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Natural catastrophes and global reinsurance – exploring the linkages[1]

Natural disasters resulting in significant losses have become more frequent in recent decades, with 2011 being the costliest year in history. This feature explores how risk is transferred within and beyond the global insurance sector and assesses the financial linkages that arise in the process. In particular, retrocession and securitisation allow for risk-sharing with other financial institutions and the broader financial market. While the fact that most risk is retained within the global insurance market makes these linkages appear small, they warrant attention due to their potential ramifications and the dependencies they introduce.

JEL classification: G22, L22, Q54.

The physical destruction caused by severe natural catastrophes triggers a series of adverse effects. Damaged production facilities, shattered transportation infrastructure and business interruption produce both direct losses and indirect macroeconomic costs in the form of foregone output (von Peter et al (2012)). Beyond these economic costs are enormous human suffering and a host of longer-term socioeconomic consequences, documented by the World Bank and United Nations (2010).

By examining catastrophe-related losses over the past three decades, this special feature explores the linkages that arise in the transfer of risk from policyholders all the way to the ultimate bearer of risk. It describes the contracts and premiums exchanged for protection, and the way reinsurers diversify and retain risks on their balance sheets. In so doing, the feature traces how losses cascade through the system when large natural disasters occur. Losses from insured property and infrastructure first affect primary insurers, who in turn rely on reinsurers to absorb peak risks – low-probability, high-impact events. Reinsurers, in turn, use their balance sheets and, to a lesser extent, retrocession and securitisation arrangements, to manage peak risks across time and space.[2]

[1] The views expressed in this article are those of the authors and do not necessarily reflect those of the BIS, the IAIS or any affiliated institution. We would like to thank Anamaria Illes for excellent research assistance, and Claudio Borio, Stephen Cecchetti, Emma Claggett, Daniel Hofmann, Anastasia Kartasheva, Andrew Stolfi and Christian Upper for helpful comments.

[2] Retrocession takes place when a reinsurer buys insurance protection from another entity. Securitisation refers to the transfer of insurance-related risks (liabilities) to financial markets.

This global risk transfer creates linkages within the insurance industry and between insurers and financial markets. While securitisation to financial markets remains relatively small, linkages between financial institutions produced through retrocession have not been fully assessed as detailed data are lacking. Further linkages can arise when reinsurers go beyond their traditional insurance business to engage in financial market activities such as investment banking or CDS writing; the implications of those activities are beyond the scope of this feature.[3] Comprehensive information is needed to monitor the entire risk transfer cascade and assess its wider repercussions in financial markets.

Physical damage and financial losses

Natural catastrophes resulting in significant financial losses have become more frequent over the past three decades (Kunreuther and Michel-Kerjan (2009), Cummins and Mahul (2009)). The year 2011 witnessed the greatest natural catastrophe-related losses in history, reaching $386 billion (Graph 1, top panel). The trend in loss developments can be attributed in large measure to weather-related events (Graph 1, bottom right-hand panel). And losses have been compounded by rising wealth and increased population concentration in exposed areas such as coastal regions and earthquake-prone cities.

These factors translate into greater *insured* losses where insurance penetration is high. At $110 billion, insured losses in 2011 came close to the 2005 record of $116 billion (in constant 2011 dollars). The reinsurance sector absorbed more than half of insured catastrophe losses in 2011. This considerable burden on reinsurers reflected the materialisation of various peak risks, notably in Japan, New Zealand, Thailand and the United States.

The level of insured losses also depends on catastrophes' geography and physical type. The bottom panels of Graph 1 show that losses due to earthquakes (geophysical events) have been less insured on average than those from storms (meteorological events). The highest economic losses caused by geophysical events occurred in 2011 in the wake of the Great East Japan earthquake and tsunami ($210 billion), for which private insurance coverage was relatively low at 17% (left-hand panel).[4] Droughts can be even more difficult to quantify and insure. By contrast, the right-hand panel of Graph 1 shows that meteorological events produced record losses in 2005, when Hurricanes Katrina, Rita and Wilma devastated a region of the US Gulf Coast having 50% or more in insurance coverage.

The volume of insured losses differs substantially across continents, depending on the availability of and demand for insurance. While overall a slight upward trend can be discerned over the past 10 years, the wide dispersion in insurance density indicates that the stage of a region's economic development plays an important role (Graph 2, left-hand panel). Residents of North America, Oceania and Europe spend significant amounts on non-life (property and casualty) insurance, whereas

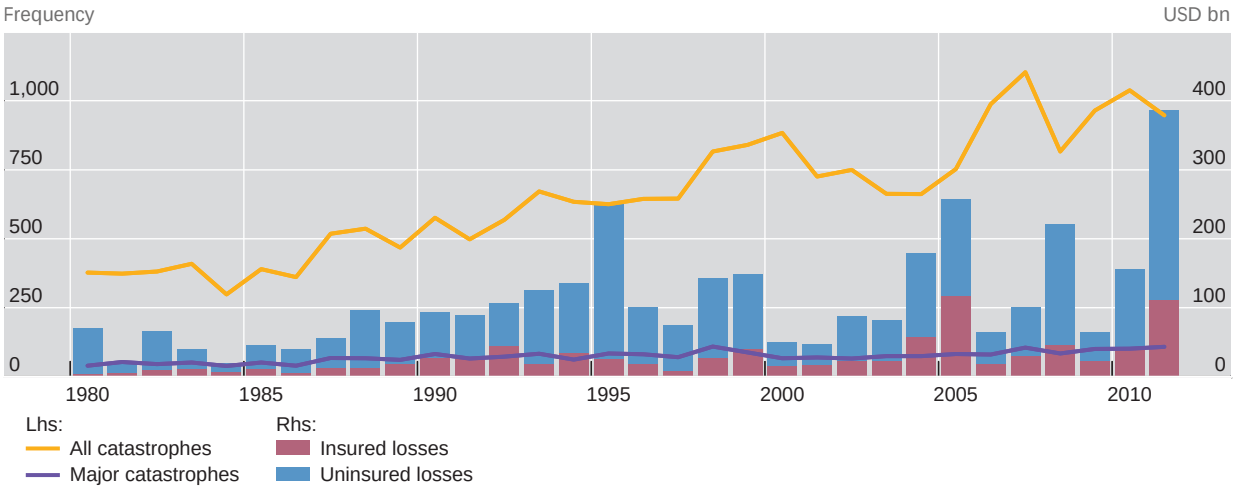
[3] The interested reader is referred to IAIS (2012).

[4] Mandatory insurance, however, can push the effective insurance coverage to near 80%, as in Chile's and New Zealand's earthquakes of 2010 and 2011.

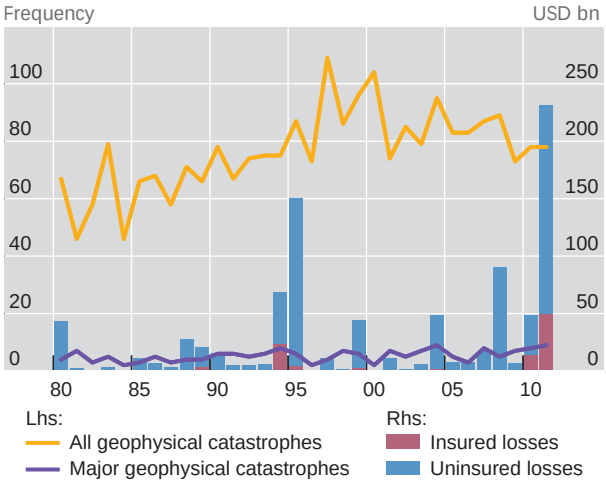
Natural catastrophes: frequencies and losses[1]

Graph 1

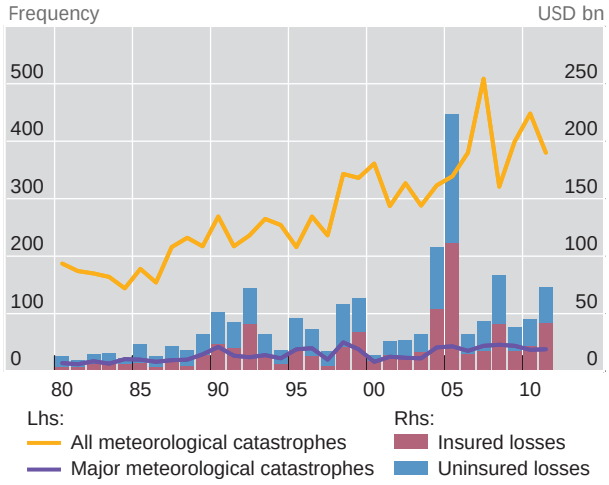
All natural catastrophes



Earthquakes and other geophysical events[2]



Storms and other meteorological events[3]



[1] Includes all natural catastrophes reported to have caused property damage since 1980. "Major catastrophes" are events causing more than 100 fatalities or more than $250 million in losses. Losses are expressed in terms of constant 2011 US dollars using the US CPI, and derive primarily from damage to property and infrastructure. [2] Earthquakes, volcanic eruptions and dry mass movement (landslides) and their direct consequences (eg the tsunami following Japan's earthquake in 2011). [3] Storms and their direct consequences (eg the flooding following Hurricanes Katrina, Rita and Wilma in 2005).

Sources: Centre for Research on the Epidemiology of Disasters EM-DAT database; MunichRe NatCatSERVICE; authors' calculations.

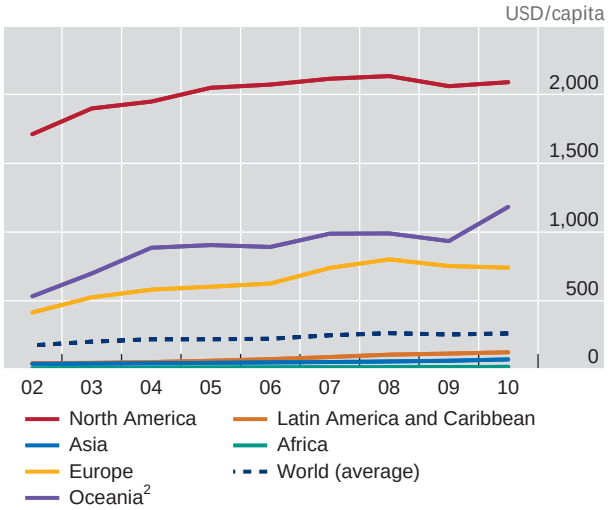
many populous countries in Latin America, Asia and Africa host underdeveloped insurance markets. Poor countries typically lack the financial and technical capacity to provide affordable insurance coverage. For example, less than 1% of the staggering economic losses due to Haiti's 2010 earthquake were insured. The pattern of insured losses thus only partly reflects the geography of natural catastrophes.

North America accounts for the largest insured losses associated with natural disasters (Graph 2, right-hand panel). In 23 of the 32 years since 1980, more than half of global insured losses originated in the region, though part of this volume was redistributed through global reinsurance companies. Asia, Oceania and, to a lesser extent, Latin America saw increases in catastrophe-related losses on the back

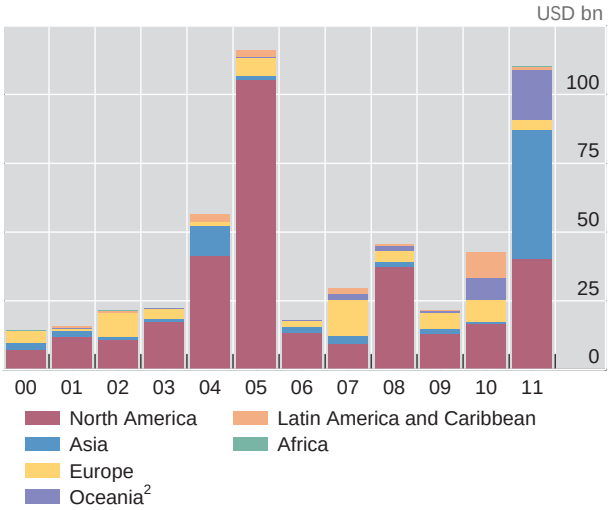
of rising insurance density over the past 10 years. Correspondingly, these three regions account for a rising share of insured losses.

Insurance density and catastrophe losses — Graph 2

Insurance density by continent[1]



Insured losses associated with natural catastrophes



[1] Insurance density is measured as the premium per capita that insurance companies receive for domestically insuring non-life (property and casualty) risks. [2] Australia, New Zealand and Pacific islands.

Sources: MunichRe NatCatSERVICE; SwissRe Sigma database; authors' calculations.

Risk transfer

Natural catastrophe-related losses are large and unpredictable. The insured losses shown in Graphs 1 and 2 reflect recent experience. This section describes the sequence of payments based on contractual obligations that is triggered when an insured event materialises.

One can think of the insurance market as organising risk transfer in a hierarchical way. Losses cascade down from insured policyholders to the ultimate bearers of risk (Graph 3). When catastrophe strikes, the extent of physical damage determines total economic losses, a large share of which is typically uninsured. The insured losses, however, must be shouldered by the global insurance market (Graph 3, light grey area). The public sector, when it insures infrastructure, often does so directly with reinsurers through public-private partnerships, although more data would be necessary to pin down the exact scope worldwide.[5] The majority of the losses relate to private entities contracting with primary insurers, the firms that locally insure policyholders against risks.

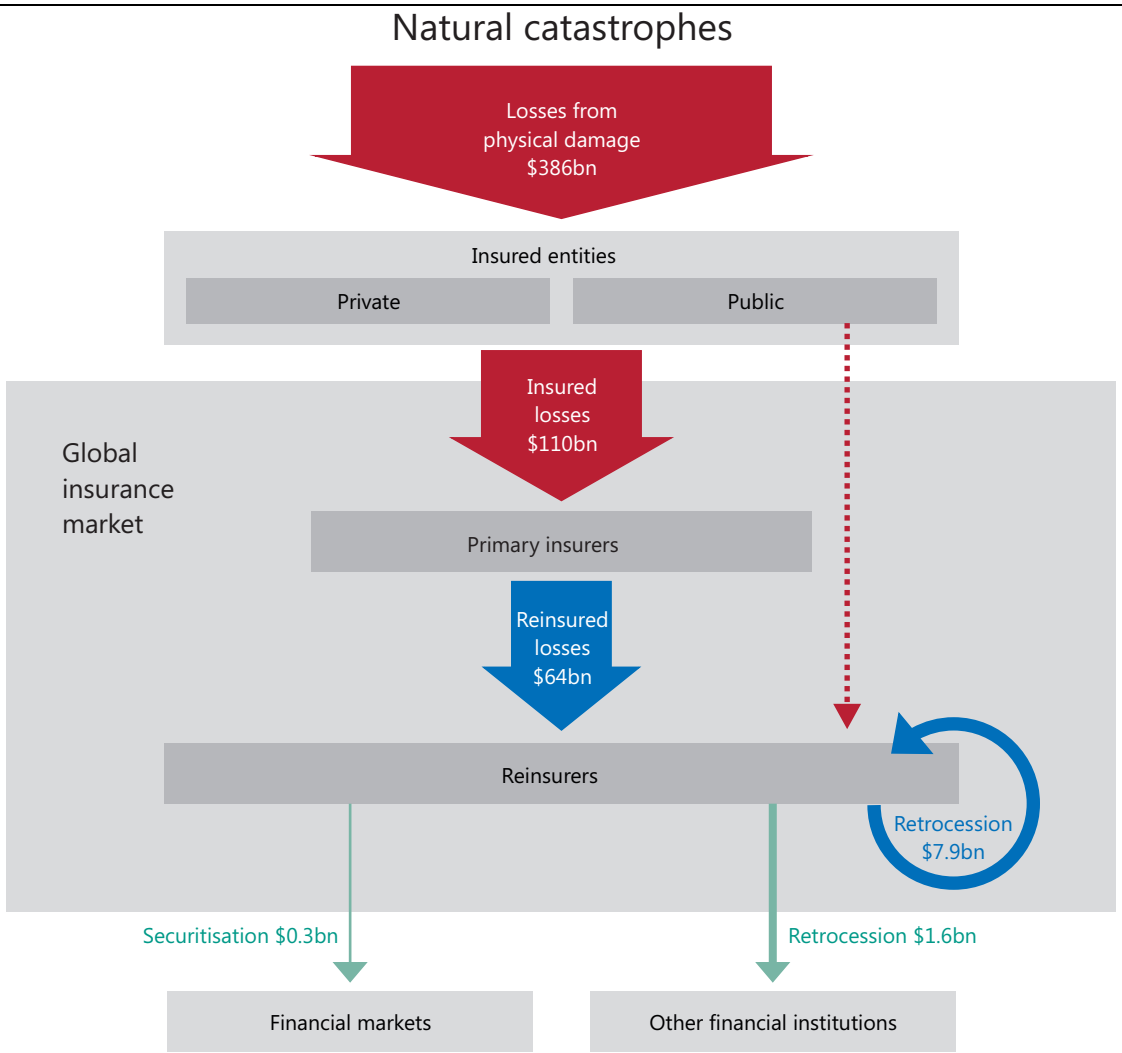
Claims for reimbursement thus first affect primary insurers. But they absorb only some of the losses, having ceded (transferred) a share of their exposure to reinsurance companies. Reinsurers usually bear 55–65% of insured losses when a

[5] For example, in the late 1990s the Mexican government established a mechanism to support the rapid rehabilitation of federal and state infrastructure affected by natural disasters (Fonden), in which reinsurers play a key role in transferring risks outside Mexico.

large natural disaster occurs. They diversify concentrated risks among themselves and pass a fraction of losses on to the broader financial market, while ultimately retaining most catastrophe-related risk (see section below).

Before disaster strikes, however, there is a corresponding premium flow in exchange for protection. Based on worldwide aggregate premium payments in 2011, policyholders and insured entities, both private and public sector, spent $4,596 billion to receive insurance protection. Some 43% of this global premium volume ($1,969 billion) relates to non-life insurance and the remainder to life insurance products (IAIS (2012)). Primary insurers, in turn, paid close to $215 billion to buy coverage from reinsurers. The lion's share, nearly $165 billion, came from primary insurers active in the non-life business. About one third of this amount, $65 billion, was geared towards protection against peak risks, with $18 billion for specific natural catastrophe contracts. By way of comparison, life insurance

Catastrophe risk transfer in 2011 Graph 3



The size of the arrows is proportional to the volume of losses caused by natural catastrophes in 2011. Reinsured losses are estimated from the average reinsurance share of insured peak losses for major natural catastrophes (0.6 * $106 billion = $64 billion). In line with this estimate, seven of the 10 largest reinsurance companies, accounting for about 40% of the market, declared a combined $26.4 billion in catastrophe-related losses in their 2011 annual reports. Losses transferred via retrocession are estimated by apportioning insured losses in proportion to the premium payments the ultimate bearers received in 2011. The loss-sharing with financial markets comes from a triggered catastrophe bond.

Sources: Company reports; authors' calculations and estimates.

companies spent 2% of their premium income, $40 billion, on reinsurance protection. This comparatively low degree of reinsurance protection is due to the fact that results are typically less volatile in life insurance than in non-life insurance. Following any risk transfer, insurers remain fully liable vis-à-vis the policyholder based on the initial contractual obligations, regardless of whether or not the next instance pays up on the ceded risk.

Reinsurance companies, in turn, buy protection against peak risks from other reinsurers and financial institutions. In this process of retrocession, reinsurers spent $25 billion in 2011 to mitigate their own downside risk. The bulk of this amount represents retroceded risks transferred to other reinsurance companies ($20 billion in premiums), while a relatively small share is ceded to other market participants such as hedge funds and banks ($4 billion) and financial markets ($1 billion).

An important aspect of this structure is the prefunding of insured risks. Premiums are paid ex ante for protection against an event that may or may not materialise over the course of the contract. These payments by policyholders and insurers generate a steady premium flow to insurers and reinsurers, respectively. Only if and when an event with the specified characteristics occurs are the claims payments shown in Graph 3 triggered. At all other times, premium flows are accumulated in the form of assets held against technical reserves (see next section).

Reinsurance contracts come in two basic forms which differ in the way primary insurers and reinsurers determine premiums and losses. Proportional reinsurance contracts share premiums and losses in a predefined ratio. Since the 1970s, non-proportional contracts have increasingly been used as a substitute. Instead of sharing losses and premiums in fixed proportions, both parties agree on the insured risks and calculate a specific premium on that basis. The typical non-proportional contract specifies the amount beyond which the reinsurer assumes losses, up to an agreed upon ceiling (first limit). Depending on the underlying exposure, a primary insurer may decide to buy additional layers of reinsurance cover, for example with other reinsurers, on top of the first limit.

"Excess of loss" agreements are the most common form of non-proportional reinsurance cover. For natural catastrophes, these contracts are known as CatXL (catastrophe excess of loss) and cover the loss exceeding the primary insurer's retention for a single event. A major earthquake, for example, is likely to affect the entire portfolio of a primary insurer, leading to thousands of claims in different lines of business, such as motor, business interruption and private property insurance. As a result, primary insurers often purchase CatXL coverage to protect themselves against peak risks.

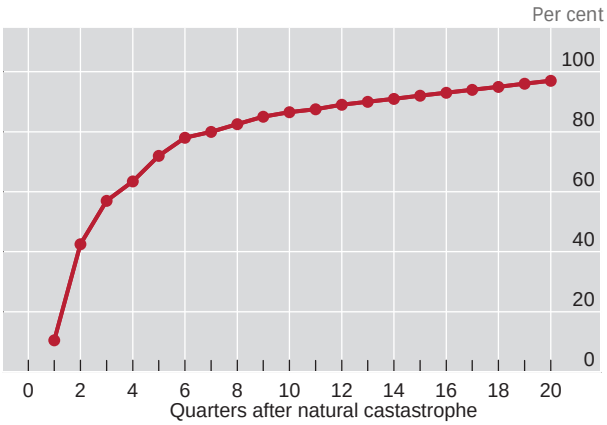
Peak risks and the reinsurance market

A reinsurer's balance sheet reflects its current and past acceptance of risks through its underwriting activity. Dealing with exposure to peak risks, which relate to natural catastrophes, is the core business of the reinsurance industry. Natural catastrophes are rooted in idiosyncratic physical events such as earthquakes. When underwriting natural catastrophe risks, reinsurers can rely to a large extent on the fact that physical events do not correlate endogenously in the way financial risk does. To

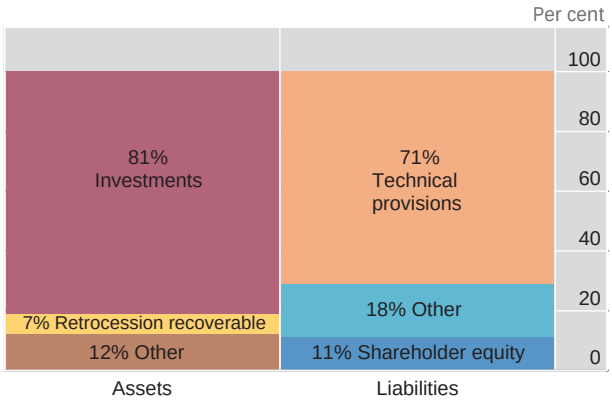
Catastrophe payouts and reinsurers' balance sheets

Graph 4

Reinsurance payout profile[1]



Generic balance sheet of reinsurance companies[2]



[1] Cumulative percentage of ultimate payout on catastrophe excess of loss contracts, based on worldwide observations with respect to the historical paid loss development until 2011. [2] Combined balance sheet of the five largest reinsurance companies outside Gen Re and Lloyd's, normalised to express percentage breakdown.

Sources: Reinsurance Association of America; ISIS database on insurance companies worldwide; company information; authors' calculations.

achieve geographical diversification, reinsurers offer peak risk protection not just for one country but ideally on a worldwide basis.[6]

Another form of diversification takes place over time. Premiums are accumulated over years, and claims payments are usually paid out over the course of months or sometimes years. Graph 4 (left-hand panel) shows the average payout profile for CatXL contracts. Statistics on reinsurance payments show that claims are typically settled over an extended period. On average, 63% of the ultimate obligations are paid within a year and 82% within two years, and it takes more than five years after a natural disaster strikes for the cumulative payout to reach 100%.

The premium inflows not immediately used for paying out claims are invested in various assets held for meeting expected future claims. In this way, reinsurers build specific reserves called technical provisions.[7] These constitute the largest block of reinsurers' on-balance sheet liabilities (Graph 4, right-hand panel). Insured losses are met by running down assets in line with these technical reserves. Losses in any one year typically lead to loss ratios (incurred losses as a share of earned premium) of between 70 and 90%. To determine whether a reinsurer can withstand severe and unprecedented (yet plausible) reinsured events, regulators look for sufficient technical provisions and capital on the reinsurer's balance sheet.

The occurrence of a major natural catastrophe dents reinsurers' underwriting profitability, as reflected in the combined ratio. This indicator sets costs against premium income.[8] A combined ratio above 100% is not sustainable for an extended

[6] For instance, the exposure to certain types of natural catastrophes is higher in the United States than in Europe. To diversify, US insurers cede (transfer) nearly twice as much in premium volume to European reinsurers than European insurers cede to US reinsurers.

[7] In addition, the catastrophe reserve is accumulated as a buffer for large unexpected losses.

[8] The combined ratio is computed as 100 * (losses + expenses) / (premium income).

period.[9] By contrast, *temporary* spikes in the combined ratio are indicative of one-off extreme events which can be absorbed by an intertemporal transfer of risk. The combined ratio spiked in the years featuring the most costly natural catastrophes to date (Graph 5, blue line): 2005, the year of major hurricanes in the US, and 2011, following earthquakes and flooding in Asia and Oceania. Both occasions also reduced the stock of assets reserved for meeting claims. Yet these temporary spikes in the combined ratio did not cut through to shareholder equity to any significant extent. Catastrophes affect equity only if losses exceed the catastrophe reserve.

Recent market developments caused shareholder equity to decrease more than insurers' core underwriting business ever has. During the global financial crisis of 2008–09, shareholder equity (book value) declined by 15% (Graph 5, red line), and insurance companies' share prices dropped by 59% (yellow line), more than after any natural catastrophe to date. In contrast, shareholder equity remained resilient in 2005 and 2011, when reinsurers weathered record high catastrophe losses.

In dealing with the consequences of peak catastrophe risks, the industry has gravitated towards a distinctive market structure. One important element is the size of reinsurance companies. Assessing and pricing a large number of different potential physical events involves risk management capabilities and transaction costs on a large scale. Balance sheet size is therefore an important tool for a reinsurer to attain meaningful physical diversification on a global scale. Partly as a result, the 10 largest reinsurance companies account for more than 40% of the global non-life reinsurance market (Graph 6, right-hand panel).

Reinsurance financial indicators[1]

Graph 5

[1] The vertical lines indicate the dates of Hurricanes Katrina (29 August 2005), Rita (24 September 2005) and Wilma (22 October 2005) and the Great East Japan earthquake and tsunami (11 March 2011). The shaded area represents the period between the Lehman Brothers bankruptcy (15 September 2008) and the equity market trough (9 March 2009). [2] The MSCI insurance sub-index and shareholder equity are rebased: 31 December 2007 = 100. The combined ratio weighted is in per cent. [3] Ten largest companies, excluding Berkshire Hathaway and Reinsurance Group of America, weighted by their yearly respective market share in gross premium income. The combined ratio expresses losses plus expenses as a share of premium income.

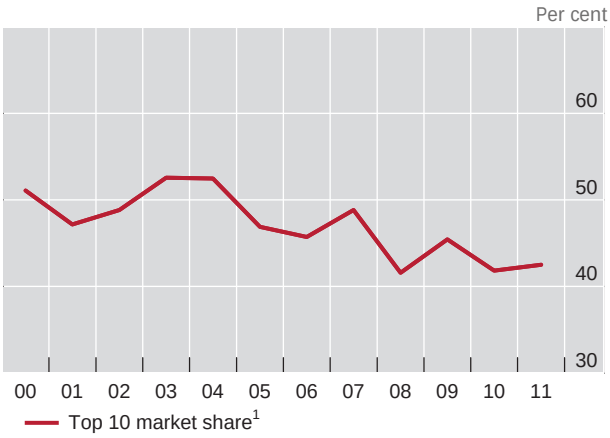
Sources: Bloomberg; Standard & Poor's, *Global Reinsurance Highlights*; authors' calculations.

[9] That said, when financial market conditions were favourable, some insurance companies pursued a business model of loose underwriting standards and low risk premiums, believing that their investment returns would compensate for their elevated combined ratio. These companies were particularly exposed when markets deteriorated.

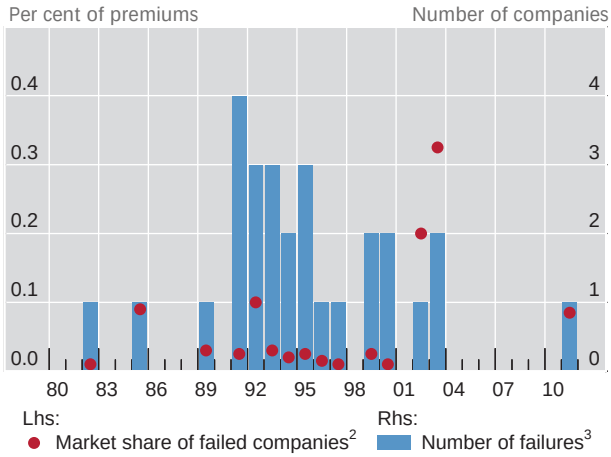
Reinsurance market developments

Graph 6

Reinsurance market concentration



Failures of reinsurance companies



[1] Market share of the 10 largest reinsurance companies, measured as a share of gross premiums written by reinsurance companies worldwide in the non-life (property and casualty) business. [2] In relation to total market size as measured by gross premiums written (premiums ceded by insurers to reinsurance companies). [3] Number of failures of reinsurance companies worldwide, per calendar year.

Sources: IAIS, based on industry data; authors' calculations.

In spite of the reinsurance market's size and concentration, failures of reinsurance companies have remained limited in scope. The largest failures to date, comprising two bankruptcies in 2003, led to an essentially inconsequential reduction in available reinsurance capacity of 0.4% (Graph 6, left-hand panel). That said, any failure of a reinsurer leads to a loss of reinsurance recoverables by primary insurers, and could cause broader market tensions in the event of a disorderly liquidation of large portfolios.

In this respect, the degree of connectedness within the global insurance market plays an important role. Based on their business model, reinsurers enter into contracts with a large number of primary insurance companies, giving rise to numerous vertical links (Graph 3). In addition, risk transfer between reinsurers leads to horizontal linkages.[10] We estimate that 12% of natural catastrophe-related risk accepted by reinsurers is transferred within the reinsurance industry, which implies that the industry as a whole retains most of the risks it contracts. In 2011, reinsurers paid 3% of earned premiums to cede catastrophe risk to entities *outside* the insurance sector. Judging by premium volume, the global insurance market transfers a similarly small share of accepted risk to other financial institutions and the wider financial markets.

Linkages with financial markets

Arrangements designed to transfer risk out of the insurance sector create linkages with other financial market participants. Retrocession to other financial institutions uses contractual arrangements similar to those between reinsurers, and commits

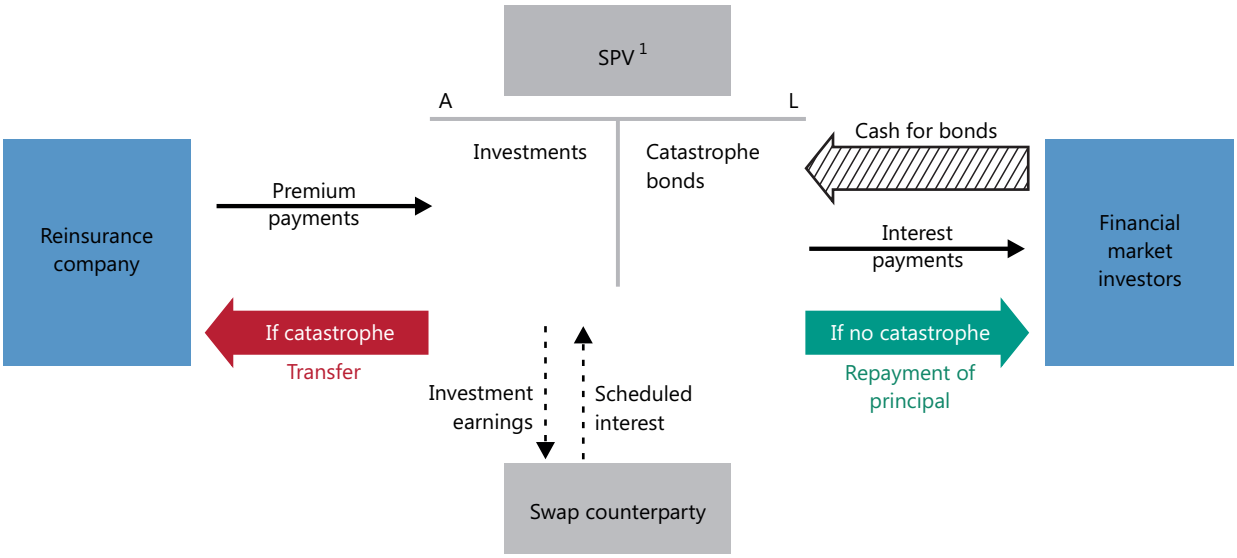
[10] For example, a reinsurer might exchange some of its exposure to earthquake risk in Japan for US flood risk with another reinsurer.

banks and other financial institutions to pay out if the retroceded risk materialises. Securitisation, on the other hand, involves the issuance of insurance liabilities to the wider financial market.[11] The counterparties are typically other financial institutions, such as hedge funds, banks, pension funds and mutual funds.

Among insurance-linked securities, catastrophe bonds are the main instrument for transferring reinsured disaster risks to financial markets. The exogenous nature of the underlying risks supports the view that catastrophe bonds provide effective diversification unrelated to financial market risk. For these reasons, industry experts had high expectations for the expansion of the catastrophe bond market (eg Jaffee and Russell (1997), Froot (2001)).

The issuance of catastrophe bonds involves financial transactions with a number of parties (Graph 7). At the centre is a special purpose vehicle (SPV) which funds itself by issuing notes to financial market participants. The SPV invests the proceeds in securities, mostly government bonds which are held in a collateral trust. The sponsoring reinsurer receives these assets in case a natural disaster materialises as specified in the contract. Verifiable physical events, such as storm intensity measured on the Beaufort scale, serve as parametric triggers for catastrophe bonds.[12] Investors recoup the full principal only if no catastrophe occurs. In contrast

Securitisation of natural catastrophe risk — Graph 7



The solid black lines show payments made ex ante with certainty. The green arrow depicts repayment that takes place if the specified catastrophe does not materialise. If the catastrophe occurs, the investments are liquidated and proceeds are transferred to the sponsoring reinsurance company for meeting claims.

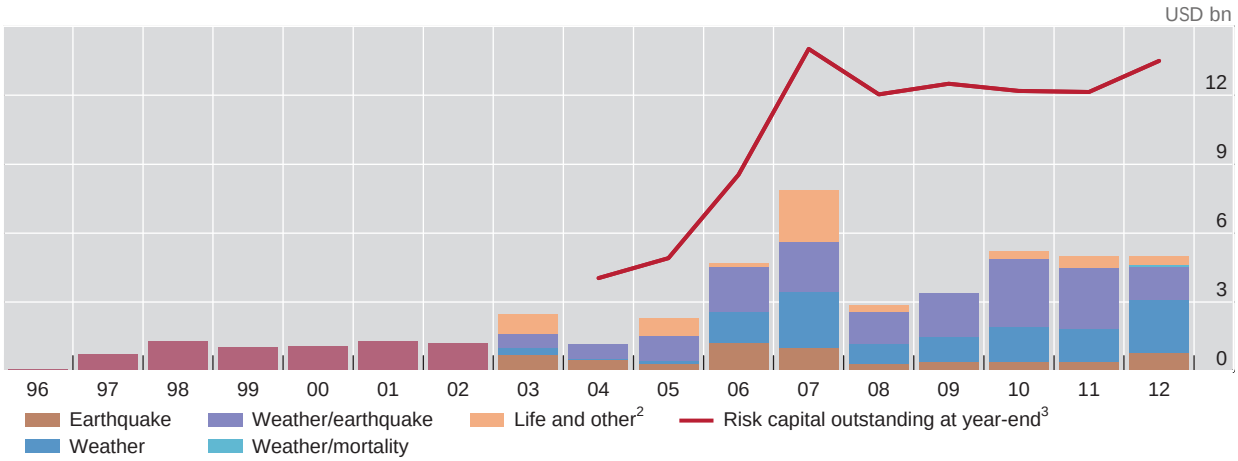
[1] Special purpose vehicle that issues natural catastrophe bonds and places assets in a trust fund.

Sources: National Association of Insurance Commissions and Center for Insurance Policy and Research; authors' adaptation.

[11] This form of securitisation differs from the practice in credit markets in two ways: the securitised item is an insurance liability, and the sponsoring insurer retains ultimate liability should the counterparty fail to pay.

[12] Such parametric solutions prevail because they are triggered by a predefined physical event and hence provide immediate clarity for all parties involved. Less common are, for example, indemnity solutions, where the trigger is based on actual losses, because it often takes a significant amount of time to determine the full loss amount.

Catastrophe bond issuance by type of risk[1] Graph 8



[1] Data before 2003 are not broken down by type. [2] Includes mortality, peril, life and worldwide risks. [3] Values are year-to-date, thus the value for 2012 is not final.

Sources: Artemis; Guy Carpenter.

to other bonds, the possibility of total loss is part of the arrangement from inception, and is compensated ex ante by a higher coupon.

Despite experts' high expectations, the catastrophe bond market has remained relatively small. Bond issuance has never exceeded $7 billion per year, limiting the outstanding capital at risk to $14 billion (Graph 8). Very few catastrophe bonds have been triggered to date. The 2005 Gulf Coast hurricanes activated payouts from only one of nine catastrophe bonds outstanding at the time (IAIS (2009)). Likewise, the 2011 Japan earthquake and tsunami triggered one known catastrophe bond, resulting in a payout of less than $300 million. Payouts to reinsurers from these bonds are small when compared to the sum of insured losses ($116 billion in 2005 and $110 billion in 2011).

The global financial crisis has also dealt a blow to this market. The year 2008 saw a rapid decline in catastrophe bond issuance, reflecting generalised funding pressure and investor concern over the vulnerability of insurance entities. The crisis also demonstrated that securitisation structures introduce additional risk through linkages between financial entities. A case in point was the Lehman Brothers bankruptcy in September 2008. Four catastrophe bonds were impaired – not due to natural catastrophes, but because they included a total return swap with Lehman Brothers acting as a counterparty. Following Lehman's failure, these securitisation arrangements were no longer fully funded, and their market value plunged. Investors thus learned that catastrophe bonds are not immune to "unnatural" disasters such as major institutional failures.[13]

A further set of financial linkages arises with other financial institutions through cross-holdings of debt and equity. Insurance companies hold large positions in fixed income instruments, including bank bonds. At the same time, other financial entities own bonds and stocks in insurance companies. For instance, the two largest reinsurance companies stated in their latest (2011) annual reports that Warren

[13] Following this episode, sponsors of catastrophe bonds employed other types of collateral arrangements in lieu of total return swaps. There has recently been a shift towards the use of government bonds as collateral.

Buffett and his companies (Berkshire Hathaway Inc, OBH LLC, National Indemnity Company) own voting rights in excess of the disclosure threshold (10% in one case and 3.10% in another). Additional shareholders with direct linkages to the financial sector have been disclosed by a number of reinsurance companies. The ramifications of such linkages in this part of the market are difficult to assess.

Conclusion

The upward trend in overall economic losses in recent decades highlights the global economy's increasing exposure to natural catastrophes. This development has led to unprecedented losses for the global insurance market, where they cascade from the policyholders via primary insurers to reinsurance companies. Reinsurers cope with these peak risks through diversification, prefunding and risk-sharing with other financial institutions.

This global risk transfer creates linkages within the insurance industry and between insurers and financial markets. While securitisation to financial markets remains relatively small, linkages between financial institutions arising from retrocession have not been fully assessed. It is important for regulators to have access to the data needed for monitoring the relevant linkages in the entire risk transfer cascade, as no comprehensive international statistics exist in this area.

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