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Resilience Bonds as a Public-Private Partnership for Managing Increasing Risks of Climate Change

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ABSTRACT

Private insurance is a major mechanism for managing natural disaster risk in the U.S. We argue that public programs cannot provide sufficient levels of financial protection to homes and businesses and that private insurance is necessary. Research indicates that increasing disaster impacts due to climate change and building in high-risk areas are undermining current methods used by the insurance and reinsurance industries to spread financial risk, including premium pricing and catastrophe bonds. A potential strategy to enhance financial sustainability is to expand business-interruption loss coverage to vulnerable populations by investing in resilience and reducing community recovery times. This would be especially effective in disadvantaged communities where slower recovery prolongs business interruption losses. Public collaboration with private industry using tools like resilience bonds would benefit both the public sector and private insurance industry as well as homeowners and businesses.

KEYWORDS: catastrophe bonds, climate change, disaster, equity, insurance, resilience, sustainability, vulnerability

1 INTRODUCTION

Private insurance is the primary method for risk management within the United States and is necessary for any business or homeowner seeking financial protection from natural disasters. To remain financially solvent, an insurance company must maintain access to enough capital to pay its claims from a large disaster. Climate change has increased the severity and frequency of weather-related disasters (Adler et al., 2019; Jay et al., 2023). Concentration of high-value assets in risky areas combined with increasing damage has caused the insurance industry to incur significantly higher claim costs (Collier et al., 2021; Web-1, 2024). Many insurers who cover property damage caused by natural disasters purchase reinsurance to maintain financial solvency (Web-2). Increases in the frequency and severity of storms and floods have caused the insurance and reinsurance industries to abandon markets in states where they are losing their ability to spread risk effectively (Charpentier, 2007; Web-1).

The cost of business interruption resulting from a weather-related disaster is often significantly higher than the cost of physical damages (Dormady et al., 2022). Demand for business interruption loss insurance has risen with the increasing frequency of disasters (Dormady et al., 2022). If resilience is defined as time required for recovery, then public policies that promote private investments in resilience could help make business interruption loss insurance more affordable to a broader market. Investing in resilience and resilient infrastructure is economically beneficial because it reduces the costs associated with both damage and business interruption losses (Dormady et al., 2022; Hallegatte, 2019; Sun et al.,

2021). Through investments in resilience, private insurers can enhance their financial sustainability by expanding business interruption loss insurance into vulnerable and marginalized populations that bear disproportionate impacts compared to the rest of the population (SAMHSA, 2017; Hallegatte et al., 2016). Reducing the potential for physical impacts on infrastructure will speed recovery times and reduce resources that are spent on disaster aid and rebuilding (Sun et al., 2020). Therefore, investment in resilience presents an opportunity for the public and private sectors to collaborate and invest in economic growth while reducing community downtime and protecting against business interruption losses due to disasters.

To contextualize the current state of the industry and risk management options, we used Google Scholar and Claude AI Professional to conduct a literature review of peer-reviewed articles, grey literature, and industry news published between 2000 and 2024 by searching for overlapping themes of climate change, insurance, finance, pricing, resilience, and risk. We read 67 articles and determined that current industry methods for spreading risk, including premium pricing and catastrophe bonds, are threatened by climate change. We describe resilience bonds as one way to enhance financial sustainability by investing in resilience and reducing community recovery time to expand property damage and business interruption coverage to vulnerable populations. We conclude by describing how public collaboration with private industry using tools like resilience bonds would benefit both the public and private sectors. Catastrophe modeling simulations could be used to optimize investments and maximize cost reduction and financial security for consumers, governments, and private insurers.

2 CHALLENGES TO INSURANCE INDUSTRY SOLVENCY

The financial strain on the insurance industry results, in part, from increasing damage costs because of climate change (Charpentier, 2007; NCSL, 2023; Web-3). The trend of increasing costs of disasters was made salient with Hurricane Andrew in 1992, which cost insurers $16 billion at the time and caused nine insurance companies in Florida to become insolvent (Charpentier, 2007; Web-3). According to Charpentier (2007) at the beginning of this century, the frequency of category 4 and 5 hurricanes had doubled compared to 35 years prior. In addition, 6 out of 10 of the most expensive disasters up until that point had occurred in the 56 years prior to 2007 (Charpentier, 2007). This is because of the increased frequency of weather-related events in addition to the increased concentration of wealth and insured assets in risky areas such as Florida, California, and Japan (Charpentier, 2007; Collier et al., 2021). Every peril from drought, wildfires, floods, hail, winter storms, freezes, severe storms, and tropical cyclones have been on the rise over the past few decades (Web-4). The cost of these disasters has reached a magnitude that is equivalent to fighting a war domestically and permanently (Bilal and Känzig, 2024). In 2022, only $140 billion of the $360 billion in direct global economic costs due to weather events were covered by insurance with $125 billion coming from private insurers and $15 billion being covered by public insurers (Web-5). Additionally, U.S. property-casualty insurers suffered $32.2 billion in net underwriting losses in the first nine months of 2023 (Web-1). This trend of debt and loss caused by disasters has precluded reinsurers globally from being unable to earn back their cost of capital in 5 of the 6 years from 2017-2022 (Web-3).

Publicly financed programs are unlikely to perform better. The National Flood Insurance Program (NFIP) is the primary form of flood insurance for people living in flood zones within the U.S. This program has been in debt of around $20 billion since 2013, reaching a high of around $30 billion in 2017 (Web-6). In October 2017, Congress cancelled $16 billion of NFIP debt, making it possible for the program to pay claims for Hurricanes Harvey, Irma, and Maria (Web-6). The NFIP currently owes $20.5 billion to the U.S.

Treasury, leaving $9.9 billion in borrowing authority from a $30.4 billion limit by law. Meanwhile, more people and properties are experiencing increased flood risk. Between 1970 and 2010 there was a 114% increase in the population living in flood zones (UNISDR, 2011).

An important tool that insurance and reinsurance companies use to spread risk and reduce financial vulnerability to disasters is catastrophe bonds (Charpentier, 2007). Catastrophe bonds are short-term investments issued by the reinsurance industry to pool capital in case policies get triggered. Catastrophe bonds are purchased and used to cover a predefined disaster risk at a set monetary threshold (Polacek, 2018). If the disaster occurs and the conditions are met, the bond capital will be used to help mitigate losses and insolvency via policy payout, but the investor forfeits the principal and interest on the bond (Charpentier, 2007; Polacek, 2018). Catastrophe bonds have the effect of keeping reinsurance prices and volatility low while allowing for the transfer of insurance risks to the bond market (Polacek, 2018). The bonds themselves are issued by insurance companies, reinsurers, and state catastrophe funds, and payouts are dependent upon several triggers including indemnity, industry loss, and parametric (Polacek, 2018). Indemnity triggers pay out based on the insurance losses experienced by the insurer, industry loss triggers pay out based on aggregate losses that are often calculated by a third party, and parametric triggers pay out based on the intensity of the catastrophe being covered (Polacek, 2018). Insurance companies are the largest issuer of catastrophe bonds, with reinsurance companies being the next largest issuers (Polacek, 2018). The associated increase in frequency and magnitude of weather-related perils due to climate change may render the traditionally safe catastrophe bonds too risky an investment for many investors (Charpentier, 2007; Morana and Sbrana, 2019). Nevertheless, we describe below how catastrophe bonds could provide a model for public-private partnership resilience bonds.

3 WHY DO WE NEED PRIVATE INSURANCE?

It was predicted in 2007 that financial pressure caused by the uncertainty of climate change would lead to a rapid increase in premiums (Charpentier, 2007). This rise in premiums can be seen in home insurance where double-digit percentage increases have been common for the past few years (Web-7). The combination of inflation, increased property damage from storms, increased challenges in assessing risk due to climate change, and excess litigation has caused some insurers to pull out of high-risk states such as California and Florida, leaving only last-resort, state-created options funded by taxpayers (Collier et al., 2021; Web-1; Web-7). In some states where insurers continue to offer disaster policies, premiums are being raised at rates that consumers cannot sustainably afford (Web-1).

Unaffordable premiums or complete exit from markets by the private insurance industry has economic consequences. The inability for real estate buyers to obtain insurance required for mortgages will create regional declines in property values and equity. If premiums increase to a threshold where the market lacks the financial capital to adapt, then it could lead to widespread displacement and a sudden decline in property values, which would have cascading impacts on other aspects of the U.S. and global economies. The ability of the government to insure the escalating risk resulting from climate change is limited, as evidenced by the financial insolvency of the NFIP (Adler et al., 2019). Efforts to restore solvency by raising premiums through legislation in 2012 were repealed due to public pressure (Horn and Webel, 2023). If last-resort, state-created insurance models become the norm in high-risk states, then the catastrophe losses previously incurred by private insurers will be passed on to the public (Web-8), most likely through repetitive and contentious legislative appropriations. Public safety nets are not meant to be the primary form

of insurance in areas of high risk (Web-8). Private investment enables companies to leverage significantly greater amounts of capital by promising returns to investors (Mauboussin and Callahan, 2020). The reinsurance industry can leverage billions of dollars globally. It is also argued that privatization should lead to cost-cutting and greater attention to customer satisfaction (Goodman and Loveman, 1991).

Some insurers are encouraging climate mitigation to decrease risk (Collier et al., 2021). Other actions that can be taken to reduce the impacts of climate change include being more proactive in explaining how mitigation actions can lead to policy discounts, lobbying for higher performance requirements in building codes, and investing more in risk assessment. We propose an additional strategy, which is to partner with public institutions to invest directly in resilience.

4 WHY INVEST IN VULNERABLE POPULATIONS?

When a large area is designated as uninsurable, it is referred to as being "blue lined" (Montgomery and Palmeira, 2023). While blue lining reduces the industry's financial risk, it establishes areas where people either must be willing to cover damages out-of-pocket or leave and live elsewhere. Within the United States, there are often social factors that contribute to inequalities in outcomes and systems that perpetuate disparities. Many blue-lined areas overlap with previously redlined areas, where racially discriminatory practices were used to consolidate minority populations and conditions that contribute to poverty (Montgomery and Palmeira, 2023). Areas with high concentrations of minorities were deemed 'undesirable' for investment by the Homeowners Loan Corporation in the 1930s (Web-9). Previously redlined areas were shown to have 25% higher flood risk when compared with areas that were not redlined (Web-9).). A total of $107 billion worth of homes exists in previously redlined areas that are at risk of flooding (Web-9).

Research on the current observable impacts of redlining and disaster response has found that historically redlined communities have higher levels of social, evacuation, and preparedness vulnerabilities when compared to communities that never experienced redlining (Dugan et al., 2022). The Dugan et al. (2022) study was conducted on the relationship between redlining, social vulnerability, and impacts during power outages, which can occur during flood events and natural disasters. Poor urban households are more exposed to floods, more likely to incur moderate to more severe levels of damage during a flood, more likely to have the bulk of their savings concentrated in their homes, and more likely to live in vulnerable housing (Hallegatte et al., 2016; SAMHSA, 2017). Low-income households also tend to take 2-3 times longer to recover financially after a disaster, which can decrease their ability to participate in the local economy and contribute to longer business recovery times (Hallegette et al., 2016; Peacock et al., 2014; Tasri et al., 2022). This has the effect of decreasing the economic capacity of disadvantaged communities, further cementing inequalities (Tasri et al., 2022). Research by Xiao and Van Zandt (2012) showed that the rapid return of households in a market area will increase the chances for businesses to return. When a disaster strikes, low-income households have the most to lose and the businesses that serve them experience longer business interruption losses.

On average, the cost of business interruption is 900% higher than that of business property damage loss during a natural catastrophe (Dormady et al., 2022). Investing in resilient infrastructure has been shown to yield economic benefits that greatly exceed costs (Multi-Hazard Mitigation Council, 2019), including significant reductions in losses due to business interruption (Dormady et al., 2022). Private investments in resilience can help to shift the insurance industry to a return-on-place model where consumers and insurers are better insulated from catastrophic losses. Historic disinvestment in socially

vulnerable populations has concentrated social, natural, infrastructural, preparedness, and evacuation vulnerability and limited access to resources within these communities (Dugan et al., 2022; SAMHSA, 2017). On the other hand, it has concentrated opportunities for the largest return on investment in resilience. This is especially true when dealing with investments in housing (Walker, 2014) and infrastructure (Pereira, 2001).

For every dollar invested in resilient infrastructure, $4.57 is saved in business interruption costs and $6 is saved in structural damage loss (Dormady et al., 2022; FEMA, 2018). Federal, state, and local governments all have an incentive to invest in resilient infrastructure to reduce overall financial and structural losses in communities. Local governments rely on property taxes for up to 61% of their tax revenue (Web-10). Suspending insurance coverage in high-risk markets threatens local tax bases as communities are less able to recover after disaster. Long-term returns on investing in resilience through updating building codes can reduce the total value of insurance claims by 70% over a ten-year period with income and employment rates rising 9% over this timeframe (Obama White House, 2016; Walker, 2014). For example, specific actions like installing green roofs on homes have been shown to reduce peak flood runoff by 65%, which reduces localized flood impacts (GSA, 2011; Web-11). While many resilience-based solutions cost more upfront, the long-term savings and financial security they provide would benefit public and private insurers. It has been shown that wealthier communities tend to be more resilient in that they recover faster (Flanagan et al., 2011). Investing the same amount of money to increase resilience in a wealthy community would have less impact than investing it in a marginalized community. This is because low-income households must spend a larger proportion of their wealth to recover than wealthier households (Hallegatte et al., 2016). The best opportunities for public-private partnerships (PPP) that help foster resilience in communities are in vulnerable areas that have historic underinvestment in infrastructure.

5 PUBLIC-PRIVATE RESILIENCE BONDS

Considering the high returns from investments in infrastructure resilience, private investors and insurers could work with federal, state, and local governments to invest in resilient infrastructure that can be maintained with tax revenues to reduce claims and allow for affordable premiums. Resilience bonds are one method for promoting resilience already used in reinsurance and insurance (Web-12). Resilience bonds are a form of catastrophe bond "that link insurance premiums to resilience projects in order to monetize [future] avoided losses through a rebate structure" (Vaijhala and Rhodes, 2018). The initial idea was proposed in 2015 as a guide for public entities looking to build and monetize resilience through risk reduction programs in their communities (Motlagh et al., 2024). The intention was to develop "integrated resilience solutions and innovative public-private partnerships for vulnerable communities" (Motlagh et al., 2024; Web-13). To illustrate how public-private resilience bonds can be leveraged to develop such solutions and partnerships, it is important to explain how they work and who is involved.

There are three primary parties involved with these types of resilience bonds: sponsors, issuers, and investors. The sponsor is the party in need of natural catastrophe insurance and investments to finance disaster resilience projects (Web-13). The issuer is a third-party that brings the resilience bond to the market, sells the bond to investors to raise capital, and manages the funds in a collateral account (Vaijhala and Rhodes, 2017). This party is also responsible for ensuring that any resilience impacts and goals are clearly defined and that appropriate investment boundaries are set (Motlagh et al., 2024). The final party is the investor who buys and holds the resilience bond until it reaches bond maturity by a specified date

(Vaijhala and Rhodes, 2017). Investors accept lower rates of return in exchange for a lower investment risk (Kunreuther et al., 2016). Ideally, public-private resilience bonds would create win-win-win scenarios for all parties involved. Unfortunately, there is no current example of implementation. However, that does not minimize their potential feasibility or importance (Motlagh et al., 2024). We believe an impediment may be lack of access to high quality catastrophe modeling needed to confidently estimate future risk reductions.

The following hypothetical scenario illustrates how a public-private resilience bond would function to finance a coastal resilience project in Miami-Dade County, Florida. Miami-Dade County will serve as the sponsor for the project. The fictitious private Florida Insurance Company (FIC) who is motivated to expand business interruption loss coverage serves as the issuer. Investors Inc. serves as the investor. Miami-Dade County is interested in constructing a comprehensive coastal flood protection system protecting 25 miles of coastline that includes economically vulnerable communities with potentially longer recovery times. Currently, the county pays $50 million in annual public infrastructure flood insurance costs and is looking to reduce a potential $2 billion in flood damages over the next 20 years. FIC is interested in issuing a resilience bond to help finance the project that will cost an estimated $500 million. Through catastrophe modeling, FIC determines that the coastal resilience project will reduce Miami-Dade's hurricane and flood losses by 60% upon completion. FIC issues the bond for $500 million with a 4% coupon rate and a $1 billion regional economic loss trigger threshold for a named storm. Investors Inc. invests $500 million from pension funds into the bond with an expected 4% annual return that drops to 2.5% upon project completion to reflect the lower risk provided by the resilience project.

Miami-Dade would pay $25 million in annual premiums to FIC, the issuer of the bond, and the funds from the premium are used to pay investors their 4% coupon payments which would be $20 million annually. The capital provided by Investors Inc. is used to construct the project while FIC monitors and reports on project milestones. Once the project is complete, Miami-Dade's flood insurance premiums drop from $50 million to $30 million annually, representing a 40% reduction in costs. The reduced risk and completion of the project lead to the investor coupons dropping to 2.5% which is equivalent to $12.5 million. The combined savings of $20 million in flood insurance premiums and $7.5 million from the coupon discount results in a $27.5 million annual resilience rebate to the county that they can use to finance additional infrastructure projects or find additional ways to invest in community resilience at their discretion.

With public-private resilience bonds, sponsors are only responsible for paying the premium to the issuer rather than repaying the principle to investors as with conventional bonds (Vaijhala and Rhodes, 2019). If a hurricane occurs during the bond period and exceeds the trigger threshold, the bond is used to cover the county's losses, resulting in a partial loss of the principal for investors, but the county itself avoids catastrophic financial loss. In this hypothetical scenario, Miami-Dade county saves millions of dollars between annual insurance savings and the resilience rebates, investors receive a stable 2.5% return with lower risks than traditional catastrophe bonds, and the community sees increased insurability, enhanced property values, and a reduced risk of displacement. Expected losses are reduced, leading to a win-win-win scenario for the county, insurer, and investor.

6 CONCLUSION

While climate change will continue to progress and cause increased weather-related damages, its impact on the economy can be mitigated with preventative measures such as investing in resilient infrastructure in vulnerable communities. The financial sustainability of public and private property-casualty insurers overburdened by damage costs could benefit from greater cooperation. An option for reducing the risk faced by insurers is to promote resilient infrastructure to decrease incurred damages and increase how quickly vulnerable communities can recover, which will minimize business interruption losses, and allow for private insurers to expand business interruption coverage. Building on pre-existing public-private insurance relationships through targeted investments in resilient infrastructure in vulnerable areas has the potential to transform communities while protecting and improving returns on private investments. More precise effects on community recovery times after a natural disaster and the return on investments in resilience can be estimated using catastrophe modeling. Catastrophe models that can calculate the mitigative effects of investing in resilient infrastructure and expanding insurance markets to previously red-lined areas could increase the adaptive capacity of communities while also contributing to the financial sustainability of the insurance industry.

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