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The Role of Natural Disaster Insurance in Recovery and Risk Reduction

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Abstract

Natural disaster losses have been increasing worldwide. Insurance is thought to play a critical role in improving resilience to these events by both promoting recovery and providing incentives for investments in hazard mitigation. This review first examines the functioning of disaster insurance markets broadly and then turns to reviewing empirical studies on the role of natural disaster insurance in recovery and the impacts of disaster insurance on incentives for ex ante hazard mitigation and land use. Rigorous empirical work on these topics is limited. The work that has been done suggests that insurance coverage does improve recovery outcomes, but impacts on risk reduction may be modest. More studies comparing outcomes across insured and uninsured properties are needed, particularly for better understanding the role of insurance in climate adaptation.

1. INTRODUCTION

Globally, the annual direct costs of natural disasters have recently averaged approximately US\$100–200 billion (Kousky 2014, Swiss Re Inst. 2018). This excludes the indirect costs of disasters, such as nonmarket damages, as well as pain, suffering, and loss of life. The costs of disasters, in inflation-adjusted terms, have been growing over time (e.g., CRED & UNISDR 2018, Cutter & Emrich 2005). A large part of this increase is due to where and how we build (e.g., Pielke & Downton 2000, Pielke et al. 2003). Some studies also detect a climate signal in loss data (e.g., Sander et al. 2013) or an increase in losses after correcting for increases in exposure (Barthel & Neumayer 2012, Gall et al. 2011). There is mounting concern that climate change is altering the frequency, intensity, spatial extent, duration, and/or timing of many weather-related extreme events (IPCC 2012), with implications for losses.

Resilience to natural disasters has been defined as “the ability to prepare and plan for, absorb, recover from and more successfully adapt to adverse events” (NRC 2012, p. 16). Theoretically, insurance has a critical role to play in promoting resilience. It can provide financial protection to insureds, preventing negative economic hardship after a disaster. It can speed rebuilding and recovery by providing postdisaster funding and liquidity soon after the event. Insurance could help promote risk reduction before a disaster through financial incentives or after an event through extra funding for hazard mitigation as part of rebuilding efforts. Insurance can only deliver on these benefits, however, in a broader landscape of risk management, supported by governments and other stakeholders. An understanding of the hazard risks and exposure, as well as an appreciation of the role of insurance, are all needed to realize this potential.

This article reviews the empirical literature on natural disaster insurance to answer the following questions:

1. How are natural disaster insurance markets currently functioning?
2. What is the role of natural disaster insurance in recovery?
3. What are the impacts of disaster insurance on incentives for ex ante hazard mitigation and land use?

A few notes are warranted on the scope of this article. This review is focused on natural disaster insurance for buildings and possessions. It does not cover agricultural insurance (for a US-focused review, see Smith & Goodwin 2013). It is heavily focused on the residential market and not commercial insurance, where disaster coverage is much more robust and widespread. It also does not focus on reinsurance (for a recent look at the contribution of global reinsurance, see OECD 2018). Finally, the review is focused on developed country insurance markets, with an emphasis but not exclusive focus on the United States; although insurance is clearly critical in developing nations as well, the types of insurance, the role it plays, and its challenges and opportunities are different in several critical respects and best treated separately (for a review of developing country index insurance for agriculture, see Carter et al. 2017). Finally, this review focuses on the empirical literature, not theoretical results or arguments.

The review finds first that there are not well-functioning private markets for most types of disaster insurance. Almost universally, governments have intervened in these markets, and these interventions have taken a wide variety of forms. Second, the empirical research on differential outcomes between those with and without insurance is extraordinarily limited. The few papers that have been written, however, indicate that insurance increases recovery postdisaster, at both the level of the household or small business and the level of the economy. There are some findings that lower-income and minority groups are less likely to have insurance or have insurance with financially sound carriers, increasing their vulnerability postdisaster.

Third, insurance may have a more limited role in promoting risk reduction before disasters strike. While premium discounts are sometimes given for risk reduction measures, there is little work cleanly documenting whether these generate new investments in hazard mitigation. There is no robust empirical work identifying a convincing link between insurance and land use, but such examinations are limited by data availability and lack of exogenous changes to exploit for identification. More research on these topics is needed.

The next section of the review discusses the challenges with insuring disaster risks. The third section builds on that discussion to elucidate why there are widespread government interventions in disaster insurance markets and discusses the form those take. Section 4 reviews the empirical work on the role of insurance in disaster recovery, and Section 5 summarizes findings on the role of insurance in creating incentives for investments in risk reduction and land use. Section 6 concludes.

2. THE CHALLENGE OF INSURING NATURAL DISASTERS

Insurance plays an important welfare-enhancing role in the economy. A risk-averse entity is willing to pay more than the expected loss to transfer a risk to another entity better able to pool the risk. This is because for the risk-averse consumer, the benefit of distributing wealth across states of the world (for example, when there is a disaster and when there is no disaster) is greater than concentrating wealth in one state. That is, the consumer wants to transfer income from states of the world where the marginal utility of income is low (no disaster) to those where it is higher (disaster).

Not all risks, however, can be transferred. Certain risks are more amenable to insurance or risk pooling than others (for more on the topic, see Cutler & Zeckhauser 2004, Schmit 1986). Here, I present five idealized conditions for insurability of a risk:

1. A degree of randomness to loss occurrences and their magnitude;
2. Independent, thin-tailed, and quantifiable risks;
3. Determinable losses;
4. Limited adverse selection or moral hazard; and
5. Demand meets supply (the market clears).

When these conditions are present, a well-functioning insurance market can exist. Natural disasters, however, may at times violate all of these criteria, most problematically the second. I discuss the other four criteria first.

Insurance is based on the premise that a loss is random; clearly, if a loss is known with certainty to occur, it cannot be transferred for less than the full amount. Although many natural disasters remain random in timing, size, and location, there are exceptions. For instance, sea level rise and climate change impacts have made some risks more certain and less random. A notable example is “sunny day flooding” in coastal communities or flood risks from high tides. When flooding occurs predictably, it is harder to insure. Inevitability threatens insurability.

The third criterion refers to the fact that insurers must be able to determine in a noncontroversial manner how much they owe the insured. For indemnity-based policies, where the payout is equal to the loss, an insurance adjuster typically visits the property to make such a determination. When losses are caused by multiple perils, not all of which are covered by the policy, attributing damage can be problematic. For example, after Hurricane Katrina, which affected portions of states on the Gulf of Mexico in 2005, many homes were wiped off their foundations. Homeowners policies would cover the damage if it was wind that destroyed the structure, but not if it

was storm surge. Given that both wind and flood waters together devastated the Gulf Coast, there were multiple lawsuits over the extent of claims poststorm.

The fourth criterion, limited adverse selection and moral hazard, has to do with the information and incentives of the insured. In the former, insureds have more information about their risk than insurers. In this case, the insurance market can “unravel” in that the insurance offered to a population of a mix of low-risk and high-risk individuals may be too expensive for low-risk individuals but not priced high enough to be profitable for a company to offer exclusively to the high-risk group. For many disasters, however, the insurer might have much better risk information than the insured, minimizing this concern. Moral hazard refers to the situation in which insurance coverage causes the insured to engage in higher-risk activities, knowing they will be compensated for a loss. This drives up the cost of insurance to the company beyond the level for which it was priced. Moral hazard is often a justification for deductibles that leave some risk with the insured as an incentive to take proper precautions.

Returning now to the second criterion, independent and thin-tailed loss distributions allow for benefits from risk pooling. In this case, the law of large numbers and the central limit theorem guarantee that the average claim will approach the expected value, and the aggregate distribution will be thin tailed or normally distributed. As an insurer writes more policies, then, they can charge a pure premium (that is, absent any loadings), closer to the expected value. They can also be assured with a high degree of confidence that their revenues will be sufficient to cover losses.

Unfortunately, damages from natural disasters are notoriously fat tailed and dependent. A fat-tailed distribution is one in which the probability of an extreme event falls more slowly, and the most extreme event can be many multiples of the second most extreme (for a more technical treatment, see Cooke et al. 2014). Empirical work has shown that damages from earthquakes, wildfires, and floods are all fat tailed (e.g., Blackwell 2015, Conte & Kelly 2017, Holmes et al. 2008). Disaster damages are also certainly spatially dependent. A defining characteristic of disasters is that many people and properties are impacted simultaneously. Further, for very severe events, many lines of business for a company can all be impacted simultaneously—that is, the losses can be tail dependent, where the dependence concentrates in the tail of the distribution. During noncatastrophe times, losses across the lines of business may be independent, but in a severe loss, all experience high amounts of claims (Lescourret & Robert 2006, RMS 2005).

The challenge with insuring these types of risks is that for an insurance company to stay solvent, it must have access to enough capital to pay losses in catastrophic loss years, where claims may greatly exceed annual revenue. For nondisaster lines, such as automobile insurance, the premiums in any given year are usually enough to cover claims from that year. This is not the case for fat-tailed and dependent disaster damages. In these cases, there is the possibility for profound losses requiring insurance companies to build up reserves, purchase reinsurance, or use other insurance linked securities to be able to pay the claims in high damage years. The firm must solve an intertemporal smoothing problem (Jaffe & Russell 1997). Mechanisms to do so, however, increase the cost to the insured, making disaster insurance more expensive than other lines of business. This can make the price of disaster insurance exceed what people are willing or able to pay (Kousky & Cooke 2012); the market will not clear. In the extreme, for very fat-tailed distributions, diversification can actually be suboptimal, increasing value at risk and creating a possible equilibrium of no diversification and no insurance market for catastrophes (Ibragimov & Walden 2007, Ibragimov et al. 2009). That is, losses can be so extreme that standard results from risk pooling based on the law of large numbers and expected utility may fail to hold.

There are thus a number of reasons natural disaster insurance can be a challenge for the private sector to write. Breakdowns in disaster insurance markets have led to myriad government interventions in these markets, discussed in the next section. Insurability, however, is not a binary

proposition, but a continuum, and there are changes to insurance practices that can make the market better able to insure disaster risk. This can include partnering with the public sector on risk mitigation to lower losses, selective underwriting, and limiting coverage through higher deductibles, for instance.

Other forms of insurance beyond standard indemnity-based policies may at times perform better for disaster risks. For indemnity policies, the claim payout is determined by the amount of damage sustained. Homeowners policies in the United States are structured in this way (as are many other types of insurance with which consumers are familiar, such as automobile and health). For property insurance, this means that postloss, claims adjusters must visit the structure to estimate damage, generating high transaction costs. The timing of indemnity-based insurance payments can be slow after very large events when there are not enough loss adjusters and claims processing is overwhelmed (e.g., King et al. 2014). For these types of policies, insurance payouts will be facilitated by insureds keeping records and evidence (e.g., photographs) of all property and its condition prior to and immediately after any loss occurring.

Parametric policies, in contrast to indemnity insurance, are policies that pay a predetermined amount when a certain objective triggering event is met, such as a given wind speed in a particular area or stream gauges exceeding a certain height. The advantage of a parametric policy is that it greatly reduces the cost of settling claims and can speed payouts. The drawback is that it introduces basis risk, the risk that the payment could be lower or higher than the actual damages. Parametric policies are growing in popularity and have been used to provide disaster cover to low-income farmers in developing countries and at the level of the nation through facilities such as the Caribbean Catastrophe Risk Insurance Facility.

Finally, some have argued that disaster risk would be better handled through the financial markets. This has been done through the growth of the insurance-linked securities market with instruments such as catastrophe bonds. The catastrophe bond market hit a record of \$30 billion in the fall of 2018. The products have largely been used for commercial clients, including insurance companies and public sector entities. For more on this market, see Cummins and Weiss (2009).

3. GOVERNMENT INTERVENTIONS IN DISASTER INSURANCE MARKETS

3.1. Forms of Government Intervention

Owing to the challenges of insuring disaster risks discussed in Section 2, there is nowhere in the world today with a fully functioning private market for disaster insurance. Governments have intervened in these markets to guarantee the availability and/or affordability of disaster coverage. The types of interventions vary substantially, however, both within the United States across perils and around the world. Some programs are fully public, whereas others are quasi-public or designed as public-private partnerships. Some programs write single line disaster insurance or multi-peril policies directly to consumers, while others provide reinsurance or a public sector backstop to insurer losses. Other types of public policy interventions include mandates on coverages, mandates on offering certain coverages, regulations on pricing and other aspects of the market, and funding or incentivizing risk reduction.

In the United States, standard homeowners policies cover many perils to a home, such as burglary, hail, tornadoes, and fire, but typically exclude flood and earthquake coverage. In some hurricane-prone regions, the policy may exclude wind or have a high deductible for named hurricanes. There is some evidence that some insurers may be withdrawing from high wildfire risk areas (e.g., Dixon et al. 2018, Sell 2018), but in many places this is still covered in homeowners

policies. In response to the exclusion of catastrophic perils from standard homeowners insurance, multiple public programs have been created in the United States to provide coverage for these types of risks.

At the federal level, the government provides flood insurance directly to residents of participating communities through the National Flood Insurance Program (NFIP), housed in the US Federal Emergency Management Agency (FEMA).¹ This program is designed as a partnership with communities; when they voluntarily enroll, communities must adopt minimum floodplain management regulations and, in exchange, flood insurance is made available to households, businesses, and municipal buildings. Coverage is capped for residential buildings at \$250,000 and contents at \$100,000, while business coverage for building and contents is each capped at \$500,000. For a detailed explication of the NFIP, see Kousky (2018).

Insurance is regulated at a state level in the United States. State insurance offices license insurance companies and agents, regulate products, oversee rate setting and forms for the admitted market, set solvency requirements, monitor market conduct, and carry out other activities. Many states have also established residual market mechanisms or fully or quasi-public entities to provide disaster insurance when it is unavailable or too costly in their state.

State insurance programs, often referred to as residual market mechanisms, take a variety of forms. One form is state FAIR (Fair Access to Insurance Requirements) plans. Following riots and civil disorder in many urban areas, federal legislation in 1968 made federal riot insurance available to states that enacted FAIR plans. These plans offer insurance to residents who cannot find policies in the voluntary market. Initially, these plans offered coverage only for fire, but many have expanded, and some even offer wind coverage (California's fire coverage includes wildfire). Beyond FAIR programs, coastal states may have state wind pools or "beach plans" that provide wind-only coverage in certain high-risk areas or hybrid programs that write both hazard-specific policies and complete dwelling coverage. Florida also has a state-level reinsurance program.

In California, there has long been state law that insurers providing homeowners coverage also offer earthquake coverage. In the 1994 Northridge earthquake, insurers paid out more in claims than they had collected in earthquake premiums over the preceding 30 years; as a result, without being able to exclude earthquake coverage from homeowners policies due to the state law, many insurers began to pull back homeowners coverage, creating a crisis in the California housing market (Insur. Inf. Inst. 2018). In response to this, the California Earthquake Authority (CEA) was formed as a privately funded but publicly run earthquake insurer. As a government instrumentality, it has favorable tax status and can accrue reserves faster than private companies. Roughly three-quarters of residential earthquake policies in the state are held by the CEA, but overall take-up (discussed in the next section) remains low.

Like the CEA, most government programs were created in the aftermath of a large disaster that raised policy concerns about the cost or availability of disaster insurance coverage. Faced with the withdrawal of private insurance companies or increases in premiums that led to political upset, many states found it necessary to step in and offer coverage. For example, the Florida state residual market mechanism was created after Hurricane Andrew (1992),² and Louisiana Citizens and the Alabama Beach Pool were created in response to Hurricane Camille (1969).

Although state residual market mechanisms differ in organization and approach, they share some common features. Most of them have eligibility requirements to ensure policies are

¹This review focuses on natural disasters, but the federal government also supports the terrorism insurance market through the Terrorism Risk Insurance Program with a backstop and reinsurance for insurers that include terrorism coverage in commercial policies.

²For more on how the challenge of insuring disasters has impacted the Florida insurance market, see Grace & Klein (2009).

purchased only after a consumer is unable to find the needed coverage in the voluntary market. The programs first cover claims out of premiums and any investment income. For higher-loss years, the programs differ in their approach. Some purchase reinsurance. Many rely on ex post bond issuances to be repaid through assessments on policyholders, insurers, or some combination. States are not usually responsible for losses, although several have at one time or another appropriated general revenues to the programs to cover deficits.

Fully to quasi-governmental disaster insurance programs exist in many other developed nations with some degree of hazard risk, and these have been compared and contrasted in several papers (e.g., see McAneney et al. 2016, Paudel 2012). These programs include an even greater diversity of institutional designs. Of note, it is more common internationally to have disaster coverage provided through risk spreading where all households are charged a flat fee and provided with full coverage, often referred to as following principles of “solidarity.” This eliminates concern about households not having coverage, as everyone participates, but does so at the expense of differentiated pricing, which is believed by most stakeholders in the United States to be more equitable and to also create financial incentives for mitigation (a claim examined in Section 5). To give a brief indication of the types of programs around the world, a few are summarized here.

Dating back to the 1950s, in Spain, the Consorcio de Compensación de Seguros (CCS) provides nationwide, guaranteed coverage for disaster events. Insurers are required to include coverage for these risks in all life, fire, property, and motor vehicle policies. Although insurers could provide disaster cover themselves, most instead add a CCS surcharge to premiums and transfer this risk to the state-run CCS. Natural disaster coverage is also mandated in France where the government sets premiums as a uniform surcharge regardless of risk level. The Caisse Centrale de Réassurance (CCR) provides government-backed reinsurance. Private insurers can reinsure with either the CCR or the private market, but many choose the CCR for at least a portion of their reinsurance since it is backed by the state and has competitive rates.

In the United Kingdom, flood insurance has been provided by the private sector since the early 1960s through a voluntary agreement between the industry and government. The latest structure of this agreement is Flood Re, a not-for-profit reinsurance pool, launched in 2016. A levy is assessed on all UK households and put into a fund. Insurers, which agree to offer flood in their policies, can choose to cede the flood portion of any policy to Flood Re. It is believed the levy and support of Flood Re will keep flood insurance more affordable in the United Kingdom. For more detail on the program, see Surminski (2018).

Earthquake-prone areas have taken a variety of approaches to making coverage available. In New Zealand, the Earthquake Commission, a government agency, offers earthquake insurance for all residences with a fire policy (it also covers other disasters such as tsunamis, volcanic eruption, and flooding). This coverage is funded by a flat, mandated fee on all household insurance policies. Coverage is provided up to NZ\$100,000; additional coverage can be purchased on the private market. Japan takes a different approach. Earthquake insurance is provided by private insurers and reinsured by the state through the Japanese Reinsurance Company. Premiums are based on structure characteristics and location. Policies can be written for periods of 1 to 5 years, depending on the insurer. Premium discounts are available based on a building’s date of construction and earthquake-resistant characteristics.

3.2. Take-Up Rates and Participation

Globally, there is a large gap between total losses and the amount that are insured, referred to as the insurance gap (Lloyd’s 2012). Data from the Swiss Re Institute indicate that more than 70% of losses from natural disaster events are uninsured globally, with the percentage being higher

for flood and earthquake, but lower for windstorms (Holzheu & Turner 2018). The same study finds the insurance gap is smaller in mature markets as compared to emerging markets. While more developed countries tend to have more developed insurance markets, it is also the case that there can be a large insurance gap for disaster losses in these countries even when other lines of insurance have greater market penetration.

Indeed, absent compulsory disaster insurance or greatly subsidized premiums, take-up rates tend to be very low for disaster insurance. For instance, only slightly more than 10% of homes in California have earthquake insurance (Marshall 2018). In Japan, around half of residential properties are insured against earthquakes (Waldenberger 2013). A recent FEMA report (2018) estimated that in the 100-year floodplain, where flood insurance is mandatory for those with a federally backed mortgage, take-up rates are on average more than 60% for those homes estimated to have a mortgage and less than 30% for those estimated to not have a mortgage. For renters, flood insurance take-up rates are much lower, at less than 15% in 100-year floodplains. Many small- and medium-sized businesses also tend to be uninsured against disaster losses. A survey of these businesses after Hurricane Sandy in 2012 found that younger and smaller firms were less likely to have insurance (Collier et al. 2018).

In countries where disaster coverage is included in standard homeowners policies, and when those are required by law or by lenders, take-up rates are much higher. For instance, in the United Kingdom, flood is included in standard home policies, such that more than 90% of residential homeowners are covered for flood (Surminski 2018). Other countries, such as France, require companies to provide disaster coverage but assist in covering the costs of the most severe events; thus, by law, take-up rates are close to universal.

Reasons for low take-up rates in cases of voluntary purchase are varied, and many have been explored in the literature (Kunreuther et al. 2013, Waldenberger 2013). There is significant anecdotal evidence from news stories and reports that price is a large barrier to purchase of disaster insurance. Price can be greater than households are either able to pay (FEMA 2018) or willing to pay. There is a large literature in behavioral economics indicating that individuals have difficulty making decisions related to risks, and this may have implications for insurance purchasing (e.g., Johnson et al. 1993, Kunreuther & Pauly 2006). Individuals may also not have full information or be aware about their disaster risk and may fail to understand the role of insurance (Botzen et al. 2009a, Ludy & Kondolf 2012, Meyer et al. 2014).

There is often speculation that expectation of federal disaster aid discourages *ex ante* risk management, but there is little empirical evidence on this point. Disaster aid provided through Stafford Act programs is designed to minimize moral hazard; recipients of both Individual Assistance grants from FEMA and Small Business Administration (SBA) disaster loans are required to maintain flood insurance for properties that have been damaged by floods. Examining flood insurance purchases in Florida after receipt of disaster aid grants from FEMA, a study finds very small reductions in the quantity of insurance purchased and no change in take-up rates, likely due to the requirement that recipients of aid insure (Kousky et al. 2018). The authors also find no impact on insurance purchases from household postdisaster loans provided by the SBA.

4. THE ROLE OF INSURANCE IN RECOVERY

4.1. How Does Insurance Impact Recovery?

Much of the funding for rebuilding and recovering from natural disasters is provided by government and donor funds after an event has occurred. It has been argued that this *ad hoc*, *ex post* funding model for disasters, particularly when it comes to international assistance, creates

ambiguities in who owns and should manage the risk, procrastination and delay in response, a “crying wolf” effect, fragmented response, and diminished incentives for preparedness and prevention (Clarke & Dercon 2016). In contrast, it is argued that prefunding disasters through insurance can minimize financial impacts, protect households and small businesses, and speed recovery.

The empirical evidence for the claims regarding the role of insurance in recovery, however, is surprisingly thin. This could be due to data limitations—few insurers are willing to make information about their policies available at a microlevel to facilitate a comparison of recovery between insured and uninsured victims. As such, most of the studies that do exist draw on surveys of those who have been impacted by a disaster, asking them for information about their insurance and about their recovery. These provide insight but are also limited by smaller and/or selective samples. There are also a few qualitative case studies that draw some conclusions about the role of insurance but are not able to causally identify relationships. Finally, there are two macroeconomic studies that look at broader impacts on the economy using aggregate measures of insurance penetration. These three types of studies are all reviewed in this section.

The first survey studies in the 1970s and 1980s found evidence that infusion of insurance money after a disaster facilitates and speeds rebuilding (Peacock & Girar 1997). Earlier case study research also found that while adequate insurance contributes to recovery, those with higher income and education levels are more likely to have such insurance (Bolin & Bolton 1986). This raises equity concerns that those who most need the financial protection of insurance are least likely to have it. Similar issues were raised in a case analysis of the Northridge earthquake. The authors observed that many of the damaged structures were low-rise, wood-frame apartment buildings without adequate insurance and that owners often abandoned them postquake, leaving areas vulnerable to gangs and criminal activity (Olshansky et al. 2006). The authors also observed greater recovery in an affluent neighborhood that had more insurance funds for rebuilding.

These findings of distributional differences were echoed in a survey of residents that sustained property damage from Hurricane Andrew. The authors found that African Americans were less likely than whites to have homeowners insurance and, troublingly, almost twice as many African Americans and non-Cuban Hispanics as whites indicated that their insurance company was not providing enough to cover the costs of needed repairs even after controlling for income and damage levels (Peacock & Girar 1997). The authors of the study found that whites were more likely to have insurance with “big name” companies and that this could account for the difference. Some smaller, poorly capitalized companies faced financial trouble after the storm and were not able to fully pay claims. The authors found that people insured with these companies tended to be African Americans and they did not receive enough claims to rebuild.

One of the only studies to empirically document and quantify the difference of being insured versus not in recovery outcomes focused on homeowners impacted by the 2005 hurricanes. The authors found that the most common reason for not rebuilding after experiencing hurricane damage was lack of funding and that if a property was insured prior to the hurricanes, it was 37% more likely to have been rebuilt (Turnham et al. 2011). The study also found that a little over 36% of those who did not rebuild said it was due to not being able to obtain or afford flood insurance. This study again provides evidence that lower-income groups may be less likely to afford insurance policies and then will be left out of insurance proceeds, echoing the concern that disasters can further marginalize these groups.

The general finding that insurance is associated with higher recovery has been confirmed in other countries, as well. Telephone surveys of over 1,200 households in Germany following damaging floods in 2002 explored the role of insurance. The authors found that households with insurance (roughly half) had higher total compensation for the damage and reported being more

satisfied with their compensation. A greater share was fully recovered eight months after the flood, although this latter finding was not statistically significant (Thieken et al. 2006).

A recent study used a unique approach to examine recovery from the Canterbury Earthquake Sequence (New Zealand) in 2010–2011 through nighttime satellite light intensity data used to capture economic activity (Nguyen & Noy 2018). The authors found that almost 95% of residential housing units were insured for these earthquakes, but payments were spread over several years as challenges with ambiguities in insurance contracts and an overwhelming number of claims slowed down settlements. This variation in timing of insurance payouts, linked to the light data, let the authors identify that building insurance payouts increased economic recovery. They also found that delays in claims payments slowed recovery.

There is also some indirect evidence on the role of insurance. A study of the impact of flooding on victims of Hurricane Katrina in New Orleans found that those who were flooded, all else equal, had lower home loan debt after the storm (Gallagher & Hartley 2017). The authors argue this could be driven by flood insurance payouts being used to pay off mortgages because the timing and magnitude of insurance payouts can explain the drop they find in mortgage debt. For homes that are completely destroyed postdisaster, occupants may need to face the question of whether to rebuild or abandon their homes. The study found evidence that the most-flooded homeowners were more likely to have repaid their mortgage if it was originated by a nonlocal lender (Gallagher & Hartley 2017). They argue this could be consistent with nonlocal lenders pressuring borrowers to repay rather than rebuild, but local lenders caring more about rebuilding the community.

For properties with a mortgage, insurance claim checks most often will be made out to both the insured and the lender. While it is usually in the interest of the lender to have the insurance funds used to repair the property and maintain the person in the home, there have been cases documented where lenders pressure borrowers to use the money to pay off the mortgage.³ There are websites that offer advice to victims to not be pressured to do this if it leaves them without a home or money to rebuild.⁴ Some states, such as Texas, have laws requiring lenders to notify borrowers within certain periods of time regarding what they must do to obtain their insurance funds. For large claims, the lender will often be involved in the repair process, putting funds in escrow and releasing them at certain points, perhaps after a lender-arranged inspection (Lerner 2012).

Most studies simply evaluate the presence or absence of insurance. There is also policy concern, however, about underinsurance, or failing to have enough coverage to completely fund rebuilding. CoreLogic (2017) estimates that roughly 60% of homeowners have less coverage than it would cost to completely rebuild their homes. Is this “underinsurance” a problem or a mistake, or is it the cost-effective decision for a household? That is difficult to determine because the appropriate amount of insurance depends not only on the replacement cost of the home but also on the specifics of the risk and the insureds’ financial position and risk preferences. For instance, a household may intentionally decide to self-insure some portion of the risk. There is anecdotal evidence of consumers intentionally choosing lower limits to save money but also other examples of households not realizing that their coverage was insufficient or failing to update their insurance policy after making upgrades to their homes (Swindell 2018).

There have been two examinations of underinsurance and wildfires in California. The first is a dissertation from the sociology department at Princeton (Hassani 2013). The dissertation focused on San Diego wildfires in 2003 and 2007, interviewing survivors about their insurance experiences,

³For example, see <http://library.hsh.com/articles/homeowners-repeat-buyers/can-mortgage-lenders-hold-your-insurance-money-hostage.html>.

⁴For example, see <https://texaslawhelp.org/article/handling-homeowner-insurance-claims#toc-5>.

as well as other stakeholders. That work found that underinsurance has been pervasive over the last 70 years in the United States and stems from both demand side challenges, such as people not realizing or choosing to save money rather than purchase greater coverage, as well as supply side challenges, such as poor estimation of rebuilding costs on the part of insurers and insurer attempts to limit payouts. The study found that when homeowners are unintentionally underinsured it can delay or impede their recovery. The approaches victims took to closing the gap between their insurance payout and the cost of rebuilding were varied but often were costly in time, resources, and emotional energy; at the extreme, victims were completely unable to rebuild. A recent examination of the wildfires and homeowners insurance in California also found evidence of lower coverage in the highest risk areas (Dixon et al. 2018). The report reviews possible explanations for insurance not fully covering the cost of rebuilding, including failing to insure to value, certain items being excluded, higher costs of debris removal from wildfires, and higher rebuilding costs in a postdisaster context.

Having appropriate and correct coverages can also be a challenge for small businesses. A survey of firms after Hurricane Sandy found that the majority of firms with property insurance, business interruption insurance, and flood insurance reported that their policy covered none of their losses (Collier et al. 2018). Part of this was because most losses were flood related, which are often excluded from other policies. Even those with flood insurance usually only have coverage for their own damage, not lost business income related to customers or utilities facing flood damage. Despite the lack of insurance, the authors find no statistically significant difference in firm survival rates several months postdisaster based on insurance coverage after controlling for other factors.

A recent study investigated the role of insurance in promoting business recovery in New Zealand following the Christchurch earthquake in 2011 and had similar findings (Poonitirakul et al. 2017). A survey was administered to impacted businesses both a few months after the earthquake and then several years afterward by a local NGO. The authors used propensity score matching on observable differences to address concerns that firms that purchase insurance may be systematically different than those that do not in ways that impact their recovery. Two years after the earthquake, they found that 70% of respondents had filed a claim and half said their insurance was inadequate. Among those with property insurance, the authors found some evidence that firms that additionally had business interruption coverage also had higher reported profitability and productivity two years later, after controlling for many additional factors.

Finally, two macroeconomic studies have investigated the impact of greater disaster insurance penetration in a country on its economic output. These papers are part of a small literature that covers the impact of disasters on macroeconomic indicators, often regressing economic output on measures of disasters for country-year observations (reviewed in Kousky 2014). Two of these studies have included measures of insurance penetration. The first was a study that used the Munich Re Nat Cat data from major catastrophes⁵ between 1960 and 2011. The authors included both the insured amount of loss and the uninsured amount, essentially treating them as two events occurring at the same time and place (von Peter et al. 2012). The authors found that the uninsured portion of disaster losses was associated with declines in economic output, but well-insured disasters can be inconsequential or even positive for growth. They found that smaller countries suffered larger declines from uninsured losses but also tended to recover faster from insured losses.

A second cross-country analysis of economic output following disaster events also found that lower insurance penetration is associated with higher output declines and a greater increase in deficits after a disaster (Melecky & Raddatz 2014). The authors used a panel vector autoregression model to regress the output variables on their lagged values, controls, country and year fixed

⁵These are events with at least 100 fatalities or \$250 million in losses.

effects, and lagged and contemporaneous measures of disaster occurrence. Their sample was biased toward high-income countries, where insurance penetration data was available.

4.2. Insurance as a Financing Mechanism for Postdisaster Risk Reduction

It is typically more cost-effective to incorporate retrofits into rebuilding than to upgrade non-damaged, existing building stock. In addition, when a disaster substantially damages buildings and infrastructure, it creates an opportunity to rethink building patterns. This can be facilitated when private sector or public sector disaster insurance has special coverages to fund the incorporation of risk reduction in rebuilding. There are no empirical studies, however, comparing choices or rebuilding outcomes of those insureds that make use of such programs and those that do not. Nor are there studies on when and why such programs would be used by insureds and when they would not be used. That said, it seems useful to briefly review the programs here. Empirical evaluation of such programs would be useful future research.

Most standard homeowners policies in the United States have law and ordinance (L&O) insurance or the option to buy this coverage. L&O coverage pays for the costs of upgrades to meet current regulations when repairing a damaged home. For example, many communities might require upgrades to meet plumbing, roofing, or electrical standards when rebuilding. This type of coverage would pay for these additional expenses.

In the United States, the NFIP standard policy has a similar additional coverage included, referred to as Increased Cost of Compliance (ICC) coverage that provides policyholders in mapped 100-year floodplains up to \$30,000 to adopt flood mitigation measures when a home is substantially damaged (at least 50%) by a flood. ICC covers the cost of mitigation actions needed to bring a structure into compliance with current floodplain regulations, but many floodplain managers are concerned that the funding is insufficient for this purpose. Mitigation measures could include elevation, relocation, or flood proofing of nonresidential structures.

The CEA offers something similar. All policies include \$10,000 in building code upgrade coverage (that can be increased to \$20,000 or \$30,000), which can be used to bring a damaged home into compliance with the seismic code. In a somewhat different approach, the North Carolina Insurance Underwriting Association (NCIUA), the state's residual market mechanism, began a pilot program in 2017 to pay for roof upgrades for policyholders that suffer a loss that damages their home more than 50% (OMB 2016).

5. INSURANCE AND INCENTIVES

It is often assumed that insurance prices can be a financial incentive regarding risk reduction investments and location choice. Surprisingly little work has been done providing evidence on these assumptions. The first subsection here examines the research on using premiums to incentivize investments in hazard mitigation, and the second turns to the relationship between insurance and land use.

5.1. Using Premiums as an Incentive for Risk Reduction

In many countries, disaster insurance is paid for through a flat fee on all citizens or all policyholders regardless of their risk. This reflects a view of disasters as exogenous events that should be borne by everyone in society—often referred to as a solidarity approach. In these places, insurance pricing cannot play the role of creating ex ante incentives for risk reduction since there is no price discrimination among properties. In the United States, however, there is a greater focus on the use of financial incentives to drive behavior. Many have argued that charging risk-based prices for insurance while providing premium discounts for investments in hazard mitigation

could create an incentive to invest in risk reduction when the costs could be paid back over time through lower insurance premiums (e.g., Kunreuther 2008). Of course, insurance only provides such incentives to insureds; Section 3.2 documents the low take-up rates for disaster insurance.

Premium reductions for hazard mitigation are offered by several insurance programs and companies in the United States. For example, the NFIP offers substantially lower rates when homes are elevated above the base flood elevation (Kousky et al. 2017). Multiple states—including Alabama, California, Florida, Louisiana, Maryland, Mississippi, New York, South Carolina, and Texas—require insurance companies to offer premium discounts for certain wind hazard mitigation investments, or they have state insurance programs that offer such discounts (Multihazard Mitig. Counc. 2015, OMB 2016).⁶ Many insurance companies offering coverage in areas at high risk of wildfire offer premium discounts for certain mitigation measures (Headwaters Econ. 2016). The CEA offers premium discounts to older homes and mobile homes that have undertaken a seismic retrofit. There has been no empirical research to determine, first, if insurance premium discount programs are associated with more mitigation and, second, if these premium reduction programs simply reward those who have undertaken mitigation for other reasons or actually incentivize new mitigation investments.

Empirical research is needed, as there are several reasons that such premium reductions may not be able to deliver on the expectation of incentivizing greater investments in risk reduction. First, the premium savings may not be enough to make the investment financially attractive. There is little information publicly available in an accessible manner on how the premium savings associated with the mitigation investment compare to the actual costs and if this can produce a payback period favorable enough for many homeowners. This type of incentive program only works if the discount on the insurance is enough for the hazard mitigation measure to be cost-effective over a time period considered beneficial to the property owner. One study examined this issue for the case of four flood mitigation measures (flood vents, elevation of mechanical and engineering, basement infill, and structure elevation) in New York City. While there were some properties for which mitigation could be financially attractive based on flood insurance premium reductions, the authors found that mitigation measures were not financially justified based on flood insurance premium reductions for a substantial number of properties (Dixon et al. 2017). Of course, mitigation investments can produce benefits beyond reduced claims, such as lowering uninsured losses, protecting irreplaceable family photographs, or minimizing below-deductible damages. There is little evidence on how consumers consider these various benefits.

Second, the insurance market is unlikely to be an efficient incentive mechanism for securing all cost-effective investments in mitigation. This is particularly true in a cyclical market like insurance. In a soft market, when prices are lower, the premium reduction may not be enough to incentivize mitigation and, in a hard market, when prices are high, many may forgo insurance entirely (Woo 1999).

Finally, even if homeowners believe hazard mitigation investments are worthwhile, many such actions, such as elevating a home, can exceed the upfront funds available to a homeowner, even with a favorable payback period. In response, some scholars have advocated for linking loans to insurance (Kunreuther 2006), yet no such funding model has yet been successful in practice. Several attempts have been made, but they have had very low rates of participation or have not

⁶If implemented poorly, mandating pricing strategies to a private market can cause greater problems, as demonstrated by the case of Florida. In 2003, the state mandated that insurance companies offer premium discounts for certain mitigation measures. The mandates, however, forced companies to provide discounts that were not justified or not reflective of actual reductions in claims payments (Medders & Nicholson 2018). This led to over half of inspected homes receiving price discounts without undertaking any mitigation measures at all, and this may have led insurers to leave the state or impeded them financially (Medders et al. 2014).

been able to scale dramatically. These include a federal program of mitigation loans as part of the disaster recovery loans offered by the SBA⁷ and a state-level program in Connecticut (Shore Up Connecticut) that offered low-interest loans to retrofit structures to make them more resilient to floods and storms.

The only study found on this topic was a survey of residents in the Netherlands, in which they were asked about their willingness to undertake mitigation measures in exchange for premium reductions on insurance (Botzen et al. 2009b). In a purely hypothetical scenario, participants were asked about purchasing sandbags, installing water-resistant flooring, and moving appliances to higher floors, and many indicated they would do these things for expanded coverage or savings on insurance premiums at the levels given. Flood insurance is not currently widespread in the Netherlands, however, so participants had no experience with the product, and all discounts were chosen by the authors, not the companies; it is not clear whether insurers would offer any discounts for the activities discussed or if the amounts would match the study.

Several studies look at the broader question of whether hazard mitigation and insurance tend to be complements or substitutes. The studies generally find a positive correlation between those who have disaster insurance and those who invest in hazard mitigation. An online survey of Gulf Coast residents found a statistically significant positive relationship between wind insurance and wind mitigation activities (Petroliia et al. 2015). A survey of German households impacted by flooding mentioned in the previous section found that awareness of hazard mitigation and investments in such measures were slightly higher among insured households than uninsured households (Thieken et al. 2006). Another phone survey in the United States and Germany found in both places that those with insurance were more likely to invest in mitigation (Hudson et al. 2017). Although these studies suggest minimal concerns about moral hazard in these markets, they cannot determine whether the correlation is due to high risk aversion or high perceptions of risk driving both insurance purchases and mitigation investments or whether the insurance is financially incentivizing the mitigation. None look explicitly at premium discounts for mitigation.

One study of participants in a Florida mitigation program, My Safe Florida Home, finds that those with higher wind premiums are more likely to invest in mitigation (Carson et al. 2013). It is unclear, however, if this is because the homes are riskier and this drives both higher premiums and more investment in mitigation or if the reason for the mitigation investment is the premium reduction. The same study finds that among those investing in mitigation, a higher deductible is associated with greater mitigation investments (Carson et al. 2013). Again, causality is unclear. External validity may also be a concern, as participants in this program are unlikely to be representative of the population since they are likely more aware of hurricane risks. Further, the program provided matching mitigation grants of up to \$5,000 for those with home value below \$300,000; not all residents would qualify or be interested in this offer.

Finally, premium reductions for mitigation could operate at the level of reinsurance as well. For instance, the North Carolina wind pool (North Carolina Joint Underwriting Association) finds that retrofits to its most exposed properties can be more than paid for by the lower reinsurance premiums (OMB 2016). The CEA also finds that grants for insureds to “brace and bolt” their home, which lowers earthquake damage, can produce reinsurance savings.⁸

⁷ SBA loans may be increased beyond the cost of repair if the funds are used to implement mitigation measures that reduce the risk of future damage caused by disasters of the same type. For example, if a home is damaged by a flood, the homeowner may borrow additional funds to help cover the cost of elevating the home or taking other actions to reduce flood risk. Additional mitigation funds may be as much as 20% of a homeowner’s total physical losses, as verified by SBA, and the maximum loan amount cannot exceed \$200,000.

⁸ See CEA Governing Board meeting notes online at <https://www.earthquakeauthority.com/EQA2/media/Meeting-Materials/CEA-Governing-Board-Meeting-Materials-uly-18-2018.pdf>.

5.2. Insurance and Land-Use Incentives

Many observers have speculated that the availability of disaster insurance, particularly if priced below the private market, would induce development in risky locations. If that were true, however, one would expect much greater take-up of insurance than is observed, suggesting that the ability to insure is not a key determinant of location choice in many cases. One area where such a causal relationship has been repeatedly claimed is floodplain development and the NFIP in the United States. There has no doubt been development of the country's floodplains since the program was created 50 years ago (Hipple et al. 2005, Wing et al. 2018). There is, however, no empirical evidence to support the claim that it was largely driven by insurance availability or pricing at levels witnessed today.

A review of evidence—mixed methods and anecdotal—in 2000 reached this same conclusion (Evatt 2000). The author finds some initial evidence that early NFIP implementation (that is no longer applicable) may, in some places, have enhanced development pressures, along with myriad other factors, but overall there was no indication that flood insurance was currently inducing floodplain development. Of course, this is not to say that if mandates about having disaster insurance were made more widespread or prices increased substantially, they would not create disincentives for certain land use in high-risk areas—that is quite possible—but empirical research to date cannot speak to those potential impacts.

There is one empirical study on the topic, which examines communities before and after joining the NFIP and while they were in the early (so-called emergency) phase of the program in which insurance was highly subsidized and in the regular program (Cordes & Yezer 1998). Estimating a reduced form equation with the dependent variable being new construction, the authors find that being in the early phase of the program did increase development but the regular phase did not. The possible explanation is that properties built while in the early phase would be granted subsidized rates and this incentivized building. Today, communities have shifted to the regular phase, and this incentive no longer operates.

Numerous studies have evaluated how hazard risk and disaster insurance are capitalized into housing values. Multiple studies have found that homes in the FEMA-mapped 100-year floodplain sell for less than homes outside this zone, after controlling for myriad potential differences in the properties themselves (e.g., Bin & Kruse 2006, Bin & Landry 2013, Kousky 2010, MacDonald et al. 1990). This could be from the higher risk, the insurance cost, or both. Another study found that disclosure laws, which require information to be made available earlier than the federal disclosure requirement on lenders, do lower housing values in flood-prone areas (Pope 2008). In coastal areas, however, it can be difficult to separately distinguish the impacts of flood risk on housing values from the high amenities of coastal location (Bin et al. 2008). Similar findings have been found for earthquakes and wildfires, both of which also lower property values—and for disasters in multiple countries (e.g., Daniel et al. 2009, Hidano et al. 2015, Mueller et al. 2009).

Apart from quantity of development in high-risk locations and housing prices, disaster insurance could impact other forms of land use if there are financial incentives for such actions. Firewise, a program run by the National Fire Protection Association, may be one such example. When communities join they assess their wildfire risk and develop an action plan and engage in some outreach and education. The insurance company USAA found that Firewise communities in different states all had lower losses than those not in Firewise communities and is thus providing discounts to residents of these localities (OMB 2016).⁹ It is unclear if this may contribute to incentives for changing land-use patterns, such as increasing defensible space, which

⁹See more at <https://www.nfpa.org/Public-Education/By-topic/Wildfire/Firewise-USA/Become-a-Firewise-USA-site/Program-benefits/Insurance-discounts-for-USAA-members-in-seven-states>.

is a buffer around homes to reduce wildfire risk. An analysis of market conditions, supporting studies, and anecdotal evidence concluded that insurance policies and prices are unlikely to determine whether or not someone develops in an area at high risk of wildfires (Headwaters Econ. 2016).

Finally, quasi- to fully public disaster insurance programs may have other mechanisms to impact land use apart from availability or cost of coverage. For example, the NFIP is designed as a voluntary partnership between the federal government and local communities. In order to join and have flood insurance made available to residents, they must adopt minimum floodplain regulations governing all new development in the mapped 100-year floodplain. These vary by FEMA-designated flood zone but include the following: (a) The community must require that all new development in the 100-year floodplain obtain a permit; (b) new development in floodways (the central portion of a floodplain that carries deep and/or high-velocity flows) must not be permitted if it increases flood heights; and (c) all new construction, or substantially improved or damaged properties in 100-year floodplains, must be elevated such that the lowest floor is at or above the base flood elevation, which is the estimated height of floodwaters in a 100-year flood (nonresidential structures can also be dry flood-proofed). In areas subject to storm surge, additional building requirements apply to address the force of waves. The NFIP also maintains a voluntary community program to incentivize greater investments in flood risk management, some of which are through land use by awarding points for preserving floodplains as open space (Brody & Highfield 2012). There is no work, however, identifying whether this program induced land-use changes in communities that would not have occurred absent the program.

6. CONCLUSION

It has long been presumed that disaster insurance has a critical role to play in promoting resilience by protecting households and businesses against negative financial shocks, speeding recovery by improving postdisaster liquidity, and potentially lowering risks *ex ante* through financial incentives. Surprisingly, rigorous and robust empirical investigation of these claims is limited. The first overarching finding of this review, then, is that more well-designed empirical research is needed to isolate and quantify the differential impacts among insured and uninsured on a variety of recovery and *ex ante* risk reduction outcomes.

The largest number of studies have been done on the role of insurance in disaster recovery. These have used multiple methods, with most being surveys. This body of research generally finds that having insurance increases the likelihood of rebuilding, minimizes financial hardship postdisaster, and speeds time to recovery. That said, some of this work suffers from limited external validity, inability to identify causal relationships, or lack of quantification. The studies also present varying degrees of evidence that certain lower-income or minority populations are less likely to be protected by insurance and as a result may have worse recovery outcomes. This raises the troubling finding that those most in need postdisaster are least likely to have access to needed funds through insurance.

There are fewer studies examining the role of insurance on *ex ante* risk reduction. While a number of companies and programs offer premium discounts for hazard mitigation investments, there has not been an evaluation of whether these induce new mitigation investments or an examination of the role they play in consumer decision making. There is some evidence that any impact may be modest at best, suggesting that careful work on this topic is needed. Although property values clearly capitalize disaster risk and/or insurance costs, there is little support for the claim that the availability of insurance has altered land-use patterns substantially. Much more research is needed on the links between risk transfer and risk reduction.

As climate change alters extreme event risk around the globe, a deeper appreciation of the role insurance can play in climate adaptation will be required. Beyond the need for further isolation of the impact of having insurance on outcomes, there is also a need for research comparing the impact of various insurance designs and other mechanisms for funding disaster losses on recovery metrics and on the distribution of who bears the cost of disasters. Finally, in other areas, insurers have played a role in developing a culture of safety, in promoting preparedness measures, and in facilitating widespread adoption of risk-reduction measures. Careful work on when, whether, and how the insurance industry could help accelerate adoption of cost-effective hazard mitigation measures for changing disaster risk will become increasingly useful.

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