

● **On Insurability and Transfer
of Pandemic Business
Interruption Risk**

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**Research
Brief**

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Abstract

The COVID-19 pandemic not only induced widespread anxiety and inactivity in the global economy but also raised questions about how society could better absorb financial damages arising from future catastrophic events. This paper addresses some important questions such as what a risk is, how risks can be transferred away from individuals and business owners, and what makes a risk insurable.

Keywords

insurability, risk transfer, correlation

1 Background

1.1 Motivation

The ongoing COVID-19 pandemic has resulted in great disruptions in the daily routines of people all over the world. Amid mandatory shutdowns, shelter-in-place orders, and overall slowdowns in economic activities, business owners are seeing ongoing lost profit. The need to provide financial relief to these business owners is imminent and, more generally, raises important questions about how the risk of pandemic-induced business interruption damages could be absorbed better in the future.

Efforts to require commercial property insurers to indemnify against COVID-19-related business interruption claims have been largely unsuccessful, primarily because many, if not all, of the currently existing business interruption policies require proof of physical damage to the business premises and/or specifically exclude virus-related perils. For this reason, insurers assert that business interruption claims arising from COVID-19 are not covered.

The American Property Casualty Insurance Association (American Property Casualty Insurance Association, 2020) published a study demonstrating that insurers are not sufficiently capitalized to absorb these losses. At current surplus levels, mandating that insurers retroactively indemnify against the colossal financial damages to business owners due to COVID-19 would likely force many property/casualty insurers into liquidation. This would then disrupt the long-term stability of the insurance marketplace and jeopardize future financial relief for those same business owners. While the lack of coverage for current pandemic losses is terrible news for business owners, it also provides an opportunity for the insurance industry to ask about coverage and product feasibility for future pandemic events. In an effort to inform these ongoing discussions, this

paper will break down the concepts of risk transfer and insurability, establish criteria for insurability based on existing literature, and demonstrate why future pandemic risk is currently not insurable by the private property/casualty insurance market. The paper will also examine alternative transfer techniques for other traditionally uninsurable risks to recommend potential solutions for pandemic events that exist outside the private property/casualty insurance market.

1.2 Definitions

1.2.1 Risk

We begin with a clarification of what we mean by risk. To keep our discussion relevant to the topic of insurability, we focus only on risks involving a sudden deterioration in someone's financial position after an event taking place. The possibility of such an event is what we call risk. The event itself must (1) take place in the future, (2) encompass uncertainty as to the location and timing, and (3) arise out of circumstances beyond the control of the individual whose wealth is impaired.

As an example, a house burning down due to a weather-induced wildfire is a risk from the insurer's portfolio-level perspective. The event of an accidental fire, if it occurs, would take place in the future, with uncertain timing and location, and in ways that neither the insurer nor the insured would be able to control or anticipate, thereby satisfying all three criteria specified above.

In contrast, a house burning down due to arson committed by the insured is not a risk from the insurer's portfolio-level perspective. Arson is, by definition, premeditated, and therefore the timing and location of it can be anticipated and controlled by the insured, thereby violating the above criteria.

1.2.2 Risk transfer

Risk transfer is an agreement made between two parties that allows one party to bear the risk of the other in exchange for an immediate and adequate financial reward.¹ An example of such an agreement would be a life insurance policy. The insured would pay the life insurance company an amount of premium, deemed appropriate for the likelihood of the insured's accidental death, in exchange for the life insurance company's commitment to indemnify against the future loss in standard of living experienced by the insured's household members following such an event.

1.2.3 Insurability

Insurability is the feasibility of creating contracts to transfer risk from the insureds to the insurer. Many criteria for insurability have been established and explained in actuarial literature (Society of Actuaries, 2020) (Ross, 2019), (Charpentier, 2008), and (Webel, 2019). We have grouped them into five actuarial criteria and two economic criteria, as shown and described in Table 1-1.

¹ Immediacy may not be present in all insurance contracts. Retrospectively rated policies, sliding-scale commissions, swing-rated policies, and other contractual provisions may alter the premium based on emergent loss experience over the life of the policy. Regulators have developed mechanisms to determine whether risk exchange has actually taken place. This typically requires the assuming entity to present persuasive statistical evidence that they may experience a financial loss.

Table 1-1: Insurability criteria

Criterion	Criterion Type	Detail
Fortuitous	Actuarial	Timing and location of future events must be uncertain and accidental.
Measurable	Actuarial	Losses must be well defined and verifiable upon occurrence.
Independent	Actuarial	There must be weak or no correlation within a portfolio of insureds.
Market-Bearable	Actuarial	Maximum possible losses in an accident year from the insured event must not be excessive for insurance markets to absorb.
Predictable	Actuarial	Ideally, costs must be estimable, which requires a sufficient number of insureds across a sufficiently large number of historical events to be used as sample data.
Fair	Economic	There should be no potential for adverse selection or moral hazard in the policy portfolio, and the contracts should not be unfairly discriminatory to individual insureds.
Affordable	Economic	The transfer price must be attractive to both the insurers and the insureds.

2 Insurability of Pandemic Risk

We now assess the insurability of pandemic risk using these criteria. Other risk examples will be mentioned for the purpose of comparison. *It is important to keep in mind that insurance products often do exist in the insurance marketplace for some of the coverages that do not meet all the criteria.* This is usually made possible with additional support from public funds, as will be discussed in Section 3.

2.1 Fortuitous

The first insurability criterion demands that future risk events be uncertain and accidental in timing and location. Note that this criterion should not be viewed from the perspective of an individual insurance contract, as the location being insured is always certain in a property insurance contract, for example. The criterion should be viewed from the perspective of the future event itself, i.e., the location of the next fire is uncertain. As an example, terrorist attacks are risks that notoriously do not satisfy this criterion [Charpentier 2008], as they are usually deliberate and planned.

In the context of virus-induced business interruption risks, proper exclusions in the policy language can allow this criterion to be met. Virus outbreaks and subsequent shelter-in-place orders are uncertain and accidental in timing and location. However, an outbreak typically develops through multiple stages to eventually become a pandemic [Dixon & Saunders-Medina 2020]. The outbreak may initially be concentrated in very few community locations and then

spread to nearby ones until it reaches entire cities. From there, it may spread to other nations and then globally. Clearly, the likelihood that an outbreak will turn into a pandemic is much greater at the later stages than at the beginning stages. Because these stages can take a long time to develop, the timing of the establishment of insurance contracts matters in terms of insurability. If an outbreak has not happened at time of contract, the risk is completely fortuitous and therefore insurable. However, if a virus outbreak has already reached national scale at time of contract, the risk is no longer fortuitous, from either the insurer's or the insured's perspective. Both parties would be entering into the risk transfer agreement with full knowledge that an indemnification will happen, and the insurers would likely be able to produce a more accurate estimate of a fair premium at a later stage of the pandemic. Usually, such a scenario results in an expensive policy. In other words, insuring for pandemic risk in this scenario is akin to selling life insurance policies to terminal cancer patients. For a valid insurance contract to exist to cover business interruption losses resulting from pandemics, insurers must identify the "fortuitous time frame" and exclude all other time frames from the coverage.

2.2 Measurable

The second insurability criterion demands that losses be well defined and verifiable upon occurrence. A clear example in violation would be the risk of losing peace of mind, as such "claims" cannot be defined or quantified. Unfortunately, the measurability criterion is also difficult to meet for business interruption losses resulting from pandemics. Quantifying the actual losses would entail tracing the insured small business's financial transactions from the beginning to the end of the pandemic. Determining when a pandemic starts is a tricky business, even for the World Health Organization [Etzion, Forgues & Kypraios 2020]. Furthermore, a pandemic can end in many ways—or it may never end, as seen in the case of historical bacterial outbreaks prior to the invention of antibiotics [H.R.7011]. New wave after new wave of infections may be possible. If there is no consensus on which loss transactions should count, then future losses caused by a pandemic cannot be measurable. This would make such risk uninsurable. Insurers can mitigate this concern by clearly defining the coverage period in the contracts.

2.3 Independent

The third insurability criterion demands that insureds within the portfolio be independent from each other, or at least have very weak correlation. To see why this assumption is crucial in making risk transfer feasible, we have included a numerical demonstration in the Appendix. Flood and other geographically correlated risks usually fail to meet this criterion within the private market, as a single such event usually impacts many properties all at once. Unfortunately, pandemic risk also fails this criterion simply by definition. A pandemic is a virus outbreak that has reached global scale, meaning it will impact all the insured small business owners at once. In other words, if a pandemic occurs, claims are automatically correlated, which would make business interruption losses uninsurable.

2.4 Market-Bearable

The fourth insurability criterion demands that the capital markets be able to absorb the probable maximum loss. Terrorism, cyberattack, and flood risks are examples that fail this criterion. If the COVID-19 pandemic is an indicator, business interruption losses caused by pandemic events are also hardly market-bearable. The American Property Casualty Insurance Association estimates the total U.S. COVID-19 business interruption losses for businesses with fewer than 100 employees to be between \$255 billion and \$431 billion per month [American Property Casualty Insurance Association 2020]. To put these numbers in perspective, the surplus for all U.S. home, auto, and business insurers combined to pay all future losses is roughly \$800 billion [APCIA

2020]. Even if the insurers have the opportunity to accumulate capital over time for the purpose of indemnifying business owners against pandemic losses, these figures show that such an effort will be substantial and will likely require an exceptionally long period of time. It seems likely that pandemic-induced business interruption losses will not be bearable by the industry for a long while, making such risk uninsurable at present.

2.5 Predictable

The fifth insurability criterion demands that future average loss costs be predictable, which would require a sufficiently large number of insureds across a sufficiently large number of historical events to be used as sample data for the predictions to be statistically significant and reliable. This can be seen in the numerical demonstration included in the Appendix. Terrorism risk and, to a lesser degree now than before, flood risk are examples that fail this criterion, as a lack of recorded historical events makes modeling and risk-predicting a challenge. This may yet be the most difficult criterion for pandemic-induced business interruption risk to meet as well. We can count on the fingers of one hand the number of pandemics that have occurred in the past century [Marsh 2020]. Pandemics that happened long ago would have impacted a quite different demographic in very different economic conditions, rendering most of the data unusable for the purpose of predicting future losses. If losses are not predictable, then insurers cannot charge fair and stable premiums for the risk. This would make a compelling argument that pandemic-induced business interruption risk is not insurable.

2.6 Fair

The sixth insurability criterion, which is an economic one, demands that insurance contracts allow no potential for adverse selection and moral hazard in the portfolio. Auto assigned risk and flood risk are examples that fail this criterion, as parties that are more likely to purchase the insurance contracts are the ones likely to experience the worst losses.

Fortunately, with help from legislation and the right underwriting guidelines, this criterion may be achievable for pandemic-induced business interruption risk. The concern here is that businesses that are least adaptable to functioning in shelter-in-place and/or shutdown scenarios have more incentive to purchase this insurance than do highly adaptable ones. This would result in an insured risk portfolio that is highly skewed toward worse loss scenarios for the insurers. To mitigate this, the government could require all business owners to buy this coverage and could establish governmental insurance programs for businesses that are out of the insurers' risk appetite.

In addition, because the timing of the onset and the end of a pandemic is difficult to define, an insured small business owner could inflate the loss amounts if a pandemic does impact the business. This is an example of moral hazard. Good legislation that severely penalizes such practices may prove greatly beneficial in this case, to both the insurers and other insureds, as inflated loss amounts over time would lead to more expensive coverage for every business owner. In summation, pandemic-induced business interruption risk could potentially meet the sixth criterion given good help and support from the government.

2.7 Affordable

The final insurability criterion, also an economic one, demands that the transfer price be attractive to both the insurers and the insureds. An easy example of a risk that fails this criterion is the auto assigned risk pool, as the underlying risks are expensive to insure. Based on the discussion in Section 2.4, pandemic-induced business interruption risk likely does not meet this criterion at current surplus levels. Even if the volume and quality of data improve to allow for

better claims cost predictions, and given enough time to accumulate enough capital, additional risk margins will likely need to be built into the premium rates to account for the fact that such losses will be highly correlated. It may be difficult for such risk to meet the affordability criterion in the future. If no one can afford to buy such policies, then there would not be enough insureds in the portfolio, rendering the insurance product impractical. This would be an argument for the uninsurability of business interruption losses caused by pandemic events.

3 Public and Private Risk Sharing

3.1 Motivation

Risks that lack the characteristics for insurability as discussed in Section 1.2.3 are uninsurable risks. Private insurance markets would typically step away from such risks, as they would pose a threat to profitability or perhaps even to the solvency of the insurer in these markets. This would create coverage gaps in the general population. As an example, individuals or businesses that are considered extremely risky by insurers may find it difficult to obtain coverage in the regular insurance marketplace.

It is important to close some of these coverage gaps. From a regulator's perspective, it is important that appropriate coverage be available to all high-risk individuals or businesses. State insurance requirements may also necessitate the availability of insurance protection for certain types of risks where a compelling public interest exists. Auto insurance is a prime example. The ability to drive is an economic necessity in places like the United States. The regulator has a compelling economic motivation, which is balanced against financial responsibility laws. Similarly, for workers' compensation insurance, the need to employ a workforce to carry out business is balanced against the responsibility to provide for the well-being of the workers. The pandemic has illustrated the need to consider business interruption as another coverage for which there is a compelling public interest. In this case, governments will need to play a significant role in closing the coverage gaps for pandemic business interruption claims, much like what we have seen in the auto and workers' compensation insurance examples.

3.2 State-Level Risk Sharing Arrangements

State governments, with their stronger ability to make funds available when compared to the private market, typically step in to close some of these coverage gaps. They do so with or without the need for the private market to participate in the loss reimbursement.

Assigned risk pools facilitate the achievement of this objective. These pools bring all otherwise uninsurable risks together to provide coverage for them. All insurance companies are required to participate in this pooled insurance framework in the same proportion that they write business in the regular (non-assigned) market. This means that all insurers share the premiums and the claims arising out of the pools in proportion to their market share for the relevant line of business in the state. The California Automobile Assigned Risk Plan, the Texas Automobile Insurance Plan Association, and the Maryland Automobile Insurance Fund are some examples.

Another framework, which Florida has adopted, is for the state to provide insurance directly to those who find it difficult to obtain coverage, or to provide reinsurance protection to other private insurance players. For example, Citizens Property Insurance Corporation was established by the Florida Legislature to provide windstorm and general property insurance to owners of homes, businesses, and condominiums who could not obtain insurance in the regular marketplace. It is a not-for-profit insurer. The Florida Hurricane Catastrophe Fund is a tax-exempt state trust fund that provides additional reinsurance for insurers writing residential insurance.

Florida also has various joint underwriting associations (JUAs) that operate as the markets of last resort for qualified applicants who are unable to purchase a particular type of insurance from the private market. The Florida Automobile Joint Underwriting Association, for example, addresses the needs of automobile insurance buyers. Other associations, such as the Florida Workers' Compensation Joint Underwriting Association and Florida Medical Malpractice Joint Underwriting Association, serve similar purposes for workers' compensation and medical malpractice coverage.

For an already disabled worker, the workers' compensation claims arising out of a subsequent injury could be materially higher than for an otherwise healthy worker. This would make the risk much less insurable from the perspective of the private workers' compensation insurance market, which could in turn act as a deterrent in the employment of such workers. Some states have established second injury funds to reimburse the workers' compensation insurer or self-insured employer for a claim arising out of an injury to an already (partially) disabled worker, thereby encouraging the employment of workers with preexisting disabilities. Second injury funds are financed through assessments made to insurers based on their workers' compensation premiums or paid benefits.

The examples mentioned so far have a scope that is limited to individual states, and the coverage gaps are addressed at the state level. There are other examples of situations in which the scope of the problem is much vaster and crosses state borders. In such cases, the risk transferring solution becomes a matter of federal public policy, as otherwise the sustainability of economic, business, and political environments at the state level would be jeopardized. To minimize the administrative burden on the federal government, these solutions tend to arrange for the state government and/or the private market to take on the administration responsibilities of issuing insurance policies, with the federal government serving as the main or sole risk bearer, or as a backstop reinsurer. The business continuity exposures arising out of a pandemic fall into this broad-scope category; therefore, it is beneficial to examine examples of existing solutions set up to address other risks. Two such examples are solutions for flood and terrorism risks. We will look at these two examples, along with their applicability to pandemic risk, in more detail in the following section.

3.3 Private Administration, Federal Risk Assumption

3.3.1 National Flood Insurance Program: Brief History of Flood Risk Transfer

Flooding events are among the most common and costly natural disasters. Historically, flood has been considered an uninsurable risk by the private market for a number of reasons. First, the cost of a flood event is substantial, rendering risk-based premiums unaffordable for homeowners living in exposed areas. Second, when modeling and pricing segmentation techniques were in their infancy, a fairness problem emerged, in that lower-risk insureds would be paying excess premiums to subsidize higher-risk insureds. Adverse selection would be expected to follow, as more homeowners living in exposed areas became more likely to purchase a policy, and homeowners living in areas that are less flood-prone deemed premiums to be too high and were discouraged from buying such an insurance product, leading to a downward spiral of profitability for the insurers. Finally, catastrophic flood losses negatively impact surplus and could lead to private insurance company insolvencies.

In the absence of a risk transfer mechanism, homeowners in flood-prone areas would be left with no protection. Mortgage lenders would be unwilling to provide loans for homes in these areas, which would depress home values and activities within the construction sector, which would then cripple the industry's ability to meet residential needs. Following frequent flooding

losses in the 1960s and increasing federal spending on relief, it became apparent that a federal insurance solution was needed to provide more sustainable financial relief.

As a result, the U.S. Congress established the National Flood Insurance Program (NFIP) in 1968 (The American Institutes for Research; The Pacific Institute for Research and Evaluation; Deloitte & Touche LLP, 2002) as a response to this protection gap. The Federal Emergency Management Agency (FEMA) manages the program, which provides federally backed flood insurance to residents and businesses in voluntarily participating communities throughout the country. Flood coverage is mandatory for anyone with a federally backed mortgage on a home in a high-flood-risk area.

As part of the public-private partnership, the NFIP takes the financial responsibility for all claims in the program but leverages the infrastructure and expertise of the insurance industry to administer policies. Private insurers, known as Write Your Own (WYO) companies, write and administer the NFIP policies under their own names, for which they receive an expense allowance. Flood coverage is identical across all WYO companies, and all rates are established by the NFIP.

However, the NFIP has suffered all the same problems the private insurance companies expected to face themselves had they launched their own flood insurance products. Initially, the NFIP's premiums were shown to be insufficient in the aggregate, and the program faced problems with the accuracy of its risk maps and price segmentation processes.

For the reasons mentioned above, private insurers have thus far not assumed much flood risk. However, in recent years, substantial advancements have been made in modeling techniques and technology to better estimate flood risk. Private insurers have therefore begun to feel more confident about risk assessment.

The Biggert-Waters Flood Insurance Reform Act of 2012 and the Homeowner Flood Insurance Affordability Act of 2014 made landmark changes that eliminated certain rate subsidies, thereby making the federal flood program more financially sound and encouraging greater private sector participation.

A greater ability to measure risks and to charge premiums that can return appropriate profits resulted in a much-improved private insurance presence. Some insurers now even perceive flood risks to be a market opportunity. Between 2016 and 2017, for instance, the number of private insurers selling stand-alone flood risk policies increased from 49 to 88, with total direct premiums jumping almost 60%, from \$357 million to \$570 million.

3.3.2 NFIP-Inspired Proposal for Pandemic Business Interruption Risk

The increasing private-market participation in flood risk coverage demonstrates that an uninsurable risk can become more insurable over time.

Within that context, a federally backed solution for pandemic-related business interruption coverage along the same lines as the NFIP could be useful in the near term, while historical data and loss-predicting techniques are still inadequate. One such option being discussed at the time of this writing is the Business Continuity Protection Program (BCPP) (American Property Casualty Insurance Association, 2020), which would be federally backed and administered by FEMA. In return for a premium, companies would stand to be reimbursed up to 80% of payroll, benefits, and operating expenses for three months after a federal declaration of a public health emergency. This proposal would follow a similar arrangement to that of the NFIP, in which the risk is assumed by the program, while the private sector takes on the administrative responsibilities.

The benefits of such an arrangement are clear from the standpoint of the private sector. The size and scope of the funds required to indemnify the insureds would be drastic in the case of a future event, and the federal government should be the party better placed to provide the required relief. The downside, of course, is that such a program may run into the same challenges as the NFIP, creating tax burdens and fairness concerns in its pricing.

As pandemic risk modeling improves, we can expect to see a transition to a more shared risk assumption between the public and private sectors, akin to what has started for flood risk. Below, we will see more examples of how losses from past pandemic events have led to some early products in the private market as advancements are made in measuring pandemic risk.

3.4 Reinsurance Backstop

3.4.1 Terrorism Risk Insurance Act: Brief Overview and History of Terrorism Risk

Commercial property/casualty insurers and reinsurers have historically covered terrorism risk. The events of 9/11, however, made clear that the scope of the risk was much greater than what had been assumed by the industry. Given the unpredictable and non-accidental nature of this risk, accurate pricing is a major challenge. For this reason, despite the fact that private sector reinsurers had helped pay out huge sums in claims payments, primary insurers still felt the pressure to exclude terrorism coverage in the future (Webel, 2019). In turn, banks were unwilling to lend money for major construction projects, which, among other reasons, contributed to a slowing of the economy.

In response to this situation, the federal government stepped in to provide backstop coverage for future terrorism acts through the Terrorism Risk Insurance Act (TRIA) in 2002. TRIA created a unique public-private partnership to support the development of the terrorism insurance market.

Under the TRIA arrangement, primary insurers administer terrorism coverage via commercial insurance policies. The federal government assumes risk only when industry losses from a terrorism event breach a certain threshold (\$200 million in 2020). The individual insurance company first meets its own deductible, which is a percentage of its direct earned premiums in the prior year (20% in 2020). Above this deductible, a share of the losses is paid by the federal government (80% in 2020), and another share is paid by the insurance company (20% in 2020). There is an annual cap on the payments (\$100 billion in 2020), above which neither the federal government nor the insurance companies are liable.

This program functions somewhat like reinsurance, but it is a backstop. Primary insurers do not pay any reinsurance premium up front for the federal share of loss payments, and the federal government does not maintain any reserves like a private sector reinsurance company typically would. The federal government supports the risk transfer by standing behind the program, but the first losses are still indemnified by the insurance companies. There is also a provision to recoup federal payments through surcharges if the aggregate losses retained by the insurance industry do not exceed a certain threshold.

3.4.2 TRIA-Inspired Proposal for Pandemic Business Interruption Risk

The Pandemic Risk Insurance Act (PRIA) (H.R.7011 — 116th Congress (2019-2020), 2020) is designed along the same lines as TRIA. It proposes that federal indemnification be triggered when industry business interruption losses arising out of a pandemic breach a \$250 million threshold. The structure being designed at the time of this writing proposes that insurers be responsible for their deductible (5% of direct earned premiums from the prior year) and then for a copayment of 5% of losses above that deductible. Federal aid would be available for 95% of

the losses above the deductible. The annual cap on the payments would be \$750 billion, recognizing the extreme damage from a full-blown pandemic.

One major difference between PRIA and TRIA is that while insurer participation is compulsory under TRIA, it is voluntary under PRIA. Also, while insurers are off the hook for loss amounts above the annual cap on insured payments under TRIA, insurers are expected to reassume the exposure above the annual cap under PRIA.

3.5 Comparison of BCPP and PRIA

It is worth comparing the proposals above specifically in the context of pandemic business interruption risk (see Table 3-1 for a summary).

Under the BCPP, all financial risk is assumed by the federal government. In contrast, under PRIA, the private sector may still potentially have to pay huge sums in the event of a future pandemic, even though the federal government may be the major shareholder. Several major insurance industry groups favor the BCPP, given the extreme capital requirements to cover this risk.

The BCPP envisions charging a premium to the insureds. As previously discussed, determining pricing would be a challenge, but the government is likely in a better position to do this than the private market. At the very least, it should be able to utilize economic data and expertise from top-ranked epidemiologists to infer expected frequencies and severities of future claims, assess the preparedness of businesses to mitigate any future losses, and collect enough funds to sustain the framework in the short term. In contrast, PRIA envisions that insurers would set the premiums for the risk, which will likely be a significant hurdle for insurers even considering the benefit of not having to pay for the backstop.

In terms of relief efficiency, the BCPP again has an edge over PRIA. The BCPP can process the reimbursements as soon as the three-month declaration period is fulfilled. PRIA, in contrast, would adjust pandemic business interruption claims the same way private insurance companies typically would for other business interruption losses. This means that the BCPP would reimburse the businesses much more quickly.

Two other relevant and related items to consider are coverage availability and take-up. Neither of the proposals would guarantee widespread availability nor require all insurers to participate. The proposals might not offer adequately or affordably priced policies and might therefore fail to attract a large group of policyholders while still enabling the industry to maintain overall solvency. It is possible that lenders could stipulate this coverage as a new requirement for business loans, which would encourage take-up. The tendency of businesses to take up coverage will also depend on what is covered. While the BCPP would reimburse businesses for a percentage of payroll and other expenses, PRIA would require insurers to provide coverage on the same terms as for other causes of loss and would therefore not result in widespread wage replacement during a shutdown.

The good news is that increasing take-up rates have been observed over time for both flood risk and terrorism risk coverage. Hopefully, the same kind of success can be reproduced within both the BCPP and PRIA.

Table 3-1: Comparison of the BCPP and PRIA

Characteristic	BCPP	PRIA
Risk Assumption	Federal government	Sharing between federal government and private insurers
Premium Setting	Federal government	Private insurers
Premium Determination	No clear guidance	No clear guidance
Premium Affordability	Government has the ability to keep premiums manageable	Private insurance is less likely to guarantee an affordable price
Coverage	Percentage of payroll and other expenses	Coverage on the same terms as other causes of loss, implying no wage replacement
Relief Efficiency	Much faster reimbursements to businesses	Relatively slower (expected to be similar to other business insurance claims settled by the private market)

3.6 Alternate Risk Transfer

In addition to the federal government, the insurance industry can also partner with the wider capital markets to help absorb losses from some of the uninsurable risk in return for an acceptable return. Doing so would allow the insurance industry to increase its capital capacity and allow capital markets to invest in the insurance industry. This provides good diversifying opportunities to both sectors. We will look at some examples of this type of risk sharing and their potential applicability to the pandemic coverage gap.

3.6.1 Insurance-Linked Securities and Catastrophe Bonds

Insurance-linked securities (ILS) broadly represent the financial instruments that derive value from insurance risk trading. Catastrophe bonds are the most common example. These bonds are typically issued by (re)insurance companies through a special purpose vehicle. The investors receive coupon payments in return for assuming the risk. However, the interest payments and the principal would be reduced or eliminated if the predefined event is triggered. (Re)insurers have been able to leverage the benefits of this arrangement to spread the most extreme natural catastrophe exposures (e.g., Florida hurricanes and Japanese earthquakes) to the wider capital markets through catastrophe bonds (or cat bonds for short).

These financial instruments have different types of triggers. For example, an indemnity trigger would pay out when the sponsor’s own losses breach a certain threshold. In this case the basis risk (risk that the reimbursement from the cat bonds will be different from the insurance company’s actual damage costs) is low, which is a benefit to the bond issuer. However, this trigger requires investors to have detailed knowledge of the exposures of the issuer and may delay the estimation of final payout until all the claims are settled, and it also creates more

opportunity for hazard risk (risk that the insurance company will inflate its own damage costs to hit the trigger).

An industry loss trigger, in contrast, would pay out if industry losses breach a prespecified value. An individual company's recovery from the bond may not completely align with its own loss experience from the event, but indemnification would come relatively quicker and be more transparent, as industry figures tend to be publicly available (Property Claim Services, for instance, provides these figures).

Alternatively, parametric cat bonds trigger a payout when an event with predefined parameters takes place. An example of a parametric trigger could be when an earthquake with a magnitude of more than 7.0 on the Richter Scale takes place in a specific geographic area. Because event parameters are available shortly after an event occurs, these transactions are very transparent and can be settled much more rapidly than those relying on other trigger types. However, basis risk could be high, as no reference is made to individual companies' exposures.

3.6.2 ILS-Inspired Proposal for Pandemic Business Interruption Risk

In the context of pandemic business interruption risk, the idea of borrowing a parametric type of trigger from cat bonds seems particularly useful. Pandemic-induced business interruption can stretch for long periods; insurance policies designed utilizing a parametric trigger would allow for quick and unambiguous coverage and claims settlement processes. Policyholders could then receive timely payments to offset ongoing losses arising from closed or reduced operations.

The hard part is determining the appropriate parametric trigger. Such a trigger must relate very closely to the risk of business interruption during pandemics, be well understood, and provide assistance in modeling the risk.

Statistical parameters such as Metabiota's Pathogen Sentiment Index could be useful. This index gauges public fear and behavioral change in the wake of an epidemic outbreak that translates into decreases in consumption. With advancements in disease tracking and reporting, machine learning, and artificial intelligence, we can expect more examples of such indices, offering increasing accuracy.

Springboard's footfall metric similarly measures changes in pedestrian traffic and can be related to changes in consumer sentiments during an outbreak. Apple's COVID-19 Mobility Trends Reports reflect requests for directions in Apple Maps and can be related to measures of consumer activity on the roads. Google's COVID-19 Community Mobility Reports could be another good example of a tool to track trends in visits over time; by geography; and across different categories of places such as retail and recreation, grocery stores and pharmacies, parks, transit stations, workplaces, and residences.

Alternatively, civil authority orders could be used as triggers. These types of triggers are based on orders from government agencies that can affect business operations, such as complete or partial lockdowns, social distancing and capacity limitations, or suspension of travel services. The strictness of the orders can be indicative of the extent to which pandemics have affected the economy.

3.7 Existing Blueprints

While the frameworks proposed thus far are still being discussed and developed, there are a few existing pandemic business interruption products that have been created due to historical events. Some did not attract significant attention prior to COVID-19, and others are still

experimental in nature. They are worth a quick look, as they relate directly to pandemic business interruption coverage gaps.

3.7.1 Pandemic Business Interruption Product for Multiple Industries

In 2018, Marsh launched a product named PathogenRX, which provides financial protection against the risk of business interruption due to an infectious disease outbreak. The product is underwritten by Munich Re and leverages the modeling from Metabiota's infectious diseases database. The product enables companies to model financial risk in the event of an outbreak, epidemic, or pandemic.

The policy is triggered using parameters such as mortality or the number of infections in a predefined area, or explicitly defined events, such as a civil authority's imposition of a lockdown or the declaration of a public health emergency. Indemnity protection is provided and can cover loss of gross profits, loss of revenue, and extra expense incurred because of an infectious disease event in a designated geographical coverage area. The product can be tailored to include specified expenses, geographies, and disease types.

Target industries for this product include hospitality and travel, sports and entertainment, higher education, retail, manufacturing, and mining. Among existing options, this product would have been closest to providing indemnity protection during the coronavirus pandemic. Unfortunately, it did not gain much attention from risk managers until the event happened.

3.7.2 Pandemic Business Interruption for Hospitals

In 2016, AXIS Healthcare launched a product named AXIS Healthcare Medical Catastrophe Business Interruption and Extra Expense, designed to provide medical catastrophe ("contagion") business interruption insurance for U.S. and Canadian hospitals. Insurance coverage offered protection against a loss of revenue caused by the outbreak of a wide range of potential pandemics or contagious diseases, including any disease that can be transmitted by direct or indirect contact.

This was essentially a parametric product, structured using four triggers. For the policy to respond, a contagion needed to result in just one of the following four triggers being breached:

- A government quarantine of a hospital
- A 25% threshold for absentee medical personnel
- A 25% threshold for reduction in inpatient stays
- A 25% threshold for reduction in emergency room visits

Similarly, parametric triggers that reflect a reduction in business activity during pandemics could prove useful in designing a product that responds directly to revenue loss during such events. The maximum length of the coverage could be limited to a few months. The AXIS product mentioned above limited the coverage to 12 months from the date the coverage was triggered.

3.7.3 Ebola Business Interruption

NAS Insurance (now Tokio Marine HCC) announced the introduction of Ebola Business Interruption coverage in 2014. Then as now, most insurance policies did not cover business interruption risk arising from causes not related to physical damage. This insurance policy attempted to address the gap and provided coverage if there was a mandatory and complete shutdown announced by government agencies due to Ebola exposure.

3.7.4 World Bank Pandemic Emergency Financing Facility

In 2017, the World Bank launched specialized pandemic bonds, the Pandemic Emergency Financing Facility (PEF), with the objective of providing financial support to developing countries facing the risk of a pandemic. This effort was aimed at transferring the pandemic risk in low-income countries to financial markets using bonds.

The financing structure, which combines funding from the bonds with over-the-counter derivatives that transfer pandemic outbreak risk to derivative counterparties, has attracted great interest from the wider financial markets.

Countries' PEF financing eligibility is triggered when an outbreak reaches predetermined contagion levels, based on factors including the number of deaths, the speed of the spread of the disease, and whether the disease crosses international borders. The trigger determinations are made based on publicly available data as reported by the World Health Organization.

During the COVID-19 pandemic, the PEF was triggered and paid out about \$196 million to developing nations. However, there has been criticism of the PEF response. For instance, the triggers of the bond are complex, which meant that considerable time passed before all the conditions were met, leading to a delay in relief reaching developing countries. In terms of relief amounts, the World Bank is now planning to spend about \$160 billion to fight COVID-19, which is about 800 times the maximum payout of the PEF and raises questions regarding its effectiveness. These shortcomings have illustrated that while the PEF was originally proposed as a robust, innovative product, there are clearly important learnings that should be taken on board for any future program design along these lines.

4 Conclusion

While relief for COVID-19 pandemic-induced losses is urgent, we cannot lose sight of business owners' longer-term needs and must protect the financial integrity of the property/casualty insurance industry. In this paper, we have shown that not all potential events are risks, that not all risks are transferrable from one party to another, and that not all transferrable risks are insurable by the private sector.

In summation, pandemic business interruption risk is hard to measure, heavily correlated, difficult for a single market to absorb, and challenging to price in the current environment. For these reasons, it is not insurable by the private sector at the time of this writing. Risk sharing arrangements with the federal government are being developed, but we can expect similar shortcomings from these arrangements as those observed under the NFIP and TRIA. However, reason for optimism lies in the fact that the world will likely be more prepared for the next pandemic. More data and more advanced knowledge and modeling techniques are likely to become more available over time, and blueprints already exist from which we can build better solutions.

5 Appendix: Risk Transfer and Correlation

5.1 Risk Tolerance

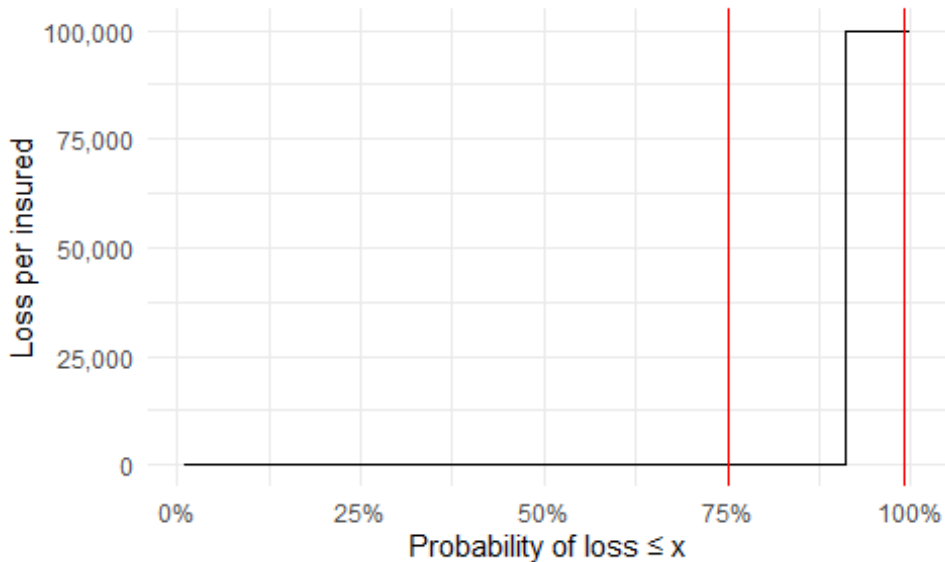
What would induce someone to take on the risk of another? We can just as easily ask what certain present cost would someone pay to be rid of the uncertain future cost. There must be a financial incentive for both parties.

We will look at this question from both perspectives. To simplify the wording, we will refer to the party that has the risk as the *insured* and the party that assumes the risk as the *insurer*.

Imagine a homeowner who wants to protect the value of her property, which is currently worth \$100,000. Assume that in any given period there is a 10% chance that the home will experience a total loss. Further assume that there is no other source of loss to the property. If the homeowner wanted to be 100% certain to hold as much wealth as the home is worth, she would need to hold \$100,000. Let's assume that she will tolerate some level of risk. If she wants to be 75% certain of no loss in value, she needn't do anything. If she wants to be 95% certain, she will again need to hold \$100,000.

We may visualize these scenarios as presented in Figure 5-1. The vertical axis shows the amount of a loss per insured, and the horizontal shows the probability that losses will be less than or equal to that amount. Note the first red line at 0.75. This indicates that 75% of the time, losses will be zero or less. Obviously, a loss cannot be less than zero. The second vertical line at 0.90 (just to the left of the axis marker at 1.00) tells us that losses will be less than or equal to 100,000 90% of the time.

Figure 5-1: One property at risk



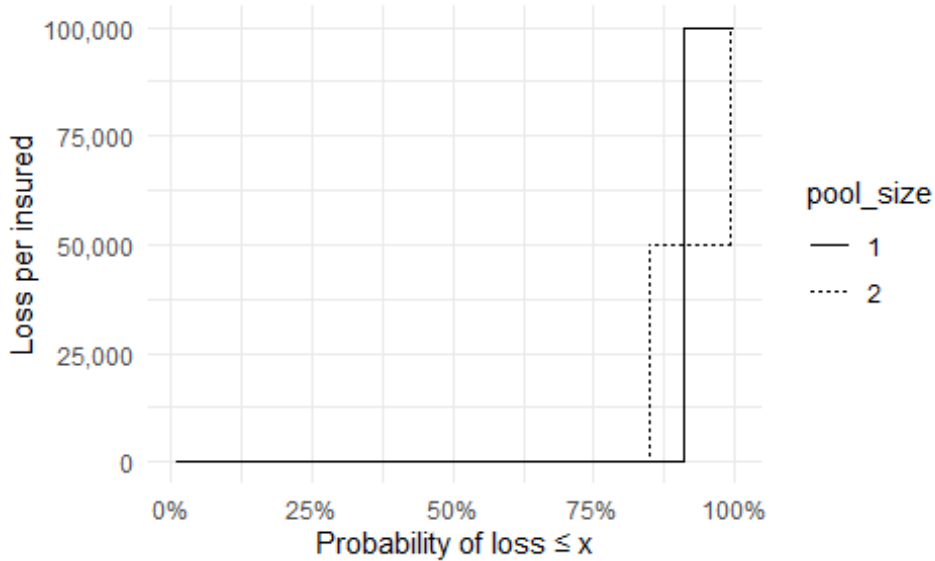
This corresponds to the scenario we have described and isn't particularly interesting. We present the first visual display because it will simplify discussion of more general cases in which more than one insured is involved.

Imagine now that this homeowner decides to pool her risk with another homeowner. The second property has the same value and risk of a total loss as the first. If either home is lost, the two homeowners will share the cost to replace it. Note that this arrangement contemplates a scenario in which one homeowner will suffer a financial loss *even when their own home is undamaged*. This may represent a rational choice because it is offset by the possibility that they will be equally compensated by the second homeowner in the reverse situation. We are not suggesting that it is likely that such an arrangement will be struck; we are simply offering an explanation for why this behavior may be plausible.

In Figure 5-2, we overlay the two-insureds scenarios (dashed curve) on top of the one-insured scenarios (solid curve). Note that for the two-homeowner case, the maximum loss in the pool

would be \$200,000, but the maximum loss per insured would be only \$100,000. The per-insured loss amount view reflects the economic reality for each individual and allows us to compare larger pools of insureds on the same visual scale.

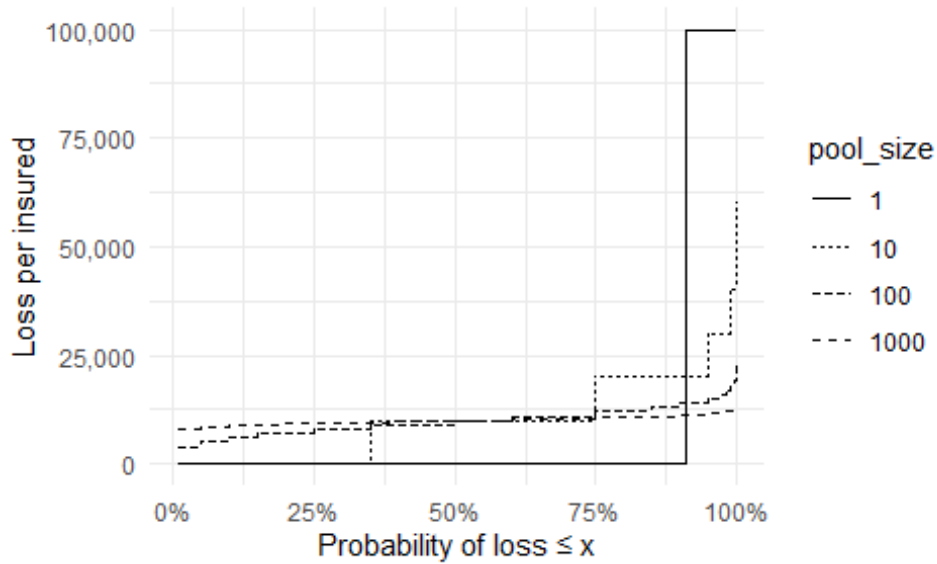
Figure 5-2: Loss payments for two homeowners



Note that compared to the solid line, the dashed line reaches maximum loss per insured at a higher probability threshold. This reflects the reduced chance associated with both homes experiencing a loss at the same time. Additionally, there is a new step at \$50,000. This reflects the case where one homeowner, but not both, experiences a loss. In this instance, the insured whose home was *not* damaged still suffers a financial loss. Moreover, the probability of experiencing any loss at all has *increased*; the dashed line reaches a non-zero loss per insured at a much lower probability threshold.

We can carry the example forward with as many insureds as we like. Figure 5-3 shows the results for one, 10, 100, and 1,000 insureds. Notice how the line for 1,000 insureds is virtually horizontal.

Figure 5-3: Loss payments for different-sized pools of insureds



This form of risk pooling is the essence of insurance. As the saying goes, “The premium of the many pays for the claims of the few.”

It may also be useful to view the results in a table. Table 5-1 shows the average amount of loss per insured for risk pools of increasing size. Looking at the top row, we see that the numbers increase, but the increase slows as the size increases. For example, the average loss at 10% moves from 0 to 4,000 when the pool increases from 1 to 50 risks. However, the pool size must increase to nearly 500 for the average loss to increase by 4,000 again. Further, the increase from 500 to 10,000 is just over half as much, at 1,420 (9,620 – 8,200).

Looking at the columns, we see that the difference between the top and bottom figures decreases as the size of the risk pool grows. By the time we reach 10,000, the difference between the top and bottom figures is less than 1,500.

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Table 5-1: Average loss and probability for pools of various sizes

loss_prob	1	2	5	10	50	100	500	1,000	10,000
10.0%	0	0	0	0	4,000	6,000	8,200	8,800	9,620
25.0%	0	0	0	0	6,000	8,000	9,000	9,400	9,800
50.0%	0	0	0	10,000	10,000	10,000	10,000	10,000	10,000
75.0%	0	0	20,000	20,000	12,000	12,000	10,800	10,600	10,200
90.0%	0	50,000	20,000	20,000	16,000	14,000	11,800	11,200	10,390
95.0%	100,000	50,000	40,000	30,000	18,000	15,000	12,200	11,600	10,500
97.5%	100,000	50,000	40,000	30,000	18,000	16,000	12,800	11,900	10,590
98.0%	100,000	50,000	40,000	30,000	20,000	17,000	12,800	12,000	10,620
99.0%	100,000	50,000	40,000	40,000	20,000	18,000	13,200	12,300	10,700
99.5%	100,000	100,000	60,000	40,000	22,000	18,000	13,600	12,500	10,780
99.9%	100,000	100,000	60,000	50,000	26,000	20,000	14,400	13,000	10,940

Remember that these are amounts of loss that a participant in a risk pool may experience with varying levels of probability. The fact that the range of loss remains more or less the same in a wide range of scenarios makes it more attractive to participants on both sides of the risk transfer transaction. An insured will be induced to transfer risk if they are relatively certain of the price, which means they will seek out a pool with a large number of participants. This, in turn, provides an incentive for an insurer to construct such a pool. The greater the size of the pool, the more likely it is that they can offer a compelling price to assume the risk.

5.2 Correlation

Thus far, we have ignored something very important. We may have heard the idea that insurance works because of “the law of large numbers.” This is not really true. It would be more accurate to say that insurance is based on the idea of “the law of low correlation.” This is not a law in a mathematical sense, nor is it even a phrase in popular use like “the law of large numbers.” We are simply indulging in a bit of word play.

Returning to our original two homeowners, we assumed that the homeowners’ risks of loss were wholly independent. That is, the fact of a loss at one dwelling has nothing to do with loss at the other. For some causes of loss—water damage caused by pipe leaks, for example—this may be reasonable. For others, like hurricanes, earthquakes, tornadoes, or similar, it is not. These are causes of loss that strike many homes in close proximity to one another. Put differently, if the homes are in New York City and Johannesburg, the independence assumption may be reasonable. If both homes are in Tokyo, it may not be.

Yet geographical distance may still permit some level of association between risks. Climate change is a global phenomenon that affects many locations to one degree or another. Building materials and engineering practices will have similarities that affect the likelihood that homes may be damaged.

We may explore this with some math. A copula is a kind of model that simulates results in a pool of insureds that are associated to some degree. The amount of association can be described with the Greek letter τ (*tau*), which can take values between -1 and 1 . A value of $\tau = 0$ means

that the risks are wholly independent: dissimilar homes in New York and Johannesburg. A value of $\tau = 1$ means that the risks behave identically: a duplex in Queens. A value of $\tau = -1$ means that the risks are always opposite. All other values in between would describe various strengths of the association in either direction.

Let us explore this idea for our set of two insureds. Imagine that we roll a 100-sided die for each house and use the two numbers to plot a point on a graph. We repeat this process 1,000 times. We will also draw horizontal and vertical red lines where the probability is 90%. Points above and to the right of these lines indicate a loss. Points in the upper right-hand corner represent two losses. This would result in a graph that looks like Figure 5-4, where no association is present anywhere. If we incorporate a uniform association across all the probabilities, the graph will look like Figure 5-5, where the points drift away from the events with only one loss and into the space where either zero or two losses occur. Some models do assume such uniform association. However, this approach came under criticism in the wake of the financial crisis, when financial risk managers did not consider that borrowers would start to behave differently during extreme negative events. In the context of insurance, such extreme negative events would include disasters like a major hurricane that damages all properties in its path. There are classes of models that would consider the case in which strong associations exist in the tail. Figure 5-6 is an illustration of the output of such a model.

Figure 5-4: Risks that are not correlated at all.

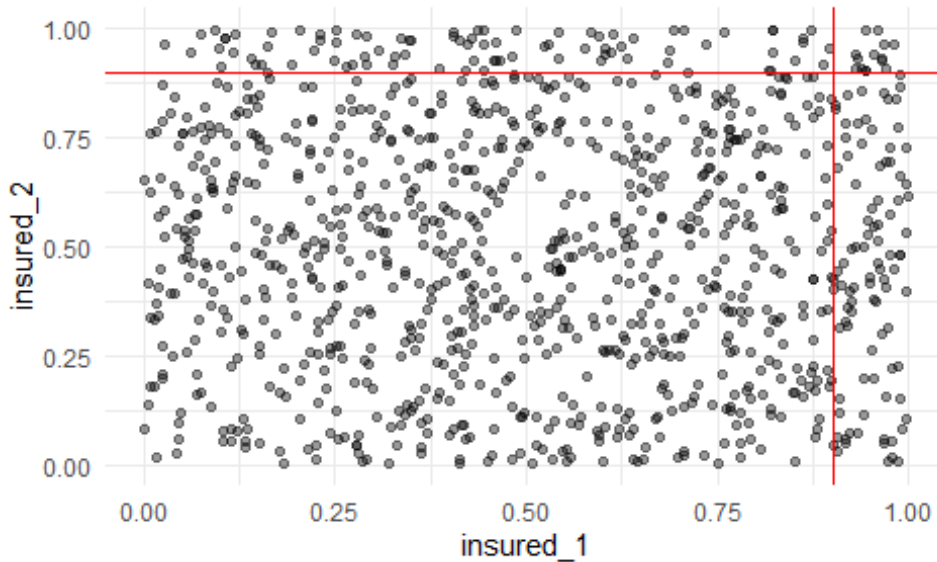


Figure 5-5: Risks that are correlated across a range of outcomes.

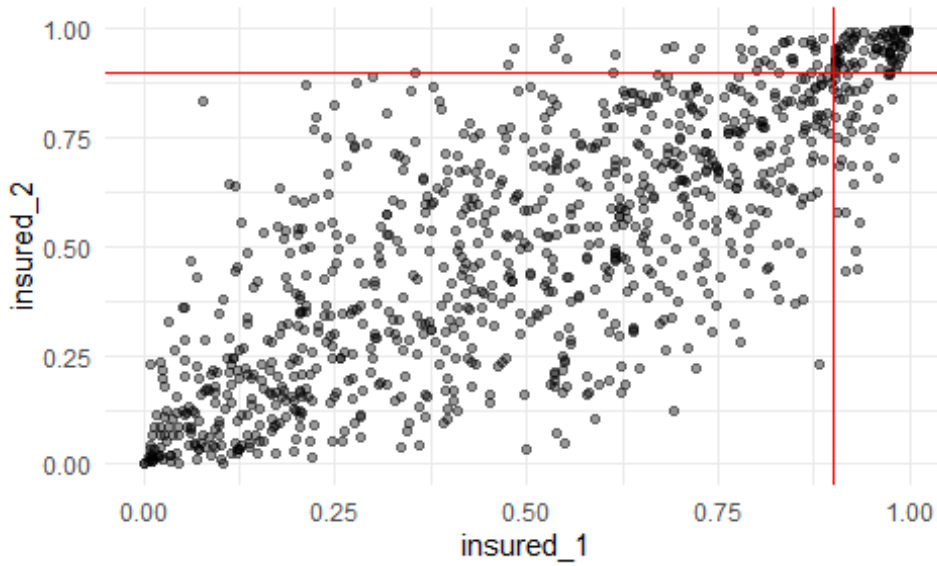
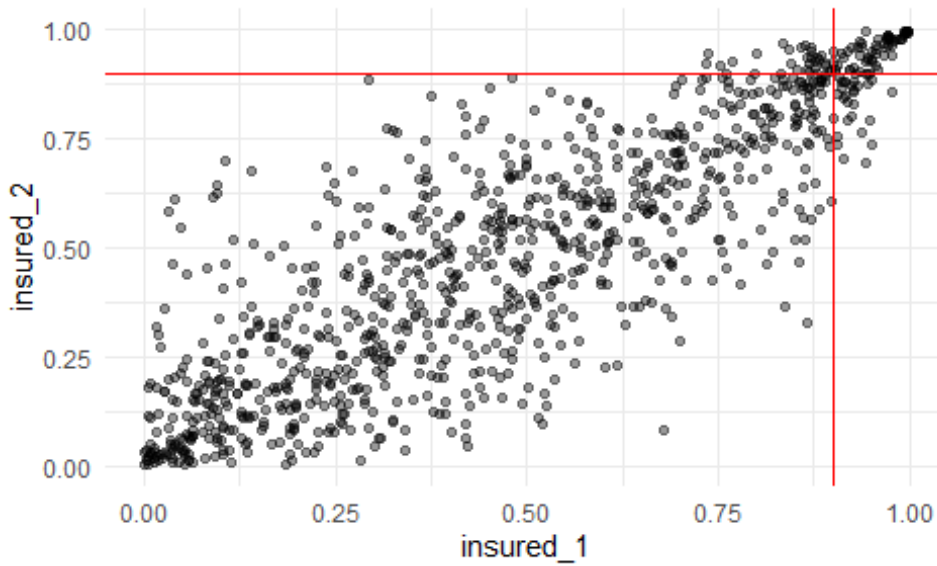
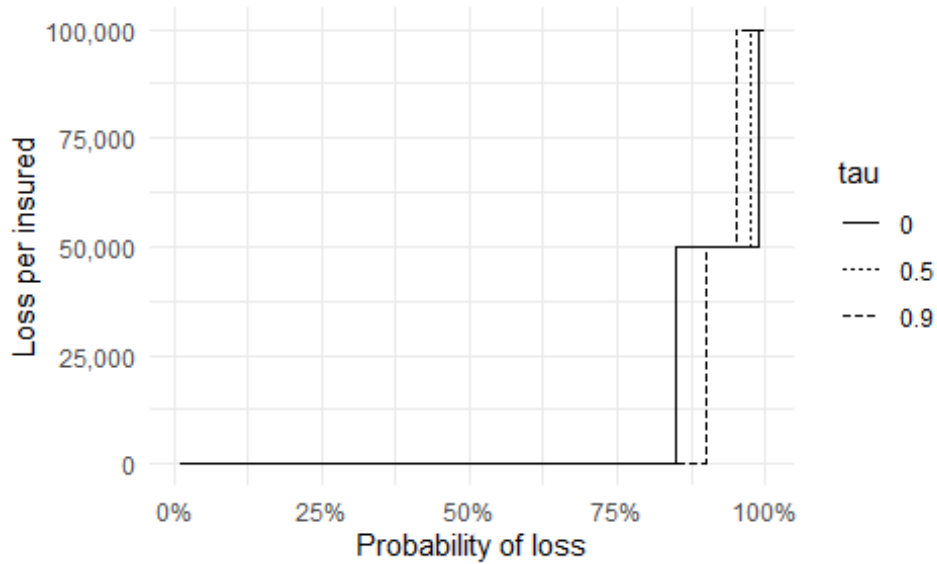


Figure 5-6: Risks which are more correlated in the tail.



When risks behave similarly, this also changes the look of Figure 5-2, as shown in Figure 5-6.

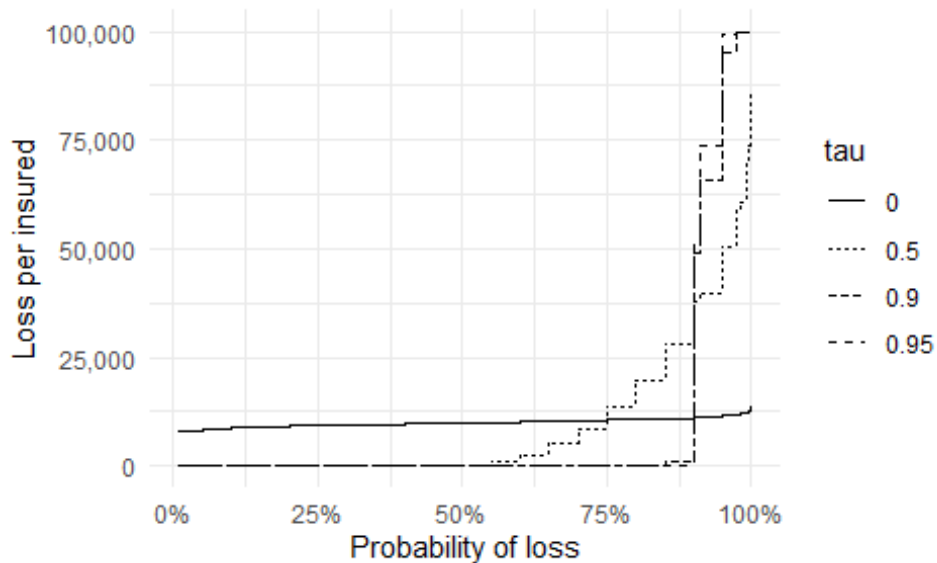
Figure 5-7: Loss scenarios for two correlated risks



In the extreme, the two insureds behave identically. That is, whenever the first homeowner experiences a loss, the second does also. The multiple insureds are now effectively a single insured.

Just as before, we can extend this to multiple insureds. Figure 5-7 shows a risk pool of 1,000 insureds with varying degrees of association. The solid line is identical to the one we saw in Figure 5-3. However, as we increase the chance that insureds are more likely to suffer loss at the same time, the line quickly resembles the curves of smaller pools of risk. With a τ equal to 0.95, a portfolio of 1,000 insureds begins to resemble a pool of fewer than 10, making the risk transfer much less attractive for both the insurer and the insureds.

Figure 5-8: A pool of 1,000 risks with correlation



This reduction in the attractiveness of risk transfer is vital to understanding insurability. When insureds suffer losses with similar frequency and severity at the same time, there is no

diversification benefit in a large portfolio. Even worse, due to high correlation in loss events, an insurance company may need to pull capital originally allocated for other product lines to account for the additional risk. As an example, imagine an insurance company with a high concentration of properties in a floodplain. In a flood event, the insurer may become so capital strapped that its ability to pay auto claims a thousand miles away is reduced.

In effect, risk pooling illustrates the idea that some portfolios are only superficially diverse. For some classes of loss, they are unique, but they grow similar in the presence of events like floods, windstorms, cybercrime, or pandemics. To paraphrase—and invert—Tolstoy, “Unhappy insureds are all alike; every happy insured is happy in its own way.”

6 References

1. American Property Casualty Insurance Association. (2020, 4). APCIA Releases Update to Business Interruption Analysis. *APCIA Releases Update to Business Interruption Analysis*. Retrieved from <https://www.apci.org/media/news-releases/release/60522/>
2. American Property Casualty Insurance Association. (2020). Business Continuity Protection Program (BCPP). *Business Continuity Protection Program (BCPP)*. Retrieved from https://www.namic.org/pdf/20memberadvisory/200521_apcia_namic_big_bcpp_summary.pdf
3. Artemis. (2016, 1). ILS could emulate AXIS’ new pandemic BI covers parametric triggers. Retrieved from <https://www.artemis.bm/news/ils-could-emulate-axis-new-pandemic-bi-covers-parametric-triggers/>
4. Banham, R. (2020, 4). This Insurance Would Have Helped in Coronavirus Crisis But Nobody Bought It. *Insurance Journal*. Retrieved from <https://www.insurancejournal.com/news/national/2020/04/03/563224.htm>
5. Charpentier, A. (2008). Insurability of Climate Risks. *The Geneva Papers*, 33, 91-109. Retrieved from <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.333.6229&rep=rep1&type=pdf>
6. Dixon, L., & Saunders-Medina, B. (2020, 7 27). Key Questions to Ask in Designing a Pandemic Risk Insurance Program. *The RAND Blog*. Retrieved from <https://www.rand.org/blog/2020/07/key-questions-to-ask-in-designing-a-pandemic-risk-insurance.html>
7. Etzion, D., Forgues, B., & Kypraios, E. (2020, 3 29). Pandemic bonds: The financial cure we need for COVID-19? *The Conversation*. Retrieved from <https://theconversation.com/pandemic-bonds-the-financial-cure-we-need-for-covid-19-134503>
8. H.R.7011 — 116th Congress (2019-2020). (2020). *H.R.7011 — 116th Congress (2019-2020)*. Retrieved from <https://www.congress.gov/bill/116th-congress/house-bill/7011/text>
9. Marsh. (2020). PathogenRX: An Innovative Solution for Pandemic and Epidemic Risks. *PathogenRX: An Innovative Solution for Pandemic and Epidemic Risks*. Retrieved from <https://www.marsh.com/us/campaigns/pathogenrx.html>

On Insurability and Transfer of Pandemic Business Interruption Risk

10. Nebehay, S. (2020, 2 24). WHO says it no longer uses 'pandemic' category, but virus still emergency. *Reuters*. Retrieved from <https://www.reuters.com/article/uk-china-health-who-idUKKCN20I0PD>
11. Pasch, K. (2020, 6 11). Coronavirus and Catastrophe Bonds: The Securitization of Catastrophic Risk in a Time of Pandemic. Retrieved from <https://globalpolicyinsights.org/coronavirus-&-catastrophe-bonds.php>
12. Polacek, A. (2018). Catastrophe Bonds: A Primer and Retrospective. *Chicago Fed Letter*, 405. Retrieved from <https://www.chicagofed.org/publications/chicago-fed-letter/2018/405>
13. Risk Management Solutions. (2012). Cat Bonds Demystified: RMS Guide to the Asset Class. Retrieved from https://forms2.rms.com/rs/729-DJX-565/images/cm_cat_bonds_demystified.pdf
14. Ross, S. (2019, 12). Elements of Insurable Risks: A Quick Guide. Retrieved from <https://www.investopedia.com/articles/insurance/082616/elements-insurable-risks-quick-guide.asp>
15. Sclafane, S. (2020, 5). *Insurance Journal*. Retrieved from <https://www.insurancejournal.com/news/national/2020/05/27/570002.htm>
16. Singer, A. W. (2019, 4). The Evolution of Parametric Insurance. *Risk Management*. Retrieved from <http://www.rmmagazine.com/2019/04/01/the-evolution-of-parametric-insurance/>
17. Society of Actuaries. (2020). Retrieved from <https://actuarialtoolkit.soa.org/tool/glossary/insurable-risk>
18. Speer, T. A. (2014, 10). New Insurance Offering: Ebola Business Interruption Coverage. *New Insurance Offering: Ebola Business Interruption Coverage*. Retrieved from <https://www.njlawblog.com/2014/10/articles/insurance-coverage-liability/new-insurance-offering-ebola-business-interruption-coverage/>
19. The American Institutes for Research; The Pacific Institute for Research and Evaluation; Deloitte & Touche LLP. (2002). A Chronology of Major Events Affecting the National Flood Insurance Program. Retrieved from https://www.fema.gov/sites/default/files/2020-07/fema_nfip_eval_chronology.pdf
20. The World Bank. (2017, 6). World Bank Launches First-Ever Pandemic Bonds to Support 500 Million Pandemic Emergency Financing Facility. Retrieved from <https://www.worldbank.org/en/news/press-release/2017/06/28/world-bank-launches-first-ever-pandemic-bonds-to-support-500-million-pandemic-emergency-financing-facility>
21. Unnava, V. (2020, 6). Understanding Parametric Triggers in Catastrophe Insurance. *Yale School of Management*. Retrieved from <https://som.yale.edu/blog/understanding-parametric-triggers-in-catastrophe-insurance>
22. Venter, G. (2002, 1). Tails of Copulas. *Proceedings of the Casualty Actuarial Society*. Retrieved from https://www.casact.org/sites/default/files/database/proceed_proceed02_02068.pdf
23. Webel, B. (2019, 12 27). Terrorism Risk Insurance: Overview and Issue Analysis for the 116th Congress. Retrieved from <https://crsreports.congress.gov/product/pdf/R/R45707>

24. World Health Organization. (2009). Pandemic Influenza Preparedness and Response: A WHO Guidance Document. *Pandemic Influenza Preparedness and Response: A WHO Guidance Document*. Retrieved from <https://www.ncbi.nlm.nih.gov/books/NBK143061/table/ch4.t1/>