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Flood Risk and the U.S. Housing Market

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1. INTRODUCTION

Flooding is the most frequent and costliest natural disaster in the United States. Scientists predict more serious flood losses in the future due to the combined forces of increasing development in areas subject to flooding and climate changes, including both changing storm and precipitation patterns and sea level rise. According to some estimates, coastal flooding may inundate 2 percent of the homes in the U.S. by 2100 due to sea level rise, with neighborhood effects, such as impassable roads, impacting far more residences (Bretz 2017). This will cause stress to housing markets in many locations over the coming decades.

Today, many homeowners are uninsured against flood damage. For example, approximately 20 percent of homes in areas affected by Hurricane Harvey had flood insurance and only 12 percent of homes in East Baton Rouge Parish, LA were protected with flood insurance in August 2016 when severe storms caused widespread flooding.¹ Federally backed or regulated lenders require flood insurance on loans collateralized with property in the 100-year floodplain as mapped by the Federal Emergency Management Agency (FEMA). However, these insurance policies are often held for only a few years. Moreover, flood damage can occur in communities outside this region from more extreme events (e.g. Baton Rouge and Houston), unmapped stormwater flood risks, or because the maps are using outdated data or methods. The lack of widespread take-up of flood insurance will not only impose financial strain on families but could have spillover effects in adjoining communities and may trigger foreclosures that hurt lenders. Among those with insurance, properties that experience repetitive losses pose an additional problem.

This paper describes the U.S. housing market's exposure to flood risk and suggests directions for future research and action. The next section characterizes the nature of flood risk in the United States. Section 3 describes how FEMA, as well as catastrophe modeling companies, assess flood risk. Section 4 discusses why homeowners often do not voluntarily protect themselves financially against floods. Section 5 describes current federal flood risk management programs in the country. Section 6 examines the interaction of mortgage and housing markets and flood risk. Section 7 concludes with a summary and a roadmap for future research and action.

2. FLOOD RISK IN THE UNITED STATES

There are three primary types of flooding in the United States. First is coastal flooding from tides or storm surge caused by winds from tropical storms and hurricanes pushing water inland. Second is fluvial, or riverine flooding that occurs when a river or stream overflows its banks. Riverine flooding can be a gradual process, as in overbank flooding, or could occur rapidly, known as flash flooding. Riverine or coastal flooding can also occur when flood defenses, such as levees or floodwalls, fail. Third, pluvial, or surface water flooding, also referred to as storm water or rainfall flooding, occurs when heavy precipitation overwhelms local drainage and is exacerbated by the prevalence of impervious surfaces. Pluvial flooding can occur away from rivers and streams in areas where there is a topographical depression, or bathtub effect, causing runoff from the surrounding area to pool in an area of relatively lower elevation.

NOAA's National Centers for Environmental Information (NCEI) monitor and evaluate weather and climate events with the most significant social and economic impacts. According to NCEI data, over 70% of water-related events (severe storms, hurricanes/tropical cyclones, and floods) exceeded \$1 billion in total losses and have accounted for more than 75 percent of losses – roughly \$1.18 trillion (adjusted to 2017 dollars) from

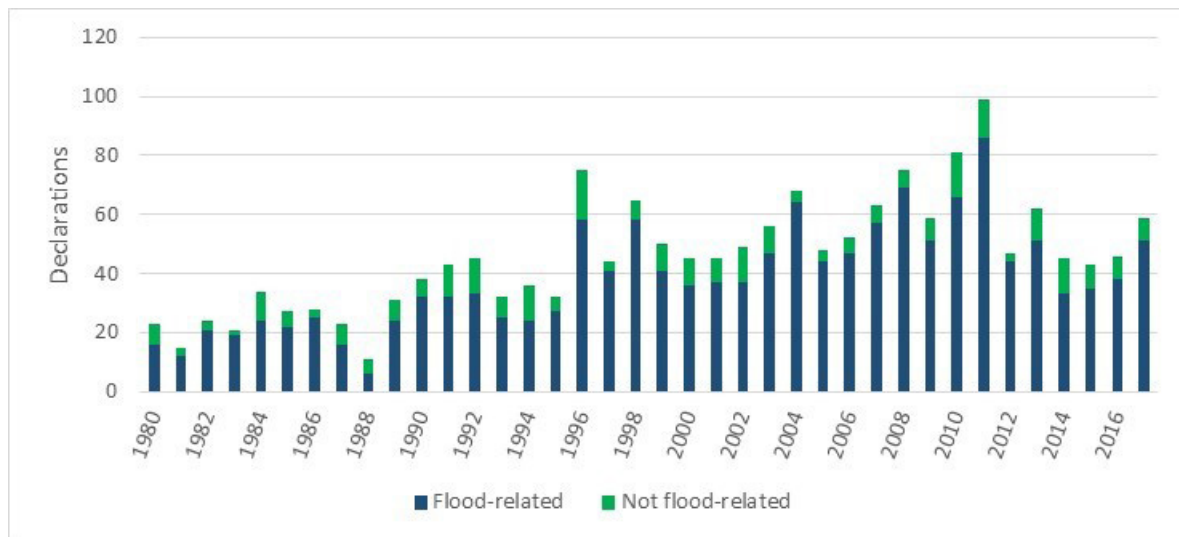
¹ FEMA and U.S. Census Bureau estimates. See: Long, H. (2017). "Where Harvey is hitting hardest, 80 percent lack flood insurance." The Washington Post. August 29, 2017. https://www.washingtonpost.com/news/wonk/wp/2017/08/29/where-harvey-is-hitting-hardest-four-out-of-five-homeowners-lack-flood-insurance/?utm_term=.4f75ab883813; and Calder, C. (2016) "Only 1 in 8 EBR residents have flood insurance, meaning many will likely bear brunt of losses." The Advocate. August 15, 2016, http://www.theadvocate.com/baton_rouge/news/article_8c8255ec-6336-11e6-aa27-63945b489f7e.html.

major flood events in less than three decades. Moreover, the data suggest that these events are occurring with increasing frequency.

The increasing flood risk in the United States is reflected in the increasing number of flood-related Presidential disaster declarations over the last several decades. Under the Robert T. Stafford Disaster Relief and Emergency Assistance Act (1988) (PL 100-707), the President may issue an emergency or major disaster declaration when an event is “of such severity and magnitude that effective response is beyond the capabilities” of state and local governments. Such declarations initiate federal support for response and recovery efforts and enable FEMA to provide assistance to impacted individuals and communities. Since 1980, the number of Presidentially declared major disasters has escalated, reaching a peak in 2011 at 99 declarations (see Figure 1). Notably, more than 80 percent of the 1,743 declarations made through 2017 were tied to floods and flood-related events such as hurricanes and severe storms.

FIGURE 1

Major Disaster Declarations 1980 to 2017



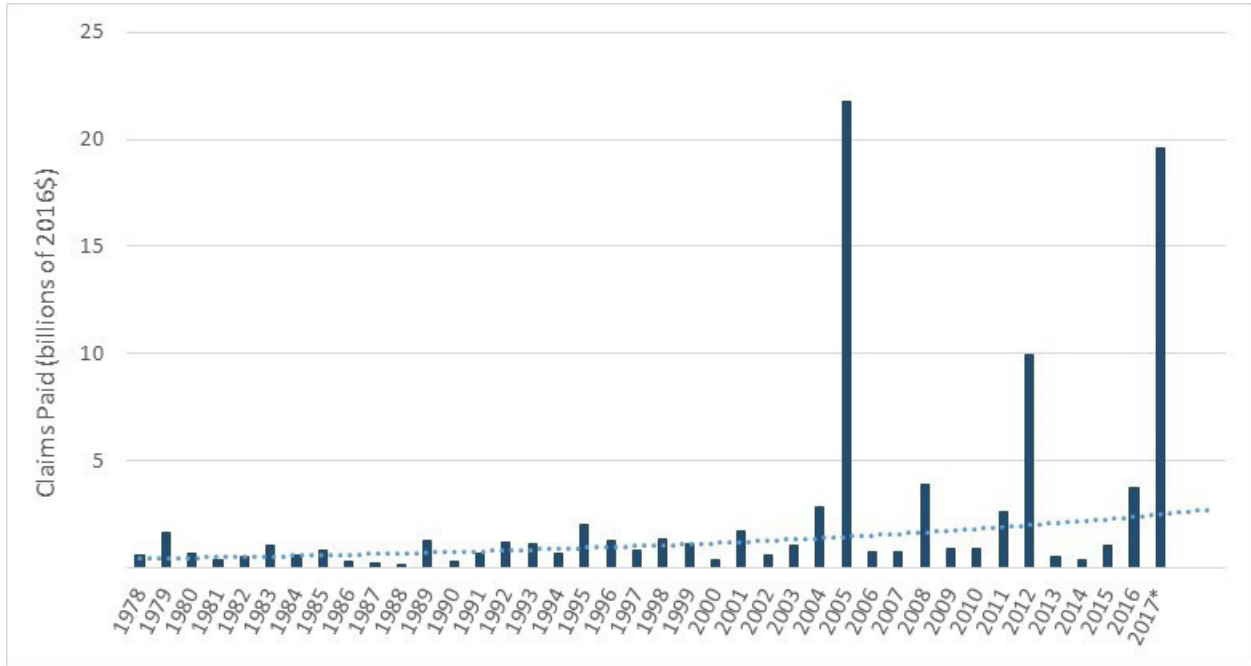
Note: Made by authors with public data from FEMA.

Flood insurance claims from the National Flood Insurance Program (NFIP) also show an increasing trend, as shown in Figure 2.² In its 50-year history, the NFIP’s six costliest years have all occurred since 2005. From the NFIP’s beginning in 1968 through 2004, the program’s flood losses were relatively modest, never exceeding \$1 billion until 1995 and peaking at \$2.2 billion in 2004. In 2005, however, the program paid out more in a single year – \$17.7 billion – than it had over the program’s entire history primarily due to Hurricane Katrina. In 2012, Hurricane Sandy led to nearly \$10 billion in claims paid, another extreme loss year. And due to Hurricanes Harvey, Irma, and Maria, 2017 is projected to be the program’s most expensive year on record at an estimated \$20 billion in claims paid. Most significant events have been associated with major hurricanes, but inland flooding has also caused substantial losses. In August 2016, historic floods devastated parts of Louisiana as a slow-moving storm system poured 20+ inches of rain in areas of Baton Rouge and surrounding parishes over a three-day period. As rainwater traveled south, rivers overflowed and thousands of homes flooded, many of which were located outside of high risk flood zones.

² Section 5.1 provides more details on flood insurance claims.

FIGURE 2

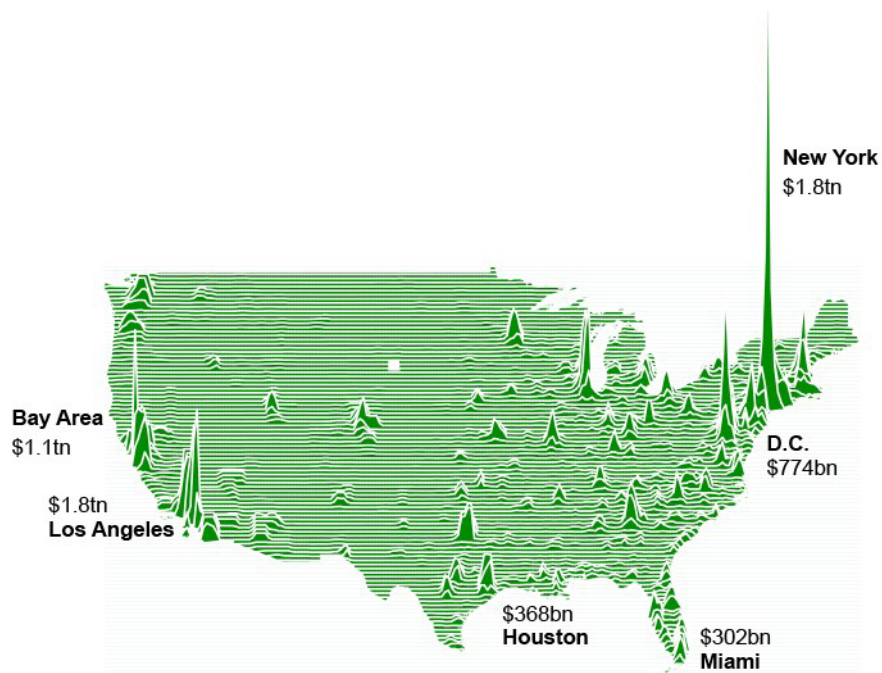
Total NFIP Claims Paid by Year (\$billions, 2016 values)



Note: All figures created by the authors with publicly available data from FEMA. Amounts for 2017 reflect current estimates only.

FIGURE 3

Total Property Value in Dollars



Map made with interpolated county-level data from the Census Bureau, downloaded from www.economist.com.



Increasing losses are due in part to development decisions in flood-prone areas. There is substantial path dependency in this development; once infrastructure is in place, it is very difficult to abandon areas (Cronon 2009, Bleakley and Lin 2012). Many of our country's metropolitan areas were built up near water for use in transportation, agriculture, and commerce. The expansion of impervious surfaces has made rainfall events more destructive. Moreover, coastal development has become more attractive and increased over time. As shown in Figure 3, the four largest cities in the U.S. are on bodies of water – New York City, Los Angeles, Chicago, and Houston – and the property values are highest near the coast.

Climate changes are also increasing flood risk. Climate-induced changes in rainfall patterns are projected to lead to increasing flooding in certain parts of the United States (Mallakpour and Villarini 2015; Prein, Liu et al. 2017). A statistical model of the relationships between precipitation and flood damages in the U.S., when linked to climate projections for changes in rainfall, predicts increasing flood damages in many areas of the U.S. as the planet warms (Wobus, Lawson et al. 2013). In addition, sea-level rise has already led to an increased probability of coastal flooding, which will continue in the coming years (Sweet and Park 2014). As an example, a recent study of New York City found that floods which were once characterized as 1-in-500 year events in the preindustrial era are already occurring at a 1-in-25-year interval and are likely to drop to a 1-in-5-year event in the next thirty years (Garner, Mann et al. 2017).

Many coastal communities are beginning to struggle with greater tidal flooding, or “sunny day flooding” as a result of sea level rise. A recent report by the Union of Concerned Scientists found that in their intermediate global sea level rise scenario of 4 feet by 2100, more than 270 communities in the United States will face chronic inundation by 2060 with more than 10 percent of the land experiencing flooding 26 times per year. In their high global sea level rise scenario of 6.5 feet of sea level rise by 2100, the number of chronically inundated communities would grow to 360 by 2060.³ A recent article in *Nature* also highlights that given the continued migration of people to coastal cities, the number of people impacted by even a modest sea level rise estimate of 2.9 feet by 2100 could affect twice the current population (Hauer et al. 2016).

Roughly half the population of the United States, around 168 million people, live in coastal watershed counties that represent just under 20 percent of the national land area (NOAA 2013). Some 23 million people, or 8 percent of the total population, live in low-elevation coastal areas (Curtis and Schneider 2011). With a significant percentage of the U.S. population at risk, researchers estimate that by 2100 storm surge and sea-level rise may cause almost \$1 trillion in damage to properties representing approximately 2 percent of the country's housing stock (Neumann, Emanuel et al. 2015; Berstein, Gustafoson et al. 2017; Rao 2017; Bretz 2017). Under a scenario of 6 feet (1.83 meters) of sea-level rise by the year 2100, an area currently home to 6 million people will be inundated and an estimated 13.1 million people could be forced to relocate elsewhere. The southeastern United States represents nearly 70 percent of the entire projected population at risk, thus implying that the impacts of sea-level rise will be highly concentrated in specific regions (Hauer et al. 2016; Hauer 2017).

3. FLOOD RISK ASSESSMENT

Flood risk information is currently available from two major sources: FEMA and private modeling firms. Section 3.1 discusses the flood hazard maps produced by FEMA and Section 3.2 discusses flood assessments from catastrophe modeling firms.

³ <https://www.ucsusa.org/global-warming/global-warming-impacts/when-rising-seas-hit-home-chronic-inundation-from-sea-level-rise#.WV2grogv2w>.

3.1. FEMA FLOOD MAPS

FEMA flood maps have become the *de facto* public information product for characterizing the current flood hazard facing a community. These maps, called Flood Insurance Rate Maps (FIRMs), however, were designed to implement the requirements of the National Flood Insurance Program (NFIP) rather than being an ideal risk communication tool for households and communities. FIRMs define different flood zones. Two zones comprise the 100-year floodplain – the A zone and the V zone. These are areas that are estimated to have a 1% chance of flooding in any given year. A zones are inland floodplains and coastal floodplains subject to waves of less than 3 feet. V zones are narrow strips on the coast subject to breaking waves of at least 3 feet. The 100-year floodplain (A and V zones) is also referred to as the Special Flood Hazard Area (SFHA). FIRMs also generally show the base flood elevation (BFE) or the estimated height of waters in a 100-year flood within the SFHA. FIRMs also show the 500-year floodplain and areas that have an annual flood risk lower than 1-in-500.

FIRMs were originally produced on paper, but over the past 15 years, the vast majority have been converted into digital maps, referred to as DFIRMs. The digital conversion was the focus of FEMA's Map Modernization program. FEMA also maintains the National Flood Hazard Layer (NFHL), a publicly available digital database with spatial flood hazard data derived from engineering and hydrological studies, FIRMs, and official map revisions. As of June 2013, the NFHL data covered about 92 percent of the U.S. population (FEMA 2013).

Riverine or coastal flood hazards are the primary focus of most flood studies (National Research Council 2015). Riverine flood studies can identify waterways (rivers, streams, other) that are subject to overbank flooding, flash floods, and urban drainage systems flooding. FEMA flood studies sometimes include shallow flooding with an average depth of one to three feet in areas where a clearly defined channel does not exist. Shallow flooding may be caused by ponding, sheet flow, or local drainage problems where runoff collects in yards or swales or when storm sewers back up. Generally, however, FIRMs tend to focus on riverine and coastal flooding and not pluvial or surface water flooding. For more on the mapping process, see King (2013).

FEMA launched the Risk Mapping, Assessment, and Planning (Risk MAP) program in 2009 to improve flood mapping data, risk assessment, and risk communication to help communities with mitigation planning for reducing future flood losses. Risk MAP, undertaken with local partners, focuses on developing products and services beyond the standard FIRM. The five goals of the program are to (1) address gaps in hazard data; (2) increase the awareness and understanding of flood risk among the public; (3) aid mitigation planning; (4) develop a digital platform; and (5) synergize across different program components. Each Risk MAP project is designed to meet the needs of individual communities and can involve different phases, services, and tools.

In some communities, local partners help with the production of flood maps through FEMA's Cooperating Technical Partners (CTP) program, established in 1999. The objective of the CTP program is to optimize limited mapping funds and create a process for incorporating unique local conditions. CTPs may be local governments, regional authorities, or state agencies. Once selected, a CTP enters into a formal partnership that allows FEMA to fund activities such as program management, base map acquisition, floodplain analyses, plus up to 10 percent of scoping and outreach costs.

FEMA FIRMs have been criticized by stakeholders over the years. One concern is that many are outdated (National Research Council 2015). While maps are supposed to be updated every five years, in reality, many maps are based on outdated data or modeling. A 2016 report by FEMA's Office of Inspector General found that over half of stream/coast miles mapped by FEMA required updating or had not been assessed (Office of Inspector General 2017). Another concern is that many maps do not capture pluvial flooding, as mentioned above, yet climate scientists predict increasing intensification of rainfall events (Prein, Rasmussen et al. 2016). The National Academy of Sciences is now investigating the impact of pluvial flooding in urban areas in the United States.

Many stakeholders are concerned that FEMA maps create a false sense that flood risk is binary by focusing on whether a property is “inside” or “outside” of the SFHA. Beyond the maps, this is exacerbated by the federal requirement that lenders disclose when a property is located inside the SFHA and require the purchase of flood insurance if the mortgage is federally regulated. Flood hazard maps that show the variation in flood risk throughout and beyond the SFHA are needed. These hazard data need to be coupled with information on specific structures, particularly their elevation in relation to the base flood elevation (BFE) for more accurate pricing of flood insurance.

The Biggert-Waters Flood Insurance Reform Act of 2012 (PL 112-141) established an ongoing effort to update maps. The Act also created the Technical Mapping Advisory Council (TMAC) to review and make recommendations related to FEMA's mapping efforts. TMAC representatives come from the private sector and from all levels of government. The council was tasked with examining the quality and distribution of FIRMs, developing performance metrics for mapping, setting standards for mapping and data, finding ways to maintain and update FIRMs, maintaining relationships with local partners, developing approaches for improving interagency coordination, and determining how to incorporate the best available climate data into mapping

TMAC has now issued a Future Conditions Report in 2015 and three Annual Reports (2015, 2016, 2017) and is finalizing an Annual Report for 2018 that can be obtained from their website: (<https://www.fema.gov/technical-mapping-advisory-council>). FEMA is now taking steps to implement many of the TMAC recommendations regarding future mapping that more accurately reflect structure-based risks so they can provide risk-based flood insurance premiums to property owners and other stakeholders such as lenders, developers and real estate agents. More specifically they are undertaking studies to move to a more graded depiction of flood risk across and beyond the Special Flood Hazard Area (SFHA).

3.2. FLOOD CATASTROPHE MODELS

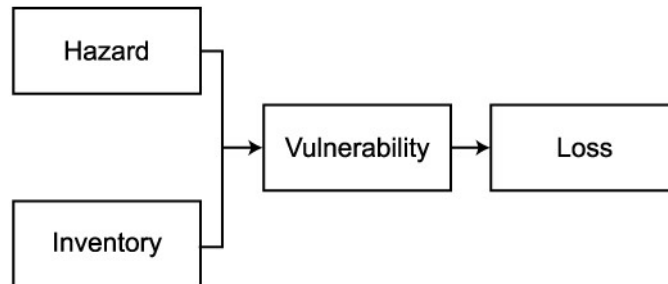
Many private companies also produce flood risk information. Some of these have probabilistic flood risk models and others provide risk scores or metrics for individual properties. Proprietary catastrophe models for many perils have been developed by modeling firms to assist insurance companies in pricing and managing their exposure. The development of natural hazard catastrophe models took off in earnest following Hurricane Andrew in 1992 as well as the Northridge earthquake in 1994, and they are extensively used by insurers and reinsurers in the property and casualty insurance industry today.

The four basic components of a catastrophe model are: hazard, exposure (inventory), vulnerability, and loss, as depicted in Figure 4 (for more detail, see: Grossi and Kunreuther 2005). First, the model determines the *hazard*, which in the case of a flood may be characterized by its frequency, associated water depth, and possibly velocity. Next, the model characterizes the *exposure or inventory* portfolio⁴ of properties at risk as accurately as possible. This includes not only locating the structure as precisely as possible, but also identifying the relevant structural characteristics of the property that impact on the amount of damage sustained. The hazard and exposure (inventory) modules are linked to calculate the *vulnerability* or susceptibility to damage of the structures at risk. In essence, this step in the catastrophe model quantifies the physical impact of the natural hazard phenomenon on the property. How this vulnerability is quantified differs across models. Based on a particular metric of vulnerability, the financial loss to the property inventory is estimated. Loss generally includes the direct impacts, such as property damage, but may include indirect losses, such as business interruption (for more on disaster losses, see: Kousky 2014).

⁴ For example, Fannie Mae generally bears the credit risk on a portfolio of approximately 18 million properties in the United States and its territories.

FIGURE 4

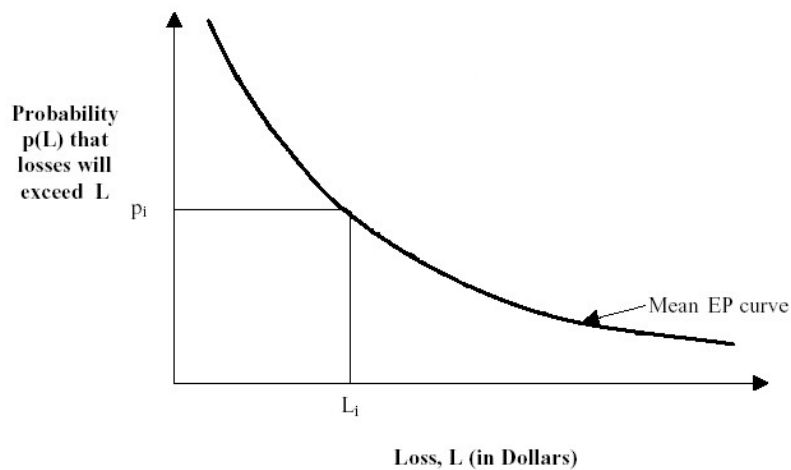
Structure of Catastrophe Models



Based on the outputs of a catastrophe model, an exceedance probability (EP) curve can be calculated. For a given portfolio of structures at risk, an EP curve is a graphical representation of the probability p that a certain level of loss $\$X$ will be surpassed in a given time period. Special attention is given to the right-hand tail of this curve where the largest losses are situated. Figure 5 depicts a hypothetical EP curve with a specific loss L_i . The likelihood that losses will exceed L_i is given by p_i . The x-axis measures the loss in dollars and the y-axis depicts the annual probability that losses will exceed a particular level. Average annual loss (AAL), a common metric of risk, is the overall expected loss for the entire set of events, or the area under the EP curve.

FIGURE 5

Example of a Mean Exceedance Probability Curve



Risk modeling companies have modeled hurricane wind and storm surge related flooding for decades. Hurricane models are constructed by combining historical and hypothetical hurricane scenarios with meteorological, topographical, bathymetrical, building, demographic, and financial data to evaluate the potential costs of wind and storm surge damage in a particular location. These models are well-developed and have now been calibrated against many loss events. The development of U.S. inland flood modeling, however, is in its nascent stages. The relative infancy of these models can be significantly attributed to the presence of the National Flood Insurance Program (NFIP) and the lack of private sector demand for inland flood models until relatively recently. Several modeling companies, however, have now developed U.S. inland flood models. In



November 2017, a U.S. flood model showcase was hosted by Lloyd's of London and Argo Global. This showcase compared the models by four companies—Applied Insurance Research (AIR), KatRisk, Impact Forecasting (Aon), and CoreLogic—against a hypothetical set of exposures across the inland U.S. RMS has also recently released an inland flood model.

These models differ in their assumptions, how they model the risk and spatial resolution, thus producing a wide range of outcomes. For example, the estimated damage from Hurricane Harvey from four catastrophe models (AIR, CoreLogic, KatRisk, and Impact Forecasting) ranged from \$497 million to \$986 million with standard deviations ranging from \$46 million to \$637 million (Wright 2017). These differences only reinforce the fact that flooding is a complex phenomenon and the U.S. is a very large territory with various weather and precipitation patterns.

One of the fundamental challenges of the modeling process is that flood risk can be especially sensitive to individual structure characteristics and location. Whereas wind or earthquake hazards are likely to cause similar damage to a set of adjacent structures, the damage a property experiences in a flood depends critically on very localized factors. For instance, a small-scale difference in elevation of a couple feet can cause large variations in flood damage.

Another major challenge for flood modeling lies in accurately depicting the risk of damage from rainfall, or pluvial flooding, that occurs when heavy rainfall overwhelms local drainage capabilities. To estimate the damage from pluvial flooding, modelers must incorporate data on impervious surface area and localized storm water drainage infrastructure, which poses technical challenges given that such data at a fine geographic scale are not currently available. The AIR Inland Flood Model estimates that roughly 60 percent of the annual average loss from inland floods in the United States comes from storm water flooding underscores the importance of accurately depicting pluvial flood risk.

Today, flood models are used by (re)insurers, insurance brokers, some government entities, and other firms to improve their understanding of flood risk, to explore market opportunities, and to design and price insurance products. Recently, to better understand its exposure and to develop a more granular, risk-based approach to premium setting in the NFIP, FEMA has licensed both the AIR and KatRisk flood models. Additionally, (re) insurers, brokers, and consultants are currently using one or more of these models to develop and price private flood insurance products (Kousky et al. 2018).

Catastrophe modelers have taken varying approaches to incorporating climate sensitivity into their models. For example, KatRisk has built in climate sensitivity with respect to storm surge, allowing the user to set sea level rise parameters. AIR does not incorporate climate change projections into their models, but each update includes the most current sea level estimates. In setting insurance premiums for the typical one-year insurance contract, there is limited need from insurers in modeling the risks associated with climate change, but there is a concern as to the long-term impact of climate change on their future book of business and their ability to insure property in flood-prone areas.

4. WHY HOMEOWNERS MAY NOT VOLUNTARILY PROTECT THEMSELVES AGAINST FLOODS

Insurance can protect lenders from defaults, but it is also resiliency-enhancing for households suffering damage from disasters. Federal aid for individuals is limited and can take months or years to get into the hands of victims. The primary financial sources for uninsured households is their savings or a loan. Many families do not have enough savings to pay to rebuild a heavily damaged home and would be burdened by additional debt.



Classical economic theory assumes that consumers make their insurance purchase decision by maximizing their expected utility. In the case of flood insurance this implies that homeowners in areas subject to water-related damage obtain data on the probability of floods of different magnitudes and the resulting damage from each of them and compare the expected benefits from different amounts of insurance protection with the resulting costs to the insured. Expected utility theory tells us that risk averse individuals are willing to purchase insurance at premiums that exceed their expected losses.

Despite these theoretical predictions and the practical benefits of insurance, there are a large number of uninsured homeowners in areas subject to flood damage. Recent data from FEMA indicates that on average nationwide the take-up rate in SFHAs is roughly 30% (Kousky, Kunreuther et al. 2018). Many of those uninsured could be without a mortgage, and thus not subject to the mandatory purchase requirement if they reside in the SFHA. Earlier estimates suggest that within the SFHA, take-up rates may average around 50 percent (Kriesel and Landry, 2004; Dixon, Clancy et al. 2013). Outside the SFHA, even fewer are covered, even in areas at risk of flooding. For example, one study of New York City (Dixon, Clancy et al. 2013) estimated that fewer than 20 percent of those flooded in Hurricane Sandy had flood insurance, suggesting that storm surge affected properties beyond the SFHA.

This section examines the principal biases associated with risk perception that may lead individuals to not purchase insurance or invest in hazard mitigation measures against floods and other low-probability, high-consequence events (Section 4.1). It then discusses a proposal from Meyer and Kunreuther (2017) for a behavioral risk audit that examines how risk communication efforts coupled with economic incentives are likely to make individuals more aware of the hazards they face and potential consequences so they consider purchasing flood insurance (Section 4.2).

4.1. RISK PERCEPTION OF HOMEOWNERS

A large body of cognitive psychology and behavioral economics over the past 30 years has revealed that individuals and organizations often make decisions concerning risk and uncertainty using rules of thumb and that individuals can be subject to systematic biases (e.g., Kahneman, Slovic et al. 1982). Nobel Laureate Daniel Kahneman has characterized the differences between two modes of thinking to explain the observed behavior (Kahneman 2011). *Intuitive thinking* (System 1) operates automatically and quickly with little or no effort and no voluntary control. This approach is often guided by emotional reactions and simple rules of thumb that have been acquired by personal experience. *Deliberative thinking* (System 2) allocates attention to effortful and intentional mental activities where individuals undertake trade-offs and recognize relevant interdependencies and the need for coordination. Choices are normally made by combining these two modes of thinking and generally result in good decisions when individuals have considerable past experience as a basis for their actions. However, with respect to extreme events such as floods, there is a tendency to either ignore a potential disaster or overreact to a recent one so that decisions may not reflect expert risk assessments. This behavior can be contrasted with models of deliberative thinking by consumers and by insurers, which would be closer to expected utility models. To design an effective flood risk management program, it is necessary to understand and counter the primary biases that lead homeowners to underinvest in insurance and preventive measures. These biases discussed in more detail in Meyer and Kunreuther (2017) are listed in Box 1.



BOX 1

Systematic Biases Characterizing Intuitive Thinking

1. Myopia	The tendency to focus on overly short future time horizons when appraising immediate costs and the potential benefits of protective investments.
2. Amnesia	The tendency to quickly forget the lessons of past disasters.
3. Optimism	The tendency to underestimate the likelihood that losses will occur from future hazards.
4. Inertia	The tendency to maintain the status quo or adopt a default option when there is uncertainty about the potential benefits of investing in alternative protective measures.
5. Simplification	A tendency to selectively attend to only a subset of the relevant facts to consider when making choices involving risk.
6. Herding	The tendency to base choices on the observed actions of others.

Myopia: Economists have long documented how decisions often seem to depart from that which would be expected if people were fully rational when discounting time (for a review of the historical treatment of time preferences in economics see Frederick, Loewenstein et al. (2002)). It has been found that people often demonstrate a heavy bias for the present and near-term. People routinely engage in what is termed *hyperbolic discounting*, where they demand far more compensation for short-term delays of gratification than could be explained by the opportunity cost of money that is measured by interest rates. (Laibson 1997).

When risk reduction measures take many years to pay back, individuals might choose not to invest in them: our intuitive planning horizons are typically shorter than that which are needed to see the long-run value of such investments. Controlled experiments and field surveys with respect to investment decisions reveal this behavior can be explained either by *myopic loss aversion*, which assumes that people are short-term oriented in evaluating outcomes and are more sensitive to losses than to gains (Gneezy and Potters 1997; Thaler, Tversky et al. 1997), or *narrow framing*, isolating the current decision from future opportunities to make similar decisions (Redemeier and Tversky 1992; Kahneman and Lovallo 1993). While we might appreciate the need for flood insurance or a safer home, our myopia imposes a handicap to our ability to adopt protective decisions.

Amnesia: Emotions, such as worry or anxiety, are often stimulated by experiencing a disaster and may lead to investment in protective measures during the immediate post-event period (e.g., Baron, Hershey et al. 2000; Schade, Kunreuther et al. 2012), but these feelings tend to fade quickly over time. Many homeowners voluntarily purchased flood insurance after suffering damage but they then may decide not to renew their policy if they have not experienced a disaster because they feel they have wasted the money they spent on their premium. An analysis of the NFIP policies-in-force over time revealed that the median tenure of flood insurance was between two and four years while the average length of time in a residence was seven years (Michel-Kerjan, Lemoyne de Forges et al. 2012). A similar pattern has also been found in housing where after a flood, home prices may decline, but then rebound in just a few years (see Section 6.2). Political scientists have found voters to be amnesic by supporting disaster relief but not disaster mitigation funding (Healy and Malhotra 2009).

Optimism: People tend to believe that they are likely to be immune from threats. It has been found that people perceive the likelihood of a specific event based on their own personal experiences rather than on statistical data. There is a tendency to underweight the probability of a disaster if one has not recently experienced the event and overweight it following a severe disaster when the event will be very salient (Hertwig, Barron et al. 2004). This behavior, termed the *availability bias*, has been observed and tested in a large number of controlled experiments and field studies (e.g., Tversky and Kahneman 1973; Slovic 2000).

A more serious source of error associated with the optimism bias is an interest in constructing scenarios that *we hope* will happen. Rather than imagining our living room being under water, we prefer to think about the



scenario of not experiencing damage from a flood or hurricane. To support this behavior, Karlsson, Loewenstein et al. (2009) developed a model supported by empirical data that implies that we seek out information after receiving good news but put our heads in the sand by avoiding additional information should we be given negative prior news.

Inertia: A principal reason why we do not undertake protective measures to reduce future losses is that we often prefer to stay with the status quo (Samuelson and Zeckhauser 1988). This saves us both time and energy by not having to collect information on the costs and benefits of new alternatives. Sticking with the current state of affairs is the easy option, favored by emotional responses in situations of uncertainty and in proverbs and aphorisms (“better the devil you know than the devil you don’t” and “when in doubt, do nothing”).

Empirical evidence in the context of insurance-related decisions supports the notion of status quo bias. In the early 1990s, New Jersey and Pennsylvania offered car owners the opportunity to buy either lower-priced policies that came with a limited right to sue in the case of an accident or a higher-priced policy that had no such restriction. In New Jersey, the default was the plan with the limited right to sue, while in Pennsylvania, the opposite held. This difference had a huge effect on policy preferences; in Pennsylvania, only 30 percent of drivers opted to restrict their right to sue, while in New Jersey, where such an option was the default, 79 percent maintained the status quo (Johnson, Hershey et al. 1993).

Simplification: With respect to extreme events there is a tendency to make choices by considering only the few factors that come readily to mind. If the perceived likelihood of a flood or hurricane is very small, a person is likely to view the probability to be below one’s threshold level of concern. In a controlled experiment on insurance decision making with money at stake, McClelland, Schulze et al. (1993) found that more than 25 percent of the subjects bid zero dollars when asked the maximum they were willing to pay for insurance protection, suggesting they may be failing to consider low probability risks at all as a way of simplifying their decision-making process.

Herding: Individuals’ choices are often influenced by other people’s behavior. If a large number of your friends and neighbors have decided not to purchase insurance, then you may follow suit (Banerjee 1992). A 2013 study of the factors that caused residents of Queensland, Australia to buy flood insurance found that ownership was unrelated to perceptions of the probability of floods, but highly correlated with whether residents believed there was a social norm for the insurance (Lo 2013). In an earlier survey of homeowners in flood and earthquake-prone areas, one of the most important factors determining whether a homeowner purchased earthquake or flood insurance was discussions with friends and neighbors rather than considering the perceived likelihood and consequences of a future disaster occurring (Kunreuther, Ginsberg et al. 1978).

4.2. USING THE BEHAVIORAL RISK AUDIT TO COMMUNICATE RISK

The above common biases in evaluating risks make it a challenge to communicate disaster risk so that people are aware of the hazard and understand its potential consequences. The way information is presented and framed can influence how people respond and react to the content. One way to deal with these biases is to conduct a behavioral risk audit (Meyer and Kunreuther 2017). It starts by characterizing how individuals are likely to perceive risks and why they might not focus on the likelihood and consequences of the risk in the same way as an expert. Strategies are then proposed that work *with* rather than *against* people’s risk perceptions and natural decision biases by drawing on the principles of *choice architecture*, which indicate that people’s decisions often depend in part on how different options are framed and presented (Thaler and Sunstein 2008). When risk communication is combined with short-term economic incentives, individuals are likely to consider investing in cost-effective insurance and mitigation measures that reduce the potential consequences of financial consequences of flood-related events.



The result of the behavioral audit will not be a single remedy for enhancing preparedness, but rather a suite of measures that are likely to evolve over time as the nature of the risk changes and innovative protective strategies emerge. Some examples of possible policies include low interest mitigation loans financed through lower insurance premiums; multi-year and multi-risk insurance policies, including all-hazards insurance for property;⁵ and presenting risk information in ways more conducive to how people think about risk, including disaster perils in homeowners' coverage, encouraging social norms for risk reduction or stretching time horizons to communicate risk. For example, to increase demand for insurance, FEMA is now presenting information to homeowners on their flood risk by stretching the time over a 30 year period and indicating that the likelihood of at least one flood occurring during this period is greater than 1-in-4 rather than 1-in-100 annually. Kunreuther (2018a) discusses the role of the behavioral risk audit in the context of flood insurance and the reauthorization of the National Flood Insurance Program.

4.3 USING FLOOD MAPS TO COMMUNICATE INFORMATION

With respect to communicating information using flood maps, there is concern that while FIRMs are produced to implement NFIP regulations and requirements, they have become the primary source of flood risk information available nationwide. As mentioned above, a concern is that the SFHA boundary creates a false perception that outside the boundary people are “safe” and that inside the SFHA the risk is uniform. In reality, of course, flood risk varies continuously across the landscape. Most people are not aware that in a 20-year period, there is an 18 percent chance that the 100-year flood level will be exceeded. Furthermore, more extreme events cause flooding outside the SFHA.

In an analysis of flood claims data throughout the country between 1978 and 2012, roughly 30 percent of claims were for properties outside SFHAs (Kousky and Michel-Kerjan 2015). Many recent storms, including named hurricanes, all led to flooding that extended beyond the SFHA and generated flood depths that exceeded the BFE by several feet (FEMA 2015a). Residual risk is not communicated in the FIRMs. The Technical Mapping Advisory Council has suggested that FEMA move toward a structure-specific depiction of risk, as opposed to the simplistic message of being “inside” or “outside” of the SFHA (Technical Mapping Advisory Council 2015).

Some local governments are engaging in their own risk communication efforts. Recognizing the need to educate homeowners about their current and future flood risk as depicted on the current and updated FIRMs, the City of New York partnered with the Center for New York City Neighborhoods (CNYCN) to develop an easy-to-use website, FloodHelpNY.org, that allows users to enter their address on a Google-Maps-like interface.⁶ Users can toggle between a view of their current and potential zone and base flood elevation (BFE). The website conveys risk in large-font, plain language. For example, for a renter-occupied property in the AE-zone the language below the map says: “Buildings in high risk (AE) zones have the potential for severe flooding—possibly in excess of several feet of water. Even though you’re not required to have flood insurance as a renter, your renters insurance won’t protect your personal property if your home is flooded.”

The website also clearly articulates the two-pronged challenge homeowners face in terms of an increase in their premiums: (1) the phase-out of long-standing rate discounts for older homes due to legislation passed in 2012 and 2014, and (2) increasing risk due to sea level rise and more frequent storms. With an infusion of money from the NY State Governor’s Office of Storm Recovery, the updated version of the site makes these challenges more concrete, including a flood insurance rate estimator (in beta) to provide users with current and future premium quotes. In addition, low- and middle-income homeowners can check their eligibility for a free

⁵ See Section 7 for further discussion of all-hazards homeowners insurance.

⁶ The “current” risk is based on the effective 2007 FIRM and the “advisory” risk is based on the 2015 Preliminary FIRM that is currently being revised as discussed below.



resiliency audit to determine feasible mitigation steps a homeowner could take to lower their flood insurance premium.

5. FLOOD RISK MANAGEMENT IN THE UNITED STATES

5.1. FLOOD INSURANCE

In 1897, an insurance company offered flood insurance to property along the Mississippi and Missouri Rivers motivated by the extensive flooding of these two rivers in 1895 and 1896. Two floods in 1899 not only caused the insurer to become insolvent since losses were greater than the insurer's premiums and net worth, but the second flood washed the office away. No insurer offered flood coverage again until the 1920s when thirty fire insurance companies offered coverage and were praised by insurance magazines for placing flood insurance on a sound basis (Dacy and Kunreuther 1968). Yet, following the great Mississippi flood of 1927 and flooding the following year one insurance magazine wrote: "Losses piled up to a staggering total which was aggravated by the fact that the insurance was largely commonly treated in localities most exposed to the flood hazard. . . By the end of 1928 every responsible company had discontinued coverage," (Manes 1938, p.161).

After 1928, few private insurance firms offered flood insurance on residential property. The rationale for this was summed up in the May 1952 *Report on Floods and Flood Insurance* issued by the Insurance Executive Association: "Because of the virtual certainty of the loss, its catastrophic nature and the impossibility of making this line of insurance self-supporting due to the refusal of the public to purchase insurance at rates which would have to be charged to pay annual losses, companies could not prudently engage in this field of underwriting."

This absence of coverage by the private sector triggered significant federal disaster relief to victims of Hurricane Betsy in 1965 and led to the creation of the National Flood Insurance Program (NFIP) in 1968. Since its creation, the NFIP has been the main provider of flood insurance nationally. Housed in FEMA, communities can voluntarily join the NFIP by adopting minimum floodplain management regulations; their residents then become eligible to purchase flood insurance policies through the program. A residential property can be insured up to \$250,000 for the building structure and up to \$100,000 for the contents, however, unlike other forms of hazard insurance, the NFIP does not cover temporary living expenses. A business can insure both structure and contents up to \$500,000. Those coverage limits were set at current levels in 1995 and are not indexed to inflation. Currently, over 22,000 communities nationwide, accounting for the majority of people at risk of flooding, participate in the program.

In 1973 Congress passed the Flood Disaster Protection Act, (P.L. 93-234) which established the mandatory purchase requirement for property owners in an SFHA with a mortgage loan from a federally backed or regulated lender. This Act also required that to be eligible for federal disaster aid, communities must participate in the NFIP. In 1974, Congress added a notification requirement that federally regulated lenders, which provide the substantial majority of mortgage loans in the U.S., inform borrowers if their property is located in an SFHA.

Take-up rates for flood insurance are low, even in areas subject to the mandatory purchase requirement. A study from a decade ago by RAND estimated that on average 50 percent of homes in SFHAs had flood insurance, but this varied considerably around the country, with higher take-up rates in the southeast (Dixon et al. 2006). Recent data suggest an average take-up rate in SFHAs of around 30% (Kousky, Kunreuther et al. 2018). As of November 2017, there were just 5 million policies-in-force nationwide representing roughly \$1.27 trillion in coverage. Although there is no reliable database on the number of properties in SFHAs nationwide, a recent estimate put the number at approximately 41 million people (Wing et al. 2018).

The number of policies in the program grew fairly steadily until 2009 and has been declining since then as shown in Figure 6. There is speculation that price increases as a result of the 2012 and 2014 reform legislation



may have driven the decline in recent years. Currently, roughly 60 firms write policies and process claims on behalf of the NFIP but bear none of the risk and are not involved in rate setting. These “write-your-own” (WYO) companies market policies and process claims (many use a vendor) in exchange for a fee.

FIGURE 6
NFIP Policies-in-Force Over Time

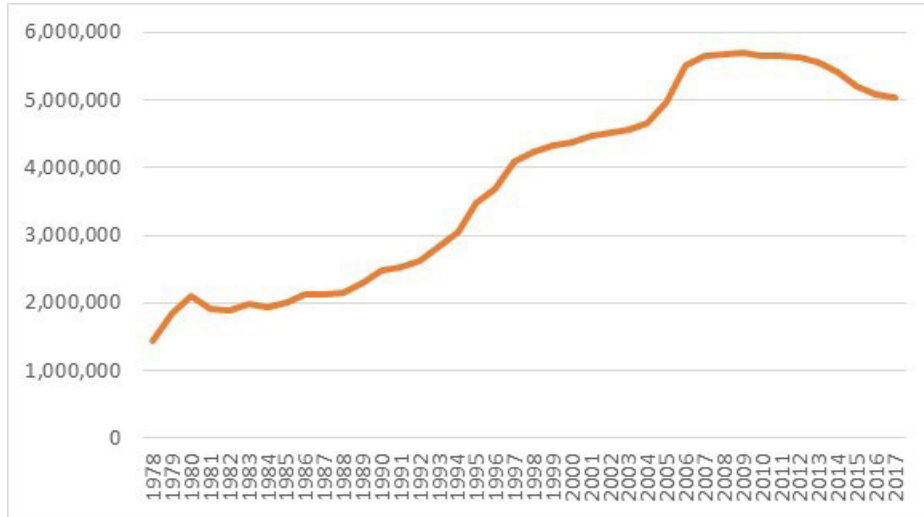


FIGURE 7
Top 30 Counties in U.S. by Number of NFIP Policies



The NFIP is heavily concentrated geographically. Roughly 35 percent of all policies are in Florida and another 12 percent are in Texas. Louisiana comes in third (with almost 9 percent of all policies), California fourth (6 percent), and New Jersey fifth (just over 4.5 percent) (Kousky 2018). Only 1 percent of counties in the U.S. are responsible for 51 percent of total policies nationwide. These 30 counties, depicted in Figure 7, are concentrated in areas of very high flood risk – Florida, the Gulf and Atlantic coasts, and Sacramento, California.

There is a very small, but growing, private flood insurance market in the United States, often providing coverage to high valued homes above the NFIP cap of \$250,000 on the structure (a so-called “excess” flood policy). These private insurers target areas where they can offer coverage more cheaply than the NFIP. The number of residential private flood policies nationwide currently is less than five percent of total NFIP policies (for details on the private residential flood market, see: Kousky et al. 2018). As with the NFIP, the largest concentration of private policies is in Florida, although there are private firms offering coverage in select areas around the country.

The NFIP prices policies based on flood risk zones as shown on FIRMs, as well as certain characteristics of the property, such as elevation, number of stories, and whether the property has a basement. The result is cross-subsidies from lower-risk to higher-risk properties (Kousky, Lingle et al. 2017). A National Research Council report noted that for most policies, premiums may be representative of the flood risk for the structure class as a whole, but not for individual structures within the class (National Research Council 2015). In its December 2015 annual report, the TMAC recommended: “FEMA should transition from identifying the 1-percent-annual-chance floodplain and associated base flood elevation as the basis for insurance rating purposes to a structure-specific flood frequency determination” (Technical Mapping Advisory Council 2015). FEMA is currently in the process of revising its rating and mapping through a process it has labeled Risk Rating 2.0.

The TMAC noted that the following information is needed for accurate mapping: the nature of the hazard (multiple recurrence periods and flood depths); structure elevation; damage estimates for different water heights and types of structures; and estimates of the average annual loss (Technical Mapping Advisory Council 2016). A recent study compared average annual losses (AALs) for single-family homes in the SFHA of North Carolina to NFIP premiums (absent administrative costs) using Hazus depth-damage functions (Kunreuther, Dorman et al. 2018). For each structure, risk-based premiums were calculated using the North Carolina ground elevation data determined by Light Imaging Detection and Ranging (LIDAR) technology coupled with Hazus depth-damage curves to obtain the AAL per \$100 of coverage. These premiums were compared to the estimated NFIP premiums per \$100 without administrative costs for these same structures. Estimates of NFIP premiums were calculated with available flood hazard and building information data maintained by North Carolina Emergency Management – Risk Management and the North Carolina Floodplain Mapping Program (<http://www.ncfloodmaps.com/>). The paper found that structure-based premiums with this methodology are substantially less than those calculated using the existing NFIP methodology. The analysis reveals that 92.8 percent of the homes in the sample have lower risk-based premiums (in terms of cost per \$100 of coverage) under the AAL methodology than under the current NFIP methodology. Risk-based prices are higher than NFIP premiums only where buildings are predicted to suffer damage from more frequent, shallow floods currently not considered explicitly in NFIP premium calculations.

Several studies have sought to identify the determinants of flood insurance demand. Unsurprisingly, they generally find take-up rates are higher in areas where the hazard is greater. These researchers also find that as education of homeowners and home values increase, so too does coverage or the likelihood of insuring (Kousky 2011; Landry and Jahan-Parvar 2011; Atreya, Ferreira et al. 2015; Brody, Highfield et al. 2016). Petrolia, Landry et al. (2013) surveyed coastal homeowners and found that those who anticipated higher damage from a flood were more likely to insure.



Researchers have also found that after a serious flood event or a year with high flood damages, take-up rates for flood insurance increase, but the effect dies out in a few years (Browne and Hoyt 2000; Gallagher 2014; Atreya, Ferreira et al. 2015). Much of this increase, however, could be driven by a requirement that recipients of federal disaster aid in the SFHA purchase flood insurance policies. An examination of take-up rates for flood insurance after hurricanes found that this requirement increased take-up rates by about 5 percent, with only an additional 1.5 percent increase in take-up rates not due to this requirement (Kousky 2016). These policies may not be maintained, however: the bump in policies is gone three years after the disaster.

Price is likely a key driver of the demand for flood insurance, but the price elasticity has been hard to estimate empirically due to a number of challenges. The first is the mandatory purchase requirement: homeowners subject to this regulation may appear price inelastic, but this may not reflect their true preferences if they could have voluntarily determined whether to purchase flood insurance. At least one study found that residents were more price sensitive (although the elasticity was still small) if they were unlikely to have a mortgage (and thus subject to this requirement) (Dixon, Clancy et al. 2006). Two methodological challenges also complicate estimating price elasticity for flood insurance. First, NFIP premiums can be highly correlated with flood risk—or homeowners' perception of risk—making it difficult to tease out the effect of price from the effect of risk without an exogenous change in price, which are not incorporated in these studies. Second, premiums are observed only for policies actually bought, and so researchers cannot examine the behavior of those who choose not to insure.

Since 2014, the NFIP has been phasing out some historic premium discounts for older structures. These price increases have called attention to the affordability of flood insurance as an important policy concern. A recent report from FEMA (2018) that matched NFIP data with US Census data revealed that just over a quarter of NFIP policyholders in SFHAs are low income and just over half of non-policyholders are low income. The report also found that the ratio of mortgage principal interest, property taxes, and insurance (not including flood), exceeded 0.4 for 12 percent of homeowners in the SFHA with flood insurance. The report found that the income of policyholders was higher than non-policyholders, suggesting affordability is a concern among those not currently insured, as well (FEMA 2018). Several reports and papers have proposed and examined possible federal policy solutions, all centered around some form of means-tested assistance for insurance and hazard mitigation investments (see, for example, Kousky and Kunreuther 2014; NRC 2015; NRC 2016; Dixon, Clancy et al. 2017).

5.2. FLOOD RISK REDUCTION PROGRAMS

Several federal agencies provide grant funding or incentives for hazard mitigation; these programs are discussed in this sub-section. Looking across the mitigation grant spending related to flood risk reduction, over 90 percent of all federal dollars are appropriated in supplemental legislation, tied to a particular Presidential disaster declaration, with much less appropriated pre-disaster (Kousky and Shabman 2017).

5.2.1. FLOOD MITIGATION IN THE NFIP

The NFIP has several carrots and sticks for encouraging policyholders and communities to invest in flood mitigation. At the household level, the program offers premium discounts for certain mitigation measures. The largest premium discounts are given for elevating a property above the BFE (Kousky, Lingle et al. 2017). Elevating homes is very expensive, however, and homeowners need grants or loans to make it financially feasible. It also may not be cost-effective to mitigate a home until it is damaged by a flood and the elevation can be done as part of the rebuilding. And for some properties, such as row houses, elevation will just not be possible.



Through the NFIP's Increased Cost of Compliance Coverage (ICC), NFIP policyholders can receive funds to help bring their flood-damaged structures into compliance with current state and local floodplain management regulations designed to reduce future flood risk. This includes the requirement that new development and substantially damaged or improved properties in the SFHA be elevated so that the lowest floor is at or above BFE. ICC coverage is a mandatory component of most NFIP policies. For residential properties, ICC provides up to \$30,000 for homeowners to elevate, relocate, or demolish their properties after a flood. According to FEMA data, among the single-family homeowners that received ICC claims payments between 1997 and 2014, 62 percent used funds for elevation, 30 percent for demolition, and less than 1 percent for relocation (Kousky and Lingle 2017).⁷

ICC claims are submitted separately from standard flood insurance claims, and recipients are limited to a total payout of \$250,000 from their standard policy and ICC. In general, a property is eligible for ICC payments only if it is substantially damaged, meaning the cost of repair is equal to at least 50 percent of the structure's value. In recent years, the program has been criticized because it is not well-understood by homeowners and because it often fails to cover the full cost of eligible mitigation measures. For example, the cost of elevating a home can easily be three to five times the \$30,000 available. Current proposals to reauthorize and reform the NFIP include provisions that would increase the amount of ICC coverage available to homeowners and expand its eligible uses, allowing them greater flexibility and resources to implement post-flood mitigation measures.

At a community level, FEMA has minimum floodplain regulations that all participating communities must adopt. These vary by flood zone but include the following: (1) the community must require that all new development in SFHAs obtain a permit; (2) 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 (3) all new construction, or substantially improved or damaged properties in SFHAs, must be elevated such that the lowest floor is at or above the BFE, which is the estimated height of floodwaters in a 100-year flood (nonresidential structures can also be dry flood-proofed). In V zones, additional building requirements apply to address the force of waves. Note that coastal A zones, while exposed to waves, do not have stricter building regulations than their inland counterparts. The community also must base all regulations on the most up-to-date map. Some communities may elect to have codes that exceed these minimum requirements.

The NFIP also creates incentives for communities to undertake additional actions through the Community Rating System (CRS). This voluntary program, established in 1990, rewards communities with lower flood insurance premiums for voluntarily reducing their flood risk. All communities are initially rated as Class 10. As they undertake actions that reduce risk, they accrue points and move through levels of the program, with Class 1 as the highest. The actions are grouped into four categories: (1) public information; (2) mapping and regulation; (3) flood damage reduction; and (4) flood preparedness. As of 2014, only 5 percent of NFIP communities participated in the CRS, but they accounted for 67 percent of all policies-in-force (FEMA 2014). Only five communities nationwide have attained one of the two highest classes: Roseville, California; Tulsa, Oklahoma; King County and Pierce County, Washington; and Fort Collins, Colorado. Several studies have examined reasons for communities participating in the CRS and the activities they chose to pursue (Brody et al. 2009; Landry and Li 2012).

5.2.2. FEMA MITIGATION GRANT PROGRAMS

FEMA has several grant programs that provide funds for flood risk reduction, collectively referred to as the Hazard Mitigation Assistance (HMA) programs. These are the Flood Mitigation Assistance (FMA) program, the Pre-Disaster Mitigation (PDM) program, and the Hazard Mitigation Grant Program (HMGP). Across FEMA's

⁷ 8 percent used funds for "other" mitigation measures.



HMA programs, state agencies with floodplain or emergency management responsibilities submit proposals to FEMA, including sub-applications from local governments and other state agencies. State and local government applicants must have FEMA-approved hazard mitigation plans in place to apply for a grant. For FMA, local government sub-applicants must also have a plan that addresses flood hazards specifically. All properties included in an FMA application must be insured by the NFIP and structures that receive mitigation funding must be insured against flood damages in perpetuity, even if the property is sold to another owner.⁸

FEMA's HMA programs provide funds for the following types of flood mitigation measures: property acquisition and structure demolition (or relocation); structure elevation; mitigation reconstruction; dry flood-proofing of historic residential structures; localized flood risk reduction projects (e.g., culverts, storm water management facilities, retention and detention basins, floodwalls, dams, etc.); structural retrofitting of existing buildings; non-structural retrofitting of existing buildings and facilities; infrastructure retrofit; soil stabilization; and state and local mitigation planning.

FEMA's Flood Mitigation Assistance (FMA) program provides funding annually to NFIP-participating communities and policyholders to implement risk-reduction actions that reduce future flood damages and claims to the NFIP. The FMA program prioritizes Repetitive Loss (RL)⁹ and Severe Repetitive Loss (SRL)¹⁰ properties – those that have proven to be the mostly costly to the NFIP.¹¹ In fact, from 2008 to 2012, FEMA operated two separate programs – the Repetitive Flood Claims and the Severe Repetitive Loss programs – specifically targeted at mitigating these structures. Those programs were discontinued in 2012 and merged with FMA. The program requires a 25 percent non-federal cost-share for most projects, though FEMA will contribute up to 100 percent of costs for SRL mitigation projects and up to 90 percent of costs for RL projects.

FMA is funded entirely by NFIP premium revenue rather than discretionary appropriations from Congress. Since 1996, program obligations have amounted to roughly \$800 million (2016 USD), though funding has increased in recent years, averaging approximately \$105 million from FY 2013 to FY 2016. Of the mitigation measures eligible for FMA funding, elevations and property acquisitions have been the most prevalent, amounting to 41 percent and 39 percent of funds, respectively. After that is flood control efforts at 9 percent.

FEMA's Pre-Disaster Mitigation (PDM) program provides funds to state and local governments for hazard mitigation activities that reduce damages from floods and other types of disasters. PDM funds projects located in SFHAs only if the community participates in the NFIP. The program also requires SFHA properties that have received PDM funds to maintain flood insurance for the life of the structure, regardless of whether the property is sold or transferred to a different owner. If the owner fails to maintain coverage, they will be ineligible for future federal disaster assistance in the event of a flood. Among the flood mitigation measures eligible for PDM, mitigation planning (20 percent), property acquisitions (18 percent), and flood control (12 percent) have received the most funding between FY 2000 and FY 2016. Next is seismic retrofits, also at 12 percent of funds, since PDM can be used for multiple perils.

PDM is funded annually by Congressional appropriations. Grants are subject to a cost-sharing arrangement in which non-federal partners are required to contribute 25 percent of project costs. However, FEMA may cover up to 90 percent of costs for small, impoverished communities.¹² From FY 2000 to FY 2016, FEMA obligated

⁸ If the property owner fails to maintain insurance coverage, they will be ineligible for federal disaster aid in the case of future floods.

⁹ A Repetitive Loss property is an NFIP-insured structure that (a) has incurred flood-related damage on two occasions in which the average cost of repair equaled or exceeded 25 percent of the structure's market value, and (b) at the time of the second incidence of flood-related damage, the flood insurance policy contained ICC coverage.

¹⁰ A Severe Repetitive Loss property is an NFIP-insured structure that has incurred flood-related damage for which four or more separate claims payments (building and contents) have been made, each exceeding \$5,000; or, for which at least two separate claims payments (building only) have been made, with the cumulative amount exceeding the market value of the insured structure.

¹¹ A 2004 Government Accountability Office study found that RL properties made up just 1 percent of policies, but 38 percent of claims payments from 1978 to 2004. And according to a study from the Natural Resources Defense Council, SRL properties accounted for 0.6 percent of policies-in-force, but 10.6 percent of claims payments from 1978 to 2015 (Eastman 2016).

¹² For a complete definition of small impoverished community, see Page A3 of FEMA's Hazard Mitigation Assistance Cost Share Guide For Applicants, Subapplicants, and FEMA, available at <https://www.fema.gov/media-library/assets/documents/117020>.

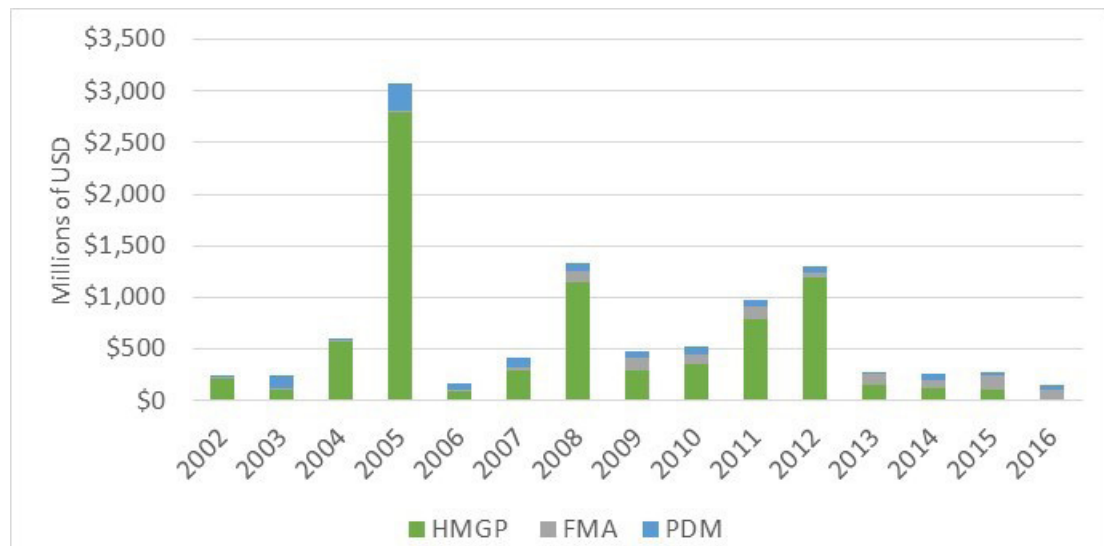
roughly \$1.06 billion in PDM funds. Funding peaked in the wake of the 2005 hurricane season as Congress distributed nearly \$260 million in a single year. Since then, total obligations have averaged about \$55 million annually.

FEMA's Hazard Mitigation Grant Program (HMGP) provides funds to state and local governments to implement mitigation measures following a Presidentially declared disaster. According to FEMA, the objective of the program is "to ensure that the opportunity to take critical mitigation measures to reduce the risk of loss of life and property from future disasters is not lost during the reconstruction process following a disaster" (FEMA 2015b). Unlike FMA and PDM, HMGP assistance is only available in states and counties where the President has issued a major disaster declaration authorizing HMGP funds. Eligible applicants include state emergency or floodplain management agencies. Eligible sub-applicants include municipal governments, other bodies of state government, and private non-profit organizations that provide an essential government service.¹³ The amount of funding available under HMGP is a function of the total disaster assistance FEMA provides under a major disaster declaration.¹⁴

HMGP does not receive direct annual appropriations from Congress. Rather, funds are disbursed from the Disaster Relief Fund (DRF), the main account from which FEMA provides disaster assistance. Congress allocates funds to the DRF each year, but the account is often depleted as the cost of assistance associated with catastrophic events exceeds DRF funds available. For this reason, Congress frequently replenishes the fund through supplemental appropriations. From FY 1989 through FY 2016, HMGP obligations totaled \$13.2 billion (in 2016 U.S. dollars)—an amount that vastly exceeds funding provided under the pre-flood HMA programs, as shown in Figure 8.

FIGURE 8

FEMA Hazard Mitigation Assistance Funding by Program (FY 2002 – FY 2016)



Source: Authors' analysis of FEMA data (updated July 12, 2017); available online at OpenFEMA: <https://www.fema.gov/data-feeds>. Total HMA funding across this period was approximately \$10.3 billion in 2016 US dollars.

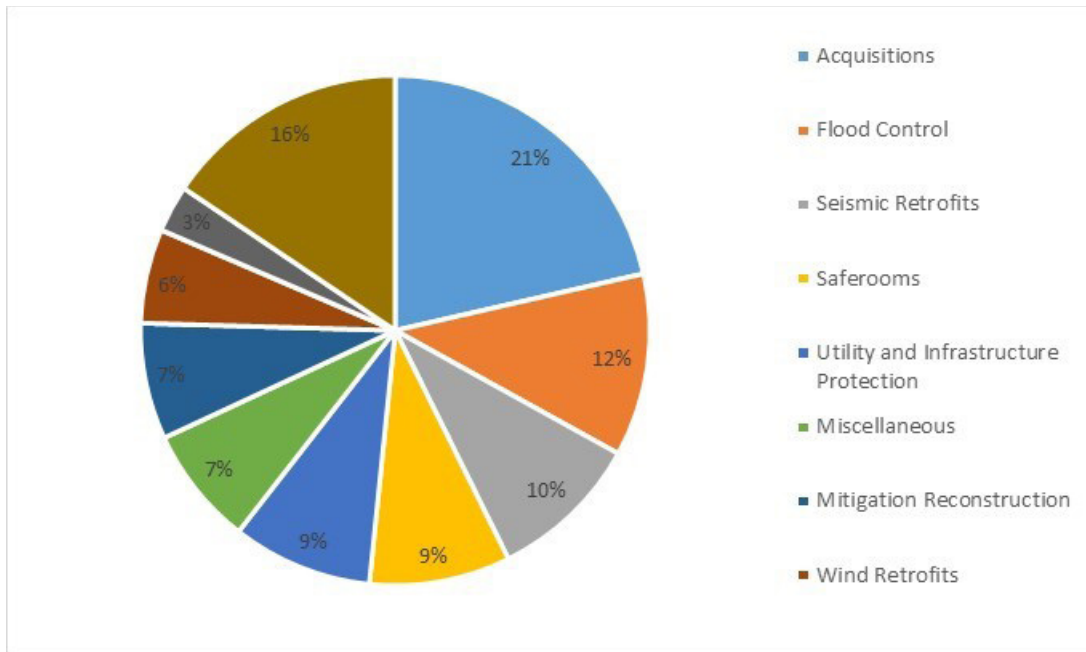
¹³ Such entities may include school districts, hospitals, public utilities, and others. See <https://www.law.cornell.edu/cfr/text/44/206.221>.

¹⁴ The HMGP funding formula allows applicants to receive: up to 15 percent of the first \$2 billion of the estimated aggregate amount of disaster assistance; up to 10 percent for the next portion of the estimated aggregate amount more than \$2 billion and up to \$10 billion; and up to 7.5 percent for the next portion of the estimated aggregate amount more than \$10 billion and up to \$35.33 billion. Applicants that have implemented "enhanced" hazard mitigation plans are eligible to receive up to 20 percent of assistance provided under a disaster declaration, up to \$35.33 billion. See 44 CFR 201.5, available here: <https://www.law.cornell.edu/cfr/text/44/201.5>

Of the \$13.2 billion distributed since 1989, 81 percent is attributable to floods and flood-related events such as severe storms and hurricanes (though not necessarily flood-related damages). Under HMGP, most flood-related spending has focused on property acquisitions, flood control projects, and elevations. Figure 9 shows the distribution of funding by mitigation measure for FYs 1989 through 2016.

FIGURE 9

Funding by Mitigation Measure for FEMA's HMGP (FY 1989 - FY 2016)



Source: Authors' analysis of FEMA data (updated July 12, 2017); available online at OpenFEMA: <https://www.fema.gov/data-feeds>.

5.2.3. COMMUNITY DEVELOPMENT BLOCK GRANTS – DISASTER RELIEF

HUD's Community Development Block Grant – Disaster Relief (CDBG-DR) program provides flexible grants to support recovery from Presidentially declared disasters, with a portion of funding focused on lower income areas. A focus on these areas is likely justified as lower income families are more likely to live in high risk flood zones and less likely to have flood insurance (FEMA 2018). The program requires supplemental appropriations from Congress; it does not have standing funding. Entities eligible for CDBG-DR funds may include states, local governments, tribal land, or other governmental units designated in a major disaster declaration. Grantee communities must have significant unmet needs and limited capacity and resources to recover. HUD does not provide funds directly to individuals, businesses, or other organizations, but these entities may access funds through state and local governments, who administer their own disaster recovery programs and decide where and how funding is used.

Eligible activities are typically identified in appropriations legislation, but state and local governments have significant flexibility in how grants are spent. Most funds are dedicated to housing repair and reconstruction,¹⁵ restoration of public facilities and infrastructure, and economic development activities to revitalize disaster-

¹⁵ As with the other programs discussed here, CDBG-DR recipients located in the SFHA are required to purchase and maintain flood insurance in the amount and duration required by the NFIP.

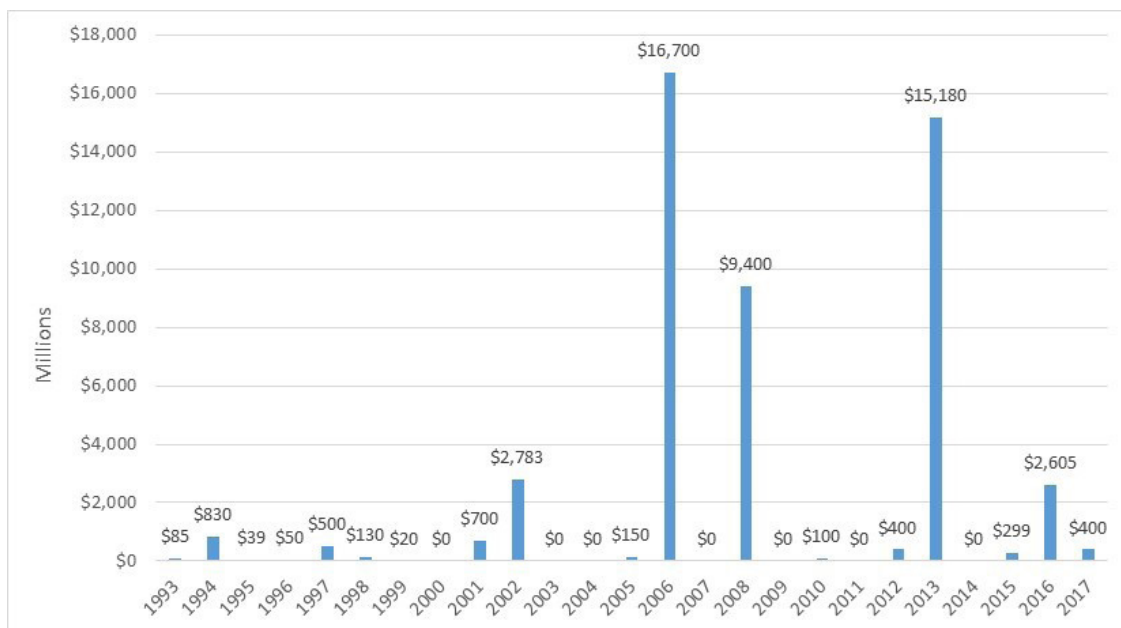
stricken areas. Beyond these, however, CDBG-DR funds are also used for mitigation measures that lessen the likelihood of future disaster damages. For instance, after the Midwest floods of 1993, Iowa floods of 2008, and Hurricane Sandy in 2012, CDBG-DR grants were used to buy private property in flood-prone areas and preserve the land as open space or convert it to recreational uses (Boyd 2011).

Data are not available to evaluate how recipients allocate funding across these categories, so the amount of funding dedicated to flood mitigation specifically is unclear. However, in recent years, HUD has strongly emphasized mitigation and resilience activities and recipients appear to be responding positively. Following Hurricane Sandy for example, New Jersey used CDBG-DR grants to fund buyouts of residential properties, elevate properties, and implement larger-scale infrastructure projects focused on flood risk reduction. Sandy appropriations further provided \$1 billion for a National Disaster Resilience Competition.¹⁶

CDBG-DR is funded only by supplemental appropriations made after major disasters. Since 1993, there have been 24 program appropriations in total, providing nearly \$60 billion to disaster-affected communities across the United States. While funds support recovery from all types of hazardous events, more than 90 percent have been appropriated in response to floods, storms, and hurricanes. Figure 10 depicts CDBG-DR appropriations made each year since the program was first implemented in 1993.

FIGURE 10

CDBG-DR Appropriations FY 1993-2017 (in millions of nominal USD)



Source: HUD N.d.- b.

5.2.4. SMALL BUSINESS ADMINISTRATION DISASTER LOANS

Under the Small Business Administration's (SBA) Disaster Loan Program, the SBA provides low-interest loans to business owners, homeowners, and renters to "repair, rehabilitate or replace property, real or personal,

¹⁶ For more information on winning projects see <https://www.hudexchange.info/news/hud-awards-1-billion-through-national-disaster-resilience-competition/>.



damaged or destroyed by or as a result of natural or other disasters.”¹⁷ For most disaster victims, SBA loans are the principal source of government assistance rather than limited, personal grants that may be provided by FEMA.¹⁸ Although the program is available through the SBA, an agency focused primarily on supporting small business development in the U.S., the vast majority of disaster loans (approximately 83 percent) are provided to individuals and households (Lindsay 2015).

Unlike the grants made available under other programs, SBA loans must be paid back to the federal government with interest. Loans typically have fixed interest rates capped at 8 percent, with maturities up to 30 years. Loans are provided with recourse and home loans over \$25,000 must be secured to the extent possible. SBA will not decline a loan if the applicant does not have sufficient collateral, but will request any collateral available, which typically consists of a first or second mortgage on the damaged property. There are two types of disaster declarations under which SBA loans may be made available to homeowners and renters: (1) major disaster declarations authorizing FEMA’s Public Assistance and Individual Assistance programs, and (2) SBA disaster declarations made in response to a governor’s request for assistance. In both situations, loans are available only to those located in the designated disaster areas.

The program allows homeowners to borrow up to \$200,000 to restore disaster-damaged homes to pre-disaster condition.¹⁹ Funds cover only un- or under-insured losses and may not be used to make upgrades, expansions, or improvements to a property unless required by local building regulations. However, homeowners may receive additional funds to carry out hazard mitigation measures to reduce losses from similar future disasters. Mitigation funds may total up to 20 percent of homeowners’ physical losses, though the maximum loan may not be more than \$200,000. For homeowners, eligible flood-mitigation measures include structure elevation, relocation, abandoning the first floor of a home, and filling basements, among others. Under this 20-percent formula, the most mitigation funding a borrower could receive is approximately \$33,000,²⁰ which may not be enough to cover the cost of these measures.

Borrowers with properties located in the SFHA are required to purchase and maintain flood insurance until the loan is repaid; if recipients fail to meet this requirement, they are ineligible for any future SBA loans made to address flood damages. SBA does not provide disaster loans for properties located in non-participating NFIP communities, Coastal Barrier Resources System units, or Otherwise Protected Areas designated under the Coastal Barrier Resources Act.

The program is funded by regular Congressional appropriations as well as supplemental appropriations made in the event of major catastrophes. From FY 2000 to FY 2014, SBA made approximately 316,000 loans, totaling \$9.7 billion, to homeowners and renters. The average loan size for these borrowers was roughly \$30,700. It is not clear what portion of the total was allocated to mitigation measures.

6. FLOODS AND THE U.S. HOUSING AND MORTGAGE MARKETS

6.1 FLOOD INSURANCE REQUIREMENTS

The mandatory purchase requirement for flood insurance, discussed in Section 4 above, is enforced when a homeowner establishes a new loan or modifies an existing loan.²¹ When a loan is issued, a bank requires a

¹⁷ Small Business Act of 1953, see Title 15 of the United States Code, Chapter 14A, available at: <https://www.law.cornell.edu/uscode/text/15/chapter-14A>.

¹⁸ FEMA provides assistance to homeowners for housing repairs and reconstruction through its Individual and Households Program (IHP). Grants are intended only to make a home inhabitable and safe, not to restore it to its pre-disaster condition. Grants are capped at an inflation-adjusted amount set at \$33,300 for FY 2017, though the average grant is for approximately \$5,000, an amount that is generally not sufficient to cover all damage costs.

¹⁹ Second homes and vacation properties are ineligible for the program.

²⁰ If a homeowner’s physical damages totaled \$166,666, 20 percent of that would be \$33,333.20, making the total loan \$199,999.20.

²¹ <https://www.fema.gov/faq-details/Mandatory-Purchase-of-NFIP-Coverage>.



FEMA-issued Standard Flood Hazard Determination Form (SFHDF) which indicates whether the property is in the SFHA.²² The determination is made by reviewing the latest FEMA Flood Insurance Rate Map (FIRM). If any part of a structure designated as collateral for the loan is inside the SFHA, the borrower must purchase flood insurance. Specifically, according to the 1973 law, applicable property owners must purchase flood insurance in the amount that is “the lesser of the following:

1. the maximum amount of NFIP coverage available for the particular property type, or
2. the outstanding principal balance of the loan, or
3. the insurable value of the structure.”²³

The insurable value requirement is typically invoked when the value of the land is deducted from the overall property value securing the loan. If a property owner does not buy a flood insurance policy, the lender will notify the borrower that they are not in compliance. After a 45-day notice period, if still uninsured, the lender may force place insurance back-dated to cover the period of non-compliance. As of January 1, 2016, banks with more than \$1 billion in assets must escrow flood insurance premiums for applicable loans.²⁴

Once a loan is issued, banks must ensure that homeowners carry flood insurance for the life of the loan. In addition, banks review their loan portfolios against FEMA map updates to ensure that properties newly incorporated into high-risk zones purchase flood insurance. Home equity loans in SFHAs are also subject to the mandatory purchase requirement. The low estimated take-up rates of flood insurance in SFHAs and occasional enforcement actions against lenders suggest there is some amount of non-compliance.

Flood insurance may reduce the likelihood of mortgage default risk. Absent a disaster, when property values are increasing, there is little, if any, mortgage default risk whether or not the homeowner has purchased flood insurance. A mortgagor unable to pay his or her mortgage can simply opt to sell the property and pay off the mortgage; if he or she does default, the mortgagee can force the property to be offered for sale through a foreclosure auction where, if no third-party bids, the lender becomes the owner of the property. When damage to a property occurs, however, its value may decrease and the risk of default may increase. A homeowner that purchased sufficient flood insurance, however, would be able to cover most if the losses through claims payments, thus reducing the default risk.

As discussed above, even when subject to the mandatory purchase requirement, homeowners might be uninsured if they cannot afford coverage or feel the perceived benefits from having insurance do not justify paying the premium. In addition they might not have good information on the flood risks they face. Even if they are provided with this information, they are likely to fall prone to the biases that characterize intuitive thinking, such as myopia and amnesia—the tendency to think in the present and forget the past. Another reason for not purchasing flood insurance is the misimpression that the household would receive substantial government assistance should they suffer damage from a water-related disaster.

6.2 HOUSING PRICE IMPACTS

Previous studies have found that housing markets do, to some extent, capitalize flood risk information. As noted earlier, lenders are required to inform borrowers if their property is in an SFHA and if so, borrowers are then required to purchase flood insurance if they have a mortgage from a federally backed or regulated lender. Studies have found that in several places around the nation, homes in the SFHA sell for less than homes outside this zone, after controlling for myriad potential differences in the properties themselves (MacDonald, White et

²² <https://www.fema.gov/media-library/assets/documents/225?id=1394>.

²³ <https://www.fema.gov/faq-details/Mandatory-Purchase-of-NFIP-Coverage>.

²⁴ <https://consumercomplianceoutlook.org/2015/third-fourth-quarter/flood-insurance-compliance-requirements/>.



al. 1990; Harrison, Smersh et al. 2001; Bin, Kruse et al. 2008; Daniel, Florax et al. 2009; Bernstein et al. 2018).²⁵ In coastal areas, however, it can be difficult to identify any risk effects on prices given the high amenities of coastal locations (Bin and Kruse 2006; Bin, Crawford et al. 2008) although several recent studies have shown a decline in price appreciation of coastal properties that are more prone to flooding (Tibbetts and Mooney, 2018; Kusisto, 2018). The timing in providing information on the flood hazard, however, is essential. One study found that home buyers are often not made aware that a home is in a floodplain until closing or after a bid has been made (Chivers and Flores 2002). Another study found that disclosure laws, which require information to be made available earlier, do lower housing values in flood-prone areas (Pope 2008).

Several studies have also found that after a flood event, there is a further decline in property values (Bin and Polasky 2004; Carbone et al. 2006). This drop, however, is often not permanent, with prices rebounding within a decade, sometimes much sooner (Atreya, Ferreira et al. 2013; Bin and Landry 2013). Declines in property values have also been found outside the SFHA after severe floods occur that cause negative economic impacts, even if specific homes were not themselves damaged (Kousky 2010). Near misses can also lower property values (Hallstrom and Smith 2005).

6.3 NEIGHBORHOOD EFFECTS

Floods can have community-wide impacts, over and beyond the damage to individual structures from buildings. All households in a community will be impacted to some degree due to infrastructure damage, business interruption, foreclosed and blighted housing, interruption in services, and lack of amenities even if their own homes are unscathed. Communities may also suffer losses in tax revenue due to the damage to the structures as well as business interruption.

The availability of financial assistance will also impact default risk with feedback effects on neighborhood property values. When displaced by flooding, households will incur additional expenses. They may not be able to come up with the money to cover monthly mortgage payments and as a result, forbearance²⁶ is often granted by mortgage holders (Overby 2007). When forbearance is not granted, homes may be abandoned, with further consequences for neighborhood decline. For example, the number of blighted properties in New Orleans rose from 26,000 before Hurricane Katrina, to over 43,000 after the storm (Kotkin 2014). Particularly in neighborhoods in decline before the event, homeowners may choose to walk away if the cost of repairing structures exceeds the value of the property. Instead, individuals may use financial assistance to relocate.

An increase in the vacancy rates, neighborhood blight and lack of amenities will exacerbate the decline in property values. Under these circumstances, given their dislocation and possible job loss, affected mortgage borrowers may face both the inability to repay their mortgage, and the inability to recoup enough funds when selling their house to cover the unpaid mortgage principal. Research has found that the variation in recovery from property damage is not just based on the magnitude of the losses but also on the social vulnerability of the impacted communities (e.g., Finch et al. 2010). In contrast to the recent financial crisis, there may be no expectations that these values should recover, especially for properties that experience repetitive losses. Furthermore, while borrowers in the crisis continued to service their loans despite being figuratively underwater, mortgage payments would be expected to cease in a physical disaster scenario.

Negative impacts on neighborhoods could worsen from sea level rise in coastal communities. In a 2017 Moody's Investors Service report (Moody's Investors Service 2017), the rating agency discusses the potential economic impact attributable to sea level rise as an increasingly relevant negative credit factor for municipal bonds issued

²⁵ For example, some of the areas studied include: Homewood, Alabama; Alachua County, Florida; Lee County, Florida; Monroe, Louisiana; Carteret County, North Carolina; Pitt County, North Carolina; Fargo, North Dakota; Moorhead, Minnesota; Lacrosse, Wisconsin; Milwaukee, Wisconsin; and Wauwatosa, Wisconsin.

²⁶ In the context of a mortgage process, forbearance is a special agreement between the lender and the borrower to delay a foreclosure.



by states and localities that lack sufficient strategies for mitigating and adapting to these forces. The impact of potential flood losses includes both decreases in the real estate tax base if property values decrease as well as increases in real estate taxes – which may factor into municipal bond ratings.²⁷

6.4 THE SECONDARY MARKET FOR MORTGAGE LOANS

As discussed in 6.1 above, lenders determine whether borrowers are required to purchase flood insurance at the time of loan origination. After origination, lenders may retain the loan in their portfolio or sell or securitize it in the secondary market. There are several avenues available for this purpose. For government-insured or guaranteed loans,²⁸ eligible lenders may directly issue Government National Mortgage Association (GNMA) (“Ginnie Mae”) residential mortgage-backed securities (“RMBS”) with the GNMA-guarantee of payment of interest and principal attached. For conforming conventional loans,²⁹ eligible lenders may sell loans to the Federal National Mortgage Association (FNMA) (“Fannie Mae”) or Federal Home Loan Mortgage Corporation (FHLMC) (“Freddie Mac”), who then issue RMBS with their attached guarantee of timely payment of principal and interest. Non-conforming loans may also be sold or securitized in the secondary market; however, they do not benefit from any governmental agency guaranty of timely payment. As a result, the RMBS issued or guaranteed by Ginnie Mae, Fannie Mae, or Freddie Mac are referred to as agency MBS. In recent years the majority of residential mortgage loans originated in the U.S. have been securitized through the agencies.

Post-securitization, the agencies are highly dependent on the financial institutions that service the loans and maintain direct contact with the borrower.³⁰ These firms are known as servicers and the agencies benefit from a range of contractual obligations³¹ they assume, including monitoring ongoing compliance with hazard insurance requirements where applicable. In the event of a major disaster event such as flood or hurricane, the agencies typically request servicers to accommodate affected homeowners through forbearance programs (under which required mortgage payments are deferred) where possible. Delinquency rates on mortgage loans in flood affected areas typically increase following the event, but decline during the recovery period that follows as insurance payouts are made and other disaster relief, as discussed earlier in Section 5.2, is directed into the area.

Servicers are generally obligated to advance loan payments to secondary market investors even when borrowers are not making payments. In the event of default and foreclosure, secondary market institutions purchase the loan out of the securitization trust and take on the task of liquidating the property which is held on their books as real estate owned (“REO”). The sale of REO generally produces losses in the sense that the property cannot be sold for a sufficient amount to cover the outstanding loan balance and foreclosure expenses.

Secondary market institutions undertake a range of activities to mitigate the risk of loss. Initially, they apply underwriting criteria such as minimum credit scores and maximum debt-to-income ratios and require credit enhancement where the initial loan-to-value ratio (“LTV”) exceeds 80 percent. Mortgage insurance, the most common way of providing credit enhancement, does not generally cover collateral damage caused by natural

²⁷ A recent S&P report (Standard & Poor’s 2018) makes the point that while bond ratings are not yet impacted, if the availability of federal disaster relief and insurance is less certain in the future, mortgage availability will be at risk.

²⁸ Principally FHA-insured or VA-guaranteed loans.

²⁹ Conventional conforming loans are loans that meet eligibility standards of the two major government-sponsored enterprises (GSEs), Fannie Mae and Freddie Mac, developed in consultation with their regulator and conservator, the Federal Housing Finance Agency (FHFA). Generally speaking, such loans must be smaller than the conforming loan limit as set annually by FHFA and carry some form of credit enhancement if the LTV exceeds 80 percent.

³⁰ Loan servicing consists of collecting payments from borrowers, including flood insurance premiums where applicable, reporting, and managing payoffs, default and foreclosure activities, and forbearance and loan modifications. Servicers receive a fee for these activities, as do the agencies for their credit guarantees.

³¹ While remedies for breaches of contractual obligations may vary, requiring the servicer or originator to repurchase the loan (or loans) at issue is a common resolution. For example, if a servicer should have maintained flood insurance on the collateral property securing the loan and failed to do so, a repurchase demand would typically be issued.



disasters. In addition, Fannie Mae and Freddie Mac have programs to transfer some portion of their credit risk to investors or to obtain reinsurance for credit losses above some threshold level.

Determining the effect of property damage arising from a natural disaster on foreclosure rates and credit losses is difficult at the secondary market level and there is almost no empirical research. While disaster-related damages are a shock to the loan-to-value ratio (which thus reduces the property's value and, thereby, increases the LTV and, hence, the probability of default), the extent of that shock is uncertain, particularly because the property's market value includes both the value of the land as well as of the damaged improvements. In addition, as noted above, there may be externalities involved if a large number of properties in the same neighborhood are damaged and other residents do not repair or rebuild. Such conditions may make it difficult, if not impossible, for borrowers to sell their property, assuming they wish to do so. Moreover, properties that are damaged and then repaired, either from insurance proceeds, federal relief programs, or from the borrower's own resources are not reported to the agencies;³² hence, important data are censored. Finally, the level at which negative equity resulting from a shock to LTV is sufficient to trigger borrower default—and ultimately foreclosure—is unknown and may depend, importantly, on the extent of the borrower's other assets, their attachment to the property and neighborhood, the nature of any forbearance relief offered, and other nearby homeowners' corresponding decisions. The extent to which the shock to LTV is expected to persist is also unknown but will impact credit losses.

BOX 2*Flood Insurance Affordability in New York City*³³

In the wake of Superstorm Sandy and the passage of the 2012 Biggert Waters legislation, New York City conducted a study with the RAND Corporation on flood insurance affordability that sought to examine the impact of rising flood risk and premium increases on households and neighborhoods. The area examined was defined by the 2015 Preliminary Flood Insurance Rate Map which includes 48,100 one- to four-family homes (Dixon, Clancy et al. 2017).

The communities studied face two challenges: first, they are financially vulnerable. Specifically, roughly 40 percent of households earn less than 80 percent of area median income, thus, flood insurance is *already* burdensome for 11,000 of owner-occupied households (25 percent) (Dixon, Clancy et al. 2017). Second, the properties are at great risk of flooding. Because the initial Flood Insurance Rate Maps for New York City did not come into effect until 1983, the majority (83 percent) of structures are “pre-FIRM” and were not subject to resilient building standards; accordingly, two-thirds of the properties in the current effective SFHA are *three or more feet below* the BFE. These pre-FIRM structures previously received discounted insurance rates but these discounts are being phased out due to legislation passed in 2014.

The RAND study examined various premium change scenarios. Currently, the median pre-FIRM premium for structures in the effective 2007 FIRM is \$3,000. In the worst case scenario, if the 2015 Preliminary FIRMs are adopted, increasing the BFE by 2.1 feet on average, unsubsidized premiums will climb to \$5,600, an 87 percent increase. For the structures that are currently outside the SFHA but that would be newly mapped, their average rate would increase more than eightfold from \$500 to \$4,200. These increases would drive 33 percent of households to be income-burdened by virtue of their housing expenditures. The RAND study also predicts that property values could fall by \$10,000 to \$100,000 if the increased premiums are capitalized into the housing stock. In line with the drop in property values, the report suggests that property tax revenues could decline by \$22 million and that mortgage default rates, especially in neighborhoods like those on the Rockaway Peninsula, could increase by 50 percent. With these scenarios in mind, the report suggests a number of remedies, including means-tested insurance vouchers and loans and grants for mitigation.

³² GNMA securities are slightly different inasmuch as HUD requirements demand that the property be repaired prior to its conveyance in the event of default and foreclosure, an obligation that falls on GNMA servicers whether the property is insured or not.

³³ We thank Katherine Greig for crafting this box on flood insurance affordability in New York City.

7. CONCLUSIONS

7.1 SUMMARY OF KEY POINTS

Flooding is the natural disaster that causes the most damage and impacts the greatest number of people worldwide. Climate scientists predict that flood risk will increase in many parts of the world and will exacerbate trends of increasing damage due to development in high risk areas. As a recent example, in 2016 and 2017, the U.S. had 10 flood events, each causing over \$1 billion of damage hitting Texas, Florida, California, Illinois, North Carolina, Missouri, Louisiana, and West Virginia.

FEMA maps flood risk in the United States. The flood insurance rate maps (FIRMs) are designed to implement the requirements of the National Flood Insurance Program but are also the primary source of flood risk information available to households and communities. These maps, however, are often inaccurate in their depiction for the flood risk and do not indicate how the risk will change in the future. Current flood maps only provide information on whether a property is inside or outside of the 100-year floodplain rather than the risk associated with other return periods (e.g., 10 year, 25 year, 50 year and 500 year). FEMA is currently redesigning its mapping program to provide more detailed information on the flood risk facing individual properties. More useful information could include whether a home had previously been damaged.

Flood insurance today is predominantly provided through the NFIP with a small, emerging private residential flood insurance market. For property in SFHAs, where the annual chances of flood-related damage are estimated to be at least 1-in-100, flood insurance is currently required as a condition for a federally backed mortgage. Empirical studies have found that homes in the SFHA sell for less than those outside this zone, after controlling for myriad differences in the properties themselves.

Since 2014, the NFIP has been phasing out premium discounts for older homes, raising concerns about the affordability of flood insurance. A recent report from FEMA (2018) revealed that just over a quarter of NFIP policyholders in SFHAs are low income and just over half of non-policyholders are low income. Several reports and papers have examined possible federal policy solutions, all centered around some form of means-tested vouchers or other forms of assistance including hazard mitigation grants and low interest loans for reducing future flood damage.

Whether affordable or not, many homeowners in flood zones do not have flood insurance policies. While federally related mortgage originators are required to force place flood insurance, it appears as though coverage is dropped by many homeowners if they have not suffered flood damage or received flood insurance claim payments. (Michel-Kerjan, Lemoyne de Forges et al. 2012). After the origination of a mortgage, lenders may retain the loan in their portfolio, or decide to sell or securitize it in the secondary market. Secondary market institutions undertake a range of activities to mitigate the risk of overall default loss by applying underwriting criteria and requiring credit enhancement where the initial loan-to-value ratio exceeds 80 percent. Unlike other shocks to loan to value ratios that impact default rates, the impact of repetitive flooding events on loan to value ratios may persist and preclude the expectation that prices will rise in the future. However, the effect of collateral damage arising from a natural disaster on ultimate foreclosure rates and credit losses to secondary market institutions is difficult to determine. Nonetheless, some localized studies, such as the RAND study for NYC, predict that housing values could fall significantly in neighborhoods like those on the Rockaway Peninsula. Extrapolating this to the 2 percent of homes nationwide that are predicted to be at risk of inundation by 2100 suggests that, if these forecasts are realized, home values at risk of foreclosure due to flooding may exceed other sources of foreclosure risk in the future.

In developing strategies for encouraging individuals to undertake protective measures to reduce their future flood losses one needs to recognize systemic biases that characterize their risk perception and influence their



behavior. These biases include: myopia, amnesia, optimism, inertia, simplification and herding. These biases can be addressed and overcome through a behavioral risk audit by reframing the risk using principles of choice architecture coupled with economic incentives so that property owners will want to purchase flood insurance and undertake cost-effective loss reduction measures to prepare for the next flood or hurricane.

7.2 PROPOSED FUTURE RESEARCH AND NEXT STEPS

Accurate flood hazard maps. Accurate flood hazard maps are an important input in setting risk-based insurance premiums and to effectively communicate the flood risk to residents, communities, developers, lender and real-estate agents and other stakeholders. Property owners in areas where FEMA has concluded that the annual probability of a flood is less than 1-in-100 are not required to purchase flood insurance today and may conclude that they are safe from future flood damage. In reality, they may suffer severe damage from a flood whose annual probability is less than 1-in-100 or from pluvial flooding that is not well-captured on most FEMA maps.

Many stakeholders agree that risk communication would be improved by a more gradated depiction of flood risk across and beyond the SFHA and the Technical Mapping Advisory Committee (TMAC) has recommended this course of action. FEMA is now in the process of modifying its mapping program, damage estimates, and insurance rating system so they more accurately reflect the risks from floods of different magnitudes.

Risk scores. As FEMA moves toward risk-based rates, there will be an opportunity to develop risk scores that specify the severity of the hazard for existing and proposed structures that are subject to flooding, as recommended in the 2017 TMAC Annual Report (TMAC 2018). If expanded beyond today's risk, a future conditions risk score could be used to communicate changing risk conditions.

As part of the development of property specific risk scores, it will be necessary to determine property specific risk characteristics that affect losses from floods. The expertise and involvement of environmental scientists, risk modelers, insurers, reinsurers, financial institutions, as well as FEMA will be needed in this determination and in the development of standards for flood resilient construction. Lenders and insurers could provide economic incentives to encourage cost-effective loss prevention measures by property owners; municipalities and states could modify building codes and zoning ordinances (Berman 2018).

Structure-specific risk scores would also provide opportunities to communicate the nature of the flood hazard to property owners and provide floodplain managers with additional tools for their dialogue with developers and future homeowners prior to construction. By incorporating the management of flood risk early in the design of structures, property owners would have opportunities to make improvements that would not only reduce their risk of flooding but also reduce their insurance premiums given the lower expected claims from future hurricanes and precipitation.

A risk score could be incorporated into state and local regulations and standards by serving as the basis for stricter building codes and land use regulations in areas most prone to flooding. Structures that have experienced repetitive flood losses could be readily identified, providing the community with the opportunity to enforce regulatory standards and encourage buyouts in areas not included in the SFHA.

Impact of sea level rise. Secondary mortgage market entities along with communities and homeowners themselves and taxpayers more generally face concerns over the credit risk associated with future flood losses if property owners do not have flood insurance and face significant damage to their property. There is a need to understand the impact that sea level rise is likely to have on coastal and inland communities in the coming years and steps that can be taken now to reduce the resulting flood related damage and the credit risks faced by financial institutions due to mortgage defaults.



Many studies have now been completed that highlight the growing coastal flood risk from the combined forces of changing storm patterns and sea level rise. For example, Zillow estimates the impact of 6 feet of sea level rise (an estimate for 2100) on the U.S. housing market and finds that 2 percent of homes nationwide—worth about \$1 trillion—would be at risk of inundation (Rao 2017; Bretz 2017). Despite these findings of widespread impacts in the coming decades, there are still many unanswered questions about how the housing market will respond and what the appropriate policy responses to this threat are in the near- and medium-term.

Facilitating community resilience. Several studies reveal that communities can be resilient following a disaster. Flood ravaged neighborhoods may be rebuilt, which explains why economic activity often increases in the aftermath of disasters (Dacy and Kunreuther 1968). The long term economic value of neighborhoods is determined by location and access to jobs and amenities, and this may remain unchanged after a natural disaster (Cavallo et al. 2013; Zandi et al. 2006). Neighborhoods subject to heightened default risk following disasters include communities subject to disinvestment, where property values prior to the event are lower than replacement values, as well as communities in regions where the storm's damage to the economy is pervasive and not covered by disaster relief, such as Puerto Rico, and in communities that may be subject to repetitive losses from flooding in the future. These effects can be lessened with financial support—whether from aid after the fact or insurance. Further work is needed on how best to support community resiliency.

All-hazards homeowners insurance. In the U.S., homeowners insurance policies cover wind, hail, and fire damages, but exclude damages caused by floods and earthquakes. In other parts of the world, however, homeowners insurance protects residents against hazards of all types, in some cases with government support. All-hazards policies offer homeowners a range of benefits, including simplicity and peace of mind in knowing that all potential disaster damages are covered. They also reduce the search and administrative costs associated with buying and possibly filing claims on separate policies. Further, all-hazards insurance helps homeowners overcome cognitive biases that cause them to ignore or underestimate catastrophic risks. By combining coverages into a single policy, homeowners will likely view the risk as sufficiently high that they will want coverage before a disaster strikes and will be less likely to cancel their policy (Kunreuther 2018b). To the extent that all-hazards policies provide greater protection to homeowners and encourage them to maintain coverage over time, they are also a benefit to lenders and hence the secondary mortgage institutions (and potentially taxpayers), as their investments are better protected against future disaster losses. All-hazard homeowners policies are likely to cost more for residents subject to flood and earthquakes, but this provides them with protection they would otherwise have.

All-hazards policies could be beneficial to insurers and reduce their costs. They reduce marketing and administrative costs by bundling coverages into a single product. They help diversify insurers' risk across hazards, providing a more certain estimate of expected claims payments. And finally, they remove the possibility of litigation arising over the relative contribution of wind versus water damage when only one peril is covered by insurance and the other is not. Such disputes have resulted in significant legal costs and reputational damage for insurers, while leaving homeowners without the funds they need to rebuild. To date, large homeowner insurance companies are reluctant to include a new peril in policies where they may not have regulatory freedom to adjust rates

In order to implement an all-hazards homeowner policy or, more generally, to encourage investments in protective measures, there is a need to develop property specific metrics such as a risk score. Such information can help align the key interested parties concerned with reducing future flood losses to property and the related credit risk and potential taxpayer exposure.

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