, C, are, respectively,

$$\frac{u_1'(\cdot)}{u_2'(\cdot)} = \frac{\pi}{1-\pi}\left(\frac{-L'(e) - R'(e)}{R'(e)}\right)$$

And

$$\frac{u_1'(\cdot)}{u_2'(\cdot)} = \frac{\pi}{1-\pi}\frac{1-p}{p}$$

Without loss of generality, we can focus on the case of perfect competition in the supply of insurance, so that premiums are actuarially fairly priced. Then $\frac{\partial E(U)}{\partial C} = 1$, implying a choice $C^* = L(e)$, or that the insured will seek full cover. The choice of effort level consistent with this choice is given by $\frac{\partial E(U)}{\partial e} = \frac{u_1'(\cdot)}{u_2'(\cdot)}$, which shows that at the optimal choice of cover,

$$\frac{1}{\pi} = \frac{-L'(e)}{R'(e)}.$$

Put differently, because the insured chooses full cover (absent budget rationing or monopolistic competition in the supply of insurance), contracting for risk transfer on strictly exogenous risks does not create any *increased* incentive for the insured to invest in costly risk reduction. The intuition for this is that cost of cover reflects risks, which the insured cannot change if the are strictly exogenous (as they would be for well-designed parametric triggers), rather than losses, which she can. It is possible for a contract to be designed to increase the incentive for investing in loss reduction while pricing the cost of risk transfer purely on exogenous risks. However, as is shown, pricing cover relative to exogenous risks alone will not create this incentive.

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