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# A Disaster Under-(Re)Insurance Puzzle: Home Bias in Disaster Risk-Bearing

Hiro Ito<sup>1</sup>  · Robert N. McCauley<sup>2,3</sup>

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## Abstract

We examine disaster reinsurance from the perspective of international risk-sharing. We find that losses from disasters are shared internationally to a generally very limited extent, unlike what the theory of international risk-sharing suggests. We propose a new dataset of cross-border reinsurance payments for 93 disasters of 44 economies in 1982–2017. Combining these balance of payments data with industry data, we find that the lack of disaster risk-sharing through international reinsurance results from low participation in primary insurance as well as limited use of reinsurance. Regression analysis finds that countries with higher levels of economic or financial development tend to insure a larger share of disaster losses while proxies for disaster myopia are associated with less insurance. Regarding the share of insured losses that is internationally reinsured, small size and de facto financial integration tend to raise the reinsurance share, while high levels of external wealth and low foreign firm presence in insurance are associated with less reinsurance. Advanced economies with little fiscal space that provide ex-post government disaster insurance without international reinsurance could experience disaster risk morphing into financial risk.

**JEL Classification** F32 · G15 · G22 · Q54

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## 1 Introduction

International sharing of the risk of disasters through insurance markets lies on a spectrum defined by two ideal types: full risk sharing and autarky. The full risk sharing case features 100% insurance coverage for losses within a country and a high degree of international reinsurance to spread the risks globally. Domestic full insurance abstracts from moral hazard, adverse selection, disaster myopia and other frictions that lead to nonparticipation, deductibles, co-pays and other departures from full insurance. Internationally, reinsurance spreads risk evenly to leave domestic investors holding only the share of their own disaster risk that corresponds to their share of global wealth. In theory, disaster insurance improves welfare if it is priced not too much above the actuarially expected loss (Ehrlich and Becker 1972; Borenstein, et al. 2017). In autarky, no reinsurance leaves each country to bear all of its own disaster risk and none of the rest of the world's risk.

We focus on risk sharing through the insurance business and on direct losses. Beyond the scope of our analysis is the possibility of a country's holding a portfolio of international assets and liabilities that mimics disaster insurance payouts.<sup>1</sup> Excluded from insurance is government aid for recovery and reconstruction, which acts like ex-post insurance, and may help explain low insurance participation rates. Direct losses exclude such hard-to-measure costs as unemployment due to an economic downturn caused by the disaster and human losses from evacuation or lack of medical access (Hallegatte 2015).<sup>2</sup>

The outcomes of two major disasters in 2011 provide distant observations on the spectrum between autarky and full risk sharing. The magnitude 9.0 Great East Japan Earthquake (GEJE) and tsunamis inflicted direct costs estimated at \$225 billion, 4% of Japan's GDP or over 1% of national wealth and about 6% of Japan's positive net international investment position (NIIP). Earthquake insurance covered only 16% of the direct cost and reinsurance covered less than a quarter of this 16%. The rest of the world thus shared only 3.6% of Japan's direct losses, placing the outcome near autarky.

That same year, the New Zealand earthquake inflicted \$18 billion of losses, 10.7% of GDP, about a sixth of New Zealand's negative NIIP. There, mortgages require fire insurance policies and these include "de facto compulsory" (Nguyen and Noy 2017) government earthquake insurance. As a result, over 90% of households participate and 70% of losses were insured. The government earthquake agency reinsured abroad an estimated 60% of insured losses, so that the rest of the world shared 42% of New Zealand's direct losses, placing the case almost halfway in the spectrum between autarky and full risk sharing.

<sup>1</sup> Outstanding securities known as catastrophe bonds are small in aggregate and are mostly issued by insurers to lay off risk. Corporate equity holdings by nonresidents can in principle share disaster risks (but not those of the household sector) but home bias limits disaster loss-sharing through this channel.

<sup>2</sup> Direct costs also exclude the costs of shutting down Japan's nuclear power plants after the 2011 earthquake.



We examine evidence from 1982 through 2017 and find that Japan's lack of international sharing of disaster risk is characteristic of large disasters. The burden of this paper is to establish this puzzle of home bias in disaster risk-sharing and to shed some light on it. We carry this burden in four steps.

First, we propose a novel method for measuring international reinsurance payments through the balance of payments. Second, we use these estimates and industry data on direct losses and insurance payouts to find surprisingly limited international risk-sharing: a novel result, to our knowledge. Third, we decompose the observed shortfall from the full insurance ideal into the shortfall of reinsurance and the shortfall of underlying insurance to demonstrate that more reinsurance alone would not remove the home bias. Fourthly, we use regression analysis to find the correlates of the rates of primary disaster insurance and reinsurance.

We find that primary disaster insurance coverage increases with the level of economic and financial development. Frequent disasters and recurring floods and storms, as opposed to rarer earthquakes, are associated with higher insurance coverage. This finding may point to disaster myopia—the tendency to overlook risks that have not recently materialized.

We find that reinsurance of disaster losses increases in smaller and more de facto financially open economies. In addition, more competitive and hence less wealthy insurance sectors seem to reinsure more against disasters. In particular, the higher the foreign firm share of the domestic nonlife insurance market, the higher the reinsurance share, perhaps owing to lower profitability and accumulated reserves. Similarly, the lower an economy's external wealth (NIIP), which includes the foreign assets of the insurance sector, the higher its reinsurance share.

We contribute to the literature in our analysis of both insurance coverage and the reinsurance rate. Although the literature offers many explanations for low insurance coverage (Kunreuther and Michel-Kerjan 2014), most studies are single-country microeconomic studies (Browne and Hoyt 2000; Raschky et al. 2013). Kousky (2011) notes that studies of flood insurance take-up analyze the choice of whether to insure or not. By contrast, we focus on big disasters and analyze actual dollar risk sharing outcomes, which is most relevant to our question. Even the cross-country macroeconomic study of Chang and Berdiev (2013) examines the determinants of insurance spending rather than risk-sharing outcomes (see also Park et al. 2002). It is well known in the insurance literature that insurance participation and coverage vary not only across countries and time, but also across hazards, but we are not aware of a study that econometrically analyzes coverage by disaster type.

Data unavailability has limited the study of reinsurance (Drexler and Rosen 2020), and to our knowledge, we are the first to attempt to measure the extent of international sharing of disaster risks. Most work is microeconomic, using firm-level characteristics to account for reinsurance demand (Mayers and Smith 1990; Gron 1999; Garven and Lamm-Tennant 2003; Cole and McCullough 2006; Drexler and Rosen 2020), including corporate affiliation (Shortridge and Avila 2004; Powell and Sommer 2007; Yanase and Limpaphayom 2017). Somewhat more related work is on the macroeconomic cost of disasters (Noy 2009) and the benefits of international insurance (Borensztein et al. 2017) for developing countries. Building on Noy 2009, von Peter et al. (2012) find that insurance reduces the macroeconomic cost of



disasters, taking as given heterogeneity in the extent of insurance. We analyze how much disasters are insured against and how much of that exposure is internationally reinsured.

The rest of the paper is organized as follows. Section 2 describes our use of industry data to identify major disasters and balance of payments data to measure reinsurance. Section 3 lays out our central finding of low international risk-sharing. Section 4 then decomposes the observed shortfall from the full insurance case to show that more reinsurance alone would not remove the home bias in disaster risk-bearing. Section 5 reports regression analysis of insurance coverage; Section 6 reports regression analysis of the reinsurance ratio. Section 7 concludes with policy implications, drawing attention to the accumulating risks of a lack of reinsurance given already high levels of government debt. In Sect. 8, we make concluding remarks and raise important questions for future research on the international sharing of disaster risks.

## 2 The Data

We develop a novel method to measure the reinsurance rate for major disasters. We combine industry data on insurance losses with balance of payments data on reinsurance receipts.

For disasters, their dates, total losses and the portion insured, we rely on a proprietary database called the *NatCatSERVICE* database. This is compiled by Munich Re, a leading global insurance and reinsurance group (see [Appendix 1](#) for data definitions and sources).<sup>3</sup> We analyze only “major” disasters: earthquakes, floods or storms whose catastrophe class is four. [Appendix 3](#) lists all the disasters we focus on, along with relevant economic variables, but does not report Munich Re’s proprietary data on total and insured losses.

For the share of insured losses that was paid by international reinsurance, we turn to the balance of payments. These data only capture cross-border flows of reinsurance payments. Starting from each disaster’s quarter, we laboriously identify reinsurance payments in IMF balance of payments data. Here, we briefly describe our method; see [Appendix 2](#) for details.

Under recently adopted balance of payments accounting (i.e., BPM6), large payments on reinsurance are registered as a *capital account transfer*. The capital account is the new name and place for stock-flow discrepancies, such as debt forgiveness.<sup>4</sup> Debt forgiveness was thought to be a one-off adjustment of the stocks of debt that did not fit with current account unilateral transfers of a recurring nature, like workers’ remittances or intergovernmental aid. Similarly, while reinsurance payments associated with normal levels of claims continue to appear in current account

<sup>3</sup> The Munich Re data are generally considered more comprehensive than the EM-DAT database compiled by the Centre for Research on the Epidemiology of Disasters at the Catholic University of Louvain, Belgium.

<sup>4</sup> Most of what used to be called the capital account in BPM5 is now termed the financial account.



unilateral transfers, reinsurance associated with major disasters now are treated as a stock-flow discrepancy included in the capital account. After all, it was reasoned, major disasters make calls on stocks of reserves rather than just the flow of premia.

This new accounting treatment facilitates our measurement of reinsurance through the balance of payments. Capital account transfers are sparse, so the appearance of inflows on this account in the quarter or quarters after a disaster strongly indicates a flow of reinsurance payments. Thus, we cumulate these flows to measure reinsurance payments.

Unfortunately, accounting diversity complicates measurement of reinsurance. Statisticians in many jurisdictions still account for major reinsurance payments as current account unilateral transfers rather than capital account transfers.<sup>5</sup> For such jurisdictions, we use *changes* in the current account unilateral transfers receipts to measure reinsurance receipts. These data are of lower quality because current receipts are plentiful, and reinsurance receipts must be estimated as differences from their baseline level.

Of the 138 major disasters for which we have total and insured losses from the *NatCatSERVICE* database, the balance of payments enables us to estimate international reinsurance receipts for 93 disasters. Thus, we can juxtapose the reality of disaster insurance for 93 disasters to the ideal international risk-sharing. The next section finds a striking shortfall.

### 3 The Limited Extent of International Risk-Sharing

To summarize the international sharing of disaster risk, we compute the ratio of reinsured losses to total losses as the product of the portion of losses insured and the portion of insurance that is internationally reinsured (Eq. 1).

International risk – sharing = the ratio of reinsured losses to total losses

$$= \underbrace{\frac{\text{insured losses}}{\text{total losses}}}_{\text{Proportion of losses insured}} \times \underbrace{\frac{\text{reinsured losses}}{\text{insured losses}}}_{\text{Proportion of insurance that is internationally re-insured}} \quad (1)$$

Recall that our ideal type of full international sharing of disaster risk posits full insurance in which all major disaster risks are insured and then reinsured internationally to the extent necessary to spread disaster risk-bearing evenly across global wealth holders. That is, the smaller a country's wealth share in the world is, the smaller the share of its own disaster risk that it should retain. Small countries should lay off internationally nearly 100% of their disaster risk. Large economies (in size) can retain some of the risk of their own disasters, even as the risks are spread evenly

<sup>5</sup> Statistics New Zealand (2011) discusses the accounting transition from current transfers to capital account transfers, while Bank of Thailand (2012) statisticians report reinsurance payments for the 2011 flood as current account transfers. Furthermore, there is no consensus on what constitutes "major" disaster. Where government statisticians announce how they account for reinsurance payments, we follow their announcement.



across the globe. Taking GDP shares as a proxy for wealth shares, the USA should lay off about 80% of its disaster risk to the rest of the world, given its GDP share of about 20%.

The ideal type of full international disaster risk sharing requires that the proportion of disaster risk that is internationally reinsured be one minus country  $j$ 's share of global GDP, i.e.,  $s^* = 1 - \frac{Y_j}{Y_{\text{global}}}$ . We call the gap between  $s^*$  and the ratio of reinsured losses to total losses from Eq. 1 the international risk-sharing gap (Eq. 2):

$$\begin{aligned} \text{International risk - sharing gap} &= s^* - i \times r \\ &= s^* - \underbrace{(\text{insured losses})/(\text{total losses}) \times (\text{reinsured losses})/(\text{insured losses})}_{\text{the ratio of reinsured losses to total losses}}. \end{aligned} \quad (2)$$

Recall that this ideal type neglects pervasive features of insurance, like moral hazard, adverse selection and disaster myopia, which lead to deductibles, co-pays and nonparticipation. Industry structures that allow rents may also lead to lower penetration of insurance or reinsurance.<sup>6</sup> However, this framework is still useful as a benchmark or ideal type.

The actual level of reinsurance coverage of disasters falls far short of the ideal type of international risk-sharing. Figure 1 plots the fraction of economic losses that were reinsured (orange bars) against our ideal type of practically 100% risk-sharing for small countries, falling to around 80% for the USA (blue line). The figure orders the disasters from the smallest economy on the left to the largest economy on the right.

On average, international reinsurance paid only 4.8% of total losses (Table 1, first row), an order of magnitude lower than the ideal type. Looking across the unweighted mean, the mean weighted by GDP or dollar losses and median, the reinsurance share tends to be higher for advanced economies (second versus third rows).

Thus, it turns out that of the two earthquakes in 2011, the very limited international risk-sharing in Japan better represented the average outcome than the very considerable international risk-sharing in New Zealand. Only 3.6% of the losses from the 2011 earthquake in Japan were passed on to global reinsurers (row 70, column 3 in Appendix 3), reflecting both low coverage of primary insurance and low reinsurance, as discussed in the next section.

New Zealand is an outlier on the high side, with almost 50% reinsurance of losses from the 2010 and 2011 earthquakes. Still, this is half the ideal type, which would suggest 99.85% of the losses should be shared internationally through reinsurance, given New Zealand's small 0.15% share of world GDP. Coverage of the de facto compulsory earthquake insurance and private add-ons are high, as is the propensity of the government earthquake agency to lay the risk off in the international reinsurance market. Nguyen and Noy (2017) describe the 2010–11 Canterbury Earthquake as “one of the most insured large disasters in history.” In addition, it must have been the most internationally reinsured major disaster in history.

<sup>6</sup> We thank an anonymous referee for insisting on this.



New Zealand’s case illustrates how extensive reinsurance provides external assets to offset the destroyed domestic capital stock. New Zealand’s reinsurance receipts of about 5% of GDP improved its big net external debtor position (62.5% of GDP in Q1 2011). This sudden improvement in the external accounts offset domestic capital stock losses and the reinsurance receipts financed extraordinary imports arising from reconstruction activity.<sup>7</sup>

Taking it all together, the balance of payments of disaster-hit economies supports the inference that international risk-sharing of disaster losses is low. In other words, home bias in disaster risk-bearing is high. The next section demonstrates that the very limited international sharing of disaster risk is not just a failure of international reinsurance.

### 4 Decomposition of International Risk-Sharing of Disasters

To demonstrate the limited role of low rates of reinsurance alone, we exploit the decomposition in Eq. 2 to partition the overall shortfall of international risk-sharing from our ideal type in Fig. 1. Starting with Eq. 2, we add and subtract  $s^*i$  (in parentheses), gather terms and substitute  $(s^* - r) + r$  in  $s^*(1 - i)$ :

$$\begin{aligned}
 \text{International risk - sharing gap} &= s^* - i \times r = s^* + (-s^*i + s^*i) - i \times r = s^*(1 - i) + i(s^* - r) \\
 &= \underbrace{r(1 - i)}_{\text{Lack of primary disaster insurance}} + \underbrace{i(s^* - r)}_{\text{Lack of warranted international reinsurance}} \\
 &\quad + \underbrace{(s^* - r)(1 - i)}_{\text{Lack of BOTH primary disaster insurance and reinsurance}}.
 \end{aligned} \tag{3}$$

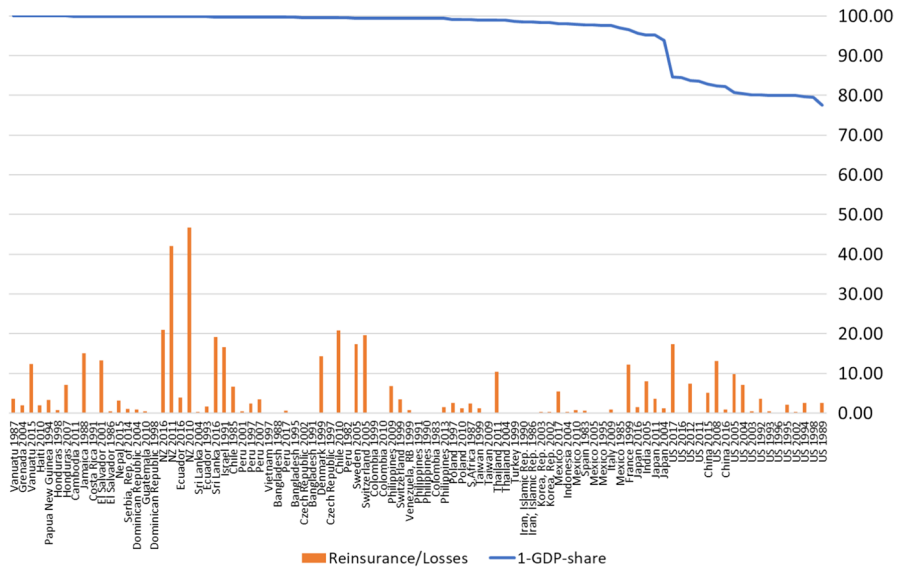
Equation 3 decomposes the international risk-sharing gap into three components. The first term represents the part for which the lack of primary insurance coverage alone is responsible, the second term the part for which the lack of warranted international reinsurance alone is responsible and the third one the part for which the interaction of the lack of *both* primary insurance and international reinsurance is responsible. In particular,  $r(1 - i)$  captures the contribution from the underinsurance of disaster risk  $(1 - i)$ , given the observed international reinsurance coverage is  $r$ . The second term captures the contribution of the lack of appropriate reinsurance  $(s^* - r)$ , given the observed level of insurance coverage,  $i$ . The third term captures the part of the international risk-sharing gap caused by the underuse of *both* primary insurance and international reinsurance. In other words, the third term represents the extent of the gap that could be filled by increasing the use of *both* primary disaster insurance and international reinsurance.

To see how this works, consider the prospect of a California earthquake. Assume that 16% of home insurance includes earthquake coverage (neglecting deductibles,

<sup>7</sup> But going forward, New Zealand’s reinsurance payments in its international services import account rose sharply as its premia about tripled (see Appendix 4 for other effects of disasters on the current account).







**Fig. 1** Shortfall of reinsurance coverage of disaster losses relative to an ideal distribution of risk. The figure plots the percentage of economic losses that were reinsured (orange bars) against as “textbook norm” of international risk-sharing (blue line). Theoretically, one minus the GDP share in the world economy should indicate the proportion of economic losses that are internationally reinsured. The figure orders the disasters from the smallest (left) to the largest economies (right) in terms of the GDP share in the world economy. *Sources:* NatCatSERVICE data; IMF balance of payments data; authors’ calculations. (Color figure online)

see Marshall (2017) and Pothon et al. (2019)<sup>8</sup> and that 50% of any insured losses are reinsured abroad.<sup>9</sup> In the US case, the warranted international reinsurance rate is about 80% (i.e.,  $s^* = 100\% - US\ GDP\ share\ (20\%)$ ), so that prospective international risk-sharing of 8% (i.e.,  $i \times r = 16\% \times 50\%$ ) would imply a gap of 72% (i.e.,  $s^* - i \times r = 80\% - 8\%$ ).

This gap is then decomposed into the part for which the lack of primary insurance coverage only is responsible, the part for which the lack of warranted international reinsurance only is responsible and the part for which the lack of both primary disaster insurance and international reinsurance are jointly responsible. The first part is calculated as the observed reinsurance rate ( $r$ ) of 50% times the difference between full insurance (1) and observed insurance ( $i$ ), i.e.,  $r \times (1 - i) = 50\% \times 84\% = 42\%$ . This part reflects the shortfall arising from low participation in primary

<sup>8</sup> According to Pothon, et al. (2019), the penetration rate of earthquake insurance among homeowners in California is never above 16% (since 2012).

<sup>9</sup> Based on the California Department of Insurance’s (2019) “Report of Examination of the CEA,” CEA’s claim-paying capacity for covered claims as of 2019 is more than \$17 billion, about half of which comes from reinsurance. However, the CEA’s financial statements and other publications do not indicate what fraction of reinsurance is bought from firms in the USA and what fraction is bought from firms abroad.



**Table 1** Summary statistics of three ratios

Group	N	# of Countries	Mean	Weighted Mean (GDP) <sup>1</sup>	Weighted Mean (Losses) <sup>2</sup>	Median	S.D.	Min	Max
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Reinsured losses as a share of total losses (%)	FULL	44	4.8	4.8	7.5	1.1	8.2	0.0	46.7
	AE	9	8.7	5.1	8.0	3.5	11.9	0.0	46.7
	EME	35	3.0	2.9	5.2	0.8	4.9	0.0	20.8
Insured losses as a share of total losses (%)	FULL	60	18.4	32.5	27.7	10.7	19.5	0.1	80.8
	AE	13	33.2	39.7	34.6	33.6	23.9	0.3	80.8
	EME	47	11.5	6.7	9.9	6.3	12.0	0.1	50.0
Reinsurances as a share of insured losses (%)	FULL	44	19.8	14.5	20.9	10.6	24.6	0.0	99.4
	AE	9	18.4	12.1	19.2	9.2	20.9	0.0	79.8
	EME	35	20.3	28.9	27.9	10.7	26.3	0.0	99.4

The volume of reinsurance is measured using current or capital transfers in the balance of payments (whose data is extracted from the IMF's Balance of Payments database). The data on total losses and insured losses are extracted from Munich Re's *NatCatSERVICE* database. For more details on these variables, refer to "Appendix 1: Data and sources." "AE" stands for "advanced economies" which are traditional OECD countries (whose IMF code is less than 200). "EME" stands for "emerging market economies." 1-The "weighted mean (GDP)" is the mean of the relevant ratios weighted by the GDP in US dollars of the economies in the sample. 2-The "weighted mean (Losses)" is the mean of the relevant ratios weighted by the sample economies' total losses in US dollars



disaster insurance given the observed reinsurance rate. The second part is calculated as  $i(s^* - r) = 16\% \times (80\% - 50\%) = 4.8\%$ , reflecting the actual reinsurance coverage with the observed level of primary insurance. The third part is calculated as  $(s^* - r)(1 - i)$  where neither primary insurance nor international reinsurance is optimally used. Hence, we interact the underuse of both types of insurances, i.e.,  $(80\% - 50\%)(1 - 16\%)$ , that yields the “interaction effect” of 25.2%. In this hypothetical case, out of the international risk-sharing gap of 72%, 42% is ascribed to a lack of primary disaster insurance alone, 4.8% is to a lack of warranted reinsurance alone, and 25.2% is to a lack of both primary insurance and international reinsurance. Thus, the proximate source of the prospective lack of international risk-sharing is mostly on the ground in California.<sup>10</sup>

$$\begin{aligned} \text{International risk - sharing gap} &= 72\% \\ &= \underbrace{42\%}_{\text{Ascribed to a lack of primary insurance}} + \underbrace{4.8\%}_{\text{Ascribed to a lack of warranted reinsurance}} + \underbrace{25.2\%}_{\text{Ascribed to a lack of both}} \end{aligned} \quad (4)$$

Figure 2 illustrates the decomposition of the international risk-sharing gap from Fig. 1 into the three components, in accord with Eq. 3. On average, out of the international risk-sharing gap of 90.5%, the lack of primary insurance coverage alone accounts for 15.0%, while the lack of international reinsurance alone accounts for only 16.9%. Fully, 59% out of the 90.5% gap can be filled only when *both* primary insurance and international reinsurance coverages improve. Hence, we can conclude that increasing the use of international reinsurance alone would not be sufficient to benefit from more international risk-sharing. Increasing the penetration of primary insurance alone is also not sufficient but is necessary to improve international risk-sharing substantially along with increased use of international reinsurance.<sup>11</sup>

A natural experiment in Japan illustrates how raising the reinsurance rate alone would not by itself lift international risk sharing much. Japan’s system is a hybrid one with the Ministry of Finance (MoF) backstopping most earthquake insurance (marketed by private, shareholder-owned nonlife insurance companies) but with cooperative mutual insurers also offering such insurance (see Ito and McCauley (2019), appendices 5 and 6). The MoF invests the insurance reserves in its own bonds and buys practically no reinsurance while the cooperatives reinsure 58% of their exposure.

If the MoF had followed the example of the cooperatives and reinsured 58%, it might seem a real game-changer. But if the overall take-up of earthquake insurance were unchanged at 2011 levels, then Japan would have shared not 4% of its losses but 9%. This would be a doubling of the international risk-sharing, to be sure. However, Japan would still have remained closer to earthquake risk autarky than to the

<sup>10</sup> By contrast, fire insurance covering half to two-thirds of the loss and over half the insurance supplied by non-US firms resulted in about a third of the cost of the 1906 San Francisco earthquake being paid by non-USA, mostly British insurers. See Odell and Weidenmier (2004).

<sup>11</sup> We report each country’s international risk-sharing gap, domestic insurance gap, international reinsurance gap and the interaction effect in the country list of Appendix 3.



frictionless full risk sharing of 96% or even the estimated New Zealand level of risk sharing between 40 and 50%.

The upshot of this natural experiment is simply a particular instance of the theme of this section: the shortfall of international risk-sharing in Japan cannot be ascribed to a low reinsurance rate alone. Looking back, an earthquake in 1979 led to higher insurance premia and an end to mandatory earthquake insurance. By the time of the Great Hanshin-Awaji Earthquake in 1995, participation rates had fallen so low that the MoF subsequently raised coverage limits and its maximum exposure to successfully increase coverage.<sup>12</sup> But still only 16% of losses in 2011 were insured, so in this case, as in the general case, increasing international reinsurance could make only limited improvements to international risk sharing.

The next two sections analyze separately the determinants of primary insurance and reinsurance in the cross section to shed light on potential demand and supply factors that contribute to gaps in primary insurance and international reinsurance. These are reduced form regressions, drawing on various theories pertaining to insurance and risk-sharing.

For primary insurance on the demand side, we test for a positive relationship to income as a superior good and negative relationship to a proxy for moral hazard and proxies for disaster myopia, including frequency of disasters. On the supply side, we test for a positive relationship with legal and financial development.

For reinsurance on the demand side, we test for a positive relationship to small economic size (as argued above), financial openness and to proxies for the profitability/capitalisation of domestic insurance firms.

## 5 Regression Analysis of Insurance Coverage

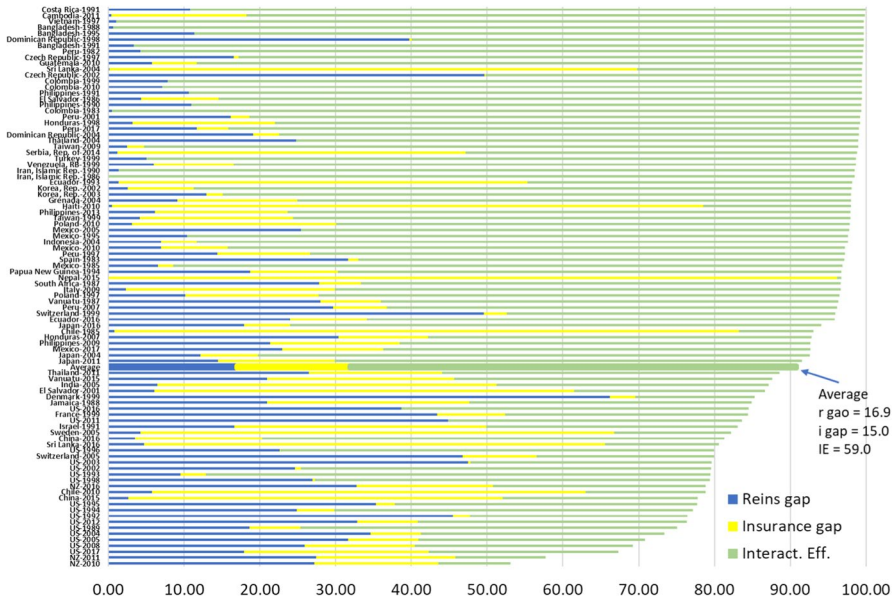
Our empirical analysis on the determinants of primary disaster insurance coverage reveals that countries with higher levels of economic or financial development tend to cover a larger share of losses from disasters. We find evidence for disaster myopia in lower insurance in response to less frequent disasters and in the lower insurance coverage of earthquakes compared to that of floods or storms.

We regress estimated insured losses as a share of total economic losses on a set of candidate variables as specified as below:

$$y_{it} = \alpha + X'_{it}B + \epsilon_{it} \quad (4)$$

<sup>12</sup> As of 1995, the participation rate of earthquake insurance was merely 9%. After the Hanshin-Awaji Earthquake, the participation rate climbed. However, as of the 2011 earthquake, the rate was still about 24%. As of 2019, it is still around 33%.





**Fig. 2** Decomposition of the shortfall into insurance cover and reinsurance. The figure illustrates the decomposition of the international risk-sharing gap from Fig. 1 into the gap due to the lack of primary insurance coverage only, the lack of international reinsurance only, and the lack of both primary insurance and international reinsurance, in accord with Eq. 3. The country list in Appendix 3 reports each country’s international risk-sharing gap and its three-way decomposition. This figure indicates the lack of international risk-sharing is not just because of the underuse of international reinsurance, but also the lack of primary insurance coverage. Sources: NatCatSERVICE data; IMF balance of payments data; authors’ calculations

where  $y_{it}$  is the share of estimated insured losses in total economic losses of the disaster(s) that occurred in country  $i$  in year  $t$ .<sup>13</sup> The sample is not a panel but rather comprises 138 disasters in 60 countries.  $X$  is a vector of candidate variables which may affect  $y_{it}$ . The baseline estimation is done using the simple OLS technique. Given the heterogeneity in economic losses, we also run weighted regressions by weighting with the estimated economic losses in US dollars.

In what follows, we discuss theoretical rationales for the choice of each variable and the expected sign for its estimate. We consider first demand, then supply factors.

At a high level of economic development, economic agents are more likely to buy insurance against risks including disasters. Here, the rationale is that disaster

<sup>13</sup> While the original NatCatSERVICE data is in daily frequency, the master dataset for the empirical analysis is in annual frequency. Hence, if there are more than one major crises in one year, the estimated reinsured losses and total losses will be added up for that year. That means while “a disaster” in the sample can originally include more than one major disasters, we call each  $y_{it}$  “a disaster.” Each disaster is identified by the combinations of  $i$  and  $t$ . Table 1 reports the summary statistics of the shares of estimated insured losses in total economic losses.



insurance is a superior good; people in relatively prosperous economies can better afford to hedge against risks.<sup>14</sup> We measure the level of economic development using per capita income in purchasing power parity terms and expect it to be a positive contributor.

A big government may reduce the demand for disaster insurance. As discussed in Sect. 7, when the risk of a disaster is not well covered by insurance, the government may end up playing the role of the ex-post insurer by compensating losses and funding reconstruction out of its budget. Conversely, if the public expects that the government would eventually behave this way, the incentive to sign up for costly disaster insurance can weaken: “charity hazard.” Hence, the size of government, measured as the ten-year average of government consumption as a share of GDP, can negatively affect the extent of disaster insurance coverage.<sup>15</sup>

Economic agents tend to underestimate the probability of experiencing rare adverse outcomes that have not recently occurred. Under such “disaster myopia,” the perceived risk of a disaster occurring is so low and the subjective price of disaster mitigation measures, such as disaster insurance, is so high that economic agents would be discouraged to take any mitigation measures (Guttentag and Herring 1986; Hertwig et al. 2004). In the case of disaster insurance, the less recent the experience of disasters is, the less demand for disaster insurance.

To test for disaster myopia, we include in the estimation a variable that counts the number of disasters during the sample period for each economy.<sup>16</sup> It measures the inverse of disaster myopia—the higher value the variable takes, the less of disaster myopia would be prevalent, and the more demand for primary disaster insurance (Drexler and Nekoul 2016). We expect the estimate of the variable to take a positive sign.<sup>17</sup>

“Disaster myopia” can be especially strong for earthquakes because of their rarity and the difficulty in calculating the probabilities compared to other types of disasters. Insurance coverage would thus tend to be low for earthquakes. We include a dummy that takes the value of one for earthquakes and expect a negative coefficient.

The extent of development in terms of legal systems and institutions also contributes to insurance coverage. As a supply factor, legal and institutional development contributes to the smooth enforcement of contracts and thereby creating and executing complex financial products including insurance against disasters (Levine et al. 2000). An economy with more developed legal systems or institutions should tend to insure more of its disaster risk.

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<sup>14</sup> Admittedly, higher-income individuals may “self-insure” out of their own wealth (Mossin 1968). The income level also impacts the supply side. Cantor and Packer (1996) found that high income makes for higher sovereign ratings. Higher rated sovereign bonds provide duration that is useful to insurance firms.

<sup>15</sup> Government spending might be a better variable since it also includes transfers, but we use the more widely available consumption. The results are unchanged when we use government spending instead of consumption.

<sup>16</sup> We also tried a variable that counts the number of previous disasters for each disaster. The estimation results are qualitatively similar.

<sup>17</sup> Disaster myopia can reduce demand. However, if the disaster insurance market is more developed in an area frequently hit by disasters, it can also be regarded as a supply factor.



**Table 2** Determinants of insurance coverage  
*Dependent variable: insured losses/total losses*

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	WR (weighted by losses in US \$)	WR (weighted by losses in US \$)
Per capita income (PPP), ( $t-1$ )	9.149							4.745	4.292	14,481	12,900
		(1.383)***						(2.529)*	(1.662)**	(2.992)***	(2.467)***
Govt consumption (% of GDP),		1.245						-0.332		-0.845	
10-year average		(0.378)***						(0.404)		(0.561)	
Number of disasters			1.265					0.247		0.852	0.845
			(0.287)***					(0.365)		(0.240)***	(0.216)***
Dummy for earthquakes				-6.657				-8.645	-9.005	-12.534	-13.303
				(3.416)*				(3.101)***	(2.768)***	(2.838)***	(2.674)***
Legal/institutional develop. ( $t-1$ )					0.432			0.120		-0.192	-0.160
					(0.063)***			(0.108)		(0.112)*	(0.105)
Private credit/GDP, ( $t-1$ )						0.192		0.054	0.116	0.023	
						(0.027)***		(0.045)	(0.033)***	(0.033)	
New Zealand				48.478				48.444	47.248	60.148	56.556
				(10.630)***				(11.690)***	(10.878)***	(7.767)***	(7.445)***



**Table 2** (continued)

*Dependent variable: insured losses/total losses*

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	WR (weighted by losses in US \$)	WR (weighted by losses in US \$)
N	137	129	122	125	138	138	138	111	128	111	122
Adj. R <sup>2</sup>	0.24	0.28	0.28	0.07	0.02	0.12	0.13	0.41	0.41	0.70	0.69

The dependent variable is the estimated insured losses as a share of total losses. The data on insured losses is from Munich Re's *NatCatSERVICE* database. The simple OLS technique is applied to columns (1) through (9). For columns (10) and (11), weighted regressions are implemented with the weights being the estimated economic losses in US dollars. "New Zealand" is the dummy variable for that country. To mitigate a risk of endogeneity from bidirectional causality, we lag the right-hand-side variables except for the earthquake dummy. \* indicates significance at the 0.10 level. \*\* indicates significance at the .05 level. \*\*\* indicates significance at the .01 level

Source: Munich Re *NatCatSERVICE* data; authors' calculations





Similarly, an economy equipped with a well-developed financial system provides a wider variety of financial instruments to hedge against risk and to invest insurance reserves. Hence, a deep, liquid and competitive financial market should yield more ways to cover the risk of disasters with a wider range of financial assets and insurance products (though more extensive and sophisticated retail distribution channels as well). In a competitive financial market, insurance firms should offer contracts closer to being actuarially fair. We test the effect of financial development by using private credit as a share of GDP.

Lastly, as we previously mentioned, New Zealand stands out from other countries in terms of having high levels of disaster insurance coverage owing to its quasi-mandatory mandatory earthquake insurance. In fact, we found that including the dummy for New Zealand significantly improves the goodness of fit. Hence, we test a dummy for New Zealand and expect a positive coefficient.

In the estimation, there is a risk of endogeneity from bidirectional causality. To mitigate this risk, we lag the right-hand-side variables except for the earthquake dummy.

When we test the candidate variables individually, each is significantly correlated with the insurance coverage (Columns (1) through (7) in Table 2). These findings suggest that, among the demand factors, an economy with a higher level of economic development, where government consumption is larger, or that experiences disasters more frequently, tends to insure more of its disaster risk. Earthquake coverage tends to be smaller. Among supply factors, legal and financial development positively contribute to primary insurance coverage. Also, the dummy for New Zealand is found to be significantly positive, indicating that the disaster insurance coverage of the country is about 50 percentage points higher than other countries.

When we test these variables altogether, per capita income and financial development stand out as robust contributors (Column (9)). These results suggest that not only highly developed economies, but also those with highly developed financial systems and markets tend to cover more of the risk of economic losses driven by disasters. In the presence of the per capita GDP variable, the positive bilateral relationship between size of government and insurance coverage flips sign to the hypothesized negative (albeit insignificant) relationship. The dummies for earthquakes and New Zealand continue to be significant contributors even in a multivariate setting.

The sample of this exercise includes a heterogeneous group of economies that experienced disasters. Especially, the size of economic losses can vary significantly across the disasters. The economic loss of Japan's 2011 earthquake/tsunami disaster exceeded \$210 billion and that of the USA Katrina disaster reached \$160 billion; these are the two largest disasters in our sample (their shares in GDP were "only" 3.5% and 1.6%, respectively). In contrast, the economic loss of the storm Dominica experienced in 2007 was \$20 million (though its share in GDP was almost 5%). In order to "follow the money," we run the regression with the observations weighted by economic losses in US dollars (Columns (10) and (11)).

Running the regression with the weights based on economic losses increase the goodness of fit significantly, which might, among other things, suggest that insurance of larger losses is better measured. We find that the level of economic development continues to promote disaster insurance coverage while financial development



is no longer a contributor. Interestingly, the estimate of the variable for each economy's number of disasters, our proxy for (the inverse of) disaster myopia, now becomes significantly positive in the weighted regression. That means those economies that experience more disasters during the sample period tend to cover more of their losses from disasters with primary insurance. In other words, we have evidence for disaster myopia affects the extent of primary insurance coverage.

## 6 Regression Analysis of Reinsurance Rate

We now analyze the determinants of reinsurance coverage as a share of total insured losses. Our findings indicate that a smaller economy (in terms of world GDP share) or an economy with greater financial openness tends to cover more disaster risk with reinsurance. In addition, proxies for the competitiveness of the domestic insurance markets are associated with higher reinsurance rates. In particular, economies with lower NIIP, including lower investments by insurers of capital and reserves, or a larger foreign firm presence in their insurance market tend to have higher reinsurance coverage.

We regress the share of reinsurance coverage in total insured losses on a set of candidate determinants as shown below:

$$r_{it} = \varphi + Z'_{it}\Gamma + v_{it} \quad (5)$$

where  $r_{it}$  is the share of reinsurance coverage in total insured losses of the disaster(s) that occurred in country  $i$  in year  $t$ . The sample is composed of 93 disasters in 44 economies.  $Z$  is a vector of candidate variables which may affect  $r_{it}$ . As was the case with the estimation of primary disaster insurance, we assume a reduce form for the estimation and apply both the simple OLS estimation technique and the weighted regression method.

As a potential determinant of reinsurance coverage, we take the relative size of the economy to negatively affect the use of international reinsurance. Larger economies may be able to depend on reinsurance opportunities domestically (which we do not measure), and thus face less need for international reinsurance. By the same token, our ideal type of disaster risk-bearing theory suggests that the smaller a country's output share in the world is, the less of its disaster risk it should retain. Therefore, we test for a negative effect of the output share in the world economy, which we capture with the GDP world share (in PPP).

Financial openness should be a positive contributor to reinsurance coverage because the benefit of international risk-sharing can be realized only when an economy is open to cross-border financial transactions. Constraints can be legal or behavioral. In fact, many studies have evidenced that financial liberalization leads to a decline in the extent of home bias (Baele et al. 2007; Mondria and Wu 2010; Sørensen et al. 2007). Hence, we can expect that greater financial openness would lead to a greater use of international reinsurance. To capture the possible positive



impact of financial openness, we use a de facto measure of financial openness using the dataset developed by Lane and Milesi-Ferretti (2001, 2007, 2017).

Furthermore, how much wealth or reserves primary insurance firms hold should matter for reinsurance coverage. If primary insurance firms are profitable and accumulate ample reserves, they may be better able to cope with an influx of insurance claims at the time of a disaster by using their internal funds and not relying on reinsurance. If the industry of concern is not highly competitive, it should be easier to accumulate internal funds over time than otherwise. Thus, the more internal funds or wealth primary insurance firms hold, the more the firms should be able to self-insure and the less demand they would have for reinsurance.

However, obtaining measures of internal funds of primary insurance firms or measures of profitability is difficult, especially in a cross-country setting. Hence, we test two variables, both of which pertain to the link between insurers' access to internal funds and reinsurance coverage. They are NIIP and the share of foreign firms in domestic nonlife markets (*Foreign*).

The NIIP measures whether an economy is a net creditor or debtor in terms of external wealth. The NIIP is an aggregate across sectors, but we take it as a proxy for the scale of capital and reserves held abroad by primary insurance firms in an economy. Insurance firms in a creditor economy are likely to have more own funds invested abroad that can be used when needed to self-insure (e.g., insurance firms in Japan, a longtime creditor country). (In New Zealand, the government earthquake agency reinsures to prevent a disaster from raising government and foreign debt, given net international liabilities in excess of 60% of GDP.) Thus, the higher NIIP an economy has, the less incentive its insurers would have to reinsure internationally, suggesting a negative sign of the estimated coefficient.

Another proxy for accumulated capital and reserves held as internal funds is *Foreign*, which measures the market share of foreign insurance firms in the domestic nonlife market. The rationale to test this variable is that the more open to foreign firms the nonlife insurance industry of a given economy is, the more competitive and the less profitable its insurance market may be. Insurance sectors with lower profitability, reserves and capital are less able to handle a possible surge in insurance claims, and therefore, they have more incentive to buy reinsurance. Hence, the correlation between *Foreign* and reinsurance coverage should be positive.

Table 3 shows that each of the candidate explanatory variables enters the estimation significantly with theoretically predicted signs, except for *Foreign*. However, these variables alone do not have much explanatory power as the low  $R^2$  indicates.

Multivariate models yield higher goodness of fit while GDP shares, financial openness and NIIP retain statistical significance and predicted signs. Again, regressing with weights based on the estimated economic loss in US dollars improves the goodness of fit.

Larger economies (in terms of their GDP shares in the world economy) are less likely to reinsure internationally, that is in line with the prediction of our ideal type of international risk-bearing. For small economies, sharing disaster risk domestically does not make much sense, and many of them do not have domestic reinsurance firms anyway.



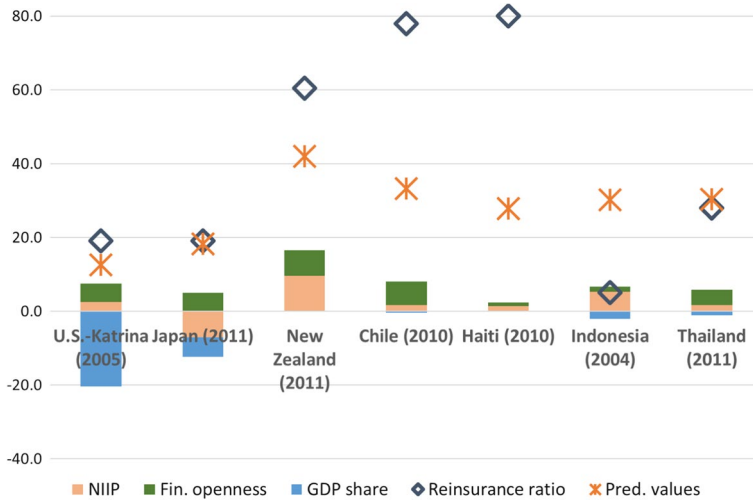
**Table 3** Determinants of reinsurance coverage

<i>Dependent variable: Reinsured losses/Insured losses</i>		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	WR (Loss in US \$)	WR (Loss in US \$)
GDP shares ( $t-1$ )	-0.639 (0.348)*					-0.723 (0.349)**	-0.751 (0.403)*	-1.045 (0.208)***	-0.615 (0.223)***
De facto financial openness ( $t-1$ )		0.170 (0.085)**				0.206 (0.083)**	0.202 (0.106)*	0.086 (0.056)	0.099 (0.063)
NIIP/GDP ( $t-1$ )			-0.104 (0.055)*			-0.098 (0.055)*		-0.124 (0.044)***	
Foreign firms share ( $t-1$ )				0.251 (0.163)			0.123 (0.174)		0.610 (0.137)***
<i>N</i>	93	90	93	39	90	90	36	90	36
Adj. <i>R</i> <sup>2</sup>	0.03	0.03	0.03	0.03	0.10	0.10	0.16	0.24	0.50

The dependent variable is the estimated reinsured losses as a share of insured losses. The volume of reinsurance is measured using current or capital transfers in the balance of payments (whose data is extracted from the IMF's Balance of Payments database). The data on total losses and insured losses are extracted from Munich Re's *NatCatSERVICE* database. For more details on these variables, refer to "Appendix 1: Data and sources." The simple OLS technique is applied to columns (1) through (6). For columns (7) and (8) weighted regressions are implemented with the weights being the estimated economic loss in USA, dollars. The variable "Foreign" measures the market share of foreign nonlife insurance firms in the domestic market. To mitigate a risk of endogeneity from bidirectional causality, we lag the right-hand-side variables except for the earthquake dummy

\* indicates significance at the 0.10 level. \*\* indicates significance at the .05 level. \*\*\* indicates significance at the .01 level





**Fig. 3** Contributions of the factors to reinsurance coverage. The figure illustrates the contributions of the potential determinants to the ratio of reinsurance over insured losses for selected disasters, based on the estimation model of Column (7) in Table 3. The effect of the estimated constant is omitted from presentation. *Source:* Authors' calculations

De facto financial openness is a positive contributor to international reinsurance. Economies with more open financial markets tend to cover more disaster risks with international reinsurance simply because of better access to reinsurance firms overseas.

The estimate of NIIP is significant with the theoretically predicted negative sign even when included jointly with other variables. A disaster-afflicted economy with positive NIIP (one year prior to the occurrence of the disaster) is less likely to reinsure internationally; its insurers are more likely to have own funds invested abroad to cash in to meet claims.

*Foreign* continues to be an insignificant factor in a multivariate setting. However, when we run a weighted regression, its estimate becomes significantly positive, consistent with our prior. A nonlife insurance market more open to foreign insurance firms tends to be more competitive and therefore less profitable. Hence, in such a market, primary insurance firms may not have ample internal funds or reserves that they can use to cover a high volume of insurance claims. Therefore, those insurance firms tend to sign up for reinsurance.

Figure 3 illustrates, for selected disasters, the contributions of these factors to the ratio of reinsurance over insured losses based on the estimation model of Column (7) in Table 3. For Japan and Thailand, the observed reinsurance coverage ratios are more or less on par with the predicted levels. For the USA and Japan, large size (GDP share) reduces the reinsurance coverage ratio. Economies with negative NIIP, such as New Zealand and Indonesia, tend to have more reinsurance coverage. Among the selected economies, Japan is the only net creditor country, which helps lower the ratio. The estimation model underpredicts for New Zealand, Chile and Haiti, and overpredicts for Indonesia.



## 7 Government and Disaster Insurance

Above we tested whether a larger government consumption footprint deters private parties from insuring against disasters and did not find any evidence for it. However, our one-dimensional fiscal proxy hardly matches the multidimensional involvement of governments in disasters. This ranges from outright insurance provision at fair or underpriced premia, as in Japan for earthquakes or France for any “catastrophe naturelle” (Muir-Wood 2016, pp 149, 311). The US National Flood Insurance Program (NFIP), whose \$1 trillion in coverage includes many mansions by the sea, is underwater notwithstanding Congressional debt relief of \$16 billion in 2017 to pay claims from Hurricanes Harvey, Irma and Maria (CRS 2020; Horn and Brown 2018).<sup>18</sup> There are also agencies that enjoy explicit guarantees (New Zealand) or implicit guarantees, as in California.<sup>19</sup> There is also government regulation of private insurers’ supply and pricing. Some government interventions may raise but others lower the insuring and international sharing of disaster losses.

Compulsory insurance seems rare but powerful. We interpret the NZ dummy as capturing the effect of compulsory earthquake insurance as an add-on to fire insurance (required for mortgages), which dates to WWII (when Churchill used the same device to pay for rebuilding housing hit by German bombs). The political challenge of combining appropriate pricing and compulsion is evident in Japan’s abandonment of compulsion after an earthquake in 1979 led to higher premia. An initiative of the US housing agencies in the 1990s to require earthquake insurance for government-supported mortgage insurance died quickly in the face of opposition from West Coast congresspeople.

Government ex ante interventions to offer insurance face a dilemma. If insurance rates are set to be affordable, participation rates would be higher, and compulsory participation may be politically feasible. But if premia are too low, the scheme will lose money and reinsurance will be problematic. If rates are set higher and even somewhat related to risks, then only a minority will participate in a voluntary scheme, as in Japan and California. The political pressure for ex-post government aid may increase.

Whether expectation of ex-post government aid gives rise to low insurance coverage or not, the observed low primary coverage and low reinsurance leave an uncertain contingent liability of the government (Koetsier 2017a). Koetsier (2017b) and OECD and The World Bank (2019) find that post-disaster fiscal intervention leads to higher government expenditure and public debt. After the 2011 earthquake, the Japanese government basically covered uninsured losses and government debt rose

<sup>18</sup> As of the end of 2020, the NFIP owes \$20 billion to the US government. In 2017, the US NFIP has begun to buy reinsurance with the funds secured by the Federal Emergency Management Agency (FEMA).

<sup>19</sup> In rating bonds of the California Earthquake Agency, Fitch rating analysts counterpose that “is not a state agency and has no connection to the state budget” against the observation “the state of California, the insurance industry in California and policyholders in California all have an interest in the CEA’s continuance as an organization” (Butler and Grimes 2018, pp 1, 2).



accordingly despite special taxes.<sup>20</sup> Observers spot a US trend toward greater Federal ex-post coverage of disaster losses from single digits in the 1950s to 80% in more recent years (Kunreuther and Michel-Kerjan 2014; Cummins et al. (2010); . And rather than just rebuilding uninsured public infrastructure or providing temporary housing, the federal government in 2006 after Hurricane Katrina even gave grants of up to \$150,000 (without an income test) to over 100,000 uninsured homeowners (Muir-Wood 2016, p 146).

The reader may wonder about COVID-19 as a disaster, but a contagious pandemic does not lend itself to global risk sharing simply because it is a global event. That said, the government response to COVID-19 has used up substantial fiscal space. By late 2020, the debt-to-GDP ratio of advanced economies reached or even surpassed the World War II level (around 120% of GDP), and that of emerging market economies surpassed the level of the debt crisis in the 1980s, i.e., 60% of GDP (IMF 2020). The fiscal consequence of the pandemic has left governments less room to maneuver in responding to disasters.

The cross-sectional relationship between disaster risk sharing and fiscal space is not reassuring. We observe nothing like the finding that countries with greater external wealth reinsure disaster risk less. Instead, countries with little fiscal space tend to share disaster risk internationally less. Figure 4 plots our ratio of internationally reinsured losses against the lagged ratio of government debt to average revenues (Aizenman and Jinjark 2011). A high ratio indicates that a government had little fiscal space when disaster struck. Among advanced economies, less international risk-sharing was associated with less fiscal room to maneuver.

Thus, meager international risk-sharing of disaster losses could set the stage for a morphing of risks. Despite the so-far calm acceptance by bond investors of higher government debt from the COVID-19 response, at high levels of debt, the realization of the contingent liability from a disaster could pose a risk to financial stability. How big a disaster loss could be absorbed by a given government's budget before investors, including domestic ones, reprice the risk of the government's debt?

## 8 Conclusion

We find that the risk of disasters is shared internationally to a surprisingly limited extent. In the cases for which we have been able to identify reinsurance payments in the balance of payments, the mean portion of economic losses received offset by reinsurance is less than 5%. And, on a value-weighted basis, the degree of international risk-sharing is still only 7.5%. These findings are far below the ideal type of full international risk-sharing, which makes allowance for larger countries shouldering more of their own disaster risk. Even qualifying this ideal for standard features

<sup>20</sup> By the time that the 2011 earthquake hit, low coverage of losses helps to explain why the central government ended up spending more than the earthquake's estimated direct economic losses at 4% of GDP (World Bank 2014, p 289). The government imposed a 2.1% surcharge on individual income taxes to run for 25 years.



of insurance contracts like deductibles and co-insurance leaves such international risk-sharing low. Even if one takes the roughly half of New Zealand's earthquake risk that is internationally shared as a demonstrated, practical benchmark, observed internationally risk-sharing falls short by an entire order of magnitude.

This result depends to a remarkably little extent on the precise measurement of reinsurance receipts. Our decomposition in Sect. 4 demonstrated that raising the extent of reinsurance alone would raise international disaster risk sharing only to a limited extent unless the use of primary disaster insurance becomes more prevalent.

Regression analysis ascribes cross-disaster variation in insurance coverage and reinsurance as a share of insured losses to different factors. Our results point to economic and financial development as important determinants of insurance participation. There is also some evidence for disaster myopia as an inhibition to such participation. The reinsurance share is related to small size, as theory would suggest. As a form of international financial integration, the international reinsurance share is also positively related to overall de facto international financial integration. In addition, we also find that more internationally wealthy economies reinsure less, suggesting that net foreign assets proxy for insurers' capital and reserves that allow them to self-insure instead of relying on international sharing of disaster risk through reinsurance. In addition, we also find some evidence that an economy with more competitive nonlife insurance market (in terms of foreign firm penetration) tends to cover more disaster risk with reinsurance, perhaps owing to greater competition and less insurer internal funds.

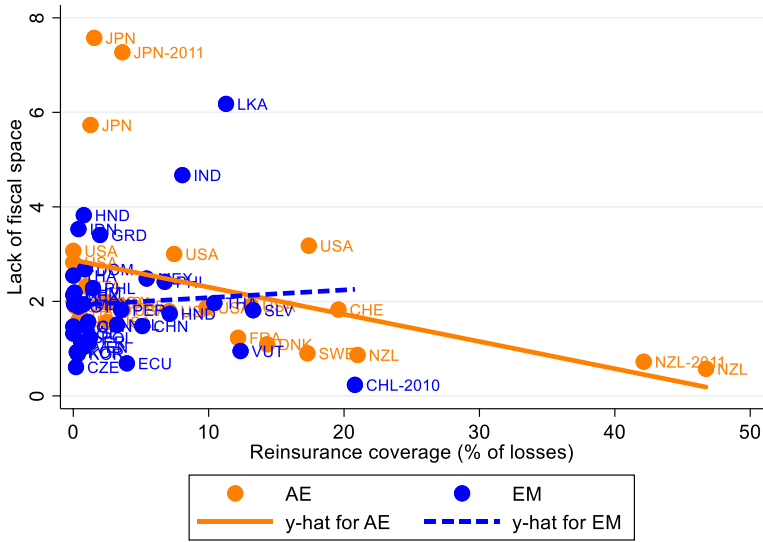
The lack of international risk-sharing against the background of low insurance coverage poses profound questions about the role of government. The practical alternative to ex ante insurance, however organized, seems to be demand for government spending to serve as ex-post insurance. Indeed, the trend in both Japan and the USA appears to be toward greater government spending in relation to disaster losses over time. But those advanced economies that enjoy less international risk-sharing also enjoy less fiscal space. Thus, the realization of a disaster risk could ratchet up already high public debt levels. In this manner, disaster risk could morph into financial risk. If we take the lesson that raising the penetration rate is a key to the extent of international sharing of disaster losses, then policies like US government-supported enterprises Fannie Mae's and Freddie Mac's providing mortgage insurance without requiring earthquake insurance are questionable.

The ongoing pandemic has highlighted various aspects of insurance discussed above, including the difficulty of assessment of low-probability events such as inoculation risk and the role of government compulsion. As suggested above, however, the global nature of a pandemic limits the possible contribution of international risk sharing.

Looking forward, global warming may be raising the losses associated with flood and storm hazards while leaving those of earthquakes unchanged. The cost of both underpriced explicit government insurance, for instance against US floods, and implicit insurance looks set to rise. At the same time, the potential benefit of using prices to provide incentives to mitigate risks could also be rising. While this study finds limited international sharing of disaster risk, public policy would be ill-advised to neglect markets and prices in responding to the challenge of climate change.







**Fig. 4** International risk-sharing and lack of fiscal space in AEs. The figure plots the measure of internationally reinsured losses as a share of losses against the ratio of government debt to average revenues which we use as the measure of the lack of fiscal space (Aizenman and Jinjark (2011)). A high ratio indicates that a government has little fiscal space. The lack of fiscal space is proxied by (one-year lagged government debt)/(5-year average revenue). According to the figure, for advanced economies, those with little international risk-sharing have little fiscal room to maneuver. *Source: IMF Balance of Payments; IMF International Financial Statistics; authors' calculations*

## 9 Appendix 1: Data and Sources

*Insured losses from disasters*—Data extracted from the NatCatSERVICE database.

*Estimated economic losses*—Data extracted from the NatCatSERVICE database.

*Current transfers, credit*—the IMF *Balance of Payments*.

*Capital account, credit*—the IMF *Balance of Payments*.

*Estimated reinsurance payments*—Current or capital transfers from the IMF *Balance of Payments*. For more details, refer to [Appendix 2](#).

*Reinsured losses as a share of economic losses*—*Estimated reinsurance payments* divided by estimated economic losses.

*Insured losses as a share of economic losses*—*Insured losses from disasters* divided by estimated economic losses.

*Reinsured losses as a share of insured losses*—*Estimated reinsurance payments* divided by insured losses.

*Per capita income*—Gross domestic product per capita in current international dollars (purchasing power parity), extracted from the IMF *World Economic Outlook* database.



*Private credit as a share of GDP*—“Private credit by deposit money banks and other financial institutions to GDP (%)” extracted from the World Bank’s *Financial Structure and Development* database.

*Legal/Institutional development*—The first principal component of law and order (*LAO*), bureaucratic quality (*BQ*) and anti-corruption measures (*CORRUPT*), all of which are extracted from the *International Country Risk Guide (ICRG)* database. Higher values of these variables indicate better conditions.

*Government consumption*—General government final consumption expenditure as a share of GDP, obtained from the *World Development Indicators*. We calculate the average from  $t-10$  through  $t-1$ .

*Dummy for earthquakes*—The value of one is assigned if the country-year includes an occurrence of an earthquake (*NatCatSERVICE*).

*Net international investment position (NIIP)*—Total external assets minus total external liabilities divided by GDP. The data on total external assets and total external liabilities are extracted from the nations’ external wealth dataset developed by Lane and Milesi-Ferretti (2001, 2007, 2017).

*GDP shares*—“Gross domestic product based on purchasing-power-parity (PPP) share of world total” from the IMF’s *World Economic Outlook (WEO)*.

*De facto financial openness*—The sum of total external assets and total external liabilities divided by GDP. The data on total external assets and liabilities are obtained from the dataset on international investment positions developed by Lane and Milesi-Ferretti (2001, 2007, 2017). The ratio of the sum of total external assets and liabilities to GDP can be very high, especially for economies with global financial centers (e.g., Hong Kong SAR, Ireland and Singapore). Therefore, we winsorize this ratio at the 10th and 90th percentiles (with both percentiles being calculated from a sample excluding all the financial-center economies) and normalize the ratio using the following formula:<sup>21</sup>

$$X_{-n_{it}} = \frac{X_{it} - X_{i,\min}}{X_{i,\max} - X_{i,\min}} \quad (5)$$

where  $X_i$  is the sum of total external assets and total external liabilities  $X_{i,\max}$  and  $X_{i,\min}$  are the global maximum and minimum of the winsorized variable  $X_i$ , respectively.

*Foreign*—It represents the market share of foreign nonlife insurance firms in the domestic market. Source: *OECD Insurance Statistics*.<sup>22</sup>

*Fiscal space*—The ratio of gross public debt to the five-year average of tax revenues. Both variables are retrieved from the IMF’s WEO. A lower value of this variable indicates more fiscal space.

<sup>21</sup> The definition of financial centers follows that of Lane and Milesi-Ferretti (2017). They are the Bahamas, Bahrain, Belgium, Cyprus, Hong Kong SAR, Ireland, Luxembourg, the Netherlands, Panama, San Marino, Singapore, Switzerland and the UK.

<sup>22</sup> “Foreign insurance firms” mean “foreign controlled undertakings” and “branches/agencies of foreign undertakings” in total domestic nonlife insurance business.”



## 10 Appendix 2: Balance of Payments Measure of Reinsurance

To examine how the risk of natural, or man-made, disaster is shared internationally, we need to know how to identify cross-border financial flows that arise from such sharing. In principle, such insurance flows are captured by the balance of payments.

One might guess that the answer lies in the current account. The residents of the country buying insurance would show a service import as they paid premia to reinsurers in the rest of the world. Correspondingly, they would show a current account unilateral transfers receipt when a disaster hit and insurers in the rest of world paid for losses. This guess *could have been* right. However, the major revision in the balance of payments accounting rule published in 2009 changed the accounting of disaster insurance drastically.

In the new Balance of Payments Manual 6 (BPM6), premium payments show up as service imports, as before. But, in principle, the claims paid after big disasters now show up in the capital account. Thus, big casualty losses no longer give a temporary boost to the current account.

Nevertheless, in *stock* terms, well-insured big disasters still improve the net international investment position (NIIP) of the economy suffering the disaster. In effect on impact, international insurance replaces the destroyed domestic capital stock with financial claims on the rest of the world.

With this preview, let us now walk through the balance of payments accounting. Households and corporations in a disaster-prone economy insure themselves against catastrophes through earthquake, storm or flooding insurance. Typically, resident companies, including affiliates of multinational insurers, provide the immediate insurance and collect the premia (top left arrow in Fig. 5). In turn, these local insurance companies may also reinsure with global reinsurance companies to cover a share of the risks or risks above a certain threshold (bottom left arrow). Reinsurance may not have to be done internationally. An insurance firm in a physically large country might find reinsuring with a domestic reinsurance firm actuarially reasonable. However, in general, purchasing reinsurance from overseas would minimize the correlation of the likelihood of a particular disaster causing economic losses between the holders and the issuers of the reinsurance.

Once the disaster hits, local insurance companies make payments to policy holders (top right arrow). These local insurers in turn file claims to receive payments from reinsurance companies (bottom right arrow). When reinsurance is provided by firms headquartered and mostly owned abroad, the risk is diversified internationally.

The balance of payments flows are represented by the two bottom arrows in Fig. 5. Premia for reinsurance are a current account outflow, i.e., a service import (bottom left). And insurance claims filed by local insurance companies on overseas reinsurers also appear in the balance of payments as an inflow since it involves a financial claim on the rest of the world.<sup>23</sup>

<sup>23</sup> Some reinsurance companies insure each other (or through other financial institutions) for potential peak risks. This kind of financial transaction is called “retrocession.”



Formerly in the Balance of Payments Manual 5 (BPM5), claims for insurance payments from overseas reinsurers appeared as unilateral transfers in the current account alongside workers' remittances, as transfers of claims on income from a foreign country to the home country. In that case, a current account transfer inflow is recorded—the transaction appears in row (A) in the simplified balance of payments shown in Table 4 (and also as arrow (A) in Fig. 6). Given the double-entry balance of payments bookkeeping, corresponding to this inflow on the current account is an outflow in the financial account—the acquisition of the claim on the insurance company abroad: row (C) in Table 4 (and also as arrow (C) in Fig. 6).<sup>24</sup>

Such treatment of reinsurance payments in the International Monetary Fund's (IMF's) BPM1 through BPM5 changed with BPM6. It relocated big reinsurance transfers from the current to the capital account.<sup>25</sup> When the scale of the disaster and the resultant losses of insurance companies are great, treating insurance claims on overseas reinsurers as unilateral current transfers would not be appropriate. BPM6, introduced in 2009, reclassified certain disaster-related insurance receipts from international reinsurers as capital transfers in the *capital account* (row (B) in Table 1 and arrow (B) in Fig. 6) instead of unilateral transfers in the *current account* (row (A)). Statistical authorities of the government decide whether to apply the capital transfers rule based on the scale of the disaster.

The rationale behind the new rule draws on both the source and use of the transfer. First, the unilateral transfers (i.e., inflows) that spike for the disaster-hit economy are usually paid for by insurance companies out of reserves, not out of income arising from “current” production. Second, since the insurance payments are used to replace destroyed capital, including such insurance payments as a current (income) transfer was judged not appropriate.<sup>26</sup>

After BPM6's introduction, the US Bureau of Economic Analysis (BEA) adopted this rule in 2009 (Flatness, et al. 2009; USBEA 2009).<sup>27</sup> New Zealand adopted the rule in June 2011, following the Canterbury earthquakes of 2010 and 2011 (Statistics New Zealand 2011), as did Japan in 2011 after the Great East Japan Earthquake in March 2011 (Japan Cabinet Office (Yoshino and Koori) (2011)). Presumably,

<sup>24</sup> It is analogous to the accounting for a home country export to a foreign country in that the exporter receives a claim on the importer. Due to the double entry nature of the balance of payments, a corresponding outflow to this reinsurance receipt occurs in the financial account, recorded as an increase of “trade credit” in the “other investment” category of the international asset. See below.

<sup>25</sup> Recall that the “capital account” here does not mean the capital account in the sense of the BPM5. In the BPM6, the former capital account is called the “financial account,” though many researchers still use the name “capital account” to refer to the financial account (Table 1). BPM6's new capital account comprises capital transfers and the acquisition or disposal of nonproduced, nonfinancial assets (which used to be reported as part of the current account in BPM5) – row (B) in Table 1. For most countries, transactions in the capital account are much smaller than those in the financial account and are often negligible.

<sup>26</sup> The change is coordinated with the System of National Accounts 2008 (2008 SNA).

<sup>27</sup> After the September 11th terrorist attack in 2001, the USBEA changed the way it treats insurance losses and reinsurance claims starting with the 2003 Comprehensive Revision of the National Income and Product Accounts that year (USBEA (2003a, b)). This change intended to smooth large swings in measured insurance services that can arise from catastrophes such as earthquakes (eg, Northridge, 1994), hurricanes (Hurricane Andrew, 1992) and terrorist attacks (September 11, 2001). See USBEA (2003a, b) for more details.



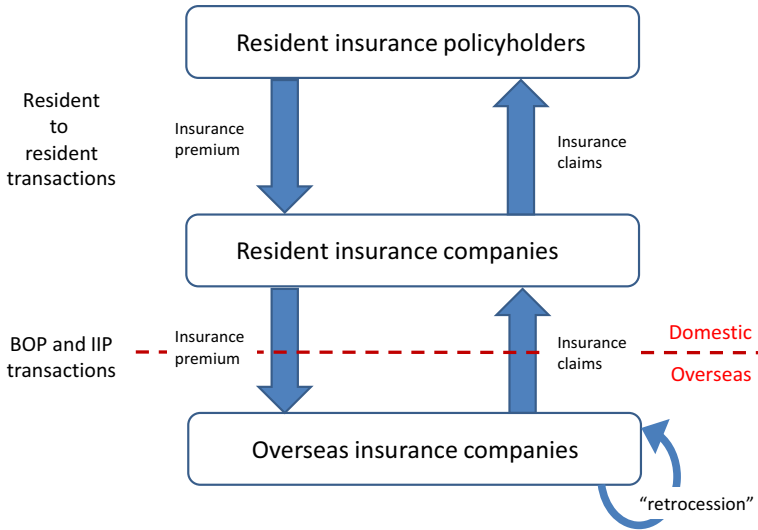


Fig. 5 Insurance transactions between residents and cross-border

Table 4 Balance of payments and earthquake reinsurance payments

**Current Account**

Exports (goods + services + income receipts)—Imports (goods + service + income payments)

(A) **Current transfer, credit**—Current transfer, debit

**Capital Account**

(B) **Capital transfer, credit**—Capital transfer, debit

Gross disposals of nonproduced, nonfinancial assets—Gross acquisitions of nonproduced, nonfinancial assets

**Financial Account** (= formally called "capital account")

**Direct investment**

Net acquisitions of financial assets—Net incurrence of liabilities

**Portfolio investment**

Net acquisitions of financial assets—Net incurrence of liabilities

**Other investment**

(C) **Net acquisitions of financial assets**—Net incurrence of liabilities

Reserve assets

other countries that adopt the BPM6 will treat insurance payments in the same manner as these countries.<sup>28</sup>

With this balance of payments accounting in hand, we can locate reinsurance payments in the international accounts of countries that have suffered big disasters

<sup>28</sup> Regular reinsurance payments unrelated to large-scale disasters continue to be recorded as unilateral transfers in the current account (arrow (A) in Fig. 2).



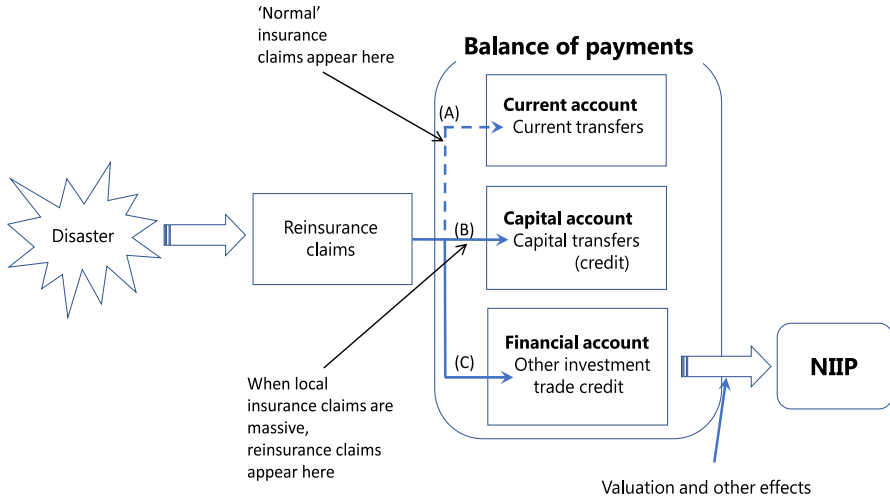


Fig. 6 BOP-IIP accounting for disaster insurance transactions

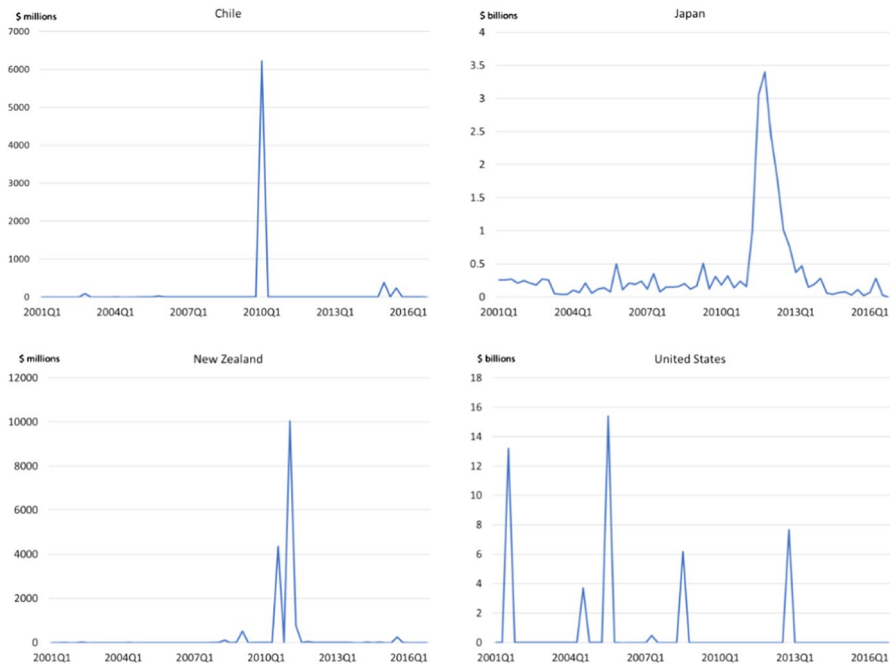
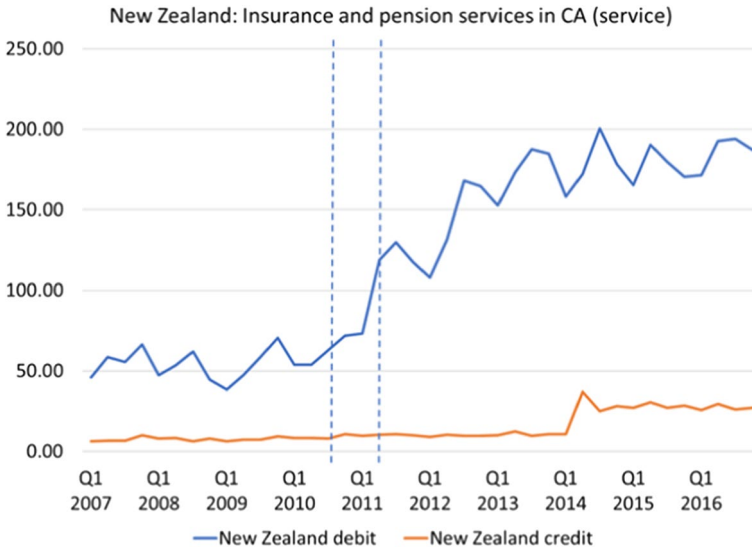


Fig. 7 Capital accounts of Chile, Japan, New Zealand and the USA

in recent years. Figure 7 illustrates the capital account credit of Chile, Japan, New Zealand and the USA. The spikes in the graphs correspond to disasters that hit these countries: the Maule earthquake in Chile in 2010, the Great East Japan Earthquake





**Fig. 8** Insurance services in New Zealand’s service trade. The two dotted lines correspond to the earthquakes in September 2010 and February 2011. *Source:* Statistics New Zealand

in 2011, the Canterbury Earthquakes in New Zealand in 2010 and 2011, and the September 11 attack in 2001 and Hurricane Katrina in 2005 in the USA. These spikes in the capital account credit indicate that these countries’ insurance companies filed massive claims on overseas reinsurers after they experienced the catastrophe.<sup>29</sup> Keep in mind that the value of capital account transactions is often negligible and generally their appearance is infrequent (except countries that often receive debt forgiveness). Thus, observing the capital account is a way to identify cross-border insurance transactions arising from a disaster.<sup>30</sup>

Whether accounted current or capital transfers in the balance of payments, reinsurance payments boost the NIIP of the disaster-hit economy because the double-entry nature of the balance of payments lead reinsurance claims to appear once as a transfer receipt and again in the financial account as an outflow from a rise in trade credit (or receivable) in the “other investment” category of international asset (row (C) in Table 4 and arrow (C) in Fig. 2). This claim represents a gain in the disaster-hit economy’s external wealth. Of course, it no more than partially offsets the loss of the domestic capital stock owing to the disaster. In practice, the impact of disaster reinsurance payments on the NIIP is not as discernible as that on the capital account

<sup>29</sup> The balance of payments can be affected in several other channels in the aftermath of a disaster. For the summary of how a catastrophic disaster affects the balance of payments in Appendix 4 of the working paper version of this article (Ito and McCauley, 2019).

<sup>30</sup> However, not all the countries that experience disasters but do not receive debt forgiveness present capital account profiles like those in Fig. 3, in which the spikes correspond to disasters, for various reasons. Economies that experienced disasters, especially those of developing countries often receive grants in the immediate aftermath of the disasters, which are generally reported as capital account transfers.



(e.g., Fig. 7) because many other factors, disaster-related and otherwise, affect the financial account.<sup>31</sup>

For the dataset compilation, we use the *NatCatSERVICE* data from Munich Re to identify disasters, their dates, total losses and insured losses. In this study, we only focus on the “major” disasters of earthquake, floods or storms whose catastrophe class is four (i.e., the most catastrophic on the 1 through 4 scale). For the disasters for which the governments of concern specifically report whether they report reinsurance payments as capital or current transfers, we follow the governments’ announcements.<sup>32</sup> For the other major disasters, we manually examine whether capital or current transfers are used to report reinsurance payments in the quarters corresponding to the crisis dates.<sup>33</sup>

While the original *NatCatSERVICE* data is in daily frequency, the master dataset for the empirical analysis is in annual frequency. Hence, if there are more than one major crises, the estimated reinsured losses will be added up for each year.

## 11 Appendix 3: List of 93 Major Disasters

	Country name	Year	GDP shares (%)	1—GDP share = 1— (1)	Est. ratio of reinsurance to losses (3)	Est. insured losses covered by international reinsurance (4)	P.c. capita income (PPP), $t-1$ (5)	International risk-sharing gap = (7) + (8) + (9) (6)	Primary insurance gap (7)	International reinsurance gap (8)	“Interactive effect” (9)
1	Peru	1982	0.42	99.58	0.00	0.00	7436.91	99.58	0.00	4.27	95.31
2	Colombia	1983	0.60	99.40	0.00	0.00	6378.04	99.40	0.00	0.50	98.90
3	Spain	1983	2.20	97.80	0.68	2.07	18233.14	97.12	1.38	31.67	64.07
4	Chile	1985	0.25	99.75	6.68	89.11	7072.95	93.07	82.43	0.80	9.84
5	Mexico	1985	2.97	97.03	0.15	2.18	13,359.01	96.88	2.03	6.52	88.32
6	El Salvador	1986	0.06	99.94	0.52	10.80	4386.85	99.42	10.28	4.28	84.86

<sup>31</sup> Disasters affect the overall balance of payments in manifold ways. Refer to Appendix 3 on the impacts of disasters on the current account. Appendix 3 of Ito and McCauley (2019) shows how valuation changes arising from exchange rate and other asset price movements affect the financial account and the NIIP. Benetrix et al. (2015) and Tille (2003) are also useful.

<sup>32</sup> The Bank of Thailand (2012) treats the reinsurance payments from the 2011 flooding as current, not capital, transfers.

<sup>33</sup> When both capital and current transfers are greater than the insured losses in size, we decide not to include the disaster of concern in the sample because it is likely that the accounts for capital, current or both, transfers include other items, not just reinsurance payments.





	Country name	Year	GDP shares (%)	1— GDP share = 1— (1)	Est. ratio of reinsurance to losses (3)	Est. insured losses covered by international reinsurance (4)	P.c. capita income (PPP), $t-1$ (5)	International risk-sharing gap = (7) + (8) + (9) (6)	Primary insurance gap (7)	International reinsurance gap (8)	“Interactive effect” (9)
7	Iran, Islamic Rep.	1986	1.53	98.47	0.00	0.00	12761.09	98.47	0.00	0.06	98.40
8	South Africa	1987	0.92	99.08	2.44	7.97	9943.35	96.65	5.54	27.84	63.27
9	Vanuatu	1987	0.00	100.00	3.69	11.66	2222.17	96.31	7.97	27.97	60.36
10	Bangladesh	1988	0.33	99.67	0.00	0.00	1268.32	99.67	0.00	0.64	99.03
11	Jamaica	1988	0.05	99.96	15.02	41.74	7957.25	84.93	26.71	20.96	37.26
12	USA	1989	22.39	77.61	2.51	9.19	35,739.85	75.11	6.68	18.67	49.76
13	Iran, Islamic Rep.	1990	1.51	98.49	0.00	0.00	10,182.81	98.49	0.00	1.39	97.10
14	Philippines	1990	0.59	99.41	0.00	0.00	4048.50	99.41	0.00	10.94	88.48
15	Bangladesh	1991	0.34	99.66	0.00	0.00	1312.42	99.66	0.00	3.32	96.34
16	Costa Rica	1991	0.06	99.94	0.00	0.00	7919.49	99.94	0.00	10.80	89.14
17	Israel	1991	0.23	99.77	16.67	50.00	20,065.38	83.11	33.33	16.59	33.18
18	Philippines	1991	0.57	99.43	0.00	0.00	4,076.49	99.43	0.00	10.65	88.78
19	USA	1992	19.90	80.10	3.67	5.98	36,483.89	76.44	2.31	45.46	28.67
20	Ecuador	1993	0.17	99.83	1.67	55.67	7449.12	98.16	54.00	1.32	42.84
21	USA	1993	20.05	79.95	0.48	3.86	37,282.82	79.47	3.37	9.51	66.59
22	Papua New Guinea	1994	0.03	99.97	3.27	14.85	2921.23	96.71	11.59	18.73	66.39
23	USA	1994	20.25	79.75	2.61	7.59	37,810.45	77.14	4.98	24.84	47.32
24	Bangladesh	1995	0.34	99.66	0.00	0.00	1429.78	99.66	0.00	11.39	88.27
25	Mexico	1995	2.35	97.65	0.00	0.00	14,140.62	97.65	0.00	10.36	87.29
26	USA	1995	20.07	79.93	2.20	4.68	38,862.43	77.73	2.48	35.33	39.92
27	USA	1996	20.06	79.94	0.02	0.07	39,449.53	79.92	0.05	22.66	57.22
28	Czech Republic	1997	0.36	99.64	0.13	0.79	19,912.89	99.51	0.66	16.56	82.28
29	Peru	1997	0.28	99.72	2.49	14.73	6,364.75	97.22	12.24	14.37	70.61
30	Poland	1997	0.87	99.14	2.60	20.22	11,846.55	96.54	17.62	10.15	68.77
31	Vietnam	1997	0.30	99.70	0.00	0.00	2153.12	99.70	0.00	1.06	98.64



	Country name	Year	GDP shares (%)	1— GDP share = 1— (1)	Est. ratio of reinsurance to losses (3)	Est. insured losses covered by international reinsurance (4)	P.c. capita income (PPP), $t-1$ (5)	International risk-sharing gap = (7) + (8) + (9) (6)	Primary insurance gap (7)	International reinsurance gap (8)	“Interactive effect” (9)
32	Dominican Republic	1998	0.11	99.89	0.23	0.57	7392.22	99.66	0.34	39.73	59.59
33	Honduras	1998	0.04	99.96	0.77	19.60	3423.61	99.19	18.83	3.18	77.19
34	USA	1998	20.48	79.52	0.14	0.42	41,786.31	79.37	0.28	26.98	52.11
35	Colombia	1999	0.54	99.46	0.00	0.00	8685.17	99.46	0.00	7.85	91.61
36	Denmark	1999	0.35	99.65	14.32	17.72	38,816.41	85.33	3.41	66.17	15.75
37	France	1999	3.39	96.61	12.17	21.16	33,813.18	84.44	8.99	43.38	32.07
38	Switzerland	1999	0.56	99.43	3.50	6.56	47,123.61	95.93	3.06	49.53	43.34
39	Taiwan	1999	0.95	99.05	1.14	21.33	24,365.38	97.91	20.19	4.16	73.56
40	Turkey	1999	1.34	98.66	0.00	0.00	13,240.77	98.66	0.00	5.05	93.61
41	Venezuela, RB	1999	0.57	99.43	0.77	11.36	15,651.35	98.66	10.59	6.00	82.07
42	El Salvador	2001	0.06	99.94	13.29	68.72	6361.23	86.65	55.44	6.04	25.18
43	Peru	2001	0.26	99.74	0.51	3.04	6616.91	99.23	2.54	16.12	80.58
44	Czech Republic	2002	0.34	99.66	0.20	0.40	21,660.35	99.46	0.20	49.63	49.63
45	Korea, Rep.	2002	1.65	98.35	0.26	8.92	21,530.26	98.09	8.67	2.58	86.84
46	USA	2002	20.07	79.93	0.36	1.16	45,937.74	79.56	0.80	24.59	54.18
47	Korea, Rep.	2003	1.63	98.37	0.34	2.50	22,997.19	98.03	2.16	12.91	82.95
48	USA	2003	19.83	80.17	0.52	0.87	46,303.20	79.65	0.35	47.48	31.81
49	Dominican Republic	2004	0.10	99.89	0.86	4.32	8,475.77	99.03	3.46	19.11	76.46
50	Grenada	2004	0.00	100.00	1.98	17.79	10,627.93	98.02	15.81	9.13	73.08
51	Indonesia	2004	1.98	98.02	0.38	5.08	6376.41	97.64	4.70	6.97	85.97
52	Japan	2004	6.16	93.84	1.27	8.87	34,355.62	92.57	7.60	12.17	72.80
53	Sri Lanka	2004	0.16	99.84	0.35	70.00	5868.99	99.49	69.65	0.15	29.69
54	Thailand	2004	1.00	99.00	0.00	0.00	10,631.14	99.00	0.00	24.75	74.25
55	USA	2004	19.56	80.44	7.08	13.65	47,158.41	73.36	6.57	34.66	32.14
56	India	2005	4.77	95.23	8.05	52.85	3,027.85	87.17	44.79	6.46	35.92
57	Mexico	2005	2.25	97.75	0.00	0.00	15,802.54	97.75	0.00	25.44	72.31



Country name	Year	GDP shares (%)	1— GDP share = 1— (1)	Est. ratio of reinsurance to losses (3)	Est. insured losses covered by international reinsurance (4)	P.c. capita income (PPP), $t-1$ (5)	International risk-sharing gap = (7) + (8) + (9) (6)	Primary insurance gap (7)	International reinsurance gap (8)	“Interactive effect” (9)	
58	Sweden	2005	0.49	99.51	17.30	79.83	40,288.22	82.21	62.53	4.26	15.41
59	Switzerland	2005	0.50	99.50	19.58	29.38	50,072.10	79.92	9.79	46.75	23.37
60	USA	2005	19.30	80.71	9.85	19.14	48,500.63	70.86	9.29	31.69	29.88
61	Honduras	2007	0.04	99.96	7.12	19.00	4,146.00	92.84	11.87	30.36	50.60
62	Peru	2007	0.28	99.72	3.54	10.63	8000.46	96.17	7.09	29.70	59.39
63	USA	2008	17.61	82.39	13.13	27.72	50,897.90	69.27	14.59	25.90	28.78
64	Italy	2009	2.40	97.60	0.95	28.57	37,341.27	96.64	27.61	2.30	66.73
65	Philippines	2009	0.56	99.44	6.75	23.87	5,387.32	92.69	17.12	21.37	54.20
66	Taiwan	2009	0.95	99.05	0.06	2.30	36,367.41	98.99	2.24	2.48	94.27
67	Chile	2010	0.36	99.64	20.80	78.01	18,479.13	78.84	57.20	5.77	15.86
68	Colombia	2010	0.55	99.45	0.00	0.00	10,702.99	99.45	0.00	7.10	92.35
69	Guatemala	2010	0.11	99.89	0.39	6.33	6,670.01	99.50	5.94	5.76	87.80
70	Haiti	2010	0.02	99.98	2.00	80.00	1,613.07	97.98	78.00	0.50	19.48
71	Mexico	2010	2.02	97.98	0.75	9.58	15,542.48	97.22	8.83	6.95	81.45
72	New Zealand	2010	0.15	99.85	46.74	63.16	31,578.79	53.11	16.42	27.15	9.54
73	Poland	2010	0.90	99.10	1.23	28.15	20,708.38	97.87	26.91	3.11	67.84
74	Cambodia	2011	0.04	99.96	0.09	17.91	2510.41	99.87	17.82	0.41	81.64
75	Japan	2011	4.82	95.18	3.63	19.04	35,883.02	91.56	15.41	14.50	61.64
76	New Zealand	2011	0.15	99.85	42.13	60.48	31,903.68	57.72	18.35	27.43	11.94
77	Thailand	2011	0.96	99.04	10.42	28.00	13,460.19	88.62	17.58	26.43	44.60
78	USA	2011	16.35	83.65	0.00	0.00	49,308.67	83.65	0.00	44.88	38.77
79	USA	2012	16.20	83.80	7.45	15.50	49,736.43	76.35	8.04	32.85	35.46
80	Philippines	2013	0.61	99.39	1.46	18.92	6011.56	97.93	17.47	6.19	74.28
81	Serbia, Rep. of	2014	0.09	99.91	1.10	47.04	12,946.84	98.82	45.94	1.23	51.64
82	China	2015	17.09	82.91	5.10	54.50	12,651.05	77.81	49.40	2.66	25.76
83	Nepal	2015	0.06	99.94	3.24	99.36	2,266.18	96.70	96.13	0.02	0.56
84	Vanuatu	2015	0.00	100.00	12.35	37.06	2473.78	87.65	24.71	20.98	41.96
85	China	2016	17.69	82.31	0.97	17.76	13,457.07	81.35	16.80	3.51	61.04
86	Ecuador	2016	0.15	99.85	3.96	14.13	10,660.33	95.89	10.17	24.00	61.72
87	Japan	2016	4.36	95.64	1.55	7.62	37,931.76	94.10	6.07	17.88	70.14



	Country name	Year	GDP shares (%)	1— GDP share = 1— (1)	Est. ratio of reinsurance to losses (3)	Est. insured losses covered by international reinsurance (4)	P.c. capita income (PPP), $t-1$ (5)	International risk-sharing gap = (7) + (8) + (9) (6)	Primary insurance gap (7)	International reinsurance gap (8)	“Interactive effect” (9)
88	New Zealand	2016	0.15	99.85	21.00	39.00	34,446.80	78.85	18.00	32.77	28.08
89	Sri Lanka	2016	0.22	99.78	19.20	80.00	11,079.71	80.58	60.80	4.75	15.04
90	USA	2016	15.47	84.53	0.00	0.00	52,975.20	84.53	0.00	38.68	45.85
91	Mexico	2017	1.93	98.07	5.42	18.74	17,947.81	92.65	13.32	22.94	56.39
92	Peru	2017	0.33	99.67	0.58	4.74	11,978.68	99.09	4.15	11.64	83.29
93	USA	2017	15.26	84.74	17.40	41.73	53,371.91	67.34	24.34	17.93	25.08

## 12 Appendix 4: Other Impacts of Disasters on the Current Account

In addition to the reinsurance claims described in [Appendix 2](#), other factors related to disasters may appear in the balance of payments. The discussion can be divided into current account and capital account.

In the current account, one might expect the trade account to deteriorate because reconstruction efforts would usually lead to a rise in absorption (i.e., the sum of private consumption, private investment and government expenditure) for a given level of income. However, the findings of Noy (2009) and von Peter et al. (2012) that GDP can fall as a result of a disaster leaves this effect ambiguous.

Also in the current account are services and these can deteriorate in the wake of a disaster. In particular, reinsurers can raise insurance premiums in the aftermath of a catastrophic disaster that inflicts great losses on insurance companies. Payments for insurance premiums to overseas reinsurers are recorded in the services trade of the current account (i.e., debit in insurance and pension services). [Figure 8](#) shows a rising trend in the service trade debit for insurance (and pension) services of New Zealand in the aftermath of the Canterbury earthquake. The service trade of the current account could also deteriorate due to a decline in tourism.

Also in the current account are unrequited transfers. If the disaster-afflicted economy receives international aid (in the form of both cash and in kind), it will appear as credit in unilateral transfers. If a disaster-afflicted economy receives debt forgiveness as a means of international support, however, this will appear as credit in capital transfer in the capital account alongside any reinsurance receipts (for a big disaster).

If many overseas migrants leave the disaster-stricken economy, the transfer of leaving migrants (capital transfer outflows) can increase, or the transfer of goods and financial assets of entering migrants (capital transfer inflows) can decline, both negatively affecting the capital account.



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