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Keywords

Risk transfer, financial markets, insurance markets

Disciplines

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Reduced returns and longevity risk are making it challenging for employers to offer defined benefit pensions. In countries with large defined benefit pension plan sectors, sponsors are transferring these obligations, and the associated investment and longevity risk, to life (re)insurers via buy-outs, buy-ins, and longevity swaps. Nevertheless, to date, there has been no successful longevity bond issuance, although there have been several false starts. This contrasts with the active market for catastrophe bonds that transfer risk associated with catastrophic events from (re)insurers to capital markets. This paper reviews catastrophe bond and other insurance risk transfer market developments, to identify the factors and design features that have resulted in success and failure. Conclusions are informed by an extensive literature review and quantitative survey, plus discussions with market participants including public policy makers. We conclude with suggestions for product design features and public policies that might kick start vibrant longevity bond markets.

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New Financial Instruments for Managing Longevity Risk

Lower expected rates of market returns and rising longevity risk make it challenging for employers to offer defined benefit (DB) pensions. In countries with large DB pension sectors (e.g., the United Kingdom and the United States), pension plan sponsors are increasingly transferring these obligations and the associated investment and longevity risk to life insurers (Figure 1). For life insurers, the longevity risk may provide a partial hedge for the mortality risk in their life insurance books. The geography of pension risk markets reflects the preponderance of private-sector defined benefit plans in those countries (Figure 2).

Figures 1 and 2 here

Ultimately these markets are driven by the private sector ‘supply’ of longevity risk. So, for example, we are not likely to see many of these transactions coming out of countries such as France, where the private sector role in pension provision is minimal. The UK, on the other hand, has all the ingredients for a healthy demand for pension scheme longevity de-risking, as does the Netherlands. In both countries, there are still a great many DB pension schemes, and accounting rules and prudential regulations compel scheme sponsors to accurately measure and report their pension obligations. Also, the actuarial communities are actively seeking to disseminate more frequent and up-to-date longevity data and forward-looking models.

In what follows, we first explain the market for longevity risk by explaining the key transaction types: buy-outs, buy-ins, longevity swaps, and longevity bonds. We also explore some of the potential reasons why so little of this risk has made its way to capital markets for transferral. Second, we examine catastrophe (CAT) risk markets, which have been quite successful at transferring insurance risks to capital markets. The third section explores the potential lessons from CAT markets that can be applied to activating capital market interest in longevity risk.

Pension and Longevity Risk Transfer Markets

DB pension risks are transferred to insurers via *buy-outs*, *buy-ins*, and *longevity swaps* (IMF 2012; Joint Forum 2013). *Buy-outs* transfer all of a pension fund's liabilities in return for an up-front premium, which in some cases is paid using an 'in-kind' transfer of the pension fund's assets (Daniel 2016). In a *buy-in*, the sponsor retains the pension plan's assets and liabilities, and it receives periodic payments equal to those made to its members from an insurer in return for an up-front premium (Figure 3). Underfunded DB plans may prefer buy-ins to buy-outs, because buy-ins do not require that the funding gap be recognized as an accounting loss.

Figure 3 here

Longevity swaps transfer only longevity risk, and the premium is spread over the life of the contract based on the difference between the actual and expected benefit payments (Figure 4). This approach is typically combined with a liability-driven investing (LDI) asset allocation approach that matches the expected cash flow profile to that of the pension benefit payments, plus an inflation swap if the plan offers indexed benefits. Underfunded plans often implement LDI gradually to defer the cost of closing the funding gap (Citi 2016). Longevity swap counterparties are typically required to post collateral depending on whether the market value of the swap is positive or negative. Collateral plays a similar role in mitigating counterparty risk as the regulatory or solvency capital that (re)insurers are required to hold. Analysis of Biffis et al. (2016) found that the overall cost of such collateralization is comparable with that of interest rate swaps, but it does require that counterparties have on hand sufficient quantities of the required assets, usually liquid high-quality fixed-income securities, to meet collateral calls. The COVID-19 pandemic raised the

possibility that, although a pandemic might push down the value of liabilities to DB plan members, the short-term rise in mortality could trigger collateral calls (O'Farrell 2020).

Figure 4 here

Who uses which technique depends greatly on the type of counterparty. Insurers and reinsurers are associated with pension buy-ins and buy-outs, whereas longevity swap transactions are associated with investment banks and reinsurers. In most jurisdictions, banks are not allowed to issue or take on longevity risk in the form of annuities, buy-ins, or buy-outs, but they can take it indirectly via swap transactions (Figure 5).

Figure 5 here

The largest DB pension risk transfer (PRT) markets are in the UK and the US (Figures 6 and 7). In both cases, recent growth surges have been driven by the introduction of stricter pension disclosure standards, and stricter regulations that mandated risk-based guarantee schemes (2004 UK Pensions Act and 2006 US Pension Protection Act). Canada has also seen a steady and growing flow of buy-out transactions, and a large longevity swap (Figure 8).

Figures 6, 7, and 8 here

PRT markets are supported by longevity risk transfer (LRT) markets in which (re)insurers transfer annuity-related risks to other (re)insurers. For example, Canada's Sun Life backed a C\$5 billion longevity swap with Bell Canada Pension Plan with *longevity reinsurance* from a couple of Canadian branches/subsidiaries of foreign reinsurers. The size of the LRT market is difficult to track because it is more opaque than PRT markets, but since 2012 about half of all PRT transactions were probably backed by LRT trades. Many of these transactions cross borders, and fluid cross-border reinsurance markets are important to the functioning of any primary insurance markets (Swiss Re 2016). For example, since 2015, Dutch life insurer Aegon has hedged the

longevity risk associated with €18 billion of annuities with Canada Life Reinsurance (Aegon 2019).

Some cross-border LRT transactions may be motivated by regulatory arbitrage. For example, Solvency 2 insurance regulations may be incentivizing European (re)insurers to look to hedge their longevity risks with (re)insurers from foreign jurisdictions having less stringent longevity risk capital charges and reserving requirements.

Cross-Border Reinsurance Frictions. Some jurisdictions have imposed regulatory frictions on cross-border reinsurance. These can take the form of onerous or vague foreign (re)insurer registration requirements, or heavy collateralization requirements. For example, for Canadian (re)insurers to get capital credit from reinsurance from ‘unregistered’ (re)insurers, the reinsurance must be over-collateralized with Canadian dollar assets held in Canada (OSFI 2010). The US rules previously worked in a similar way, but since 2011, US (re)insurers can get capital relief from offshore-sourced reinsurance, without full collateralization if the reinsurer is rated at least BBB and from a qualified jurisdiction as determined by the National Association of Insurance Commissioners (NAIC).¹

For European (re)insurers to get capital credit from offshore-sourced reinsurance, collateralization of covered liabilities and associated capital requirements may not be required if the reinsurer is rated at least BBB *or* from a jurisdiction deemed equivalent for reinsurance supervision.² Yet according to market sources, aside from the UK, country-specific implementation of the rules has been spotty (Pruitt et al. 2019). This should improve as the EU-US Covered Agreement is phased in, eliminating collateral and local presence requirements for qualified US reinsurers operating in the EU and UK insurance markets, and vice versa.³

Capital Market Transactions. A relatively untapped pool of potential longevity risk takers may consist of asset managers, sovereign wealth funds, private equity funds, and hedge funds. Asset managers and sovereign wealth funds may be encouraged by the fact that longevity risk is likely to be largely uncorrelated to the other risk factors in their portfolios.⁴ However, hedge funds may be put off by the long duration of the contracts (and the potential need to make collateral arrangements over this time frame), which may make them inappropriate for most hedge funds' investment styles.

Buyers of longevity risk may be discouraged by the illiquidity of instruments. Sellers of longevity risk would tend to seek customized hedge contracts to maximize effectiveness of risk transfer, yet many buyers of this risk would likely prefer standardized investments to maximize liquidity. This fundamental difference in perspective complicates the development of an active market. More standardized products would improve liquidity for risk buyers, but would also increase basis risk for risk sellers, since standardization will likely increase the demographic differences between the actual pool of retirees and the reference pool on which payments are based.

In addition, buyers face the problem of asymmetric information. Given that a pension fund may have a better idea of how healthy its population of retirees is likely to be, the resulting asymmetric information may create a selection bias whereby only those pension funds with the longest-living populations would want to hedge the risk. The existence of such asymmetric information can lead to a breakdown of the market (see Mitchell and McCarthy 2002). Pricing contracts with asymmetric information is difficult, and so mispricing often occurs in the early stages of most markets when such asymmetries are most acute. Index-based transactions may lessen the problem of asymmetric information but will increase basis risk.

Both buyers and sellers of longevity risk face counterparty risk. Counterparty risk arises because longevity risk transfer deals tend to be long-term contracts where the counterparty may not (be able to) honor its financial commitments over time. It is usually dealt with by collateralization, which can involve significant costs because it requires that the proceeds be invested in high-quality liquid securities that may be in short supply. This consideration favors longevity swaps, which require collateralizing only the difference between what each swap participant owes the other.⁵

Several unsuccessful attempts have been made to launch longevity bonds.⁶ The payout on a longevity bond depends on the longevity experience of a given population, so the payment is related to the number of survivors in the population (Figure 9). In essence, it pays out a declining series of coupons as the proportion of survivors in the reference population declines (Blake and Burrows 2001). One disadvantage is that, unlike with a swap, the bond buyer makes a large upfront payment to the issuer, resulting in a counterparty risk exposure to the issuer. Such counterparty risk would be mitigated if the bonds were issued by a high-quality sovereign or supranational,⁷ or by a special purpose vehicle that invested the proceeds in low-risk highly liquid fixed income securities, from which the income covers the bond payouts. The issuer might also transfer some or all the longevity risk to a reinsurer, probably via a longevity swap contract.

Figure 9 here

Swaps may be more likely to activate broader capital market interest. For example, the 2012 €12 billion longevity swap between Dutch insurer Aegon and Deutsche Bank used standard International Swaps and Derivatives Association (ISDA) documentation and was targeted specifically at institutional investors (Whittaker 2012). It had a 20-year maturity with a close-out mechanism that determined the final payment, as opposed to the open-ended maturities of more

traditional transactions. In addition, the longevity-indexed floating payments are floored and capped so that investors are not exposed to open-ended risk if longevity is either under- or overestimated. Finally, it used a longevity index based on publicly available data to drive cash flows, as opposed to the actual longevity experience of Aegon's annuity book.⁸ Aegon followed up with a similar transaction in 2013, a €1.4 billion deal structured and syndicated by Société Générale (Osborn 2013). Nevertheless, there have apparently been no similar transactions since then.

Finally, both sides of the market are also affected by a lack of reliable and sufficiently granular information about longevity developments. Life tables are updated infrequently and are only available for relatively aggregated groups in the population. Several unsuccessful projects have attempted to solve this problem. In 2005, Credit Suisse introduced a US longevity index based on publicly available US government mortality tables but quietly pulled it sometime later (Credit Suisse 2005). In 2007, Goldman Sachs introduced a mortality/longevity index (QxX) on the US insured population over the age of 65, aimed primarily at the life settlements market,⁹ but it was shut down in late 2009 (Goldman Sachs 2007). In 2007, J.P. Morgan launched the LifeMetrics index of historical and current statistics on mortality rates and life expectancy, across genders, ages and nationalities (J.P. Morgan 2007). In 2010, J.P. Morgan transferred this operation over to the Life & Longevity Markets Association (LLMA) founded in 2010 to produce standardized index-based longevity swap curves and pricing models, but the LLMA closed down a few years later.¹⁰ In 2007, Deutsche Bourse launched exchange-traded longevity swaps based on their XPECT family of longevity indices supported by data from Club Vita, but these have also since closed (Sachsenweger and Rogge 2011). Nevertheless, Club Vita, founded in 2008, lives on and

is producing Canadian, UK, and US VitaCurves. Because these are not publicly available, they have been of little use for pricing capital markets transactions.

Before examining more recent proposals for structuring longevity risk transfer transactions, the next section looks at catastrophe risk transfer markets, from which useful lessons for longevity risk transfer can be gleaned.

Catastrophe (CAT) Risk Transfer Markets

(Re)insurers are using catastrophe risk transfer markets to finance their coverage of low-probability high-severity event risk in return for a pre-specified return.¹¹ These markets help (re)insurers diversify their sources of risk capital through highly-collateralized transactions, while providing attractive yield to sophisticated investors (such as special purpose funds, hedge funds, pension funds, and family offices). Most market-based CAT risk protection is fully collateralized against peak exposures, and it is paid out more quickly than reinsurance liabilities (rarely redeemable on demand and where claims payments can be spread over many years). Most institutional investors active in this asset class probably do so via specialist funds, of which there more than 50 managing over \$100 billion of investments (Evans 2020e).

Nonetheless, the market remains small relative to traditional reinsurance (Figure 10). At end-June 2019, outstanding CAT risk transfer instruments totaled \$93 billion (about 15 percent of total global reinsurance capital) comprised of collateralized reinsurance (\$49 billion), CAT bonds (\$30 billion), and limited purpose reinsurance vehicles such as sidecars and industry loss warranties (\$14 billion) (Aon 2019a, 2019b; Figure 11). Some of the growth may be related to Europe's Solvency II insurance regulation, which went into effect in 2016 and redefined how (re)insurers can use these instruments to hedge natural CAT risk (Braun and Weber 2017).

Figures 10 and 11 here

CAT bonds are like regular bonds, in that in exchange for an up-front investment, they pay interest until they are redeemed (Figures 12 and 13).¹² Embedded in these bonds is a call option that puts the principal payment of investors fully at risk. On the occurrence of a loss event, proceeds are released from the transaction to help the (re)insurer pay all claims arising from the event (i.e., ‘creating insurance recoverable’); investors could lose their entire principal if the contingent event is sufficiently large. In return for the option, investors receive a premium to the investor based on the likelihood of such a loss event. If no loss event occurs during the term of the bond, the collateral is returned to investors based on a release schedule that defines the time frame and threshold that must be met in order for the collateral release. If there is uncertainty as to whether there has been an event, part or all of the collateral can be ‘trapped’ until all facts have been clarified, and losses, if any, have been confirmed. For example, COVID-19 has introduced legal uncertainties around property (re)insurance coverage-related business interruption claims that could lead to collateral trapping in 2020 and beyond (Evans 2020c). All collateralized CAT risk transfer instruments are subject to trapped collateral risk.

Figures 12 and 13 here

Collateralized reinsurance is a contractual commitment in which a reinsurer assumes a portion of an insurer’s risk in exchange for an agreed amount of premium (Figure 14). It can be structured on an excess-of-loss basis, by which losses are triggered if they exceed a predefined threshold, or on a proportional basis by which the reinsurer takes a pro-rata share of premiums and losses associated with a specific book of business. Collateralized reinsurance is much cheaper and more streamlined to structure than a CAT bond. A CAT bond issuer must pay for credit ratings, distribution costs, and legal costs; moreover, US SEC Rule 144A compliance requires extensive

documentation and disclosure. Also, CAT bonds issued under Rule 144A can take an average of 10 weeks to close, versus four weeks for a collateralized reinsurance deal. The latter may also dispense with the third-party risk assessment required for CAT bonds (Woodall 2013).

Figure 14 here

Sidecars are a limited-life special purpose vehicle funded by capital market participants and sponsored by a reinsurer from which it derives its business or quota share. The sidecar assumes a percentage of the ceding reinsurer's underwriting risk in exchange for a similar percentage of the associated premiums (Figure 15). The sidecar's capital is typically funded via equity and debt issuance, the proceeds of which, along with premiums and investment income, are transferred to a collateral trust that fully collateralizes the underwritten risk. Because risk is shared via a quota share arrangement, information asymmetries between counterparties with regard to the sponsor's underwriting portfolio are reduced (Cummins and Barrieu 2013). Unlike other CAT risk transfer product, sidecars are often not restricted to only covering losses from specifically named perils, so their performance tends to track the loss experiences of the re/insurer and can often include a broader range of perils. Hence, sidecars could be more vulnerable, for example, to COVID-19 related claims burdens (Evans 2020d).

Figure 15 here

Industry loss warranties (ILWs) are dual-trigger reinsurance contracts that pay off when a specified industry wide loss index exceeds a threshold and the issuing insurer's losses from the event equal or exceed a specified amount (Figure 16). The second trigger is usually quite low compared to the main trigger. The term is typically one year. ILWs may have binary triggers, where the full amount of the contract pays off once the two triggers are satisfied, or pro rata triggers where the payoff depends upon how much the loss exceeds the warranty. Because the second

trigger and the contingent payout is indemnity-based, ILWs are treated as reinsurance for regulatory purposes.

Figure 16 here

CAT products with indemnity triggers based on actual losses provide perfect coverage, which makes them a close substitute for a reinsurance contract. Yet loss recovery periods are longer, and investors cite potential moral hazards inherent in these structures. In this context, moral hazard refers to the risk that the reinsured counterparty relaxes underwriting standards, including ongoing monitoring (where relevant), and/or may settle claims less stringently. Instead, investors tend to prefer index-based, modeled and parametric indices. Parametric and index-based instruments determine the contingent payments on objective data that are correlated with issuer or insured party potential losses. Index-based contingent payments are based on generic industry-wide and/or geographic indices of insured losses correlated with the issuer's or insured party's potential losses.¹³ Parametric instruments use scientific and statistical data related to the cause and magnitude of a catastrophe, such as wind speeds for hurricane-linked instruments. Index-linked instruments are simpler to structure and execute than parametric instruments, but they expose reinsured parties to the basis risk that the coverage may not exactly match actual losses.

The securitization of 'peak mortality' risks, primarily related to pandemic-type events, relies on parametric triggers. For example, the contingent payouts on the \$521 million Swiss Re Vita III principal at risk notes issued in 2007 were based on indices of general population mortality rates in the covered countries. Losses to each of the note's nine tranches are triggered when the index exceeds their corresponding attachment point and reach 100 percent when the index reaches the exhaustion point (Moody's 2007).

Mortality bonds were last issued in 2017 when the World Bank issued \$320 million of three-year pandemic bonds. Two classes of bonds were issued, \$225 million of Class A bonds that cover flu and coronavirus, and \$95 million of Class B bonds that cover filovirus, coronavirus, lassa fever, rift valley fever and Crimean Congo hemorrhagic fever. The bonds provided parametric protection linked to the occurrence of specific pandemics, the trigger for both bonds being based on World Health Organization reported deaths and cases that hit the covered areas, which for some perils is global, others a subset of countries. In April 2020, the COVID-19 pandemic triggered payouts of \$37.5 million on the Class A bonds and \$95.0 million on the Class B bonds (Gross 2020).

Since 2010, Aetna has been issuing morbidity bonds that transfer risk of extreme claims for medical costs (Figure 17). For example, Aetna issued its 11th series of Vitality Re morbidity bonds in January 2020, a \$200 million two-tranche deal, with \$140 million of Class A and \$60 million of Class B notes (Figure 18). For each annual risk period, the payout trigger is based on an index of Aetna's medical benefit claims ratio, the annual incurred benefits divided by the annual total premiums. If the index rises above a predefined attachment point level for either of the tranches, it will trigger a payment. The Class A notes cover Aetna for losses above an index of 102 percent (equivalent to a \$1.02 billion loss level on the covered premia), and the Class B notes cover losses above 96 percent (\$960 million). None of the Vitality Re ILS transactions have ever paid out for Aetna, even though the COVID-19 pandemic drove significant numbers to hospitals in the US and elevated health insurance claims levels (Evans 2020b).

Figure 17 and 18 here

What Hope for Vibrant Longevity Risk Transfer Markets?

If one were to look to CAT risk transfer markets for guidance on how to ignite capital markets interest in longevity risk, the keys would seem to be short terms to maturity and full collateralization to minimize credit risk (Table 1). The theoretical literature seems to provide little guidance on other potential factors. Some models suggest that capital markets-based insurance risk transfer is more viable for insurance risk portfolios in which potential losses are large and/or highly correlated, making retaining them expensive for (re)insurers to maintain prudent capital levels (Cummins and Trainar 2009). Yet most of the recent increase in CAT instrument issuance is due to collateralized reinsurance that protects smaller losses. Hence, large losses are still primarily either retained or transferred through traditional reinsurance (Subramanian and Wang 2018).

Table 1 here

Hagendorff et al. (2014) found that access to insurance risk transfer markets should be easiest for (re)insurers with less risky portfolios. Investors will shy away from riskier portfolios because they do not have access to the private information that reinsurers have, so they must use publicly available information to assess portfolio risk. These investors will likely demand higher yields, making capital markets-based solutions less attractive than capital market-based solutions to such insurers. Yet Subramanian and Wang (2018) used a signaling model to show that (re)insurers riskier portfolios will be more likely to issue CAT bonds.

Product design could overcome information asymmetry problems. For example, according to Finken and Laux (2009), CAT risk transfer products with parametric or index triggers are insensitive to information asymmetry and may be attractive to low-risk insurers who suffer from adverse selection with reinsurance. Products with indemnity triggers may be unattractive to capital markets investors because they fear that low-risk insurers will opt for reinsurance, and only high-

risk insurers will opt to tap capital markets. Low-risk insurers will only issue parametric- or index-triggered risk-transfer products if the reinsurance premium exceeds the expected costs from the resulting basis risk.

As noted above, a few longevity risk transfer transactions in the past did tap capital markets, but there has been no follow-up. A big challenge is resolving the tension between the long-term nature of longevity risk and investor preference for a short-term investment horizon (Blake et al. 2019). Cedents may also prefer shorter horizons due to the risk of the loss of capital relief if regulations change. Other challenges include finding, funding, and safekeeping prudent collateral. Bugler et al. (2020) proposed a sidecar structure for longevity risk transfer (Figures 19). Langhorne Re was set up by Reinsurance Group of America (RGA) in 2018 to carry out such transactions, but it has yet to do one (Evans 2020a).

Figure 19 here

Transferring risks in the financial markets depends on the ability to identify, measure, and isolate specific risk characteristics. In this regard, longevity risk transfer markets may be held back by a lack of reliable and sufficiently granular information about longevity developments. Better longevity risk management and transfer would benefit from much more granular demographic data (including, for example, by postal code and cause of death), which can reduce basis risk and could generate indexes that would facilitate the design and trading of longevity risk transfer instruments. Index-based transactions may also lessen the problem of asymmetric information.

A better marketplace would also be well served by a common agreement between market participants on which mortality models to use for the design and pricing of each longevity-linked deal. A main reason why Aegon's deal with Société Générale went ahead in 2013 was that all parties agreed to use the same mortality model. Even if a particular model produced the wrong

forecasts (which it is bound to do), if those forecasts were not systematically biased, then it becomes a potential candidate for use in this market. The Black and Scholes (1976) option pricing model and its variants are examples of such models operating in traditional financial markets. Ideally, such models are reasonably parsimonious and amenable to closed-form solutions, from which underlying parameters can be bootstrapped from market data.

We also recognize that there may be a tension between investors' preference for index-based risk transfer, and cedents' for indemnity transactions. Yet Michaelson and Mulholland (2014) claim that hedge programs can be designed using customized population-wide index-based mortality data that minimize basis risk between the hedger's portfolio and the population referenced index. First, it involves customizing three elements of the hedge exposure; the cohorts (combinations of age and gender), relative cohort weighting over time ('exposure vector'), and 'experience ratio matrix' based on an experience study of the hedger's portfolio. Second, it involves designing an out-of-the-money spread option product structure with attachment and exhaustion points set to minimize the cost of capital for the cedent's capital relief taking into account market dynamics and investor preferences (see also Cairns and El Boukfaoui 2019).

MacMinn and Zhu (2018) have addressed the topic of optimal design at a broader level, showing that value-based hedging instruments dominate a full cash-flow hedging ones by generating a higher stock value to the company's shareholders. Cash-flow hedges consist of a series of payments that offset or stabilize the liability cash-flow of cedent, such as buy-ins and buy-outs. Value-based hedges consist of one cash payoff contingent on a publicly observable longevity/mortality event. The key difference between the two is that, while the value-based hedge only benchmarks its payments based on the underlying systematic shocks, the cash-flow hedge also hedges unexplainable shifts in future mortality.

Nevertheless, MacMinn and Brockett (2017) note that hedging can make annuity portfolios more valuable and makes annuity holders better off, as it reduces the value of shareholders' effective put option on the cedent. So even if a hedge frees up reserves to invest in a positive NPV projects, it would only be worthwhile if project NPVs exceeds the firm's put value. The authors claimed that the failure of capital markets-based longevity risk transfer could be as simple as this. Furthermore, Zelenko (2014) has blamed the failure of the Chilean longevity bond on another moral hazard problem: the perceived likelihood that the government would bail out (re)insurers and/or annuitants hit by systematic longevity risk events.

Conclusion

Today, longevity risk transfer markets' 'buy side' remains largely comprised of (re)insurers, and there have been only sporadic efforts to tap capital markets. Although CAT risk transfer activity is also dominated by traditional reinsurance, there is active participation by institutional investors in alternative risk capital markets. The CAT risk transfer market analysis and academic literature summarized above suggests what some of the impediments and solutions may be.

A major constraint to new product is a dearth of granular longevity and demographic data. Governments are best placed to provide such data, perhaps through national statistical offices or government actuaries. Most important would be longevity information disaggregated by geographic area, gender, socio-economic status, cause of death, and occupation. Governments could also usefully track the emergence and evolution of new diseases, especially those afflicting the elderly, medical advances, and life-style changes.

Ideally, longevity risk transfer products would be based on common and publicly available data. In that regard, it is a shame that all the efforts at building such databases and making them

public have failed (e.g., LifeMetrics and XPECT). Of course, there may be a tension with cedents' preference for indemnity transactions to minimize basis risk, but there are some promising ways to bridge this gap (Michaelson and Mulholland 2014; Cairns and El Boukfaoui 2019). For instance, Blake et al. (2010) have advocated government-issued longevity bonds that would provide benchmarks and liquidity to the market, in the same way that government-issued inflation-linked bonds helped capital markets thrive. Although governments are already heavily exposed to longevity risk, they argue that there would be no increase in aggregate longevity risk if such issuance were coupled with the indexation of retirement ages to longevity increases. In practice, however, such indexation has proven to be politically very difficult.

There also needs to be agreement between market participants on mortality models, ideally ones that are reasonably parsimonious and amenable to closed-form solutions from which underlying parameters can be bootstrapped from market data. Standardized data and models could also open the door to investors who prefer shorter terms to maturity. Taking a cue from CAT risk transfer markets, the sweet spot could be three to five years, since as MacMinn and Zhu (2018) showed, value-based products with shorter terms could be more attractive to cedents than cash-flow based risk transfer. Biffis and Blake (2014) have also proposed that an optimal format would entail a tranching principal-at-risk instrument very much like a CAT bond.

Of course, it may be that activating investor interest in longevity risk transfer markets is an intractable problem, as suggested by MacMinn and Brockett (2017): what is good for annuitants may not be best for cedents, on account of the loss of the balance sheet put option. Moreover, markets may be held back by the moral hazard problem related to the perceived likelihood that the government would bail out (re)insurers and/or annuitants hit by systematic longevity risk events (Zelenko (2014)). The next decade will provide new insights.

References

- Aegon (2019). 'Aegon Reinsures Longevity Exposure in the Netherlands.' Press Release, Netherlands: December 19.
- Aon (2019a). 'Insurance-Linked Securities Annual Report.'
<http://thoughtleadership.aonbenfield.com/pages/Home.aspx?ReportCategory=Insurance-Linked%20Securities>.
- Aon (2019b). 'Reinsurance Market Outlook.'
<http://thoughtleadership.aonbenfield.com/pages/Home.aspx?ReportCategory=Reinsurance%20Market%20Outlook>.
- Biffis, E. and D. Blake (2009). 'Mortality-Linked Securities and Derivatives,' Cass Business School Pensions Institute Working Paper PI 0901. London, UK. <http://www.pensions-institute.org/wp-content/uploads/2019/workingpapers/wp0901.pdf>.
- Biffis, E. and D. Blake (2014). 'Keeping Some Skin in the Game: How to Start a Capital Market in Longevity Risk Transfers.' *North American Actuarial Journal*, 18(1): 14-21.
- Biffis, E., D. Blake, L. Pitotti, and A. Sun (2016). 'The Cost of Counterparty Risk and Collateralization in Longevity Swaps.' *Journal of Risk & Insurance*, 83(2): 387-419.
- Black, F. and M. Scholes (1973). 'The Pricing of Options and Corporate Liabilities.' *Journal of Political Economy* 81: 637–654.
- Blake, D., T. Boardman, and A. Cairns (2014). 'Sharing Longevity Risk: Why Governments Should Issue Longevity Bonds.' *North American Actuarial Journal*, 18(1): 258-277.
- Blake, D. and W. Burrows (2001). 'Survivor Bonds: Helping to Hedge Mortality Risk.' *Journal of Risk and Insurance*, 68(2): 339-348.

- Blake, D., A.J.G. Cairns, K. Dowd, and A.R. Kessler (2019). 'Still Living with Mortality: The Longevity Risk Transfer Market After One Decade.' *British Actuarial Journal*, 24: 1-80.
- Braun, A. and J. Weber (2017). 'Evolution or Revolution? How Solvency II Will Change the Balance Between Reinsurance and ILS.' *NAIC Journal of Insurance Regulation*, 36:4.
- Bugler, N., K. Maclean, V. Nicenko, and P. Tedesco (2020). 'Reinsurance Sidecars: The Next Stage in the Development of the Longevity Risk Transfer Market.' *North American Actuarial Journal*, forthcoming.
- Cairns, A.J.G. and G. El Boukfaoui (2019). 'Basis Risk in Index-Based Longevity Hedges: A Guide for Longevity Hedgers.' *North American Actuarial Journal*, 0(0): 1-22.
- Citi (2016). 'The Coming Pension Crisis.' *Global Perspectives and Solutions*: March.
- Cummins, J. D. and P. Trainar (2009). 'Securitization, Insurance, and Reinsurance.' *Journal of Risk and Insurance*, 76(3): 463-492.
- Credit Suisse (2005). 'Credit Suisse First Boston Introduces Credit Suisse Longevity Index,' *Business Wire*, December 12.
- Cummins, J. D. and M.A. Weiss. (2009). 'Convergence of Insurance and Financial Markets: Hybrid and Securitized Risk-Transfer Solutions.' *Journal of Risk and Insurance*, 76(3): 493-545.
- Cummins, J.D. and P. Barrieu (2013). 'Innovations in Insurance Markets: Hybrid and Securitized Risk-Transfer Solutions.' In Dionne, G., *Handbook of Insurance*. New York: Springer, pp. 547-602.
- Daniel, W. (2016). 'Supplanting Cash in Annuity Buyouts: Asset-in-Kind Transfers Move Toward Mainstream.' In Bruce, B.R., ed., *Pension & Longevity Risk Transfer for Institutional Investors*. Institutional Investor Journals, pp. 14-17.

- European Insurance and Occupational Pensions Authority (EIOPA) (2020). 'Equivalence.'
https://www.eiopa.europa.eu/browse/international-relations/equivalence_en.
- Evans, S. (2011). 'Life and Longevity Markets Association Takes Ownership of J.P. Morgan's LifeMetrics Index.' *Artemis.bm*: April 27. <https://www.artemis.bm/news/life-and-longevity-markets-association-takes-ownership-of-j-p-morgans-lifemetrics-index/>.
- Evans, S. (2020a). 'First Langhorne Re Transaction Still Elusive for RGA, but Pipeline Building.' *Artemis.bm*: January 30. <https://www.artemis.bm/news/first-langhorne-re-transaction-still-elusive-for-rga-but-pipeline-building/>.
- Evans, S. (2020b). 'Aetna's Claim Ratio Well-Below Vitality Re ILS Trigger in Q1 Despite COVID-19.' *Artemis.bm*: June 20. <https://www.artemis.bm/news/aetnas-claim-ratio-well-below-vitality-re-ils-trigger-in-q1-despite-covid-19/>.
- Evans, S. (2020c). 'Varying Pandemic ILS Impacts, Trapped Capital May be Held for Years: A.M. Best.' *Artemis.bm*: May 11. <https://www.artemis.bm/news/varying-pandemic-ils-impacts-trapped-capital-may-be-held-for-years-a-m-best/>.
- Evans, S. (2020d). 'Sidecars & Quota Shares May Face Highest COVID-19 Claims: A.M. Best.' *Artemis.bm*: May 15.
- Evans, S. (2020e). 'Insurance Linked Securities Investment Managers & Funds Directory,' *Artemis.bm*. <https://www.artemis.bm/news/sidecars-quota-shares-may-face-highest-covid-19-claims-a-m-best/>.
- Evans, S. (2020f). 'Catastrophe Bond & ILS Market Statistics and Data.' *Artemis.bm*: June 20. <https://www.artemis.bm/dashboard/cat-bond-ils-market-statistics/>.
- Finken, S. N. and C. Laux (2009). 'Catastrophe Bonds and Reinsurance: The Competitive Effect of Information-Insensitive Triggers.' *Journal of Risk and Insurance*, 76:3.

- Goldman Sachs (2007). 'Goldman Sachs Launches Tradeable Index for Longevity and Mortality Risks.' *Business Wire*: December 14.
- Gross, A. (2020). 'World Bank Pandemic Bonds to Pay \$133m to Poorest Virus-Hit Nations.' *Financial Times*: April 19.
- Hagendorff, B., J. Hagendorff, K. Keasey, and A. Gonzalez (2014). 'The Risk Implications of Insurance Securitization: The Case of Catastrophe Bonds.' *Journal of Corporate Finance*, 25: 387-402.
- Hunt, A. and D. Blake (2015). 'Modelling Longevity Bonds: Analysing the Swiss Re Kortis Bond.' *Insurance: Mathematics and Economics*, vol. 63(C): 12-29.
- Hymans-Robertson (2009-2020). 'Buy-outs, Buy-ins and Longevity Hedging.' Quarterly and Semi-Annual Reports. <https://www.hymans.co.uk/insights/research-and-publications>.
- Insurance Services Office, Inc (2020). 'PCS: ISO's Property Claim Services (PCS) unit is an internationally recognized authority on insured property losses from events.' <https://pcs.iso.com/>.
- International Association of Insurance Supervisors (IAIS) (2012). 'Reinsurance and Financial Stability.' July 19. <https://www.iaisweb.org/file/34046/reinsurance-and-financial-stability>.
- International Monetary Fund (IMF) (2012). 'The Financial Impact of Longevity Risk.' Chapter 4 in *Global Financial Stability Report*, World Economic and Financial Surveys (Washington: April).
- Joint Forum (2013). 'Longevity Risk Transfer Markets: Market Structure, Growth Drivers and Impediments, and Potential Risks.' Basel: Bank for International Settlements, December.
- J.P. Morgan (2007). 'J.P. Morgan Launches Longevity Index.' *Business Wire*: March 13.

- Kessler, A. (2019). ‘New Solutions to an Age-Old Problem: Innovative Strategies for Managing Pension and Longevity Risk.’ *North American Actuarial Journal*, 0(0): 1-18.
- Lakdawalla, D., and G. Zanjani (2012). ‘Catastrophe Bonds, Reinsurance, and the Optimal Collateralization of Risk Transfer.’ *Journal of Risk and Insurance*, 79(2): 449-476.
- Life Insurance Marketing and Research Association (2020). Personal communication. On file with author.
- MacMinn, R. and P. Brockett (2017). ‘On the Failure (Success) of the Markets for Longevity Risk Transfer.’ *Journal of Risk and Insurance*, 84(S1): 299–317.
- MacMinn, R. and N. Zhu (2018). ‘Hedging Longevity Risk: Does the Structure of the Financial Instrument Matter?’ Unpublished manuscript.
- Michaelson, A. and J. Mulholland (2014). ‘Strategy for Increasing the Global Capacity for Longevity Risk Transfer: Developing Transactions That Attract Capital Markets Investors.’ *The Journal of Alternative Investments*, 17(1): 18-27.
- Mitchell, O. and D. McCarthy (2002). ‘Annuities for an Ageing World,’ NBER Working Paper No. 9092. Cambridge, MA: National Bureau of Economic Research.
- Moody’s (2007). ‘Vita Capital III.’ Moody’s Investors Services: April 9.
- National Association of Insurance Commissioners (NAIC) (2019). ‘NAIC List of Qualified Jurisdictions.’ https://content.naic.org/sites/default/files/inline-files/committees_e_reinsurance_qualified_jurisdictions_list_1.pdf.
- New York State Department of Financial Services (NYDFS) (2020). ‘Certified Reinsurer Information.’ https://www.dfs.ny.gov/apps_and_licensing/insurance_companies/certified_reinsurer_information.

- O'Farrell, S. (2020). 'Longevity Swap Investors Warned over Collateral Calls.' *Pensions Expert*: April 28.
- Office of the Superintendent of Financial Institutions Canada (OSFI) (2010). 'Guidance for Reinsurance Security Agreements.' (Updated Dec. 23 2015). December. <https://www.osfi-bsif.gc.ca/Eng/fi-if/rai-eri/sp-ps/Pages/rsa.aspx>.
- Osborn, T. (2013). 'SG CIB Completes Longevity Trade for Aegon.' *Risk.net*: December 5. <https://www.risk.net/derivatives/2317036/sg-cib-completes-longevity-trade-aegon>.
- Pruitt, J.S., H. Laing, C.R. Shoss, and D. Moreira (2019). 'Covered Agreement—An Overview.' Eversheds Sutherland Legal Alert: August 20. <https://us.eversheds-sutherland.com/mobile/NewsCommentary/Legal-Alerts/196936/Covered-AgreementAn-overview>.
- Roseman, R.N. (2020). 'Vitality Re XI Ltd. (Class A and Class B Notes).' Standard & Poor's Global Ratings: January 7.
- Sachsenweger, S. and H. Rogge (2011). 'Index-Based Longevity Risk Transfer to Capital Markets.' Deutsche Börse Market Data: September 8.
- Sagoo, P. and R. Douglas (2012). 'Recent Innovations in Longevity Risk Management; A New Generation of Tools Emerges.' Eighth International Longevity Risk and Capital Markets Solutions Conference: 8 September.
- Subramanian, A., and J. Wang (2018). 'Reinsurance versus securitization of catastrophe risk.' *Insurance: Mathematics and Economics*, 82: 55-72.
- Swiss Re (2016). 'The Benefit of Global Diversification: How Reinsurers Create Value and manage Risk.' October.

Whittaker, T. (2012). 'Aegon €12 Billion Longevity Swap Shows Appetite of Capital Market for Diversifying Assets.' *Risk.net*: February 27.

Willis Towers Watson (2014-2019). 'Group Annuity Market Pulse.'

Willis Towers Watson (2020). 'Global Pension Assets Study 2020.'

Wolfe, H. (2016). 'The Insider's Guide to the Canadian Annuity Market.' Sun Life Assurance Company of Canada.

Woodall, L. (2013). 'ILS Investors Fuel Collateralised Reinsurance Growth,' *Risk.net*: July 12.

Zelenko, I. (2014). 'Longevity Risk and the Stability of Retirement Systems: The Chilean Longevity Bond Case.' *Journal of Alternative Investments*, 17(1): 35-54.

Endnotes

¹ Although the new rules were introduced in 2011, it was not until January 1, 2019 that all US states adopted them. Under them, the collateralization requirement is 10 percent for AA-rated reinsurers, 20 percent for those rated A+ and A, 50 percent at A-, and 75 percent at BBB (NYDFS 2020). Bermuda, France, Germany, Ireland, Japan, Switzerland, and the UK are NAIC-qualified jurisdictions (NAIC 2019).

² The European Commission has granted Australia, Bermuda, Brazil, Canada, Japan, Mexico, Switzerland, and the US equivalence for reinsurance, excepting Bermudan captives and special purpose insurers (EIOPA 2020).

³ The EU-US Covered Agreement (and the parallel US-UK Covered Agreement) entered into force on April 4, 2018, but the reinsurance collateral reduction elements are not required to be fully implemented until September 22, 2022.

⁴ The value of longevity risk transfer instruments are correlated with interest rate levels via their role in the present value discounting of future payouts, so the lack-of-correlation rationale may be less than expected.

⁵ Biffis et al. (2016) show that longevity swap collateral costs can be quite reasonable, especially when counterparty default risk and collateral rules are symmetric.

⁶ There was the Swiss Re-issued 2010 Kortis Bond, which was touted as a longevity bond, but was actually more of a longevity basis bond. The bond's payout was based on the divergence in mortality rates between the UK and the US, where Swiss Re reinsured pensions and annuities in both countries (Hunt and Blake 2015). It was touted to be the 'next big thing', but there have been no such offerings since.

⁷ The AAA-rated European Investment Bank tried to issue a longevity bond in 2004, but it was cancelled due to lack of interest on both the buy- and sell-side (Biffis and Blake 2009). The AAA-rated World Bank tried a similar product in 2010, but it also failed (Zelenko 2014).

⁸ The Aegon-Deutsche Bank transaction references Dutch population mortality data published by the Dutch National Office for Statistics. See Sagoo and Douglas (2012) for more detail.

⁹ A life settlement occurs when the owner of a life insurance policy sells the policy for an amount below the face value of the policy. The purchaser becomes responsible for making premium payments in return for collecting death benefits.

¹⁰ The LLMA was a non-profit group made up of several investment banks, insurers, and reinsurers interested in facilitating the structuring of longevity risk transfer deals (Evans 2011).

¹¹ Reinsurers provide insurance for insurers and reinsurance for reinsurers ('retrocession'). Reinsurance gives (re)insurers capital relief and expanded underwriting capacity and opportunities for regulatory arbitrage (IAIS 2012).

¹² The proceeds from these bonds fully collateralize the transfer of insurance exposures (up to the aggregate contractual policy limit) from or more ceding (re)insurance companies.

¹³ A frequently used set of indices for US-based perils is that compiled by Property Claims Services (Insurance Services Office, Inc 2020).

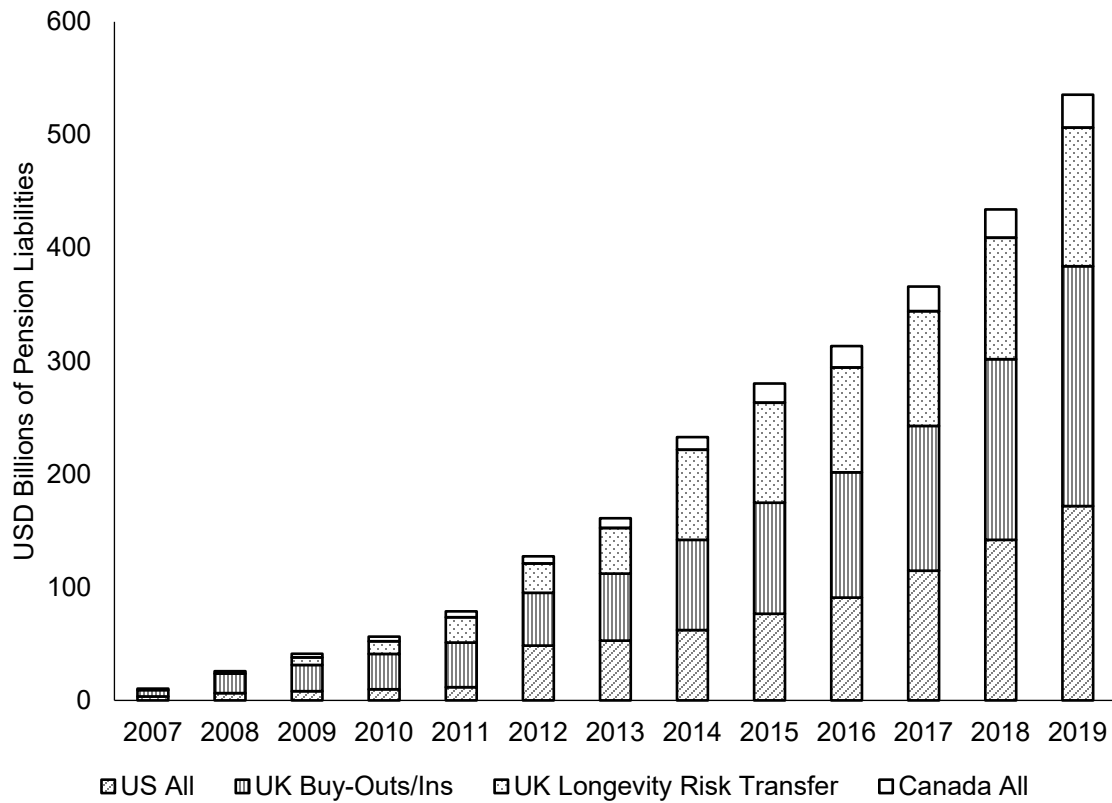


Figure 1. Cumulative pension risk transfer totals by country and product

Source: Kessler (2019).

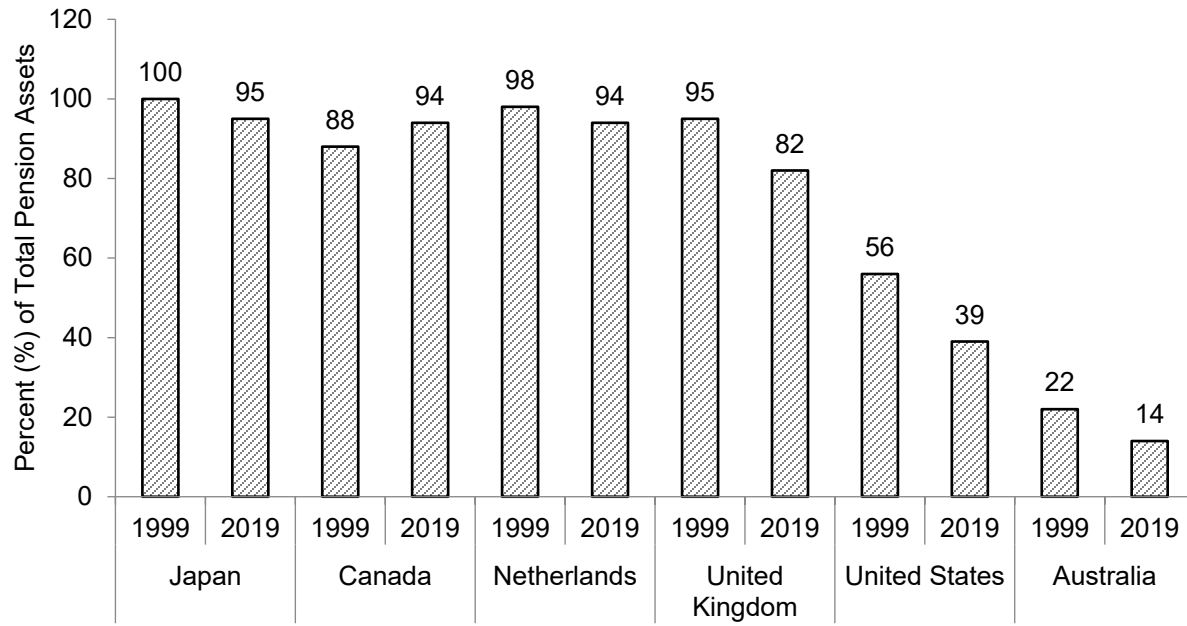


Figure 2. Assets held in defined benefit pension funds
Source: Willis Towers Watson (2020).

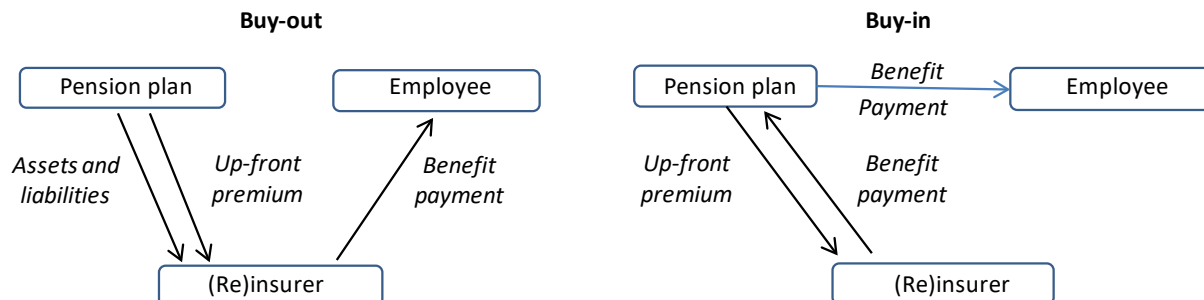


Figure 3. Structure of pension buy-out and buy-in transactions
Source: Joint Forum (2013).

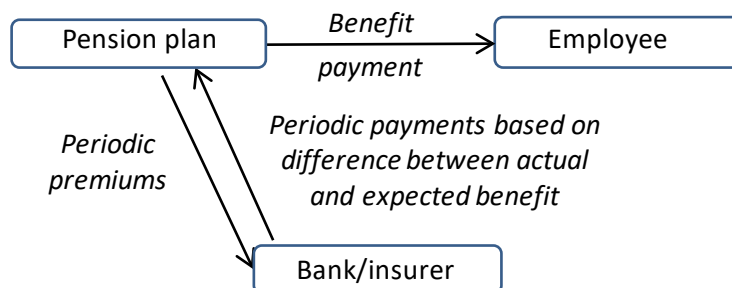


Figure 4. Structure of longevity swap transactions
Source: Joint Forum (2013).

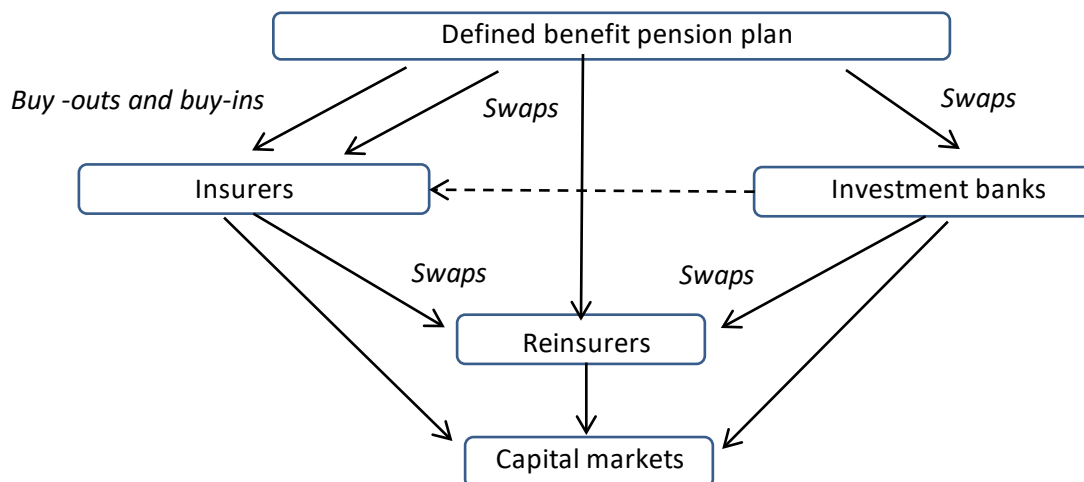


Figure 5. Structure of longevity transfers by defined-benefit pension plans, by type of counterparty
Source: Joint Forum (2013).

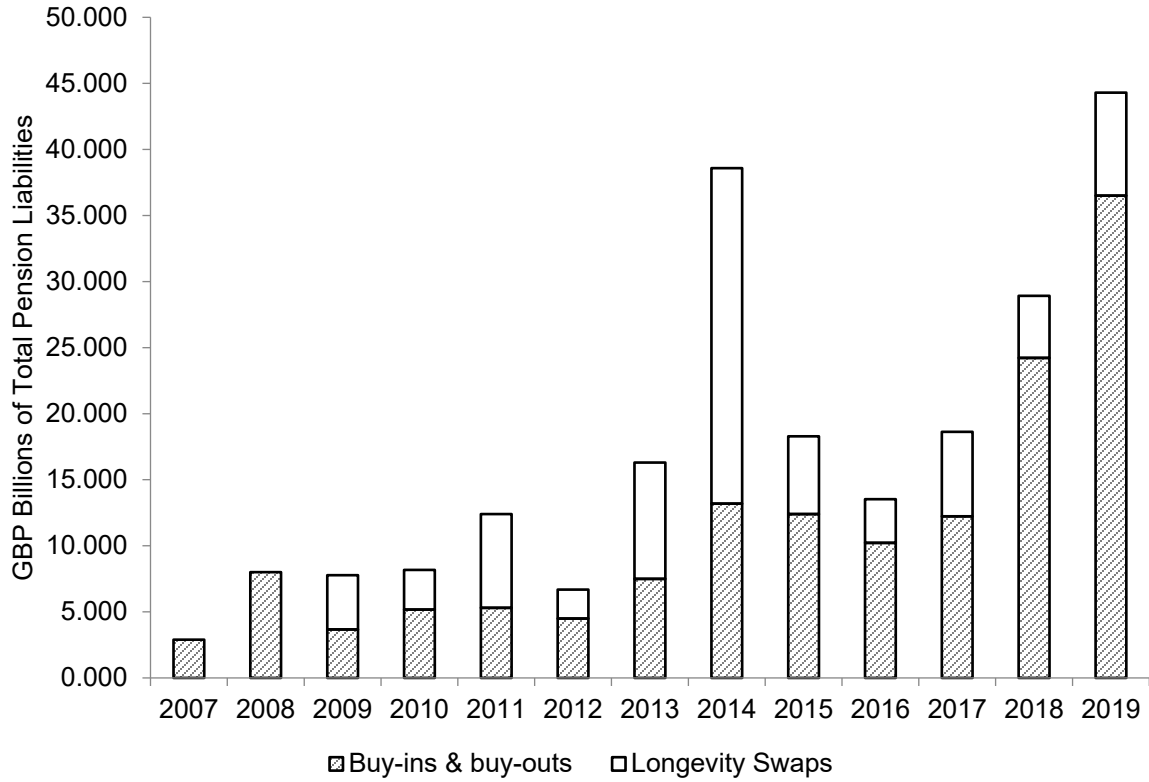


Figure 6. UK pension risk transfer transactions
Source: Hymans-Robertson (2009-2020).

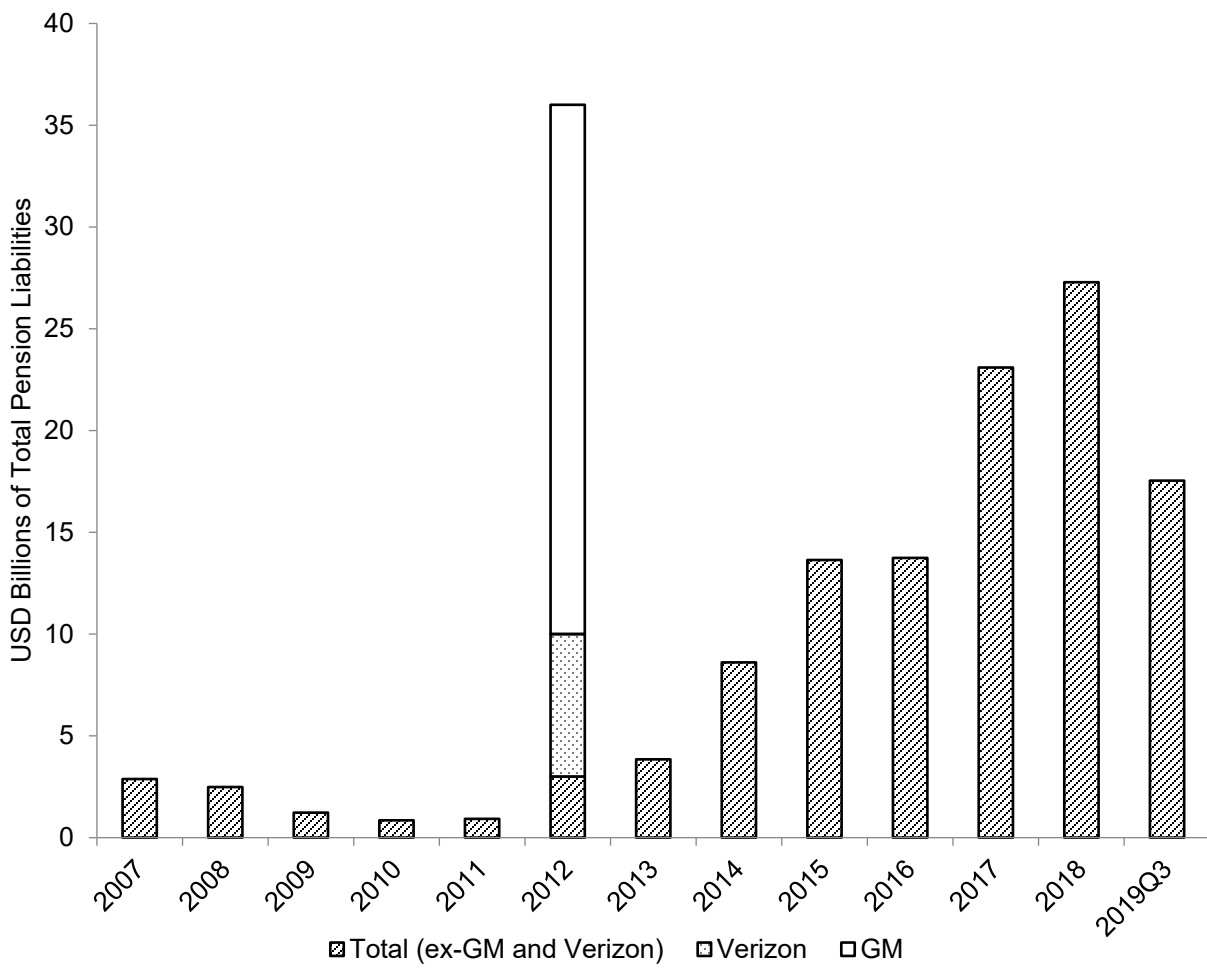


Figure 7. US pension buy-out and buy-in transactions

Source: Personal communication from the Life Insurance Marketing and Research Association.

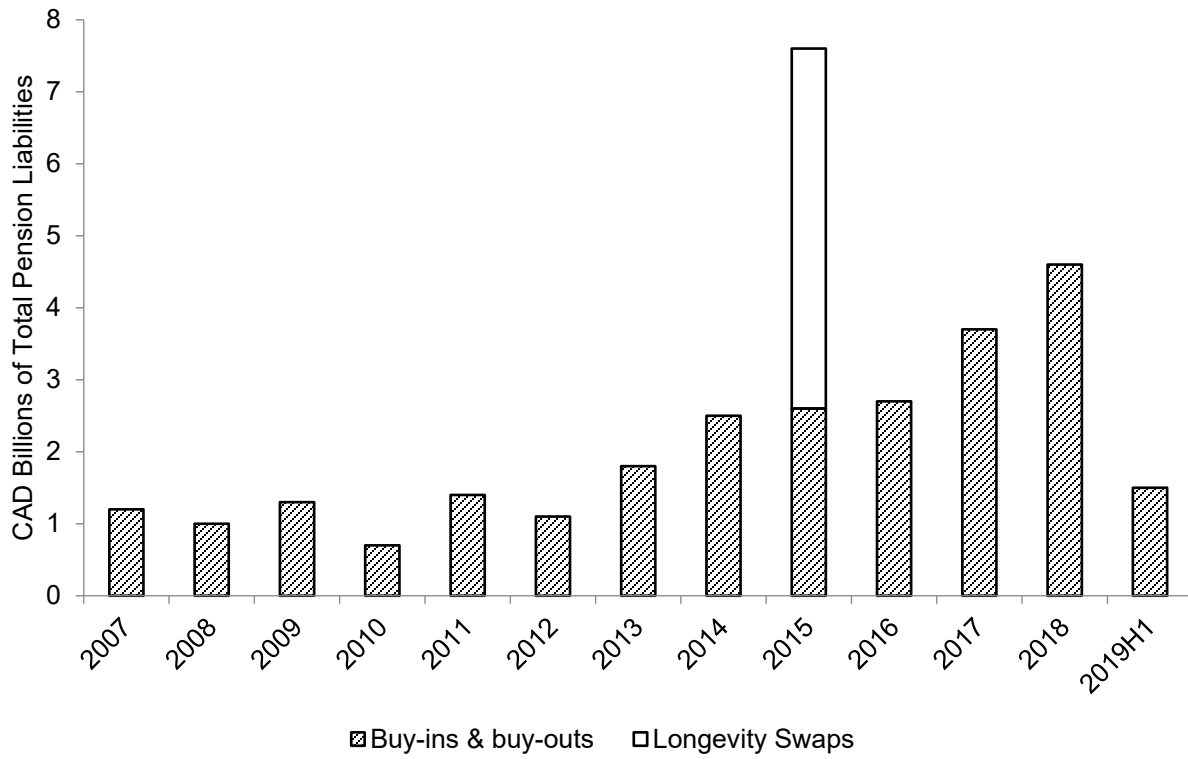


Figure 8. Canadian pension risk transfer transactions

Source: Willis Towers Watson (2014-2019) and Wolfe (2016).

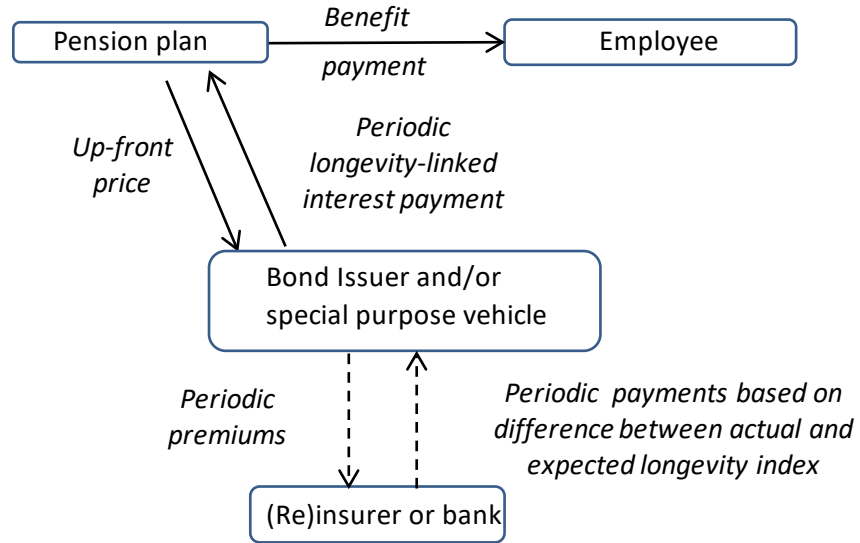


Figure 9. Structure of longevity bond transaction
Source: Joint Forum (2013).

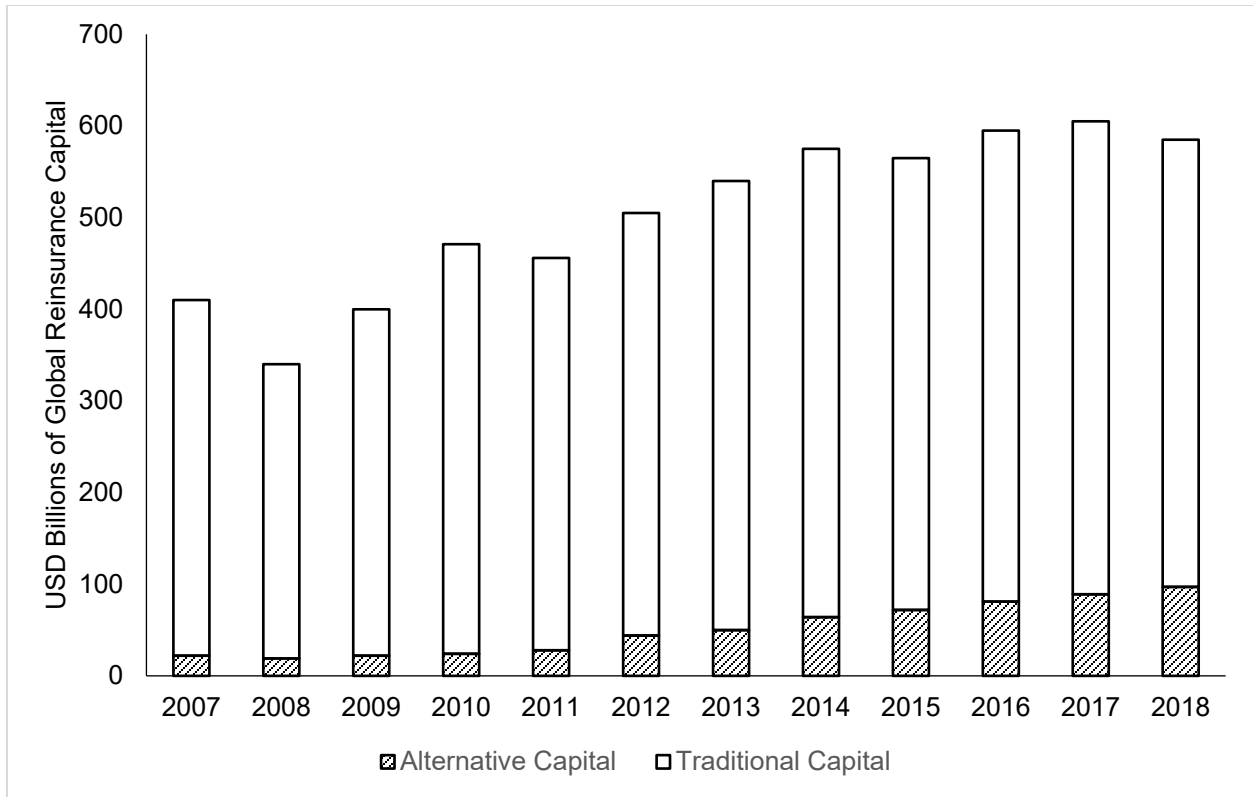


Figure 10. Global reinsurance capital

Source: Aon Capital (2019b).

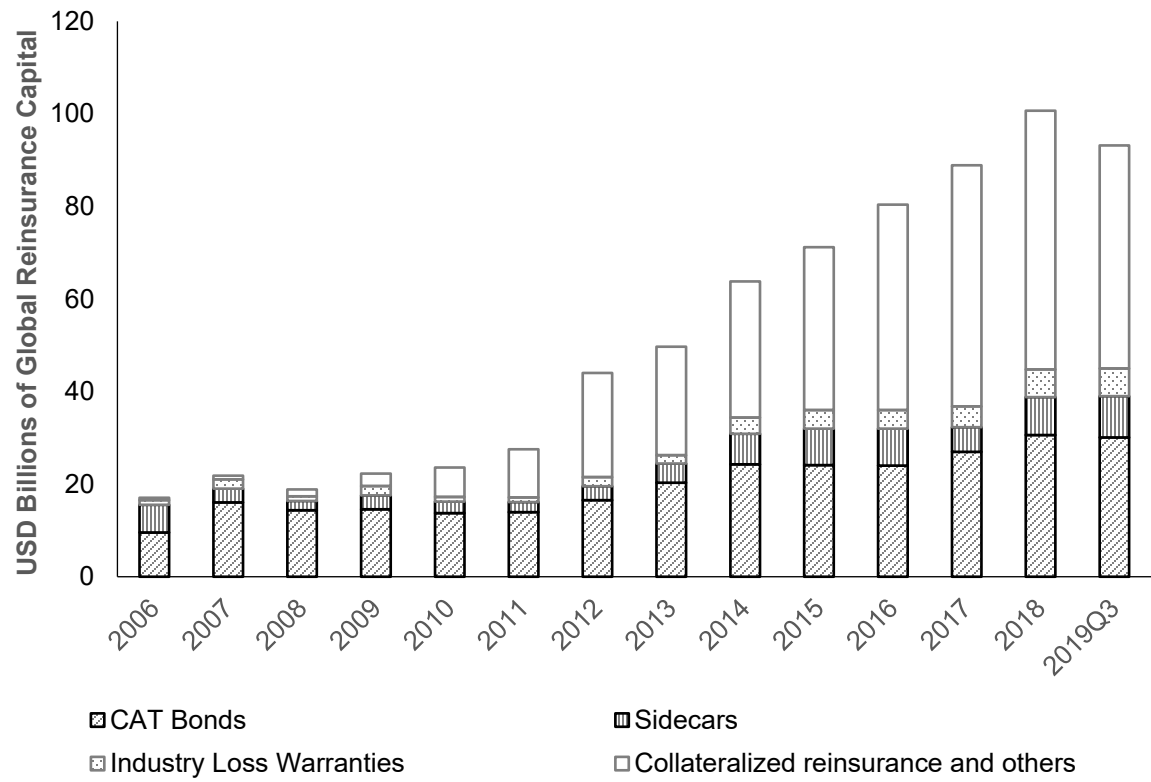


Figure 11. Alternative global reinsurance outstanding
Source: Aon Securities (2019a).

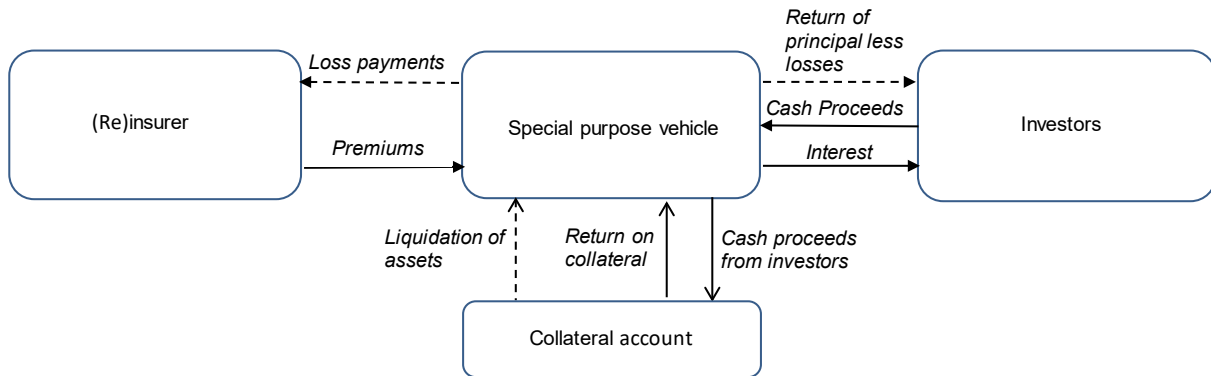


Figure 12. Structure of a CAT bond transaction
Source: Joint Forum (2013).

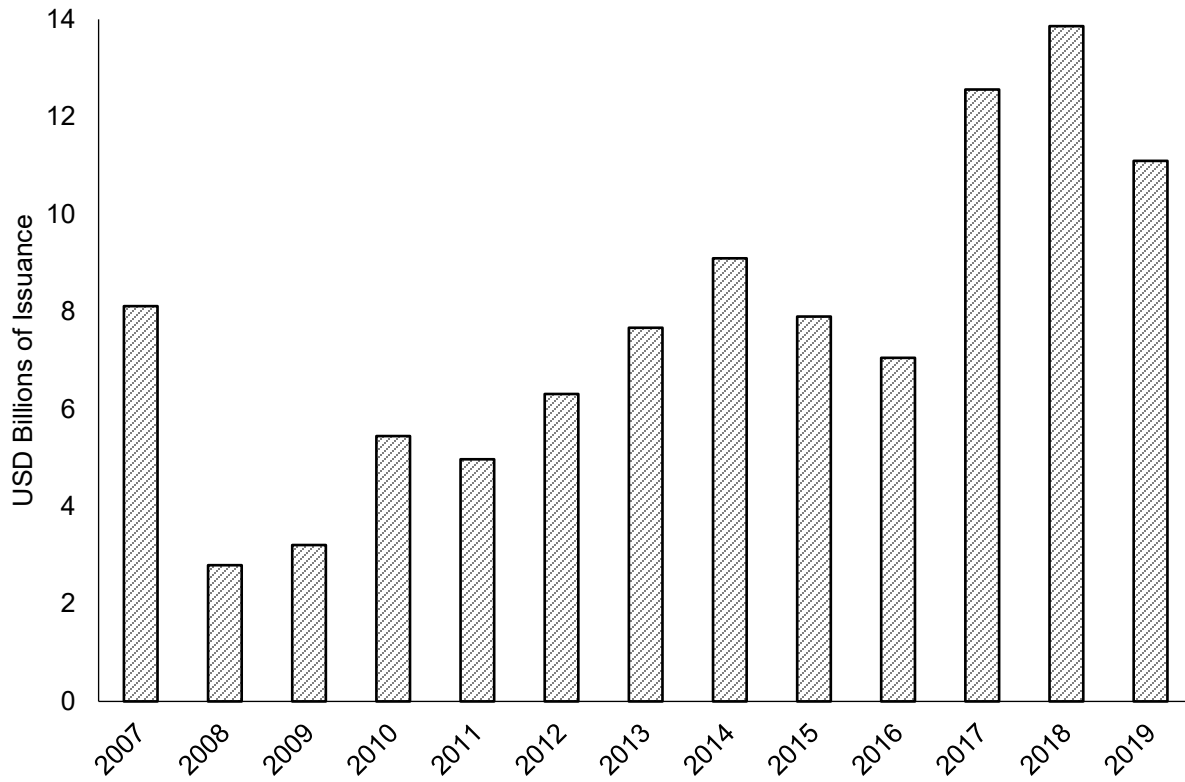


Figure 13. CAT bond and insurance-linked securities issuance

Source: Evans (2020f).

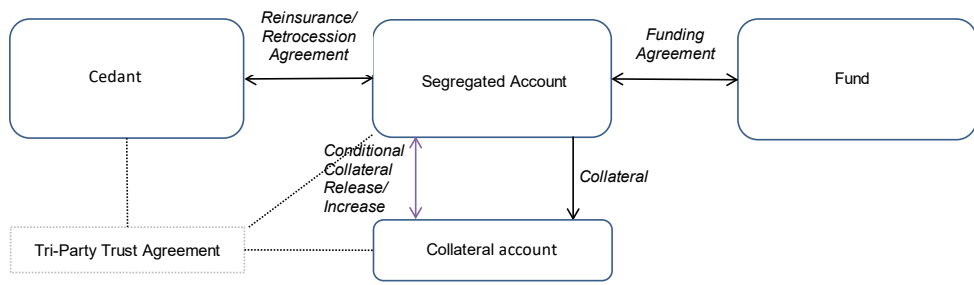


Figure 14. Structure of a collateralized reinsurance transaction

Source: Author

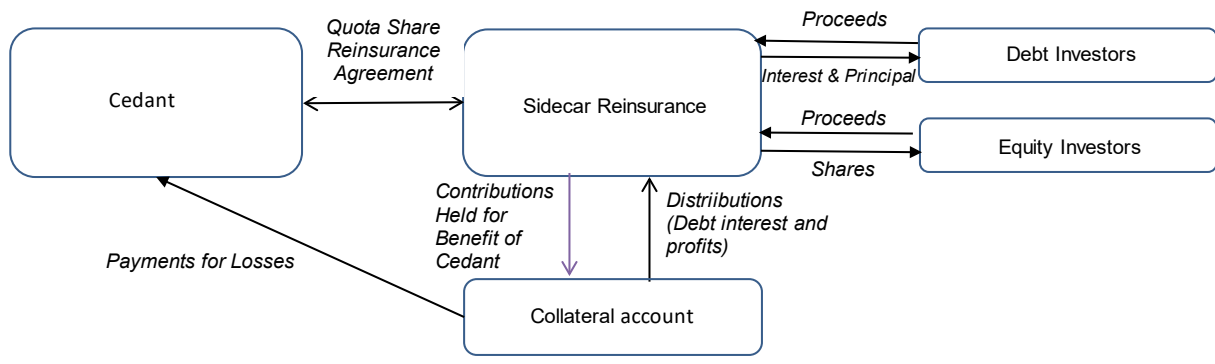


Figure 15. Structure of a sidecar transaction

Source: Author

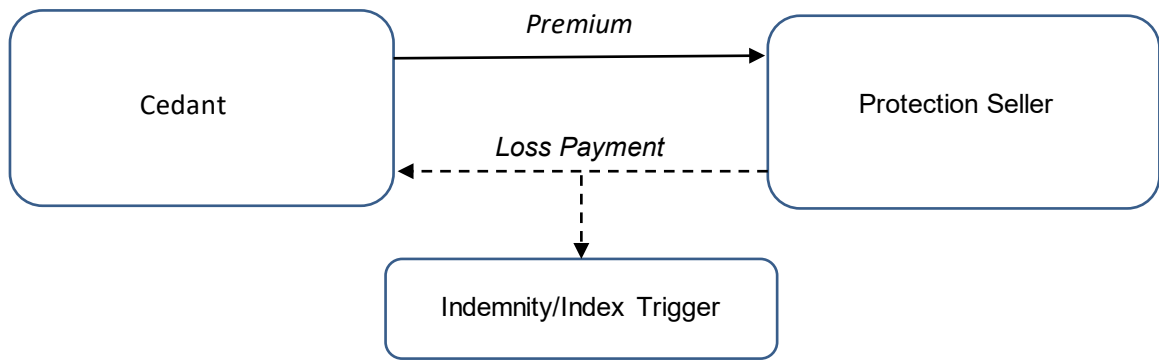


Figure 16. Structure of an industry loss warranty transaction

Source: Author

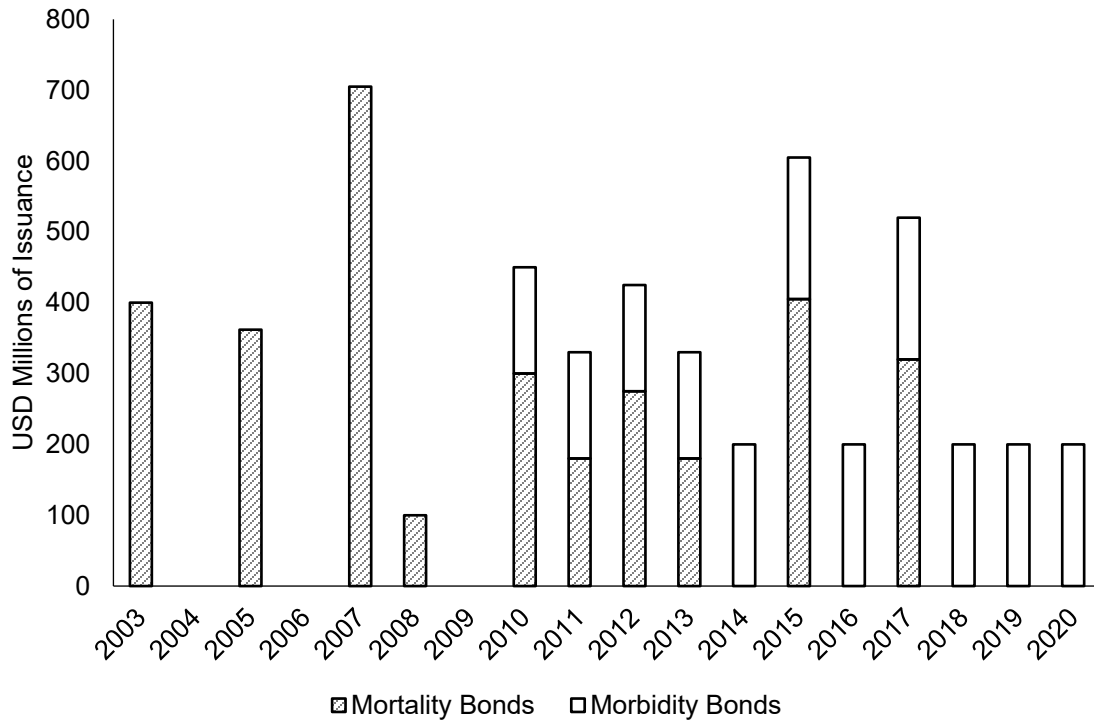


Figure 17. Extreme mortality/morbidity bond issuance
Source: Evans (2020f).

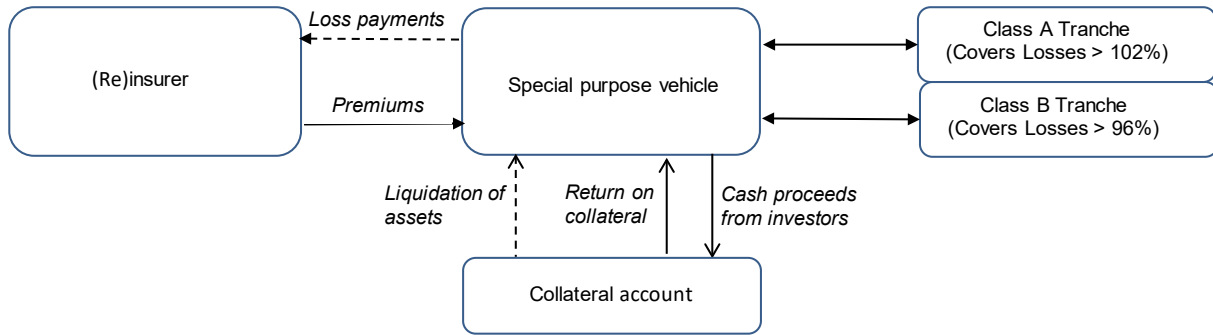


Figure 18. Structure of a morbidity bond
Source: Author

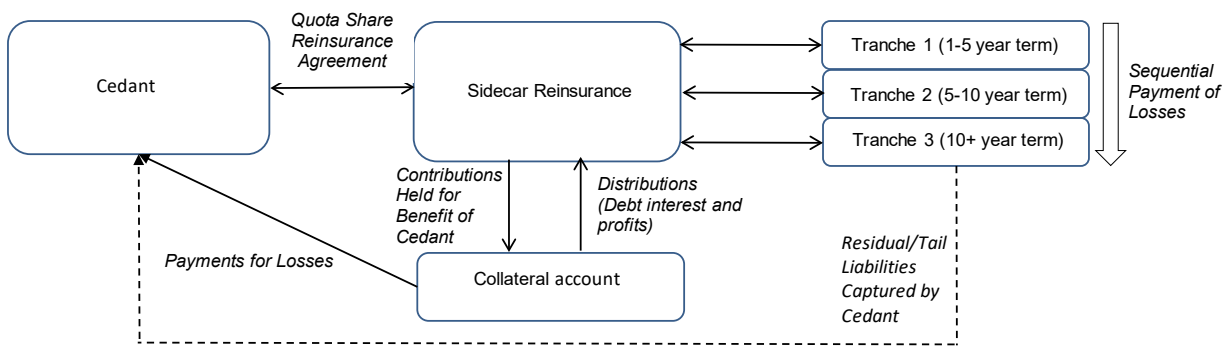


Figure 19. Structure of a long-term sidecar transaction

Source: Author

Table 1: Summary of active capital markets-accessible CAT risk transfer vehicles

	<i>CAT Bonds</i>	<i>Collateralized Reinsurance</i>	<i>Industry Loss Warranties</i>	<i>Sidecars</i>
Credit risk	Minimal ^a	Minimal	Depends ^b	Depends ^c
Basis risk	Depends ^d	Minimal	Yes	Minimal
Moral hazard	Yes	Yes	No	Moderate
Transparency	High	Low	High	High
Typical term	3-5 years	1 year	1 year	1 year
Standardization	Moderate	Low	Moderate	Low
Liquidity	Moderate	Low	Low	Low
Outstanding (2019)	\$30 billion	\$49 billion	\$14 billion	

Notes:

^a CAT bond credit risk is usually minimal but depends on investment restrictions, swap counterparty arrangements, topping up rules, etc.

^b Industry loss warranty credit risk depends on if the limit is collateralized

^c Sidecar credit risk depends on structure and collateral arrangements

^d CAT bond basis risk depends on whether it is indemnity-based (no basis risk) or not.

Source: Cummins and Weiss (2009), and author's assessments based on market surveillance and particularly the Artemis.bm website.