

## CHAPTER 16

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# Improving Individual Flood Preparedness Through Insurance Incentives

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Every year we are exposed to news with images of severe flood events that occur around the world. Each flood event is unique, in terms of particular flooding conditions, impacted community, number of casualties, and economic costs. Nevertheless, the storylines that these events share are often very similar. Floods are destructive acts of nature that cause massive human suffering and economic consequences. Even though the impacted areas were designated as potentially flood-prone years ago, people continued to build and live in high-risk areas near rivers and the coast. The flood comes as a shock and people are badly prepared for it. Many have not purchased flood insurance nor taken measures to protect their house or belongings against flood waters. Afterward there are feelings of regret about being badly prepared. Moreover, there is pressure to repair damage quickly so that life can continue the way it was before the disaster, while knowing that a next flood can again damage the properties that are being rebuilt. A main challenge that these flood-prone regions face is how to design policies that help people better prepare for flood disasters. This chapter addresses this question by focusing on the role insurance can play in encouraging risk reduction.

During the last decades, the economic losses caused by natural disasters have increased around the world and floods are among the most costly hazards in these disaster records (IPCC 2012). Examples are the flooding caused by Hurricane Sandy in 2012, with about \$19 billion of losses in New York City alone (City of New York 2013), and the 2013 floods in Germany and neigh-

boring states that resulted in \$16 billion of property damages (Munich Re 2013). Expectations are that flood risks will increase as a result of climate change and socioeconomic developments, such as population and economic growth in floodplains (IPCC 2012, 2014). As an illustration, a recently developed probabilistic risk model of all main European rivers predicts that current average annual flood losses in the European Union are bound to increase more than fourfold by 2050, if no additional measures to reduce risk are taken (Jongman et al. 2014).

These trends in flood risk highlight the need for investments in flood-protection infrastructure to reduce the likelihood of flooding as well as in measures that limit damage of future flood events. Nevertheless, even after cost-effective investments in limiting flood risk are made, a residual flood risk will remain. The reason is that reducing flood risk to zero is either technically infeasible or too costly relative to the benefits of avoided flood damage. This means that there is an important role to play for insurance in covering this residual risk. Insurance arrangements can spread flood risks over many policyholders, give peace of mind to residents of flood-prone areas, and speed up the recovery process after a flood disaster (Botzen 2013). However, insurance should not act as a substitute for the investments required to limit the expected increase in flood risk. The challenge is thus to design flood insurance arrangements that give incentives that encourage risk reduction. This is especially important because large adaptation efforts are needed to limit trends in flood risk caused by climate change.

Kunreuther (1996), and others, have proposed that flood insurance with risk-based premiums can encourage policyholders to invest in cost-effective flood risk mitigation measures. For example, homeowners who “flood-proof” their home can be rewarded for this by receiving a discount on their flood insurance premiums. There are only a few examples of natural disaster insurance arrangements incentivizing risk reduction (Surminski 2014). For instance, the National Flood Insurance Program (NFIP) in the United States charges lower premiums to homeowners with elevated homes, but these discounts insufficiently reflect the lower risk, partly because many NFIP premiums are not truly risk based. Proposals have been made to reform the NFIP and to strengthen the link between premiums and risk reduction activities by policyholders (Michel-Kerjan 2010; Michel-Kerjan and Kunreuther 2011).

Similar reforms have been proposed for flood loss compensation schemes in other countries, like the Netherlands (Botzen 2013). Households in the Netherlands have been able to insure flood losses in recent years through a

separate flood insurance policy that differentiates premiums according to the risk a policyholder faces. This insurance offers premium discounts to policyholders who take measures that limit flood damage. However, the uptake of the flood insurance is low due its relatively high premiums compared with risk. This implies that the large majority of households relies on ad hoc compensation for flood damage by the government in the event that a flood disaster occurs. This government arrangement for flood loss compensation does not incentivize flood risk reduction, and there has been a debate as to whether to establish a broad flood insurance coverage with risk-based premiums.

However, it is not evident that insurance can effectively promote risk reduction. In this respect, it is important to note that the way that the economics literature views relations between insurance coverage and individual risk reduction efforts has changed over the last decades. Seminal theoretical papers from the 1970s assumed fully informed rational agents who make decisions about purchasing insurance and engaging in other risk reduction activities on the basis of financial returns and self-interest. The theoretical prediction that follows from this work is that insurance and risk reduction are substitutes (Ehrlich and Becker 1972; Arnott and Stiglitz 1988). This can lead to moral hazard when people invest less in risk reduction after they have purchased insurance, and if financial incentives for policyholders to limit risk are insufficient. For example, moral hazard can arise when insured individuals expect that the insurance company will compensate damage regardless of their risk mitigation efforts, and premiums insufficiently reflect risk reduction from mitigation. Furthermore, adverse selection can occur when it is mainly high-risk individuals who choose to purchase insurance. Moral hazard and adverse selection can lead to problems for the insurance company when, due to information asymmetries, the higher risks of the insured (either through selection into the insurance, or moral hazard after the policy is bought) are not completely reflected in the insurance premiums (Akerlof 1978; Rothschild and Stiglitz 1978).

The literature on behavioral economics developed subsequently has stressed that individuals are often not fully rational and are instead “boundedly rational,” which means that they act upon their own beliefs even though these may be inaccurate, such as perceptions of risk which deviate from expert assessments or objective risk. Moreover, behavioral characteristics of individuals may drive decision-making in addition to financial interests, such as social norms and their feelings about risk, like minimizing worry. More

recent theoretical work has shown that if one accounts for such behavioral drivers, the opposite of moral hazard and adverse selection may arise, for instance, because behavioral mechanisms, like high risk aversion, cause people to both purchase insurance and invest in risk reduction (de Meza and Webb 2001).

Few studies have empirically examined relationships between flood insurance and flood risk mitigation by policyholders. Lindell and Hwang (2008) found that correlations between flood risk mitigation measures and flood insurance purchases were small for a sample of households in Texas. Thielen et al. (2006) observed that insured households in Germany take more flood risk mitigation measures than households without flood insurance. These results suggest that moral hazard may not pose serious problems for flood insurance markets, but more solid empirical evidence is needed to support this claim.

In this chapter I will highlight some key findings of recent research I conducted with colleagues about empirical evidence of the relationship between flood insurance coverage and individual flood risk mitigation measures in the United States and Germany. This evidence suggests that there are opportunities to encourage risk mitigation with insurance incentives and that moral hazard effects of flood insurance coverage may be minor. Before presenting this evidence, this chapter will discuss the rationale for stimulating flood risk reduction through insurance, and also provide experiences in this regard with insurance products other than for flood. After presenting our empirical evidence, we take a broader perspective than the individual and provide a discussion of how insurance can influence flood risk reduction efforts at the community level. A final section concludes and discusses directions for future research in this area.

## **The Rationale for Stimulating Flood Risk Reduction Through Insurance**

### Shifts Toward Integrated Flood Risk Management

In many countries, flood risk management has traditionally relied on engineering approaches that aim to reduce the likelihood of flooding by building flood protection infrastructure, such as dikes and storm surge barriers. This

has been gradually changing to integrated flood risk management approaches that, in addition to flood protection, include (building level) measures that limit potential flood damage. This change has been motivated by the expected increase in the flood hazard from climate change and an increased recognition that flood protection infrastructure is not failure proof (Kabat et al. 2005). Integrated flood risk management implies that there is an important role for households in floodplains to take measures that limit flood damage to their property. An emerging evidence base shows that individuals experience significantly lower damage during floods if they have implemented “dry-proofing” measures that aim to prevent flood waters from entering their home or “wet-proofing” measures that aim to limit damage once water has entered (Kreibich et al. 2005; Kreibich and Thielen 2009; Bubeck et al. 2012; Hudson et al. 2014; Poussin, Botzen, and Aerts 2015). Cost-benefit analyses have demonstrated the cost-effectiveness of implementing flood damage mitigation measures in areas with a high flood hazard (Kreibich, Christenberger, and Schwarze 2011; Aerts et al. 2014; Poussin, Botzen, and Aerts 2015). Nevertheless, the evidence base for the effectiveness of specific flood damage mitigation measures is small since empirical estimates are made by only a handful of studies that use data from a few countries. There is a need for further research about how much flood damage can be saved by implementing specific flood damage mitigation measures under a variety of possible flooding conditions.

#### Individual Flood Preparedness Decisions

Unfortunately many floodplain inhabitants insufficiently prepare for flooding and do not take flood damage mitigation measures, even when these are cost-effective. Explanations for why individuals do not invest in reducing low-probability/high-impact risk can be found in the literature on behavioral economics. Individuals can be characterized as being “boundedly rational,” which means that they act upon their own beliefs, while they are not fully informed about the risk they face and may not acquire such information because of (intangible) search costs (Kunreuther and Pauly 2004). Low individual perceptions of flood risk imply that individuals underestimate the benefits of measures that mitigate flood risk, which reduces their demand for such measures (Botzen and Van Den Bergh 2012). Several decision-making

heuristics can explain underestimation of low-probability disaster risk. For instance, a survey conducted by Botzen, Kunreuther, and Michel-Kerjan (2015) of flood risk perceptions of ~1,000 homeowners who live in flood-prone areas in New York City shows that most respondents underestimate the damage that they would suffer from a future flood. That study found that underestimation of flood damage occurs among individuals who have not experienced damage during past flood events; think that the flood probability is below their threshold level of concern; have a high trust in government flood risk management; and worry less about the flood hazard. For these individuals, insurance could play a useful role in helping them to make better flood preparedness decisions. Pricing flood insurance according to the risk that policyholders face sends a price signal that can correct for low perceptions of flood risk. Moreover, insurance companies can give premium discounts to reward policyholders who reduce their flood risk, for example, by elevating newly built properties in the flood zone.

### **Experience from Other Insurance Products Stimulating Risk Reduction**

Linking insurance coverage with risk reduction is not only relevant for flood risk, and there are relevant experiences from other insurance products contributing to risk reduction. For instance, as described by Freeman and Kunreuther (1997) in the case of fire insurance, insurance companies have a long history of combining insurance coverage with incentives for risk reduction. Since the early years of provision of fire insurance, insurance companies did assess the risk of companies when they applied for fire coverage (Bainbridge 1952). Companies with a high risk were not allowed to get fire insurance coverage unless fire mitigation measures were implemented, like sprinkler systems. Policyholders who had taken measures to limit their fire risk were eligible for lower premiums. Using these financial incentives, as well as by providing advice about fire risk mitigation measures, insurance companies were a driving force behind the large improvements in fire safety that occurred over time (Freeman and Kunreuther 1997).

Other examples in the context of natural disaster insurance are earthquake insurance systems in California and Japan (Paudel, Botzen, and Aerts 2012). The California Earthquake Authority (CEA) is a publicly managed, but

privately funded, organization which covers earthquake risk in California. CEA policies are sold by private insurance companies. The CEA sets premiums on the basis of risk zones and kinds of insured building. Efforts of the CEA to mitigate risk include raising risk awareness and providing premium discounts to policyholders who retrofit their houses in an earthquake-resilient way. Moreover, additional compensation is available to policyholders for bringing damaged properties into compliance with earthquake-resistant building codes. Another example is the Japanese earthquake reinsurance scheme in which private insurers can participate for offering earthquake coverage as an extension of regular property insurance. Financial incentives for risk mitigation are provided through risk-based premiums, while in addition construction is regulated using earthquake-resistant building codes. An important lesson from these earthquake insurance systems is that a combination of incentives at the policyholder level and broader applicable building codes can be an effective mix for achieving risk reduction.

## **Empirical Evidence of Relations Between Flood Insurance Coverage and Individual Flood Risk Mitigation Activities**

### Key Empirical Findings

This section highlights key findings of recent research I conducted with colleagues about empirical relationships between flood insurance coverage and flood risk mitigation activities by policyholders.

**Key findings:** General relations between flood insurance coverage and flood risk mitigation measures implemented by policyholders show that insured individuals engage in more risk mitigation activities than the uninsured, even when they are not rewarded for this by premium discounts. This evidence suggests that moral hazard effects of flood insurance coverage are minor.

This finding is supported by two recent studies that will be discussed next: namely, a study about relations between flood insurance coverage and risk mitigation measures implemented by households in Germany and several areas in the United States by Hudson et al. (2017), and a study that examined

such relations for homeowners who live in flood zones in New York City by Botzen, Kunreuther, and Michel-Kerjan (2016). It should be noted that these empirical studies did not focus on insurance products that stimulate risk mitigation using premium discounts. These studies examine whether, in the absence of such incentives, insured individuals engage in more or less risk reduction than uninsured individuals. This information is useful for identifying potential moral hazard effects of insurance coverage. Alternatively, insured individuals can be more careful and engage in more risk mitigation than those without insurance, which has been called advantageous selection (de Meza and Webb 2001).

In the first study I collaborated with Paul Hudson, Jeffrey Czajkowski, and Heidi Kreibich (see Hudson et al. 2017). This study examined how the implementation of a variety of household-level risk mitigation measures differs between individuals with, and without, flood insurance coverage in Germany. For this study we used data from surveys by Kreibich et al. (2005) and Kreibich, Christenberger, and Schwarze (2011) of about 2,000 flood-prone households that were conducted in the Elbe and Danube river catchments after flood events occurred in 2002, 2005, and 2006. Among many other variables, this database includes household-level information on implemented flood risk mitigation measures, flood insurance purchases, damage suffered during the last flood event, and flood hazard characteristics, such as experienced inundation depth during flood events. Using this data, we estimated simple probit models of relations between having insurance and implementation of flood risk mitigation activities, while controlling for other relevant explanatory variables.

The results show that individuals with flood insurance coverage in Germany are significantly more likely to have employed mobile flood barriers that keep flood water out of their home, while other measures (flood-proofing homes and adapting building use to flooding) were equally often implemented by insured and uninsured individuals (Hudson et al. 2017). These findings suggest that a moral hazard effect of insurance coverage is absent since households with flood insurance prepare more for floods. Moreover, the absence of a moral hazard effect is confirmed by further analyses that show that the flood damage suffered by insured households does not significantly differ from uninsured households, if it is taken into account that the flood hazard experienced (inundation depth) is more severe for the insured (Hudson et al. 2017). Additional analyses indicate that the better flood preparedness among the insured is related to the seeking of information about flood



risk, which can signal that the insured are more risk averse and for that reason take flood risk mitigation measures as well.

Furthermore, Hudson et al. (2017) present similar analyses for windstorm and flood insurance coverage in the United States. The data originate from field surveys conducted by Meyer et al. (2014) that measured risk preparedness activities of about 1,700 coastal residents when three hurricanes—Irene (in 2011), Isaac (in 2012), and Sandy (in 2012)—approached the United States during the 2011 and 2012 hurricane seasons. Results of these analyses also show that individuals with windstorm and flood insurance coverage are more likely to engage in activities that reduce the risk they face of these hazards. It appears that this higher risk mitigation by the insured is not triggered by the insurance deductible. The majority of the individuals in the sample were not aware of their deductible level and for those who did know their deductible, it had only a small, if any, effect on their risk mitigation activities (Hudson et al. 2017). These findings from the United States suggest that it is the higher risk aversion of the insured that is triggering them both to purchase flood insurance and engage in other risk reduction activities.

In the second study that supports the aforementioned key findings, I collaborated with Erwann Michel-Kerjan and Howard Kunreuther. To gain insight into flood preparedness decisions by residents of flood-prone areas in New York City, we implemented a detailed phone survey of more than 1,000 homeowners with a ground floor (Botzen, Kunreuther, and Michel-Kerjan 2016). Respondents were carefully selected to ensure that they lived in an area that was prone to flooding. This survey was implemented six months after large parts of New York City were flooded by Hurricane Sandy. Respondents were asked about a hundred questions with respect to the following topics: flood risk perceptions, motivations for flood preparedness activities, flood insurance purchases, implemented flood risk mitigation measures, and their sociodemographic characteristics. The completion rate of the survey was 73%. Figure 16.1 shows the percentage of respondents who implemented specific flood risk mitigation measures. A distinction is made between homeowners who voluntarily purchased flood insurance and those who chose not to purchase flood insurance. This distinction hardly matters for the elevation of homes, which is not surprising since the elevation of residential homes in the 1/100-year floodplain in New York City is subject to building code requirements. The other flood risk mitigation measures are voluntary activities. It is clear from Figure 16.1 that homeowners who voluntarily purchased flood insurance were also more likely to have implemented these

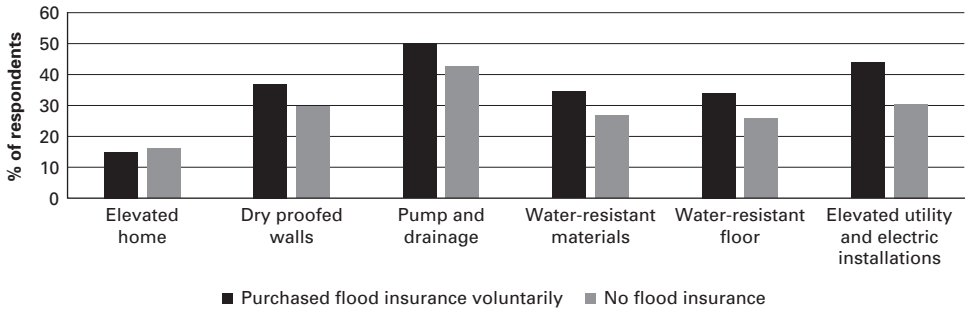


Figure 16.1. Percentage of homeowners in flood-prone areas in New York City who have implemented specific flood risk mitigation measures, distinguishing between those who purchased flood insurance voluntarily and those who have not purchased flood insurance. *Source:* Botzen, Kunreuther, and Michel-Kerjan (2016).

flood risk mitigation measures than homeowners without flood insurance coverage. With further statistical analyses (not reported here), we aim to identify reasons behind the higher levels of flood preparedness among the insured.

### Other Related Research

There are several studies about other insurance markets than flood insurance that support the findings that insured individuals have a higher interest in engaging in risk mitigation. Carson, McCullough, and Pooser (2013) use survey data to examine the relationship between windstorm insurance and the implementation of measures that reduce windstorm risk in the My Safe Florida Home Program in the United States. They find a positive relationship, suggesting that households with windstorm insurance engage in more risk mitigation activities. Petrolia et al. (2015) present a similar analysis for windstorm insurance and risk reduction by households along the U.S. Gulf Coast. They find a positive relationship between the decisions to purchase insurance and mitigate risk, which may be interpreted as advantageous selection. Lindell, Arlikatti, and Prater (2009) find small positive correlations between earthquake insurance purchases in the United States and a variety of measures that households have taken to limit earthquake risk. Furthermore, a variety of studies about U.S. health insurance markets show that an individual's

health coverage is positively related with activities that reduce health risk (e.g., Finkelstein and McGarry 2006; Cutler, Finkelstein, and McGarry 2008). This does not mean that these findings of the absence of a moral hazard effect always hold. Cohen and Siegelman (2010) provide a review of empirical studies of moral hazard effects in a large diversity of insurance markets (excluding natural disaster insurance), and show that results are mixed. This implies that separate investigations per insurance product are needed, as presented in this chapter for flood insurance.

The results concerning positive relations between flood insurance coverage and flood risk mitigation activities are obtained for flood insurance products with premiums that are not fully risk based, because policyholders did not receive premium discounts for employing the risk mitigation measures. Actively stimulating household investments in flood-proofing of homes using premium incentives could have resulted in a higher implementation of flood risk mitigation measures. However, to my knowledge, the effectiveness of such financial incentives in stimulating risk reduction has hardly been studied empirically. An exception is Botzen, Aerts, and Van Den Bergh (2009), who conducted a survey of about 500 homeowners in flood-prone areas in the Netherlands to examine their (hypothetical) willingness to take specific flood risk mitigation measures in exchange for incentives from their insurer. It turns out that a majority of Dutch homeowners are willing to take measures that flood-proof their home, like installing water barriers, if they receive a reward in the form of a premium discount. Although this finding suggests that insurance incentives can be effective in improving flood preparedness, future research should examine whether these results translate into actual decision-making in the field.

### **Stimulating Community-Level Flood Risk Mitigation Using Insurance**

In addition to the incentives that insurance can provide to stimulate risk reduction at the individual level, insurance can be used to target flood risk mitigation at the community level. This can be done through regulation, such as zoning and building code policies, or by providing incentives such as premium discounts to policyholders who live in communities that invest in risk mitigation. Such community-level regulations and incentives can be complementary to those that encourage mitigation at the policyholder level for the

following two reasons. First, a certain minimum level of flood-proofing to mitigate flood damage can be economically efficient for all buildings in a specific flood zone. However, due to behavioral biases in flood-preparedness decisions (considered earlier) not all individuals will voluntarily invest in this level of flood-proofing. In that case, imposing minimum building code standards that make flood-proofing compulsory can be economically efficient. Second, some flood risk management measures, like providing information about risk mitigation options and local flood protection infrastructure, are best taken at the community level due to their public good characteristics. Rewarding communities for such measures by providing their policyholders with lower insurance premiums can also make sense from the insurer's perspective because expected claims on policies decline.

The National Flood Insurance Program in the United States is an interesting example of how flood risk mitigation at the community level can be stimulated through regulation that imposes minimum construction standards, and through financial incentives provided by the Community Rating System. Communities can voluntarily decide whether they want to participate in the NFIP, but once they join they have to comply with minimum construction standards which apply to a flood zone that is expected to be flooded once in 100 years on average. These standards prohibit new construction in floodways. Moreover, new buildings and buildings that are substantially renovated have to be elevated above the potential flood water level that a 1-in-100-year flood event would cause. It has been shown that, overall, these minimum requirements have substantially saved flood damage to new constructions in flood zones (Sarmiento and Miller 2006). However, NFIP mitigation policies have done little to limit vulnerability of existing buildings to flooding and have been ineffective in limiting the continued development in high-risk flood zones over time (Aerts and Botzen 2011). These problems may be overcome by providing incentives at the individual policyholder level by charging risk-based flood insurance premiums that discourage building in high-risk areas as well as reward flood-proofing of existing buildings with lower premiums (Michel-Kerjan and Kunreuther 2011).

Communities that have joined the NFIP can voluntarily decide to participate in the Community Rating System. This system rewards communities which engage in flood risk management activities with premium discounts to policyholders who live in the community. These discounts range from 5% up to 45% depending on the kind of flood risk management activities the community undertakes. Most NFIP policies fall under this system. An

assessment shows that communities in Florida mainly undertake low-cost measures to earn premium discounts, like information provision, and invest less in more expensive flood risk mitigation measures, like dam infrastructure (Brody et al. 2009). Nevertheless, participation in the Community Rating System has been found to limit flood risk since it is associated with lower claims (Michel-Kerjan and Kousky 2010).

### **Conclusions and Agenda for Future Research**

The expected increase in economic losses from flood disasters as a result of climate change and continued development in floodplains requires large investments in flood protection infrastructure and measures that limit damage from future floods. This integrated approach to flood risk management entails that households should implement cost-effective measures to limit flood damage to their homes. In practice, flood preparedness is suboptimal when many floodplain inhabitants do not invest in flood risk mitigation measures, for example, because they underestimate the flood risk that they face. It has been argued that flood insurance could play a useful function of incentivizing policyholders to take flood risk mitigation measures in addition to providing financial coverage of flood risk. On the other hand, insurance could result in a moral hazard effect when insured individuals engage in fewer risk reduction activities, because they expect that the insurance company will cover their damage anyway if a flood occurs. Few studies have examined empirically the relationship between flood insurance coverage and flood risk mitigation activities of individuals. This chapter presented two recent studies I conducted with colleagues that find that general relations between flood insurance coverage and flood risk mitigation measures implemented by policyholders show that insured individuals engage in more risk mitigation activities. This evidence suggests that moral hazard effects of insurance coverage are minor.

The aforementioned key findings as well as those from other related research discussed in this chapter provide a basis for future research about how flood insurance arrangements can provide incentives that help policyholders better prepare for flood disasters. The existing evidence originates from a few flood insurance markets and countries, and future research could examine whether these results hold in other country and market contexts. As also argued by Lindell, Brody, and Highfield (2016), the literature on

behavioral economics and behavioral decision theory should be taken as a starting point for examining why there appears to be a disparity between economically rational behavior and what people actually do in terms of preparing for natural disasters in practice. Economic experiments and field surveys could aim to identify what behavioral mechanisms explain the higher interest in risk mitigation among individuals with flood insurance. Furthermore, future research is needed to understand how effective financial incentives by insurance, such as risk-based premiums, are in incentivizing policyholders to invest in cost-effective risk mitigation measures. Economic experiments could be conducted to obtain such insights, and ideally this topic will be examined in field studies about actual decision-making in practice. Moreover, there may be opportunities for using insurance as a mechanism for stimulating risk reduction at the community level, but a thorough evaluation of the effectiveness of such mechanisms as the Community Rating System in the United States is in order. The research presented in this chapter can provide a starting point for a future research agenda on these themes.

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