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BACKGROUND PAPER

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MODELING THE INDIRECT AND FISCAL RISKS FROM NATURAL DISASTERS FOR INFORMING OPTIONS FOR ENHANCING RESILIENCE AND *BUILDING BACK BETTER*

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1. Introduction: modelling and managing fiscal risk based on a comprehensive data set

The need to proactively engage in dealing with (extreme) risks has been featured prominently in publications on global assessments of risks and development. For example, the Global Assessment Report – GAR 2013 (UNISDR, 2013) emphasized the need to shift from unplanned and ad hoc responses to proactive and systematic risk management and provides a number of entry points for doing so, including working towards better and more comprehensive risk assessments. The GAR 2013 and the Global Risk Report published by the World Economic Forum (2014) concluded that better efforts are needed to understand, measure and foresee the evolution of interdependencies (of risk). Notably, the GAR 2013 issued a stark warning that economic losses linked to disasters are "out of control" and will continue to escalate unless disaster risk management becomes a core part of public sector and business investment strategies.

Dealing with extremes in a proactive manner requires assessments on a forward-looking basis making use of catastrophe risk modeling (Michel-Kerjan et al., 2012). Generally speaking, disaster risk is a function of the hazard, the vulnerability and the exposed elements. Catastrophe modeling approaches combine these elements to derive risk estimates (UNISDR 2011). The most important outcome of such analysis is usually in the form of a loss distribution (or loss exceedance probability curve). Such distributions are extremely useful as they not only indicate the range of possible losses but also the corresponding probabilities (see GAR 2011).

Often risk finally ends up as the responsibility of public entities and sovereign risk management has seen a lot of emphasis over the last few years. We focus on national governments as risk bearers in terms of the fiscal position, and examine the risks due to earthquake, wind, storm surges, tsunami, and flooding hazards. We base our analysis on newly produced risk estimates from the GAR consortium (2015) and combine these estimates with updated resource information on a government's capability to cope with these events. We draw heavily on the method explained in Hochrainer-Stigler et al. (2014), which performed a similar analysis for climate related hazards (including flooding).

In addition to identifying risk generally, with such risk information it is possible to determine risk tolerance and threshold events where risk tolerance is exceeded. So-called risk-layering approaches seem especially useful in cases where disaster risk assessments in terms of loss distribution are available (Linnerooth-Bayer and Hochrainer-Stigler 2014).

Mechler et al. (2014) suggest the need to distinguish between distinct risk layers for which different risk management options would be preferable (Figure 1). The figure distinguishes between four layers comprised of:

1. Frequent, low-consequence risk, for which assessments have shown that risk reduction holds great potential for managing risk at this lower level;
2. Medium-layer risks, for which risk reduction will often be integrated with insurance and other risk-financing instruments;
3. Rare, catastrophic events, for which international assistance will be necessary as domestic coping capacity is exceeded;
4. A very high-level risk layer, for which even the capacity of international donors and financial institutions can be exceeded over time (e.g., with strong climate warming, extreme event risk may exceed the capacity of the international system to respond, which signals a need to undertake stringent greenhouse gas reduction efforts).

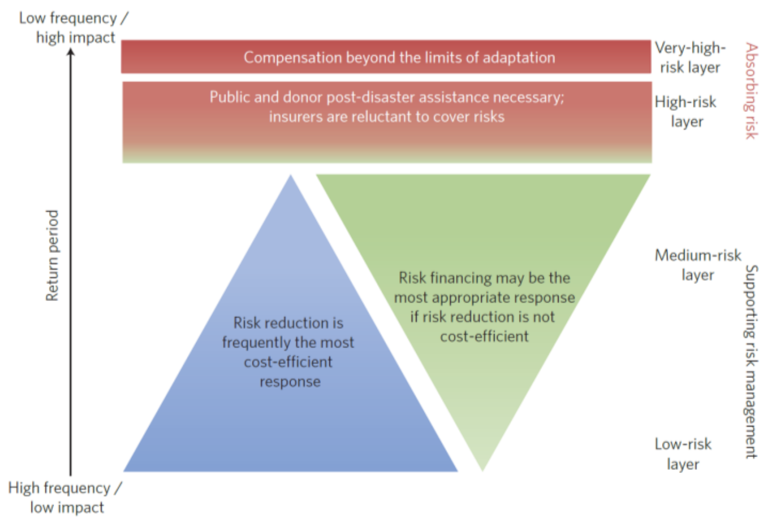

Figure 1. Risk layering approach. Source: Mechler et al., 2014.

The CATSIM model was developed to understand and identify these layers by conducting stress testing that identifies thresholds. CATSIM can then be employed to help understand policymakers' needs for devising public risk management and financing strategies in both a pre- and post-disaster context. Finally, national-level assessments can be combined to global or regional-level estimates to evaluate financing needs of regional and global pools.

Solid and comprehensive risk information is an essential input to CATSIM, which requires national-level loss-exceedance distributions as an input as described by Hochrainer (2006) and for specific applications in Hochrainer (2014).

For the GAR '15 assessment, a unique dataset of country–wide risk distributions for 180 countries was provided by the GAR consortium. This dataset allowed to conduct innovative and salient assessments regarding national, regional and global-level applications. Data was available for earthquake, extreme wind, storm surge, and tsunami hazards, with empirically derived risk estimates for flooding from Hochrainer-Stigler et al. (2014) via convolution.

2. Methodology

Overview

The CATSIM methodology combines estimates of the direct, monetary risk a country is exposed to with an evaluation of sovereign fiscal resilience (Mechler, 2004; Hochrainer, 2006; Hochrainer-Stigler et al. 2014). National hazard, exposure, and resilience data is input into CATSIM, which is used to identify the likelihood of a disaster to overwhelm the government's ability to finance the recovery process. Expected public sector losses are calculated for events of varying return periods, and these losses are compared to the estimated available financial measures for recovery; a shortfall indicates a resources gap, leading to delayed reconstruction and recovery, and eventually shifting development trajectories and hampering long term economic growth.

We define *fiscal resilience* as a country's ability to access domestic and external savings for any purpose – urgent or longer term. Combining fiscal resilience with direct risk (probabilistic losses) leads to an assessment of *fiscal vulnerability*, defined here as the lack of government access to domestic and foreign savings for financing reconstruction investment and relief after a disaster. Any gap in financing is measured by the term *fiscal gap*. We consider fiscal (or resource) gaps to be the difference between required investments in an economy to achieve growth objectives and the actual available resources. Following this perspective, a fiscal gap is understood to be the lack of fiscal resources to restore assets lost due to natural disasters and continue with development as planned.

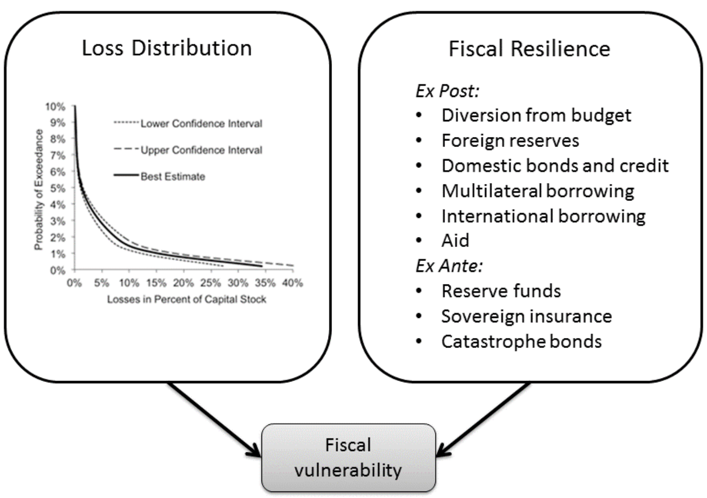

Figure 2. Resource gap calculation. Source: Hochrainer-Stigler et al. 2014

CATSIM helps to understand whether a government is fiscally prepared to serve its contingent disaster liabilities, i.e. repair damaged infrastructure and provide adequate relief and support to the private sector for the estimated losses. For this assessment, it is necessary to examine the government's sources, including sources that will be relied on (probably in an ad hoc manner) after the disaster and sources put into place before the disaster (ex-ante financing). The approach applied is described in Hochrainer-Stigler et al. (2014) is visualized in figure 2. Table 1 lists key fiscal resilience variables and parameters.

Table 1. Overview of ex-post and ex-ante sources of fiscal resilience

Measure	Description
Ex-post:	
Budget diversion	If a government runs a budget deficit > 5%, no diversion capability is assumed; if diversion is possible, 10% of total revenue is diverted towards relief
Domestic bonds and credit	Assumed limit of 1% of total credit from private banking sector
MFI / International borrowing	Limit based on 2012 country holdings of Special Drawing Rights (SDR) defined by the International Monetary Fund
Taxation	Not included, considered difficult to implement in a disaster-effected economy and ineffective in terms of time required to pass legislation and collect revenue
Aid	10.4% of direct losses from disaster assumed to be financed via outside assistance (Hochrainer-Stigler et al 2014)
Ex-ante:	
Reserve funds	Up to now only a few such instruments are in place for financing losses for extremes (such as FONDEN in Mexico) and most of them are targeted for immediate help after the disaster (such as the CCRIF) which is usually only a fraction of the total costs (World Bank, 2007; see also Cardenas et al., 2007 for the case of Mexico). Hence, these measures are not included.
Sovereign insurance	
Catastrophe bonds	

Estimating monetary risk (direct risk)

For this analysis, direct risk estimates for four different hazards, including earthquake, windstorm, storm surge and tsunami, were available for 180 countries. 20-, 50-, 100, 250-, 500, and 1000 year event loss estimates were given, but due to computational issues, only 20-, 50-, 100, 250-, 500- year loss events were used. As we were interested in the financial vulnerability of the government to all of these hazards our first task was to combine these estimates to derive a multi-hazard risk distribution. Simply summing the corresponding return periods would have led to an overestimation of risk (as these hazards are assumed to be independent) and therefore convolution of the distributions was required. This was done based on a numerical convolution approach discussed in Hochrainer-Stigler et al. (2014) and adapted to fit the purposes of this research. The final total loss distribution (in billions constant 2005 USD) was used as input for direct risk calculations.

To avoid underestimating the size of losses the government is liable for, we assumed that it is liable for half of the total losses (and includes also help to private sector entities). From the loss distribution, loss events were sampled (via a Monte Carlo simulation approach) and after determining the respective resources to finance these losses, financial vulnerability was calculated. Financial vulnerability is represented by the fiscal gap year event and gap sizes (in billions constant 2005 USD) for the 20-, 50-, 100, 250-, 500- year loss events.

Building back better

Fiscal risk modeling can be linked to new thinking on resilience, involving the concept of building back better, in order to study the cost implications. Increasingly, national and international policymakers are emphasizing the need to not only build back to the status quo post event but to build back better (BBB) and reduce risk in the long term.

The existing literature indicates that building back better requires additional preparedness in terms of fiscal and technical resources (see Keating et al., 2014). For many developing countries characterized by high vulnerability in terms of structurally weak housing and infrastructure, poor land-use planning, and lack of risk-based public and private investment decision-making, simply building back as it was before perpetuates a vicious cycle of risk continuum and poor developmental practices. Post-disaster situations provide an important ‘window of opportunity’ to break this cycle and transform the built environment to a safer and more sustainable one. A society’s ability to seize such opportunity depends on a number of factors including their level of fiscal preparedness.

We performed an analysis of this concept using the following approach. We were specifically interested in assessing the potential fiscal benefits for countries with high risks of experiencing a financing gap below the 100 year event. The average annual funding required to cover the unfinanced losses on the global scale is estimated to be around 7.7 billion USD, according to our estimates for a business as usual scenario. In this case, on average, all losses above the financing gap – conditional that it is below the 100 year loss event – will be financed by the fund. In order to calculate the fiscal benefits of a BBB approach, we assume that an additional 10% of resources (in this case, 10% of the gap size, which is covered by a hypothetical global fund) are utilized to recover from an event, based on previous estimates. We also assume the cost-benefit ratio for investments is 1 to 4 (i.e. 1 additional dollar invested saves 4 dollars in the future, on average), based on recent analysis. Given these assumptions, we increase the fiscal resources available to countries by 4 times 10% of their 100 year event gap size. We then recalculate the global estimates of fiscal vulnerability using these increased resilience parameters and determine the effects on fiscal vulnerability and risk pooling mechanisms. We can thus compare the annual average costs of a global fund for disasters for 20, 50, 100, 250, and 500 year event layers for both business as usual (BAU) and BBB approaches.

3. Results

Country-level perspective

Assessing fiscal vulnerability to natural disasters globally based on the extended GAR risk modeling data set and the elaborated fiscal risk assessment provides a systematic and holistic basis for evaluating countries' ability to bear risks as well as options for managing risk (such as risk prevention and regional risk pooling structures). Figure 3 shows an updated global assessment for fiscal vulnerability and risk assessment (fiscal stress threshold in terms of return period events (20, 50, 100, 250, 500) beyond which a country would not be able to function as planned) for the business as usual or "building back the same" case. This work builds off of previous iterations of such analysis and incorporates improved estimates of countries' ability to finance losses (new parameters and updated dataset to latest years available). The new global estimates include risk curves for ~180 countries provided by the GAR consortium.

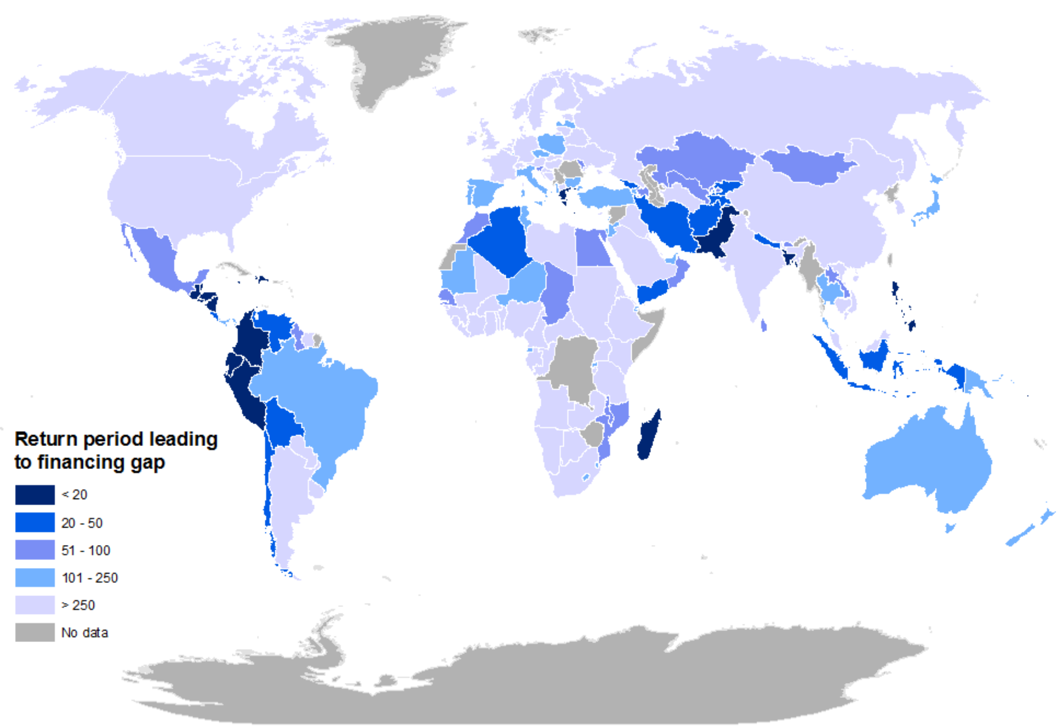

Figure 3. Global analysis of fiscal gap return periods for flooding, windstorm, tsunami, and earthquake hazards.

The method employed moves beyond assessing monetary losses and emphasizes the risk of a financing gap, which produces a different picture of global disaster risk. Countries traditionally noted as having extremely high impacts may have ample fiscal resources to recover from shocks, whereas other nations with comparatively smaller impacts may be much less well off in terms of resilience, with a much higher risk of a fiscal shortfall and resulting resources gap. This global analysis can provide a base for planning risk management options, and also serves to highlight hotspots for more focused research, such as Central and South America, Indian Ocean countries and some Asian states.

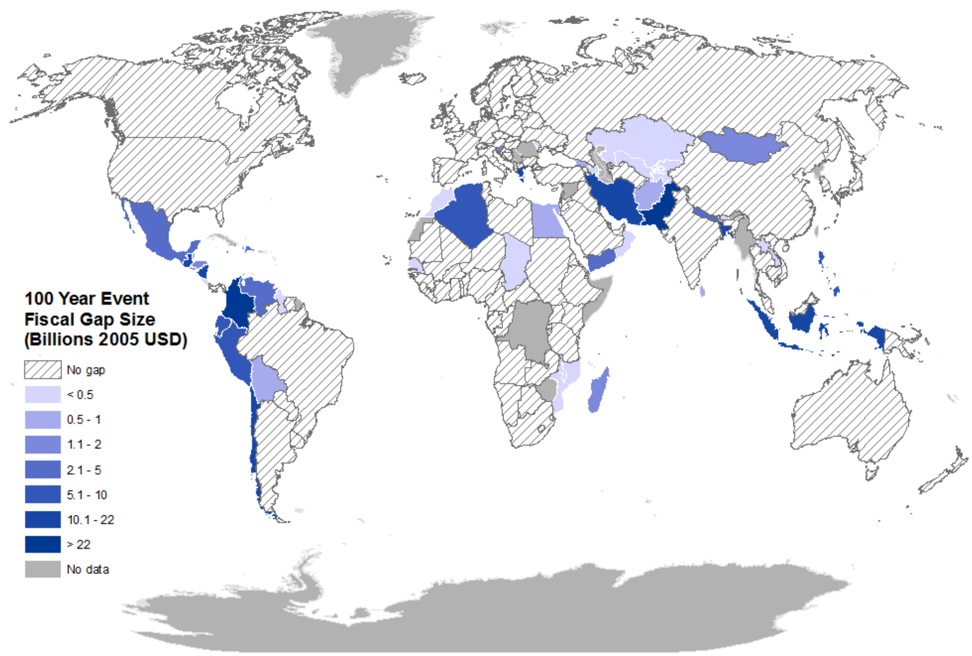

Figure 4. Size of estimated resource gap, in billions 2005 US dollars, for countries facing a 100 year return period disaster event.

As can be seen (and according to theory due to their ability to better pool and share risks), larger and wealthier countries have fewer problems financing loss events. However, conventional measures of wealth such as GDP are imperfect indicators of a country's financial and fiscal vulnerability. For example, out of G-20 economies, both Mexico and Indonesia, which hold 1.9 and 0.8% of the global share of GDP, both are at risk of a fiscal gap for events more frequent than a 100 year return period. In the top 30 global economies (based on World Bank GDP data for 2012) Iran is also highly vulnerable, potentially experiencing a fiscal gap due to a 23 year event. Absolute land area is also not a good predictor of vulnerability either, with 7 of the top 20 largest countries experiencing resource gaps at a 100 year event or less (they are: Kazakhstan, Algeria, Mexico, Indonesia, Iran, Mongolia, Peru, and Chad). However, it should be emphasized that generally, smaller countries with weaker economies and high impacts are more at risk of a fiscal gap (13 of the 20 smallest countries by land area are affected by < 100 year fiscal gaps), but it should be noted that our analysis only incorporates the current situation and financial vulnerability may be weakened after such events, eventually leading to financing problems for future events. The notion of path dependency as well as fiscal space provides an entry point for such countries, which would require a more detailed and in-depth analysis (see the discussion section). Additionally, as drought effects are not considered in this work, the global picture could look quite different with its inclusion, especially for African countries.

The global assessment follows a standardized, structured approach for a first estimate of disaster risk, and can be followed up by country-level analysis, taking into account factors not considered in the global analysis, such as incorporating existing *ex-post* and *ex-ante* financing options like country-specific reserve funds, insurance, or risk pooling measures. The Indian Ocean region, as well as Laos and Cambodia, were examined via in-depth case studies, and are discussed in the boxes on the following pages.

Box 1. Country -level analysis of Indian Ocean countries shows that considerable fiscal risk continues, highlighting the need for further risk management strategies in these countries.

Madagascar along with Small Island Developing States of Mauritius, Seychelles and Comoros face considerable economic and fiscal risk due to natural disasters. Updated global risk assessment and fiscal risk analysis done for the GAR shows that these countries are exposed to annual average losses of approximately 1 to 6% of GDP. In the case of a catastrophic disaster with a return period of 500 years, face losses of approximately 7 to 18 % of GDP. The limited availability of ex-ante resources including reserve funds, contingent credit agreement and insurance along with constrained ex-post financing options mean that these countries may encounter difficulty in raising sufficient fund for recovery and reconstruction relatively frequently. Using two sources of risk information estimated by UNISDR/IOC (2014) and Hochrainer-Stigler et al. (2012), fiscal gaps were estimated to be 23-24 years for Madagascar, 56-77 years for Comoros, 62-87 years for Mauritius, 102-329 years for Seychelles and no gaps for Zanzibar.

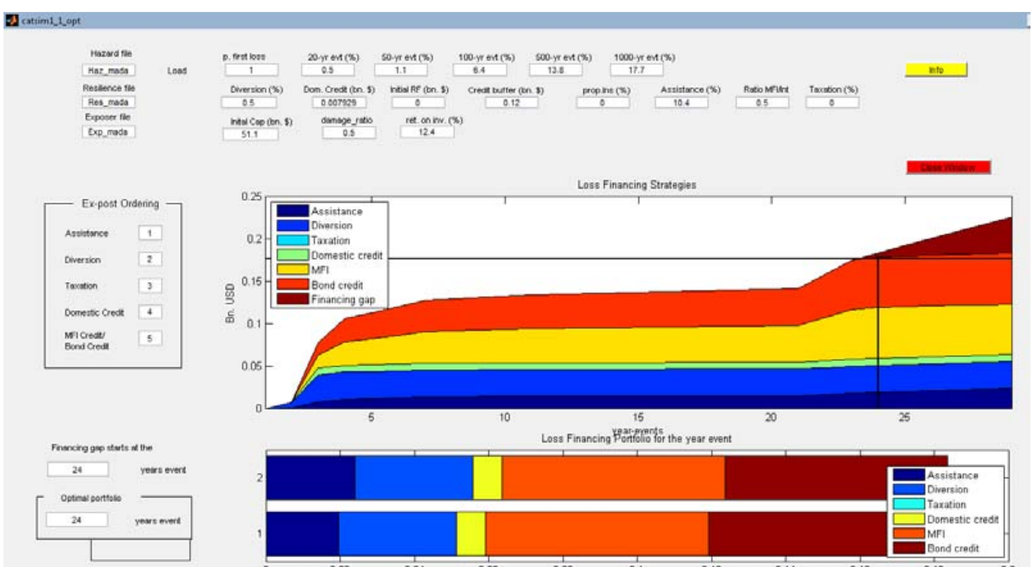

Figure 5. Resources Gap Year for Madagascar. Source: Authors.

Box 2. County-level analysis of Cambodia and Laos shows that indirect impacts of natural disasters could be sizable. The time-dependent nature of these follow-on effects means that ex-ante arrangements of response and recovery could be effective at reducing indirect economic losses thereby improving disaster resilience of these economies.

Good fiscal preparedness of governments, along with public and private continuity planning and other ex-ante arrangements are increasingly seen as an integral part of disaster resilience-building globally. The reliance on ex-post financing is seen as problematic from the standpoint of recovery time, as raising funds domestically and internationally often cause unnecessary delays in recovery and reconstruction. Work done on Laos and Cambodia as informed by GAR estimates show that these countries are highly exposed to natural disasters and rely mostly on ex-post sources of funding such as in-year budget reallocations and international assistance (World Bank 2012). To examine the impact of ex-post reliance, time-dependent inter-industry model was developed to evaluate the impact of transport, water and energy disruption caused by the typhoon Ketsana of 2009 (Table 2 below).

*Table 2. Scenarios evaluated in time-dependent inter-industry modeling. Note: *For modeling purposes, a stock to flow conversion rate of 10% was used. Source: LPD (2009) and RGC (2000)*

	Laos (in million USD)	**Cambodia**
Total Damage and Losses	51 (damage) 7 (losses)	58 (damage) 73(losses)
Damage to transportation and communication sector*	17.13	14.39
Damage to water and irrigation*	0.98	2.84
Damage to Energy *	3.16	0.03
Scenarios:		
Faster Recovery	Recovery and reconstruction take place immediately following the initial damage (recovery and reconstruction take 1 year)	
Lagged Recovery	A 6 month delay to raise ex-post funding following the initial damage (recovery and reconstruction take 1.5 years)	

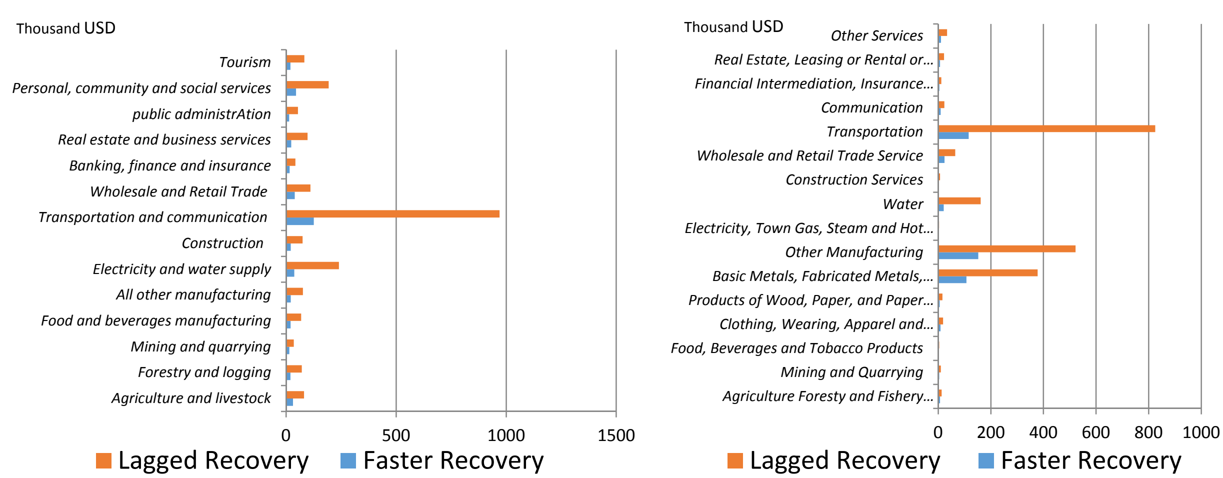

Figure 6. Inter-industry effects of infrastructure disruption in Laos (left) and Cambodia (right)

The delay in reconstruction caused by approximately 6 months will result in the indirect loss of 2.2 million USD (Laos) and 3.0 million USD (in Cambodia). In Laos, sectors such as personal, community and social services and forestry and logging are found to be the vulnerable (sensitive) sectors to critical infrastructure disruption. In Cambodia, other

Regional and global perspective

An estimate of global fiscal vulnerability and risk analysis can provide a basis for planning risk management options ranging from risk prevention to preparedness to risk financing. One example is devising regional risk pooling structures or setting up a global funding mechanisms for absorbing high level fiscal stress beyond coping. Regional and global risk information and funding requirements are seeing increasing attention by the global community, e.g. for work under the Global Facility for Risk Reduction (GFDRR) and the Warsaw Loss and Damage mechanisms. These efforts are focused on identifying financial support for DRR and adaptation. As global fiscal vulnerability and risk analysis can provide a basis for regional entities and the global community for devising regional risk pooling structures or setting up a global funding mechanism for absorbing different layers of fiscal stress beyond coping, we extend the analysis from Hochrainer-Stigler et al. (2014) which provided annual average costs for such a fund and performed a probabilistic global assessment on funding requirements. Assuming independence between countries, we convolute resource gap distributions to arrive at a global resource gap distribution, which can be seen as a "funding needs" distribution for a hypothetical global fund.

Figure 7 describes the global funding requirements that would be needed to cover resource gaps for different risk layers. These estimates reflect the risk layering approach, which can be utilized to prioritize financial support or certain investments (e.g. risk reduction for 'lower' return period layers) over others.

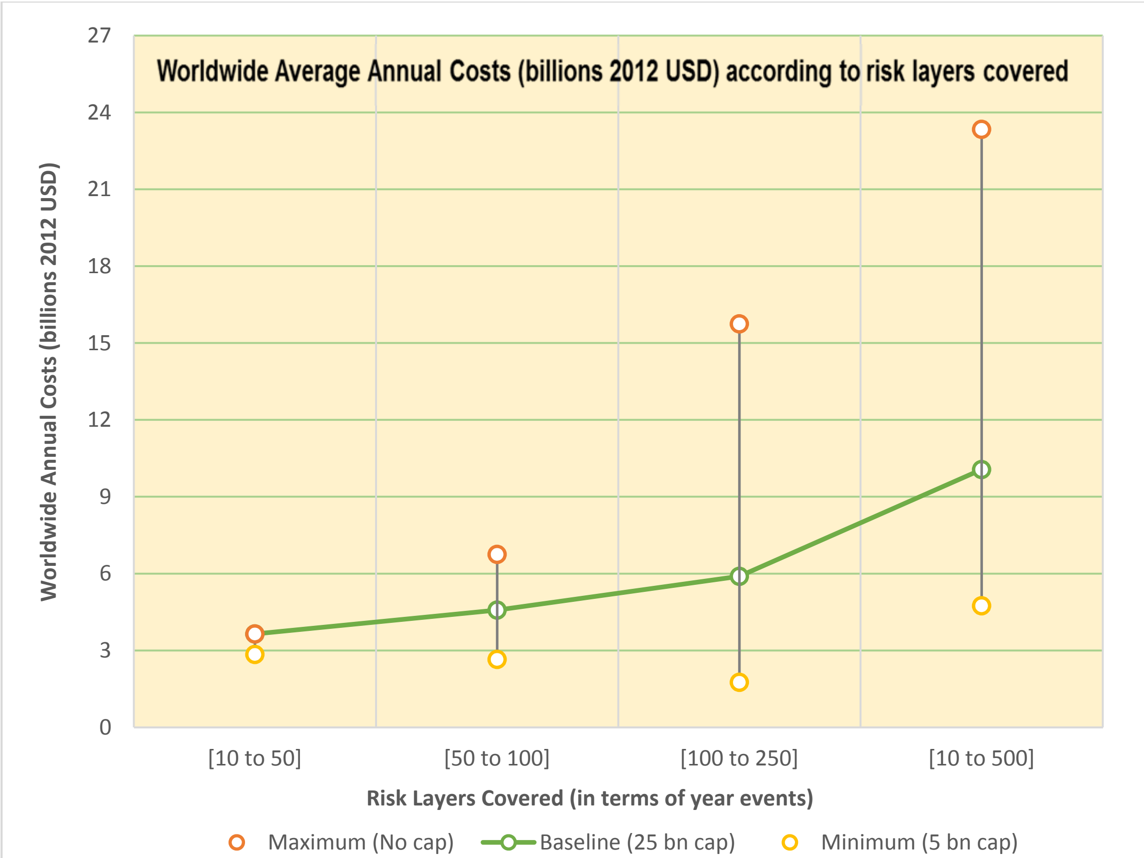

Figure 7. Funding requirements to cover resources gaps for different layers of return periods. For a baseline scenario, capping payouts for losses at 25 billion USD, covering losses from the 10 to 50 year risk layer would cost 3.6 billion USD annually. The 50 to 100 year layer would amount to 4.5 billion, and the 100 to 250 year layer 5.8 billion. To cover the entire spectrum of return periods would cost an estimated 10.1 billion. For a scenario with no cap, the return periods and costs are as follows: 10-50: 3.6 billion USD; 50-100: 6.7 billion; 100-250: 15.8 billion; and 10 – 500: 23.3 billion per year. A minimum scenario with a 5 billion USD cap on payouts would reduce funding requirements for return periods as follows: 10-50: 2.8 billion, 50-100: 2.7 billion; 100-250: 1.8 billion; and for all events (10 – 500): 4.7 billion.

To avoid bias due to very large losses in some events, we put a cap on losses to be eligible to be financed through this global mechanism. Additionally we, as already indicated in section 1, distinguish between different layers of risk. For the full risk layer, i.e. from 10 to 500 year event, annual funding needs are around 23.3 billion without a cap and 10.05 billion with a 25 billion cap. Annual financing losses for the small risk layer, e.g. the 10 to 50 year financing gap, are around 3.6 billion on average and 6.7 billion as well as 15.7 billion for the 50 to 100 and 100 and 250 year layer. The loss range is in accordance with previous analysis in the past (see Hochrainer-Stigler et al. 2014).

Building back better

While the results discussed above are based on an assumption of disaster recovery only building back to the same level as pre-event, the recent emphasis on "building back better" could have important implications on the costs of recovery, the point at which a country reaches a resources gap, and the overall costs of a global fund for disasters, as well as where to target for risk reduction. To build a safer environment during disaster reconstruction require additional costs in terms of technological modernization, relocation to safer places, other costs to meet the disaster risk reduction standards. These are additional costs that must be financed in addition to simple costs of capital replacement. In order to estimate the size of disaster risk reduction, we have used the cost-benefit ratio of 4, assuming that for every $1 spent in building back better, an additional $4 is saved in terms of annual average losses. For our assessment, we use 10% of the size of a 100 year event financing gap as the starting expenditure to build back better for each country, and find the overall benefit to fiscal resilience based on 4 times this investment. If a country does not experience a gap up to a 100 year event, they hypothetically would not invest in building back better, as discussed in the introduction, due to other strategies being more effective.

Figure 8 below represents the shift in resources-gap-years that countries could experience when moving from a strategy of *building back the same* to *building back better*. For countries under a business-as-usual scenario with low vulnerability, such as the USA, shifting to a strategy of building back better will not result in any large changes to this measure of fiscal vulnerability. However some countries could see a larger benefit to such a strategy, shifting their resources gap to a higher level. This strategy mainly addresses countries with resources gap years in lower risk levels, and may indicate that a *building back better* approach would link well with risk reduction measures.

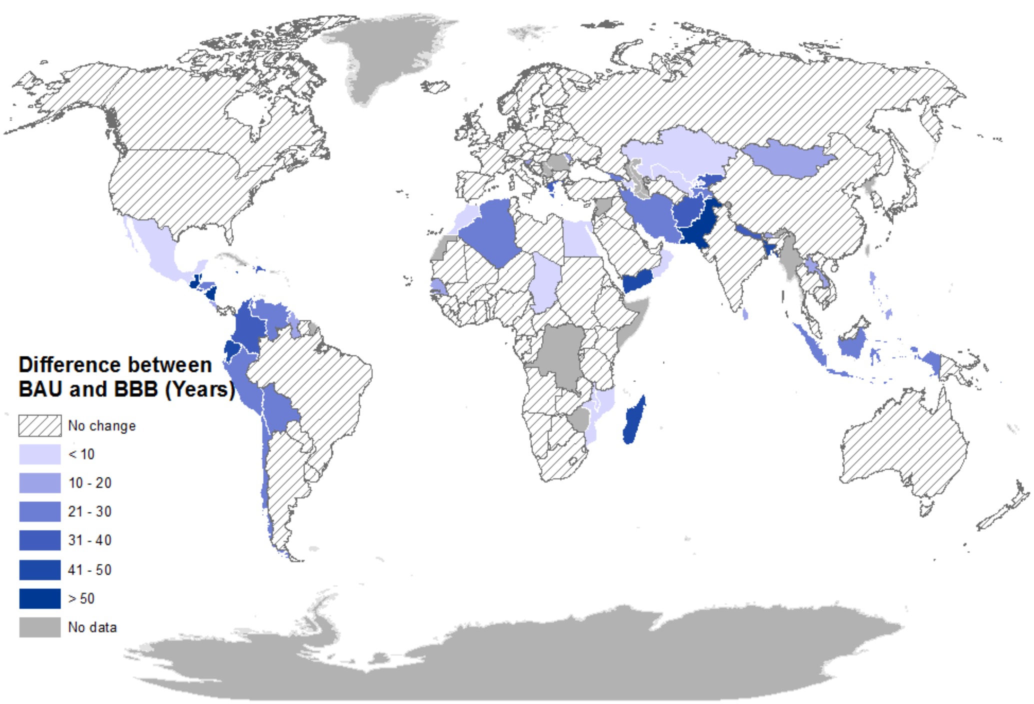

Figure 8. Comparing Business as Usual and Building Back Better: This map displays the shift, in years, of an event which would cause a resources gap. (Ex. Madagascar improves from a 6 year return period causing a gap, to a 54 year return period, under a BBB scenario)

We can also compare the annual average costs of the fund up to the 20, 50, 100, 250 as well as 500 year event layers with the no BBB (BAU – Business as Usual) as well as BBB scenario. Table 3 shows the results.

Table 3. Comparison of a global fund with a BBB option and no BBB (Business As Usual) option

Fund covering from 1 year event up to:	With BBB (bn 2005 USD)	Without BBB (bn 2005 USD)	Difference
20 year event	**0.1**	0.9	0.8
50 year event	**0.3**	3.6	3.4
100 year event	**3.1**	7.7	4.5
250 year event	**14.9**	19.4	4.5
500 year event	**18.7**	23.3	4.5

As one can see, the structure would be highly beneficial from a fiscal standpoint, as the average funding needs for the 100 year layer nearly double from BBB to BAU. Furthermore, many countries would be able to be move out of the below 20 year event financing gap layer, with some moving so far as to be above the 50 year layer as well. It should be noted that these numbers have to be treated as averages, as the assumption is that over a long time period all countries eventually will experience a 100 year financing gap. It is clear that other smaller events would also happen and therefore could be used to BBB. Therefore our estimates are optimistic in the sense that they incorporate benefits based on only a single 100 year event happening. Nevertheless, the analysis demonstrates the potential of BBB to not only help build better and reduce national vulnerability, but also shows the sharp decrease in future risk (here shown in terms of the decrease in average funding needs of a global fund) with an additional amount of only 10 percent of the eligible costs.

4. Discussion

The need to deal with extreme risks has been well documented in recent assessments of global risks, such as the 2013 GAR and the World Economic Forum's Global Risk Report, which emphasize a need for better understanding and measuring risk interdependencies. As well, these reports caution against the escalating economic losses due to disasters, emphasizing that disaster risk management has to become a core factor in public sector and business investment strategies. As well, regional-and global-level risk management and financing platforms are emerging for tackling risk across countries with support from international institutions.

Beyond generating loss distributions that indicate the range and corresponding probabilities of possible losses, disaster risk management approaches can identify the level of risk at which risk bearers can no longer cope with or be able to finance all losses they are responsible for. In this report, we worked to identify this level of risk at a national scale across the globe, which when combined with a risk layering approach, can identify which support and risk instruments might be most effective to address fiscal gaps. We focused on the public sector and national governments as risk bearers, and assessed fiscal risk with a view towards earthquake, wind, storm surge, tsunami, and flooding exposure. Our analysis is based on a novel and very comprehensive dataset with risk estimates from the GAR 2015 process holding 182 country risk distributions combined with information on governments' fiscal resilience.

We assessed fiscal risk by determining the year a country would face a fiscal gap and hold insufficient resources to recover from a disaster event: we also calculated the size of such a gap for key return periods (20, 50, 100, 250, 500 year events). Building off of this, we were able to determine the annual funding requirements needed to create a global fund which would cover these gaps, either for all events or for certain risk layers. We also assessed the effects of a building back better approach, which is a strategy linked to resilience thinking that emphasizes investing more after a disaster event to lower long-term risk. We found that the size of disaster impacts does not necessarily indicate high risk of a fiscal gap; generally speaking, larger geographically-diversified and economically well-positioned countries are less vulnerable and have fewer problems financing large events, whereas smaller and heavily-exposed countries in South America, Asia, Africa and Oceania face the possibility of significant fiscal gaps, sometimes from extremely frequent (e.g. less than 20 year return period) events. A building back better approach would help lift many countries out of danger of a 20 year event gap, and even a 50 year gap.

In terms of regional assessment, work in the Indian Ocean Council region involving modeling analysis combined with consultation with the countries of Madagascar, Mauritius, Seychelles and Comoros identifies considerable economic and fiscal stress from natural disasters. Updated global risk assessment and fiscal risk analysis done for the GAR shows that these countries are exposed to annual average losses of approximately 1 to 6% of GDP. In the case of a catastrophic disaster with a return period of 500 years, face losses of approximately 7 to 18 % of GDP. The limited availability of ex-ante resources including reserve funds, contingent credit agreement and insurance along with constrained ex-post financing options mean that these countries may encounter difficulty in raising sufficient fund for recovery and reconstruction relatively frequently. The research accentuates the need for increasing regional efforts for managing disaster risk involving a comprehensive risk management and financing regional platform, which is currently under discussion in the region, informed by developments regarding other regional platforms (CCRIF in the Caribbean, PCRFI in the Pacific, ARC in Africa) that often have focused strongly on risk financing (sovereign insurance).

As to the global perspective, debate is ongoing regarding global financial needs for tackling disaster risk, including a possible role for the Loss & Damage mechanisms. Using a risk layering principle, we calculate funding needs based on exposure to risk as well as capacity to service these liabilities, which we combine to estimates of fiscal gaps indicate the threshold event, which countries would just not be able to completely recover from.

For example, for the full risk layer covered in the analysis, from 10 to 500 year events, we calculate annual funding needs to completely absorb countries fiscal gaps at about USD 23 billion, whereas for smaller risk layer, such as the 10 to 50 year layer, our estimate amounts to close to USD 7 billion. If a building back better-strategy is employed these costs can be reduced sizably.

Our analysis applied a common means of calculation to all countries in order to easily assess the global scale and provide cross-comparisons, but this represents a first order estimate of country risk. There are many country-specific factors not included in a global assessment, such as individual factors to resilience such as borrowing limits and ex-ante measures, which can change the overall picture on risk, including the absence of drought risk in our analysis. As an important modeling choice and innovation, we also departed from the methodology in Hochrainer-Stigler et al. (2014) by using the IMF's SDRs as a measure of international borrowing. The approach taken previously was limited by lack of data and was not feasible at such a large scale; moreover, we found that using SDRs actually bolstered national resilience in almost all cases, providing a more optimistic estimate than before. A better estimate of borrowing limits would require consultation with national Finance Ministries, but our approach was found to be much closer to Ministry estimates when consulting with Cambodian officials for the regional case study.

Overall, we suggest that the work serves to highlight areas that may be vulnerable and which should be assessed in greater detail, such as was done in the Indian Ocean Countries and Laos and Cambodia. Finally, the assessment provides a regional and global perspective on fiscal disaster risk, and proposes a way forward to further inform thinking on regional and global pools and funds for managing disasters.

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Annex I: Country finance gap years for a BAU and BBB scenario, and 100 year resources gap sizes.

Country	ISO Code	First year experiencing a fiscal gap (BAU scenario)	100 year event gap losses (BAU scenario - Millions 2005 USD)	First year experiencing a fiscal gap (BBB scenario)
Afghanistan	AFG	25	664.23	61
Albania	ALB	103	0.00	103
Algeria	DZA	35	5,134.44	60
Angola	AGO	550	0.00	550
Antigua and Barbuda	ATG	4	1,289.05	24
Argentina	ARG	550	0.00	550
Armenia	ARM	115	0.00	115
Australia	AUS	128	0.00	128
Austria	AUT	550	0.00	550
Azerbaijan	AZE	85	77.18	91
Bahamas	BHS	4	5,972.59	10
Bahrain	BHR	550	0.00	550
Bangladesh	BGD	7	13,420.97	56
Barbados	BRB	7	518.50	28
Belarus	BLR	550	0.00	550
Belgium	BEL	550	0.00	550
Belize	BLZ	5	824.90	58
Benin	BEN	550	0.00	550
Bhutan	BTN	63	19.01	76
Bolivia	BOL	31	541.48	59
Bosnia and Herzegovina	BIH	550	0.00	550
Botswana	BWA	404	0.00	404
Brazil	BRA	129	0.00	129
Brunei Darussalam	BRN	550	0.00	550
Bulgaria	BGR	117	0.00	117
Burkina Faso	BFA	550	0.00	550
Burundi	BDI	550	0.00	550
Cambodia	KHM	550	0.00	550
Cameroon	CMR	550	0.00	550

Canada	CAN	550	0.00	550
Cape Verde	CPV	550	0.00	550
Central African Republic	CAF	550	0.00	550
Chad	TCD	99	1.29	100
Chile	CHL	22	15,336.12	52
China	CHN	550	0.00	550
Colombia	COL	18	22,562.46	58
Comoros	COM	100	0.07	100
Congo	COG	550	0.00	550
Costa Rica	CRI	43	293.59	62
Cote d'Ivoire	CIV	550	0.00	550
Croatia	HRV	321	0.00	321
Cyprus	CYP	550	0.00	550
Czech Republic	CZE	105	0.00	105
Democratic Republic of the Congo	COD	550	0.00	550
Denmark	DNK	550	0.00	550
Djibouti	DJI	164	0.00	164
Dominica	DMA	5	247.04	21
Dominican Republic	DOM	6	4,938.44	45
Ecuador	ECU	10	7,262.91	57
Egypt	EGY	77	578.20	87
El Salvador	SLV	8	1,167.06	39
Equatorial Guinea	GNQ	197	0.00	197
Eritrea	ERI	550	0.00	550
Estonia	EST	550	0.00	550
Ethiopia	ETH	363	0.00	363
Fiji	FJI	6	221.54	18
Finland	FIN	550	0.00	550
France	FRA	550	0.00	550
Gabon	GAB	550	0.00	550
Gambia	GMB	550	0.00	550
Georgia	GEO	23	804.13	53
Germany	DEU	550	0.00	550
Ghana	GHA	266	0.00	266
Greece	GRC	8	11,109.26	42

Grenada	GRD	5	210.82	33
Guatemala	GTM	4	16,050.25	61
Guinea	GIN	550	0.00	550
Guinea-Bissau	GNB	550	0.00	550
Guyana	GUY	51	189.66	66
Haiti	HTI	3	1,700.88	33
Honduras	HND	3	1,918.95	31
Hungary	HUN	455	0.00	455
Iceland	ISL	550	0.00	550
India	IND	550	0.00	550
Indonesia	IDN	34	11,028.02	60
Iran (Islamic Republic of)	IRN	23	12,324.01	52
Iraq	IRQ	550	0.00	550
Ireland	IRL	550	0.00	550
Israel	ISR	137	0.00	137
Italy	ITA	117	0.00	117
Jamaica	JAM	6	2,635.06	53
Japan	JPN	158	0.00	158
Jordan	JOR	151	0.00	151
Kazakhstan	KAZ	92	80.65	96
Kenya	KEN	550	0.00	550
Kiribati	KIR	550	0.00	550
Kuwait	KWT	550	0.00	550
Kyrgyzstan	KGZ	25	320.92	59
Lao People's Democratic Republic	LAO	56	61.96	70
Latvia	LVA	103	0.00	103
Lebanon	LBN	114	0.00	114
Lesotho	LSO	140	0.00	140
Liberia	LBR	550	0.00	550
Libyan Arab Jamahiriya	LBY	550	0.00	550
Lithuania	LTU	550	0.00	550
Luxembourg	LUX	102	0.00	102
Madagascar	MDG	6	1,378.86	54
Malawi	MWI	79	42.40	87
Malaysia	MYS	275	0.00	275

Maldives	MDV	31	153.06	63
Mali	MLI	550	0.00	550
Malta	MLT	550	0.00	550
Marshall Islands	MHL	550	0.00	550
Mauritania	MRT	109	0.00	109
Mauritius	MUS	45	157.34	63
Mexico	MEX	81	2,885.23	88
Micronesia (Federated States of)	FSM	7	23.83	30
Moldova, Republic of	MDA	56	282.56	70
Mongolia	MNG	51	1,547.15	65
Montenegro	MNE	550	0.00	550
Morocco	MAR	79	256.13	87
Mozambique	MOZ	97	4.79	99
Namibia	NAM	309	0.00	309
Nepal	NPL	21	2,622.87	59
Netherlands	NLD	550	0.00	550
New Zealand	NZL	119	0.00	119
Nicaragua	NIC	5	12,046.75	57
Niger	NER	130	0.00	130
Nigeria	NGA	550	0.00	550
Norway	NOR	550	0.00	550
Oman	OMN	84	192.13	91
Pakistan	PAK	4	169,767.64	61
Palau	PLW	6	136.68	41
Panama	PAN	224	0.00	224
Papua New Guinea	PNG	108	0.00	108
Paraguay	PRY	550	0.00	550
Peru	PER	6	5,647.80	34
Philippines	PHL	3	5,235.73	22
Poland	POL	102	0.00	102
Portugal	PRT	108	0.00	108
Qatar	QAT	550	0.00	550
Republic of Korea	KOR	550	0.00	550
Romania	ROU	71	791.86	82
Russian Federation	RUS	550	0.00	550
Rwanda	RWA	177	0.00	177

Saint Kitts and Nevis	KNA	5	334.78	24
Saint Lucia	LCA	5	216.09	27
Saint Vincent and the Grenadines	VCT	5	153.07	34
Samoa	WSM	5	280.24	52
Sao Tome and Principe	STP	550	0.00	550
Saudi Arabia	SAU	550	0.00	550
Senegal	SEN	61	146.75	74
Serbia	SRB	550	0.00	550
Seychelles	SYC	104	0.00	104
Sierra Leone	SLE	550	0.00	550
Singapore	SGP	550	0.00	550
Slovakia	SVK	550	0.00	550
Slovenia	SVN	56	1,963.18	70
Solomon islands	SLB	4	233.08	29
South Africa	ZAF	550	0.00	550
Spain	ESP	141	0.00	141
Sri Lanka	LKA	55	766.69	69
Sudan	SDN	260	0.00	260
Suriname	SUR	550	0.00	550
Swaziland	SWZ	101	0.00	101
Sweden	SWE	550	0.00	550
Switzerland	CHE	550	0.00	550
Tajikistan	TJK	31	227.71	60
Thailand	THA	104	0.00	104
The former Yugoslav Republic of Macedonia	MKD	550	0.00	550
Timor-Leste	TLS	27	46.96	57
Togo	TGO	550	0.00	550
Tonga	TON	6	46.41	46
Trinidad and Tobago	TTO	11	2,673.74	40
Tunisia	TUN	118	0.00	118
Turkey	TUR	108	0.00	108
Turkmenistan	TKM	260	0.00	260
U.K. of Great Britain and Northern Ireland	GBR	300	0.00	300
Uganda	UGA	311	0.00	311

Ukraine	UKR	550	0.00	550
United Arab Emirates	ARE	110	0.00	110
United Republic of Tanzania	TZA	271	0.00	271
United States of America	USA	550	0.00	550
Uruguay	URY	323	0.00	323
Uzbekistan	UZB	98	10.59	100
Vanuatu	VUT	5	160.01	23
Venezuela	VEN	25	3,710.65	49
Viet Nam	VNM	550	0.00	550
Yemen	YEM	21	4,891.86	62
Zambia	ZMB	550	0.00	550