



Market Incentives for Private Insurance Markets: Literature Review

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1. Introduction

There is growing societal concern over the increasing frequency and severity of recent hurricanes threatening communities along the coastline of the United States (Goldenberg et al., 2001; Klotzbach et al., 2008; Smith et al., 2010). Hurricane-induced losses make up the largest proportion of all insured losses associated with natural disasters (Bevere et al., 2013). Accelerated population growth and exposure of assets to damaging storms pose substantial risk to property and business owners, private insurers and reinsurers, as well as strain public resources to aid with recovery (Kleindorfer and Kunreuther, 1999). Transferring hazard risk to a third party (i.e., insurers) is one way to manage increasing risk; however, the fundamental dilemma private insurers face is how to handle the host of interrelated problems that arise when dealing with catastrophic risks (Jaffee and Russell, 1997). To address these concerns, insurers have sought to employ a more rigorous risk-modeling approach to adequately price policies, reduce their catastrophic exposure and avoid uninsurable losses, while further seeking various risk-diversification strategies, including reinsurance and financial markets.

Low probability-high consequence events are hard to insure because they increase the cost of insurance, ultimately leading to such high prices that buyers are not willing to pay. Furthermore, markets are constrained by various state regulatory mandates imposed on insurers in terms of pricing, policy terms, capital and solvency (Kousky, 2011). These regulations, while intended to increase the availability and affordability of insurance and protect insureds from insolvent insurers, are believed to substantially distort market incentives and undermine market responses to make appropriate adjustments and adequately manage catastrophic risk (Grace, Klein and Kleindorfer, 1999). Notably, regulatory restrictions have been complemented by state residual markets as the vehicle to supply affordable insurance in high-risk areas where private insurers are not willing to

underwrite policies. These residual markets may create a suite of disincentives for private market developments; therefore, well-rationed depopulation strategies are important to encourage private insurers to assume more policies from state residual programs.

It is important to understand the characteristics of catastrophic markets, features of regulatory stringency targeting various markets, financial and operational aspects of the insurance business and their impact on insurers' performance, as well as how they interplay with state residual markets. Such knowledge will inform policy related to depopulation of state-run insurance programs.

This document provides a comprehensive literature review associated with the issues of private insurance to provide risk-bearing capability against catastrophic disaster losses. While the primary focus of the review is to inform market incentives for wind/hail insurance, examples from other catastrophe insurance markets, such as flood insurance, are also drawn. We proceed as follows. In Section 2, we first review features of catastrophic insurance markets, focusing on challenges posed by fat tails, spatially correlated risks and tail dependence. We then move to describing market forces and the market structure from both the supply and demand sides and highlight several important aspects for market functionality (Section 3). These cover costs to insurers and their degree of risk aversion and heuristics (i.e., availability bias) that may play a role in limiting consumers' insurance decisions, among other factors, including government disaster programs perceived as insurers of last resort.

In Section 4, we provide a review of regulatory and statutory aspects of insurance market regulation and highlight several deficient areas in which regulatory adjustments can potentially promote market efficiency. In Section 5, we briefly review the differences between homeowner and commercial line insurers as they deal with catastrophe risk. State residual programs across

multiple states are discussed in Section 6 by highlighting their unique features in supplementing markets for uninsurable losses. We further review the literature related to various mitigation incentives insurance can provide through reduced premiums (Section 7). Finally, in Section 8 we summarize best practices that could potentially foster insurance market dynamics.

2. Catastrophic Disaster Risk and the Challenge to Insuring

Catastrophic perils have unique characteristics, and understanding them is particularly relevant to managing the risks they pose to insurers (Grace and Klein, 2009). Specifically, catastrophic disaster losses are best described by the fat tail distributions suited to the type of data seen when the probability of observing extreme value (i.e., severe events) declines more slowly relative to the magnitude of that value (Newman, 2005; Schoengerb et al., 2003). The implication of fat tails is that the most extreme event observed to date may be orders of magnitude larger than the previous most extreme event, and so on. Depending on the relative fatness of tails, one or both major statistics commonly used to describe a distribution (e.g., the mean and the variance) may be infinite, and sampling distribution of the mean may also have infinite variance, compromising the implications of the Central Limit Theorem (Kousky and Cooke, 2009).¹ With fat tails, historic records could be a poor guide to estimating future losses.² A recent empirical analysis of tropical cyclone damages from 1900-2012 showed evidence that damages followed a fat-tailed distribution, and, after adjusting for inflation, income and population, even though the mean of distribution was finite, the variance was estimated to be infinite (Conte and Kelly, 2018).

¹ Technical discussion about fat-tailed distributions is beyond the scope of this literature review. For mathematical details, please refer to Resnick (2007) and Brielant et al. (2005). Empirical evidence from U.S. flood and hurricane perils are shown in Kousky and Cooke (2009).

² For example, to date, Katrina still remains the costliest hurricane in U.S. history (excluding Harvey, which was primarily a precipitation event), whose estimated \$162 billion dollars of losses (in real 2017 prices) was orders of magnitude larger than the previous most damaging hurricane, Andrew, in 1992 (\$32 billion losses; NOAA, 2017). We should also note that in terms of damages, Harvey losses fell slightly short of the losses generated by Katrina.

Another feature of catastrophic risks is that losses are spatially correlated, and, as the magnitude of an event increases, so do the damages sustained by structures and buildings that are geographically clustered. Losses are further correlated as buildings in close proximity are structurally similar because they adhere to the same building codes and local zoning and land-use regulations (Dehring and Halek, 2013). This is unlike a regular insurance market such as vehicle insurance, in which the risk of vehicle theft does not simultaneously increase the likelihood other vehicles from the neighborhood will also be stolen (Klein, 2014).

In addition to these two unique features, Kousky and Cooke (2011), highlighted two other features of catastrophic loss, tail dependence and micro correlation,³ which could particularly undermine common risk diversification strategies insurers undertake. In the context of natural catastrophe, tail dependence refers to positive dependence between two random variables taking on extreme values simultaneously; that is, when one variable takes on extreme value it is likely other random dependent variables will also take on extreme value. Hurricane Katrina prompted tail dependence across damage types and insurance lines by generating losses not only to property and businesses because of flooding and winds, but also due to the levee breach, storm surge, power outages, fires, toxic spills, rise in energy costs, etc., effectively impacting insurers across multiple lines (e.g., offshore energy, cargo, marine and recreational watercraft, floating casinos, automobile, health and life insurance; Risk Management Solutions [RMS], 2005).⁴ Tail dependency is particularly prevalent in loss data for insurers operating in hurricane-prone states because severe hurricanes can cause both flood and wind damages. During non-catastrophic years, losses across lines of businesses may be independent, but in catastrophic years, high amounts of

³ Along with fat tails, these two features are metaphorically referred to as the “unholy trinity” due to unique obstacles they create for private catastrophic market function (Kousky and Cooke, 2009).

⁴ Although not caused by natural catastrophe, losses due to the 9/11 terrorist attack also generated tail dependence across multiple lines of insurance (Kousky and Cooke, 2009).

claims are expected across all lines of businesses (Lescourret and Robert, 2006). Kousky and Cooke (2009), using flood damage data paid for by National Flood Insurance Program (NFIP) and wind-induced claims covered by the Florida Citizens Property Insurance Corporation during the period from 2002-2008, showed significant tail dependence across the two types of perils.

Another feature characterizing catastrophic insurance markets relates to micro-correlation of perils, describing a correlation between perils that is so small it mostly goes undetected; however, amplified by aggregation, it can potentially compromise common risk diversification strategies pursued by (re-)insurers globally (Kousky and Cooke, 2009). El Nino events can trigger such micro-correlation perils (Dilley and Heyman, 1995) by causing fires due to droughts and floods in geographically unrelated locations, such as Australia and Florida (Herring et al., 2016; Ummenhofer et al., 2009). The two perils at such distant locations are not otherwise correlated unless triggered by El Nino events. Each of these features not only creates unique challenges to private underwriters, but also has implications for state- and national-level regulation of insurance markets (Born and Klein, 2016) that we further discuss in the following sections.

3. Markets for Catastrophic Insurance

For insurance companies to properly function in the catastrophic market, several conditions should hold. Some are critical for the functionality of the wind and hail insurance market, while others may be less concerning. Here we focus on five fundamental features in the context of natural disasters as discussed in Kousky (2019) and highlight ones that are particularly concerning for the wind and hail insurance market. First and foremost, insurance operates on the premise that losses are random, thereby allowing their transferability from insured to insurer for less than the full amount (Cuttler and Zeckhouser, 2004; Schmit, 1986). The less random the event becomes in terms of its timing, size and location, the more certain losses are and the harder it becomes to insure

it. While the majority of perils, including hurricane and hail, remain random, others have become less and less random. A recent report by NOAA shows alarming upward trends indicating that high tide flooding, also referred to as nuisance or sunny day floods, will become an everyday event in the eastern Gulf of Mexico region, due to sea level rise and ongoing climate change (Hino et al., 2019; Sweat et al., 2018; Sweet et al., 2016).

The second criterion relates to the ability of insurers to determine losses. Insurance policies in the United States are primarily indemnity-based policies – i.e., payment size is equal to the size of the loss (Klein, 2005). In a common approach for indemnity-based policies, once the disaster happens, insurance adjusters typically visit properties to assess damages (often, homeowners are required to keep photos to validate their damages). Furthermore, because there are exclusions to risks covered under insurance policies in the U.S., determining the cause of damage may sometimes become controversial. Notable examples are hurricane-induced damages, for which a homeowners policy covers only damages caused by wind and not by flood. For many homes that were totally destroyed by Katrina in 2005, the absence of witnesses (as residents were evacuated) posed significant challenges for insurers to determine the proportion of losses caused by flood and wind separately, which led to several lawsuits (Abraham, 2007).

The third criterion relates to adverse risk selection and moral hazard issues translating into various (mis-)incentives for insureds. An adverse selection refers to a situation in which loss information is private to consumers (i.e., buyers of insurance), but because insurance companies cannot distinguish types of buyers, they have to offer a single price to a pool of seemingly homogeneous but heterogeneous customers (i.e., low- and high-risk pool; Arrow, 1968; Cohen and Siegelman, 2010; Pauly, 1974; Rothschild and Stiglitz, 1976; Stiglitz, 1983). The implication of such pricing is that the premium may be too high for the low-risk pool but underpriced for the

high-risk pool, resulting mainly in individuals who face a risk too high to hold insurance and creating negative impact on the profitability of private insurers (Akerlof, 1970; Einav and Finkelstein, 2011; Rothschild and Stiglitz, 1976). In the context of disasters, however, insurers may possess more accurate information about the hazard risk and expected losses than their insureds (Grossi and Kunreuther, 2005), minimizing concerns over adverse selection.

On the other hand, moral hazard is a concern in the catastrophic insurance market. Moral hazard arises when insureds engage in high-risk activities that increase the probability of losses if the event occurs, knowing that they will be compensated for their loss (Arnott and Stiglitz, 1988; Ehrlich and Becker, 1972; Kunreuther and Michel-Kerjan, 2014). Such behaviors often drive the cost of insurance above its price. Moral hazard poses a problem if premiums do not completely capture risk-taking behavior (Chiappori and Salanie, 2000). Deductibles are used as a means of transferring some risk back to the insureds as an incentive for them to undertake precautionary measures and reduce increased risk exposure (Pauly, 1968).

The fourth condition relates to independent, thin-tail distribution of losses. When losses are independent, with an increasing number of policies – assuming premiums are set closer to the expected value of losses – insurers will generate enough revenues to cover losses. Natural disasters certainly violate this condition. As discussed earlier, damages are fat-tailed (Blackwell, 2015; Conte and Kelly, 2018; Holmes et al., 2008), often tail dependent (Lescouret and Robert, 2006; RMS, 2005) and spatially correlated (Cutter and Emrich, 2005; Grossi et al., 2005).

Finally, the fifth criterion is that demand meets supply and at that price (i.e., premium) markets clear. However, a market that is loaded with high potential for catastrophic losses faces myriad complex problems. To cover losses during catastrophic years and also remain solvent, insurers need to build up reserves, purchase reinsurance and have access to other forms of liquid capital

through financial markets. These all add to the cost of insurance and can make insurance prices exceed what consumers are willing or able to pay (Kousky and Cooke, 2012). Hence, the market will not clear. In addition, heavy regulations imposed on insurers may distort market efficiencies. Below we provide both the demand and supply side perspectives of the catastrophe insurance market.

3.1. DEMAND SIDE

The basic demand model for insurance was described in Arrow (1971). Dionne and Harrington (1992) and Kunreuther (1998) further expanded it to incorporate consumers' behavioral responses and several biases in evaluating disaster risk. Other studies have posited a demand decision as a choice between *ex ante* mitigation (i.e., self-insurance) and risk transfer (i.e., insurance; for example, see Dionne and Eeckhoudt, 1985; Ehrlich and Becker, 1972; Kunreuther and Kleffner, 1992; Kunreuther and Slovic, 1978). Specifically, several heuristics and behavioral biases help explain why the demand for disaster insurance is low and why individuals do not voluntarily purchase insurance. The prominent reason is availability bias, which suggests that people judge the likelihood of an event based on its salience (Tversky and Kahneman, 1974). Economic agents tend to overreact in response to recent incidents when the risk is more salient. The implication of such bias is that there is a general uptake of insurance after a large-scale incident; however, the impact disappears as the memory of the disaster fades away (Attreya et al., 2015; Michel-Kerjan et al., 2012).

A growing number of empirical studies employing aggregate level data (e.g., by county, zip-code) have provided support for the short- and long-term implications of the availability heuristics in disaster insurance purchase, primarily inferring such effects from the variable that measures disaster frequency and/or impacts (e.g., number of past incidents, presidentially declared disasters,

past damages, heavy precipitation, etc.). Gallagher et al. (2014), using the NFIP flood insurance policy across all U.S. counties, showed that insurance significantly increases after a recent flooding event (proxied by presidentially declared disasters) and declines steadily to its baseline. Notably, such a sharp decline provides more support for the availability bias, albeit little to no support for the Bayesian learning model, which postulates that economic agents who possess full information about historical events should weigh them equally in insurance decisions (Davis, 2004; DeGroot, 1970; Viscusi, 1991). Davlasheridze and Miao (2019), using the national sample of NFIP policies, also estimated a significant spike in flood insurance take-up rates one year following a rainfall shock, but the significant effect persisted only up to three years. Other studies have also shown similar patterns, lending further support to the behavioral bias (Atreya et al., 2015; Botzen et al., 2009; Botzen and van den Bergh, 2012; Brown and Hoyt, 2000; Kahneman and Tversky, 1982; Kousky, 2011, 2017; Kousky and Michel-Kerjan, 2010, 2017) and perhaps some support to the learning model, but these effects are only short-lived. While failure to voluntarily purchase insurance has been attributed to behavioral biases and lack of information, Kousky and Cooke (2012) argued that it may be rational and optimal to forgo insurance when faced with catastrophic risks, because the premiums required to cover losses are greater than homeowners are willing to pay, given their budget constraints.

Studies based on household-level surveys are better positioned to determine factors affecting insurance purchase decisions, particularly those investigating the role of the subjective and perceived probability of risk in insurance decisions. In the context of floods, for example, Kriesel and Landry (2004) showed that demand for flood insurance increases if it is required by mortgage companies and is also higher in communities with erosion protection measures. On the other hand, insurance demand declines with distance from the shoreline and an increasing interval between

hurricanes. Landry and Jahan-Parvar (2011) also suggested that an insurance decision is positively affected by policy subsidy and the objective measure of flood risk (often proxied by 100-year floodplains).

Standard insurance models assume households' subjective risk perceptions are equivalent to calculated objective hazard risk (Mossin, 1968; Smith, 1968). In reality, as past studies have indicated, individuals tend to underestimate not only the hazard risk but also the magnitude of losses (Camerer and Kunreuther, 1989; Chivers and Flores, 2002; Kunreuther, 1984, 1996, 2006). If risk is systematically underestimated, individuals will be expected to find voluntary insurance unattractive even at subsidized rates.⁵ In fact, the significant gap between total losses and insured losses globally consistently indicates that unless there are mandatory requirements or substantially subsidized premiums, general interest in catastrophe insurance remains low (Lloyd's, 2012; Marshall, 2018). It should be noted, however, that the insurance gap is relatively lower for windstorms than for floods and earthquakes (Holzheu and Turner, 2018). Even with mandatory insurance requirements imposed, for example, on properties located in 100-year floodplains by federally backed mortgage companies, recent estimates suggest that the take-up rate is more than 60% (Federal Emergency Management Agency [FEMA], 2018). The survey after Hurricane Sandy also indicated that smaller and younger businesses were less likely to have hazard insurance (Collier et al., 2020). On the contrary, in places where disaster coverage is part of standard homeowners insurance policies, take-up rates are higher. For example, in the UK, flood is included in the standard insurance policy and the insurance uptake is more than 90% (Surminsky, 2018). While the wealth of the literature has dealt with understanding the factors contributing to the purchase of hazard insurance, research has primarily focused on residents for whom insurance is

⁵ Such behavior has been observed in other types of insurance including crop insurance (Shaik et al., 2008), wildfire risk (Talberth et al., 2006) and earthquake insurance (Naoi, Seko and Samita, 2010).

mandated. Relatively little is known about the drivers of voluntary insurance decisions outside of hazard zones (e.g., 100-year floodplain). Brody et al. (2017) provided one of the few studies to explore this question using a survey-based study from four locations in Texas and Florida. Their results indicated that residents with high levels of education, expensive homes and long tenure of residency were the primary determinants of voluntary insurance purchase decisions. The findings of Linder-Baptie et al. (2020), based on semi-structured interviews and a survey of community officials (e.g., floodplain managers, emergency managers and city planners), indicated that in addition to residents' income, recent or repeated flooding and outreach and education programs were key determinants of voluntary flood insurance purchases outside of spatial flood hazard areas (SFHA).

Risk preference is another household-level factor of risk mitigation behavior (Holt and Laury, 2002; Kachelmeier and Shehata, 1992; Lusk and Coble, 2005; Petrolia et al., 2013). Wind and hail insurance decisions are likely to be similar to those made about floods and other perils; however, empirical research about this peril is relatively scant. Petrolia et al. (2015) is one of the few studies that explored wind insurance decisions in coastal zone counties in the U.S. Gulf states. Using household-level survey data, the authors explained how wind insurance and mitigation decisions are affected by household risk preferences and perception, the perceived credibility of an insurer and community risk-management strategies, along with wealth and household demographic characteristics (e.g., race and ethnicity, families with kids, marital status) and housing features (e.g., age, condo, mobile homes, mortgage). Their findings suggested that risk aversion plays an important role in insurance decisions over the loss domain; however, they found no statistically significant relationship between the perceived expected storm frequency, conditional on expected damage or past damage, and the probability of purchasing wind insurance. Furthermore, the

authors suggested that residents in coastal zone counties generally exhibit higher wind insurance uptake and residents with mortgages are more likely to have wind coverage. Household income is another significant determinant of the wind insurance decision. Notably, within the Gulf states, respondents from Texas and Alabama/Mississippi are significantly more likely to purchase wind insurance compared to residents of Louisiana and Florida. The study found no statistically significant effect of perceived insurer's credibility on wind insurance decision (Petrolia et al., 2015). Wang et al. (2017) examined flood and wind insurance demand decisions among North Carolina homeowners, using the survey, and found that the insurance decision for the two perils were similar in terms of determinants. Specifically, the probability of purchasing insurance increased with recent hurricane experience, with lower premiums and lower deductibles, and with increasing income and if homeowners were younger (Wang et al. 2017)

Research employing controlled experiments and surveys provide some insights that could explain such limited under-insurance behavior. One explanation is myopic loss-aversion and narrow framing. Specifically, individuals tend to be short-sighted when evaluating outcomes and subsequently put more weight on losses than gains (Gneezy and Potters, 1997; Thaler et al., 1997). They further tend to isolate current decisions from future opportunities to make similar decisions (Kahneman and Lovallo, 1993; Redelmeier and Tversky, 1992).

It is widely believed that ex-post disaster aid could create perverse incentives for private ex-ante risk mitigation and insurance behavior for homeowners and private businesses, because they assume the government will step in as an insurer of last resort in the event of large-scale devastation. Notably, government aid (for example, increased spending on public mitigation projects) may also be perceived as a substitute for private ex-ante mitigation and risk transfer behavior (Davlasheridze and Miao, 2019). While empirical evidence is scant in support of the

moral hazard hypothesis, a few recent studies have shown some evidence that disaster aid could reduce incentives to invest in risk mitigation and private risk transfer (Deryugina and Kirwan, 2017; Kaplow, 1991; Kelly and Kleffner, 2003; Kousky et al., 2018; Kunreuther and Pauly, 2006). Petrolia et al. (2015) found limited evidence that the perceived probability of receiving post-disaster assistance could significantly explain the likelihood of wind/hail insurance purchase. However, they also suggested that community-level mitigation efforts proxied by the investment in flood protection (even though community-level mitigation data specific to wind hazard does not exist), significantly reduce insurance decisions, thereby lending support to the view that public projects are substitutes for rather than complementary to private risk transfer behavior.

Grace et al. (2004) estimated the demand for homeowners insurance subject to different levels of catastrophic and non-catastrophic risks using zip-code level data from Florida and New York, while also estimating the effects of various firm-specific characteristics and regulatory measures on the demand for insurance. Their findings suggested demand for insurance subject to catastrophic risks to be more price elastic, indicating that with the increasing cost of insurance one would expect a decrease in the demand for insurance. Relatedly, regulatory measures targeting rate suppression/compression were found to increase the demand for insurance. The authors also suggested a preference for better rated insurers among policy holders whose coverage exceeded the state guaranty fund limits,⁶ used as a proxy for company solvency. Policy holders with coverage below guaranty association limits showed greater preference for low-rated insurers (e.g., A.M. Best rating). We further discuss the effect of guaranty associations in Section 6.

Other important factors often overlooked are that, in the United States, a standard homeowners policy may not cover disaster peril(s) (e.g., flood insurance is fully excluded from standard

⁶ Section 6.3 discusses in more details the effects of Guaranty associations/funds on private insurance market.

residential and commercial property insurance policies; while wind perils are generally included in insurance policies, they are not part of the insurance for coastal areas prone to high risks of hurricanes and tropical storm) and households may not possess full/good knowledge about hazard risk (Kousky, 2011; U.S. GAO, 2008). Furthermore, if disaster policies are not automatically renewed and/or are not paid from mortgage escrows, homeowners may either fail to renew the policy or deliberately opt out of the insurance.

3.2. SUPPLY SIDE

Conventional insurance models assume that insurers are risk-neutral and the supply of insurance is primarily driven by the cost of providing insurance coverage (e.g., expected claims paid to the insured, cost of capital, etc.; Stone, 1973a, 1973b). The cost of insurance itself is determined by the cost of gathering information about the insured's risk, as well as the cost of diversifying (or retaining) the risk. An increasing degree of uncertainty raises the risk to insurers, which in turn increases the cost of capital required to remain solvent (Grace et al., 2003).

Past studies have indicated that insurers may be risk averse and, in some instances, even act as ambiguity averse, implying that they would avoid risk that is difficult to assess (Kleindorfer and Kunreuther, 1999; Kunreuther, 1998). When insurers are risk-averse and risk is ambiguous, the supply of insurance coverage would also be constrained, and higher premiums would be charged, signaling insurers' willingness to accept catastrophic insurance only at higher prices, if at all (Hogarth and Kunreuther, 1985; Kunreuther and Hogarth, 1992).⁷ Also, risk-averse insurers may adopt the so called safety first model (Roy, 1952), in which instead of maximizing expected profits, insurers focus on keeping the probability of insolvency below certain threshold levels (Stone,

⁷ While not a natural disaster, following the 9/11 catastrophe, despite increased demand for insurance, most insurance companies refused to cover terrorism risk, except for the few at extremely high premiums (Michel-Kerjan and Kunreuther, 2018).

1973a). Shifting to threshold level as a decision guide is also driven in part by state regulations or the minimum capital requirements by rating companies (Cummins and Harrington, 1987). We further expand this issue below in discussing the effects of rating stringency on insurers' risk-taking behavior.

Absent significant entry (exit) barriers, the insurers' supply curve in the short term is upward sloping, indicating that unit cost of insurance increases with the increased amount of coverage (Grace et al., 2003). In the long-term, however, it appears that insurance is relatively price-elastic, suggesting that insurers should be able to supply coverage to meet increasing demand without increasing market price (Cummins and Weiss, 1991; Joskow, 1973). Kunreuther and Michel-Kerjan (2009), using county-level data from Florida on insurance supply, estimated the price elasticity of supply to be very high. Specifically, their results indicated that a 10 percent increase (decrease) in price would increase (decrease) the quantity of policies supplied by 27 percent. Such a high elasticity also implies that in states where regulators suppress rates, a severe insurance availability problem is to be expected.

In the catastrophic insurance markets, insurers cannot assume large amounts of catastrophic exposure (Grace et al., 2006; Jaffee and Russell, 1997; Kunreuther and Michel-Kerjan, 2007). The implication is that the supply curve will slope sharply upward beyond some level of output, thereby signaling that the coverage can be provided only at a substantially higher premium, if at all. While during non-catastrophic years, general annual premiums are typically sufficient to cover losses (ratio of losses paid to annual premiums received stays at or below one), insurers face a greater probability of insolvency during catastrophic years (Kleindorfer and Klein, 2003).

To be viable for risk-spreading, private insurers should solve this problem intertemporally, identifying a way to smooth annual premiums against the non-smooth flow of annual loss

payments (Jaffee and Russell, 1997). When framed this way the catastrophic insurance problem becomes a capital market problem. That is, for the insurer to cover catastrophic losses, the insurer would be required to hold large amounts of capital (i.e., by charging higher prices insurers can build up reserves) and/or have access to enough liquid capital to cover the largest possible losses⁸ through reasonably priced reinsurance or use of the financial markets. These options could significantly increase the cost of insurance above what property owners and businesses are willing and able to pay to transfer risk (Kousky and Cooke, 2012).

Existing literature that explores the supply side of the insurance market subject to catastrophic risk is relatively scant, coming from only a subset of states and focusing on property markets and lines of businesses. For example, Klein and Kleindorfer (1999) and Grace and Klein (2006, 2007) have provided an interesting conceptual discussion of performance of the homeowners insurance market in Florida with respect to prices and contract terms, availability of coverage and insurers' profitability. Detailed analysis of the market indicates limited availability of insurance subject to catastrophic risk and general decline of insurers in Florida due to substantial catastrophic losses experienced there.

Employing state-level data from all U.S. insurers between 1984 and 2004, Born and Viscusi (2006) also showed empirical evidence that insurers suffer a greater degree of loss both in response to unanticipated catastrophes and the so-called blockbuster catastrophes for which losses exceeded 1.7 billion dollars; they adapt by substantially raising premiums and reducing total number of insurance policies, in addition to exiting the markets. A more recent study by Aseervatham et al. (2016) also suggested that insurers evaluate disaster risk not only by considering hazard severity and frequency but also the type of hazard. Controlling for the size of natural disasters, the

⁸ Jaffee and Russell (1997) give an example of an event which has one percent annual probability of occurrence for which the capital requirement would equal 100 times the annual expected loss from the event.

Aseervatham et al. (2016) study of all property insurers, which spanned the period of 1992-2012, suggested that hurricanes are more likely to challenge insurers' supply decisions than tornadoes, despite the latter being more ambiguous in terms of predictability – the probability of exiting or reducing the business increased after a severe hurricane season, threatening both the availability as well as affordability of insurance, absent state residual market mechanisms.

Hagendorff et al. (2015) also explored the effects of 19 mega-catastrophes on property liability insurers' performance (share price, market-adjusted abnormal return for an insurer) from 1996-2010. Their results also supported the growing evidence that mega-catastrophes adversely impact insurers' performance and that the negative impact is greater for insurers with greater exposure to mega-catastrophes and higher competition among insurers. The findings further indicated that insurance firms were better able to cope with the consequences of mega-catastrophes caused by hurricane (e.g., in the sample 11 out of 19 mega-catastrophes studied were related to hurricanes and storms). Overall, Hagendorff et al. (2015) concluded that property liability insurance firms in the United States offer a robust risk-sharing mechanism capable of withstanding the insolvency concerns of mega-catastrophes, likely due to significant adjustments in the hurricane risk model post-Hurricane Katrina.

Studies from other perils such as earthquake show similar challenges experienced by insurers facing catastrophe risks. For example, Kleffner and Daugherty (1996) analyzed the effects of insurers' characteristics (e.g., leverage defined as the ratio of liabilities and assets, diversified portfolio, stock and public insurers and more) on their risk bearing for earthquake insurance, using cross-sectional data of insurers from California. Their findings suggested that when the cost of bearing risk increases, insurers reduce their risk exposure. Furthermore, the greater leverage a company has, the lower risk it assumes; more diversified companies and stock insurers tend to

assume greater risk than mutual insurers. Catastrophes can also impact stock values of insurance companies and increase insurer stock volatility (Thoman, 2013). On the one hand, such events are expected to reduce stock prices as insurers experience rapid depletion of reserves to pay out losses to insureds. On the other hand, as catastrophes make risk more salient, there is an unusual spike in demand for insurance in the aftermath of the event, which may benefit insurers. Shelor and colleagues' (1992) analysis of insurers' stock prices after the Northridge earthquake supported this latter hypothesis. Nevertheless, a study done in the aftermath of Hurricane Andrew in Florida indicated that the storm had a negative and lasting adverse effect on stock prices, which was remediated, however negligibly, by a small positive effect due to increased post-hurricane demand (Angbazo and Narayanan, 1996).

3.3. MARKET STRUCTURE

Drawing upon the structure-conduct-performance framework adopted from organizational management literature, Grace and Klein (1998) provided an extensive discussion about the catastrophic insurance market structure, which determines insurance market conduct and performance. In the domain of market structure, important aspects to consider are market concentration (number of players and their sizes in terms of output shares), barriers to entry and exit, cost structure, vertical integration and the degree of product differentiation. Market conduct relates to an insurer's latitude of independence in setting prices and output levels and their behavior in terms of capital investment, product differentiation and marketing strategies. Market performance translates market conduct into measurable metrics, such as price, profits, economic efficiency in production and allocation, equity, etc. Solvency of insurers and the availability of coverage are two additional relevant metrics in evaluating insurer's market performance.

In understanding catastrophic insurance market structure, it is important to assess the degree of market concentration. Less and greater concentrated markets, while both have their advantages (e.g., less concentrated markets could promote greater competitiveness and risk diversification, and greater concentration could foster economic efficiency; Allen and Gale, 2000, 2004), may have implications for the vulnerability of insurers. For example, excessively concentrated markets raise concerns about a limited degree of competitiveness and greater exposure of insurers to catastrophic losses (Shim, 2013). Notably, market concentration is not static and can change with the economic environment and profitability prospects, updates in catastrophic risk, and the government and regulatory environment. We discuss potential effects of regulation in the following section. Market concentration can be reduced if large players reduce their business operations, while it can increase if small insurers exit from the market to reduce their exposure to catastrophic risks. Absent significant barriers, the entry (exit) decision is largely determined by growing (decreasing) prospects of profits,⁹ but in markets where entry (exit) is constrained, insurers may find themselves stranded and insolvent.

The Herfindahl-Hirschman Index (HHI) is a commonly used metric for market concentration and is calculated as the sum of squared market shares of all firms operating in the insurance market. Its values can range from 0 to 10,000; higher values indicate greater concentration, with 10,000 being an absolute extreme with only one firm in the market. More specifically, adopting the benchmark of the U.S. Department of Justice for merger guidelines, HHI values higher than 1,800 generally indicate highly concentrated markets; values between 1,000 and 1,800 show medium concentration; and HHI below 1,000 is indicative of low market concentration (U.S. Department

⁹ Evaluating profit across multiple lines of catastrophic insurance, Grace and Klein (1998) indicate negative profits, high loss ratios and low rates of return to be primary explanations for a net decline in insurers in disaster-prone states between 1989 and 1995.

of Justice,1997). While recent HHI values for catastrophic insurance markets are unavailable, Grace and Klein (1998) estimated HHI values and their changes between the years 1989 and 1995, providing some initial guidance about the catastrophic insurance market structure. The authors specifically focused on U.S. earthquake and hurricane insurance markets in Florida and California, and, in addition, estimated HHI for the so-called aggregated catastrophe-prone region made up of selected states and U.S. territories (California, Florida, North Carolina, South Carolina, Puerto Rico, Texas, and the U.S. Virgin Islands). Their findings provided some evidence for the increased concentration of markets and the decrease in the mean insurers in both homeowner and commercial multi-peril lines, likely due to increased exposure to risks, negative profits, mergers and consolidations and retrenchment, specifically in commercial lines in response to soft pricing and excess capacity (Grace and Klein, 1998).

In summary, correlated losses associated with natural catastrophes challenge fundamental conditions related to independence and diversification of risks that buffer insurers from potential risk of default if one or a series of events occur (Rejda and McNamara, 2014). Furthermore, without accurate models to assess risks, insurers are challenged to estimate future expected losses and price policies appropriately, structure reinsurance or make reasonable investment decisions. In effect, solvency constraint is one primary cause limiting the availability of the catastrophic insurance market. To address these concerns, insurers need to employ sophisticated risk models and various risk-diversification strategies that could be costly, further hampering risk-diversification efforts. Pressure from regulators may further compound these problems. We discuss risk-diversification strategies and challenges to adopting them in the following section.

3.4. RISK-DIVERSIFICATION STRATEGIES

Private insurers can adopt multiple risk-diversification strategies, including restricting risk exposure, modifying contracts and changing underwriting standards, risk mitigation, increasing capital reserves and access to liquid capital, reinsuring and diversifying using financial instruments (Grace and Klein, 1998). Notwithstanding, the constraints to the availability of these mechanisms can hamper risk-diversification efforts. The problem can further be compounded given the pressure from regulatory agencies to keep prices reasonably low and constraining insurers to reduce exposure after recent incidents. Here we primarily focus on reinsurance and recently developed financial markets for catastrophic risks.

3.4.1. Reinsurance

The basic premise of reinsurance builds on the notion that locally dependent risks can be globally independent. The reinsurance market allows insurers to diversify risks for mega-catastrophes (Cummins and Weiss, 2000, 2014; Cummins and Xie, 2008). However, as highlighted in the literature, not all events are insurable globally. Such risks, if other conditions hold, could be diversified through capital markets. In addition, there are categories of risks that cannot be diversified even through financial markets because they are very large and difficult to model. Losses from such events are referred to as cataclysmic or globally undiversifiable and commonly warrant government intervention (Cummins, 2008; Cummins and Weiss, 2009).

The U.S. is leading the reinsurance market globally in terms of both demand for reinsurance and loss payments by reinsurers. For example, in 2005 the U.S. accounted for 87% of worldwide insured catastrophe losses and 61% in 2006 (Swiss Re, 2006, 2007). The U.S. insurance market depends on both domestic and foreign (alien) reinsurers. Cummins (2007) showed that, while domestic reinsurers have been crucial vehicles for risk diversification, U.S. insurers have also

relied heavily on alien reinsurance: the percentage of reinsurance ceded to alien reinsurers increased from 38.4% in 1997 to 51.8% in 2005. Therefore, any potential factor that could erode international relationships may have a negative implication for the U.S. insurance industry; the price for reinsurance will likely go up, which will further jeopardize the financial solvency of U.S. insurers. Cummins (2007) further detailed the performance of reinsurance markets in response to catastrophic losses of 2004-2005 and showed that, while several reinsurance companies became insolvent, reinsurers overall have made significant progress in risk and exposure management, capital allocation and the ability to raise new capital. The catastrophic season in 2005, nonetheless, has hardened the reinsurance market, and premiums (measured by rate online) rose by approximately 76 percent in 2006; the increase was much higher for Florida-only insurers. While premium increases attracted more capital and premiums declined after markets softened in 2008, the decrease was not much, and the premiums remained significantly higher than those in 2005 (Kunreuther and Michel-Kerjan, 2009).

Pricing different layers of coverage is more complex and reinsurers consider both the expected loss and the variance of losses, as well as marketing, brokerage and claims processing expenses, while ensuring that the coverage would yield enough expected return on equity to attract investors. Furthermore, reinsurers are just as concerned as insurers about concentration of risk and reducing exposure. Consequently, reinsurance prices usually increase after catastrophic years as markets harden and the supply of coverage is limited (Cummins and Weiss, 2009; Froot, 2008). The regulatory stringency on reinsurers may create another impediment to risk diversification strategy, an issue we discuss in the regulation section (Section 4).¹⁰

¹⁰ Review of reinsurance is beyond the scope of this literature review. Froot (2008) provides an evaluation of reinsurance markets and further discusses several market imperfections related to regulation pertinent to reinsurance, accounting, tax and rating agency factors. For the presence of moral hazard in reinsurance, refer to Doherty and Smetters (2005).

3.4.2. Financial Markets to address extreme events

Convergence of capital markets and re(insurance) sectors in the past decade have allowed insurers to employ more complex risk diversification strategies through financial markets and tap into new capital reserves for funding (NAIC, 2020a). Several factors have accelerated the convergence, including advancement in computing and communication technologies, existing market deficiencies due to re(insurance) underwriting cycles (these cycles tend to have low correlation with securities market returns), and increase in the frequency and severity of catastrophic risks, along with accumulation of assets and growth in property value in risk-prone areas (Cummins and Weiss, 2009). Currently, catastrophic bonds (CAT bonds) are the most dominant types of outstanding insurance-linked securities (ILS) products in the market, and the most valuable source of risk diversification for investors (Litzenberger et al., 1996). A variety of other hybrid products have also been developed since the convergence, combining the features of reinsurance and financial products, including finite reinsurance, multi-year and multi-trigger products and retrospective excess of loss covers (RXLs), as well as other more evolutionary products, such as industry loss warranties (ILW) and sidecars. Cummins and Weiss (2009) provide an extensive review of all these products.

Unlike a traditional reinsurance contract that is signed for one year, CAT bonds offer longer term coverage – one to five years, and sometimes longer. A trigger event can be indemnity-based (payments equal actual losses), a pre-determined industry index of losses (which establishes the basis risk), or a parametric index (e.g., category 5 hurricane). Given that reinsurance prices are highly volatile in the aftermath of large catastrophes, CAT bonds offer price stability to insurers with multi-year maturity (Lakdawalla and Zanjani, 2012).

ILWs are another important financial instrument for (re)insurers and focus almost exclusively on catastrophic risks (Gatzert and Schmeiser, 2012; Guy Carpenter, 2006). Their popularity has particularly increased since Hurricanes Katrina, Wilma and Rita. The simplest structure of an ILW is based on the so called basis risk – that is, regardless of the actual amount of loss, the buyer of the instrument can claim the amount that equals the limit of ILW, when the pre-defined industry loss index exceeds a threshold level (called the trigger) for a particular state or a region (Gatzert et al., 2011). ILWs are increasingly used by large companies and those who possess large market share, as their losses are likely to represent the industry loss in the aftermath of a major disaster. Furthermore, ILWs represent important hedging instruments for single state (re)insurers (Zeng, 2005). In the U.S., the Insurance Services Office (ISO) is the organization that measures industry losses, a number that is then used as a reference index (NAIC 2020a). An advantage of an ILW is that it involves low transaction costs for both buyers (insurers and reinsurers) and sellers (e.g., hedge funds), as the sellers do not need to evaluate the loss for a specific company, but only the exceedance probability curve of the entire industry (Gatzert and Schmeiser, 2012). Hence, for an ILW, the accurate estimation of industry loss is a critical component.

Sidecars are more recent products and provide risk diversification exclusively to reinsurers or large insurance companies by issuing securities to investors (Buglar et al., 2020). Unlike ILWs and CAT bonds that generally provide excess-of-loss reinsurance, sidecar companies often share the risk of insurance/reinsurance policies in exchange for a portion of the premiums (up to 50%) and dividends in shares (Michel-Kerjan and Morlaye, 2008). Sidecars typically require large investments and are designed for the short term (2 years or less). They are particularly useful and tactical financial instruments during a hard market.

It is noteworthy that financial markets have become more and more attractive; just in the fall of 2018 the catastrophic bond market hit a record level of \$30 billion, with their financial products largely being used by insurance companies and public sector entities (Kousky, 2019). In sum, financial markets are important risk diversification strategies that offers less expensive financial protection. These alternative risk diversification techniques also allow investors to interact with the insurance industry more directly because they provide protection. Furthermore, investing in these products could enhance investors' portfolios as they tend to not be highly correlated with other financial risks (Cummins and Weiss, 2009). However, with the increasing frequency of extreme events, experts believe that these strategies will not be sufficient to generate a large, liquid and sustainable ILS market. Several other factors are also concerning, including pricing of ILSs and designs of ILSs as they relate to a trigger (e.g., indemnity-based vs. parametric- or index-based), lack of standardized quantitative methods for investors and reliability of catastrophic models, among others (for more discussion, see Michel-Kerjan and Morlaye, 2008).

How much the development and access to the ILS markets have allowed insurers to reduce their cost of capital and therefore assume more risk remains an important research question. To date and to the best of our knowledge, the literature has not explored this important aspect. However, studies do point out that both the securities markets and the capital markets are affected by a large-scale catastrophe (Cummins and Weiss, 2009) and both are vulnerable to financial crisis. For example, the recent analysis of CAT bond premiums from secondary markets covering the 2002-2012 period showed that the financial crisis (bankruptcy of Lehman Brothers was used as an indicator for the crisis) resulted in a statistically significant increase in CAT bond risk premiums, and suggested similar cyclicity to that of the reinsurance cycles (Gutler et al. 2016). The same study also found that investors adjusted their expectations of losses after large scale hurricanes

such as Katrina in 2005 and Ike in 2008, reflected in increased premiums for CAT bonds in the aftermath (Gutler et al. 2016). Implications of these findings is that CAT bonds may be vulnerable to both future catastrophic events and future financial crisis.

3.4.3. Insurance Rating

Insurers' financial solvency is an important tenet for insurance market stability (Froot, 2001). In the U.S., the strength of an insurer's rating is linked to its financial solvency (Cummins and Weiss, 2014). A.M. Best is one of the oldest raters of insurers and brokers¹¹, and its ratings are used to determine an insurer's quality. Financial soundness itself has implications for claims payout if an insured event materializes. Hence, an insurer's credit quality can play a critical role in its ability to sell policies because policyholders generally are sensitive to insolvency risk (Kartasheva and Park, 2013). However, corporate buyers appear to be more sensitive to insurers' financial standing because their contracts are more sophisticated and require more substantial underwriting efforts than those of personal property owners who seek relatively more standardized personal property insurance policies; corporate buyers may be more willing to pay higher premium prices for policies provided by highly rated insurers (Doherty et al., 2012). It is thus expected that insurers who have a large proportion of commercial lines will benefit from a good rating. Empirical analysis of premiums based on data from all property/casualty insurers across commercial and personal lines rated by A.M. Best from 1991-1999 indicated significant premium declines for downgraded insurers in the year following the rating downgrade (Epermanis and Harrington, 2006). The decline was particularly prominent for insurers writing large amounts of commercial

¹¹ A.M. Best rates approximately 95% of U.S. insurance companies; only a small percentage is rated by Standard and Poor and Fitch (Doherty, Kartasheva and Philips, 2012).

insurance and for those whose downgrade went from investment grade to below investment grade rating.

In the context of catastrophic risks, rating methodology assigns greater weights to catastrophic exposures. In particular, increase in frequency and severity of recent disaster events has been used by rating agencies to increase capital requirements for catastrophic risks (Kunrtheither and Michel-Kerjan, 2009). For example, before the 2005 hurricanes, the risk-adjusted capitalization requirement was based on a projected loss from a 100-year windstorm or hurricane, depending on other risk factors and reinsurance programs. In 2006, A.M. Best revised its requirements and introduced a second event, again a 100-year windstorm or a hurricane, as a tool to reasonably reflect the risk profile immediately after the catastrophic event (A.M. Best, 2011). Employing data from 2001-2008 of all property-casualty insurers rated by A.M. Best and using the 2004-2005 hurricane season as a natural experiment, Basten et al. (2019) showed that rate standard stringency affects insurers' risk-taking behavior and overall increased capital equity. However, exploring heterogeneity across the lines, the results suggested that the effect was driven primarily by insurers with a high concentration of commercial lines, for whom defending their rating was more beneficial and the capital less costly to obtain. On the other hand, low-rated personal insurers, who tend to have a high concentration of catastrophic risk exposure lines and a relatively high cost of capital, have responded by reducing their capital, thereby suggesting the costs of maintaining a rating outweigh the benefits (Basten et al., 2019).

4. The insurance Market Regulation

The insurance industry is one of the most heavily regulated industries in the United States (NAIC, 2011). Regulation plays a particularly important role in catastrophic insurance because of the unique complexity of the types of insurance contracts (e.g., risk information, pricing and

coverage, etc.). With the dramatic increase in the frequency and severity of natural disasters in the recent decade, there is a growing interest among researchers and policy makers in understanding the implications of regulatory policies implemented in high-risk-prone areas with respect to the cost and the availability of insurance along with the effects on risk management strategies. In this section, we review several important aspects covering financial and market regulations.

The primary objective of regulation is to protect consumers by ensuring that insurers are solvent and financially sound enough to pay claims and treat policy holders/claimants fairly (Skipper and Klein, 2000). While states may differ in their regulatory approaches, a majority of their regulatory functions involve aspects of either solvency or market regulations. Specifically, they cover areas such as insurer/producer (brokers and agents) licensing, product and price regulation, market conduct, financial regulation and consumer services (NAIC, 2011). Politics also play a role in setting regulations, and regulation analysis cannot abstract from the political context (Klein, 1995, 2007; Weinkle, 2019).

While the federal government retains the authority to regulate insurance, the McCarran-Ferguson Act enacted in 1945 delegates the primary regulatory authority to states (Kimball and Boyce, 1958). The regulatory structure of insurance in each state is primarily concentrated within the state's insurance department. State commissioners regulate rates, oversee insurance availability and evaluate firms' solvency. Furthermore, the National Association of Insurance Commissioners (NAIC), represented by the chief commissioners from each state, was created to coordinate activities and resources across states and regulation of multi-state insurers (NAIC, 2011).

Except for 11 states where commissioners are elected, in the majority of U.S. states, governors appoint commissioners for a pre-determined term (Klein and Sfiridis, 1997). For example, in Gulf Coast states exposed to hurricane disasters, commissioners are elected in Florida and Georgia only.

Past studies indicate that insurance rates and other practices of insurers in states with elected commissioners are more constrained relative to the states in which they are appointed (Harrington, 2002; Klein, 1995). Elected commissioners who seek voters' direct political support may appease their constituents with promises to impose more stringent regulations as a way that constrains insurance practices (e.g., by lowering rates).

Primary functions of insurance commissioners related to the market aspect of insurance regulation comprise admission and licensing of insurers and producers; overseeing products, prices and underwriting practices; regulating claims handling processes; and overseeing other market functions. The solvency aspect of regulation involves oversight of insurers' solvency requirements and investments, reinsurance activities, transactions among affiliates and many more. Despite assuming primary regulatory authority, the commissioners' roles are limited, as many public and private institutions take part in the regulation system (Klein, 1995). Furthermore, their authority is constrained by the regulatory framework of a general government under which the commissioners operate. In terms of regulation, it should be noted that regulation of rates and market practices also affects insurers' financial performance, and regulation of solvency of firms has implications for rate setting and affects the types of products insurers can offer to insureds. We briefly review each of the regulatory aspects below.

4.1. RATE REGULATIONS

Insurance rates and policies are subject to some form of state regulation, and the degree of stringency in imposing these regulations differs substantially across states (Klein, 1995). For example, some states do not require rate approval before rates go into effect and let competitive markets determine them (often referred to as a competitive rating system), while others require pre-approval (non-competitive rating; Insurance Information Institute [III], 2009). However, the

degree of regulatory stringency in rate setting is not solely determined by the type of rate regulatory system states follow; some states that have rate approval systems may still allow markets to determine the rates by approving the rates proposed by insurers (Klein, 1995).

Under the two broader categories of regulatory systems, there are six rating systems that states currently exercise for homeowners insurance. Definitions based on the Insurance Information Institute (2009) for these individual systems are provided in Appendix Table A1. The Prior Approval, Modified Prior Approval and Flex Rating systems fall under the non-competitive category, and the remaining three systems, File and Use, Use and File and No File, are considered competitive systems. It should be noted that the majority of U.S. states, including Texas, operate under competitive rating systems. As of 2020, Texas continues to use the File and Use system. For its catastrophe pool, the Texas Windstorm Insurance Association (TWIA), Texas uses a hybrid file and use/prior approval system. Under the hybrid system, rate changes below a set threshold are file and use and above that threshold are prior approval (TWIA, 2020). In rate regulation, not only are the differences in rate setting systems important, but so is the timing it takes to get rates approved. For example, Born et al. (2018) showed that delayed and prolonged approval timing has adverse consequences for insurers' market performance and risk mitigation strategies.

The degree of rate regulatory stringency itself is affected by multiple factors, including politics and the sensitivity of rates to political pressure (Cummins et al., 2001; Meier, 1988, 1991), risk of loss, changes in legislation, insurer's economic leverage, as well as the regulatory system and the overall regulatory philosophy (Grace and Klein, 2007). For example, rates appear to be more vulnerable to political manipulation in states with a Prior Approval system, although the competitive markets are not fully immune to political influence (Harrington, 1992). The higher the underlying risk of loss and when the cost of insurance is escalating (a feature of catastrophic

insurance), the more pressure regulators may exert to suppress or compress rates.¹² Regulators generally tend to disapprove large spikes in rates. After Hurricane Andrew, Florida regulators did not approve a one-time sweeping increase in rates, but allowed a gradual rise over a decade, which had some implications for the supply of coverage, as the regulated rates were inadequate (Grace, Klein and Kleindorfer, 2004).

Furthermore, regulators of large states may use economic leverage to tighten rates. For private insurers, exiting a large market (e.g., Texas) may have greater consequences than exiting a small one (Klein, 1995). The state commissioner selection system (elected vs. appointed) may also affect rate regulation stringency; in particular, elected regulators have been found to exhibit higher pressure to constrain rates than appointed regulators. However, the empirical evidence of such an effect is inconclusive and those who suggest the effect have found it to be small (e.g., see Besley and Coate, 2003). States also differ in their philosophies related to regulation; some call for stricter rules, while others allow market forces to drive the outcomes (Meirer, 1988). Last, but not least, changes in legislation and laws have substantial influence on regulatory policies, in part because legislatures enact new laws and approve and change existing regulations.

Past studies have conveniently used the two types of rate regulatory systems (Prior Approval vs. competitive rating systems) to identify insurance market performances attributed to rating systems. The primary presumption is that insurers in states with competitive rating systems would outperform those operating in states with Prior Approval systems. However, there has been little to no empirical evidence of adverse effects on market outcomes commonly measured as loss ratios (Harrington, 2001).

¹² Rate suppression is used in reference to regulators' attempt to constrain rates for all classes of insureds, whereas rate compression refers rate constraints for different risk classes (e.g., higher vs. low risk classes; Klein, 2009).

Empirically it has been challenging to measure the rate of regulatory stringency, largely due to the type of data such measurement requires. Other, albeit not perfect, proxies also have been proposed. For example, Klein (1986) measured stringency as the difference between the rates filed by insurers and the rates approved by regulators. Alternative measures have included the size of the residual markets as well as the External Climate Index (ECI), developed by combining various indicators about the regulatory environment (e.g., regulatory law, commissioner status, ratio of full-time employees to the number of insurers; Klein, Phillips and Shiu, 2002).

Overall, past studies have indicated that rate suppression/compression generally increases the demand for homeowners insurance subject to different levels of catastrophic risk (see Grace et al., 2004), thereby resulting in greater dead-weight loss, as price subsidies generally distort market incentives for mitigation and may also encourage sorting in risky areas (Bakkensen and Ma, forthcoming).

More recently, scholars have also considered other dimensions of rate regulation stringency. For example, Born et al. (2018) explored the effects of rate regulation on insurers' performance (e.g., loss ratios and profitability) using two different dimensions of stringency: (1) rate adequacy and (2) timeline – the time it takes for an insurer to get a rate approved after it has filed for it. The authors complemented conventional measures of rate stringency (e.g., prior approval, competitive, flexible, file and use, use and file) with alternative, survey-based measures based on insurers' perceptions of state rate regulation across these two dimensions of stringency. The regression results revealed somewhat more mixed effects of rate regulation than previously suggested. Specifically, absent catastrophes, rate regulation decreased insurers' loss ratio, while this effect was reversed after a catastrophic event. Longer approval time also increased loss ratio after a catastrophe but had no effect without catastrophes. The authors postulated that in non-catastrophic

years insurers might adjust using other strategies and tactics. Specifically, filing an amended rate increase after an initially proposed rate change was disapproved in lieu of settling for a smaller increase, albeit not fully adequate (Born et al., 2018). In terms of delays associated with rate change approvals, insurers could employ more strategies, including tightening underwriting standards (e.g., rejecting or not renewing risky policies) or changing claims adjustment and settling practices (for example, being less generous).

While empirical results are inconclusive, it is still critical to discuss implications of rate stringency when insurers are unable to adjust. Born et al. (2018) surmised several potential effects, including poor market performance (e.g., negative profit, higher loss ratio), limited entry and more exit decisions and the indeterminate effects of market concentrations (e.g., concentration would increase if small insurers exited, and could decrease if large insurers exited the market). More importantly, greater rate stringency could also imply less surplus devoted to the market and/or less reinsurance purchased, and could also shift insurers from geographically more diversified and larger in size to small and relatively less diversified, ultimately pushing customers toward state-run residual market mechanisms.

4.2. REGULATION OF POLICY TERMS (DEDUCTIBLES, EXCLUSIONS, OTHER POLICY TERMS)

Regulations related to insurance policy terms can have significant implications for wind/hail insurance market development. It is noteworthy that all policy provisions are subject to a regulator's approval. While some of these provisions may be incorporated into policies as options, from which the insured may choose (e.g., deductibles and premiums to be paid), others are non-optional and non-discretionary (Klein, 1995). Policy provisions are tied to insurers' willingness to sell coverage in certain high-risk areas and for some risky lines, given that the insured is willing

to accept them. Policy regulations pertinent to setting deductibles and scope of coverage could have important implications for hurricane/wind insurance development in risk-prone areas (Grace and Klein, 2005). For example, a typical wind/hurricane policy includes the amount of deductible, set as a percentage of the coverage limit for the dwelling. While common deductibles are set at one to two percent, more recently insureds are also presented with the option of higher than two percent deductibles, with the provision that they can buy broader coverage for an additional premium (Klein, 2009). Furthermore, in some states insureds are given an option to exclude wind coverage from their homeowners policy. In high-risk coastal areas insurers may also exclude wind/hurricane coverage from homeowners insurance. Excluding wind/hail coverage provides a significant cost reduction in premiums, but also implies that insureds retain a greater amount of financial liability in an event of a loss. Presumably, such exclusions are only available if the house is not financed by a mortgage, as lenders typically require wind/hail coverage for the duration of a mortgage term (Petrolia et al., 2015). Although a typical homeowner's insurance generally includes wind/hail coverage, in coastal areas subject to high risk of wind damage, the wind coverage is excluded. In coastal areas it is common that the insured (if under mortgage) to obtain wind/hail coverage from state residual programs. We discuss state residual programs in Section 6.

Laws related to setting deductibles differ across states. Some states mandate a general deductible on policies in higher risk areas; others (18 U.S. states including Texas and other Gulf states) do not mandate but permit insurers to have additional deductible related to a specific hurricane/wind peril after the National Weather Service has issued the occurrence of the named storm (III, 2020).¹³ In both cases, higher deductibles transfer greater risk back to the insured and allow insurers to manage their catastrophic exposure and losses. Furthermore, because higher

¹³ The TWIA does not have a named storm deductible.

deductibles are offered at lower premiums, insureds may prefer policies that give options for higher deductibles rather than pay higher premiums absent deductibles. Examining homeowner insurance policies in Florida and New York, Grace et al. (2004) found empirical evidence that higher deductibles are associated with higher demand. While it is common for the deductible to be applied for each loss occurrence, some states require deductibles to be imposed only once per season to reduce the financial burden on the insured.¹⁴ Per-occurrence deductible, nonetheless, remains an important risk management strategy for insurers and also reduces the pressure for a needed rate increase in the aftermath of a catastrophe (Klein, 2009).

4.3. UNDERWRITING REGULATIONS

Insurers hold wider discretion in developing and applying underwriting guidelines for homeowners insurance. These guidelines in turn allow them to accept/decline applicants as a way to manage risk exposure and improve financial performance. However, certain statutory and regulatory restrictions may constrain certain underwriting practices. For example, a majority of the states restrict insurers from rejecting applications based solely on a home's age or its market value. Insurers may be constrained from employing credit scoring as a decision guide in underwriting home insurance (Grace et al., 2003). Regulators may also constrain insurers from reducing/limiting exposure by abruptly cancelling and not renewing existing policies. For example, in New York insurers are not allowed to limit their exposure by more than two percent per year. After Hurricane Andrew in 1992, Florida imposed a moratorium on policy cancellations and non-renewals to keep insurers in the market (Medders and Nicholson, 2018). Similar restriction was imposed in

¹⁴ After multiple hurricanes experienced in 2004, Florida has mandated that insurers impose a deductible only once per season on one storm, not per occurrence.

Louisiana and Mississippi after Hurricane Katrina.¹⁵ In Louisiana, by statutory regulation (Louisiana Insurance Code; RS 22:1267), insurers cannot cancel or refuse to renew policies that have been in force for more than three years.¹⁶ The Texas Insurance Code Chapter 551 (Subchapter C) requires that insurers provide the insured with a written statement explaining reasons for declination, non-renewal or cancellation..

It is generally accepted that underwriting restrictions related to cancellations/declines limit private insurers' flexibility to adjust underwriting practices and may also discourage them from underwriting new policies (Born and Klimaszewski-Blettner, 2009, 2013). While regulators may exercise such restrictions in the short term, it has proven challenging to prevent private insurers from cutting back their exposure in the long term. In coastal areas subject to a high risk of hurricanes, state regulators, however, cannot prohibit insurers from declining new applications. Access to data on non-renewals and declines will aid understanding the decision-making process.

It is also important to consider that some insurers are able to reduce exposure by placing policies in standard or non-standard companies, as well as in single-state companies within their groups. Such placement is a compelling strategy insurers can use to bypass filing for a rate increase and effectively raise premiums by placing policies across different categories of companies (Klein, 2007).¹⁷ Furthermore, some large national insurers may choose to establish single-state companies

¹⁵ Emergency Rule 23 was issued immediately after Hurricane Katrina, restricting private insurers from canceling or not renewing residential, commercial property insurance policies on properties located in Katrina and Rita damaged areas (Rule 23, Suspension of Right to Cancel or Nonrenewal Residential, Commercial Residential or Commercial Property Insurance Due to Hurricane Katrina or Rita; Louisiana Register Vol. 32, No. 01; (www.lidi.state.la.us/)). This prohibition stayed in effect for up to 60 days. In Mississippi, a 60-day moratorium was imposed on policy cancellations and non-renewals (Mississippi Insurance Department 2005; <https://www.mid.ms.gov/legal/bulletins/20057bull.pdf>).

¹⁶ Available online: <https://law.justia.com/codes/louisiana/2016/code-revisedstatutes/title-22/rs-22-1267/>

¹⁷ Non-standard homeowner's insurance is the insurance that does not qualify or is denied standard homeowner's insurance (e.g., hazard risk or repetitive disaster losses would qualify the insurance as non-standard). Such policies are typically offered by lower rated (referred to as non-standard) insurance companies. While standard homeowner's insurance is offered by high-rated (standard) companies. Both standard and non-standard insurance companies are allowed to have higher rates for risky policies.

as a way of separating financial performance across the state. In case of insolvency, a single-state company can be easily let go rather than being bailed out from other companies within the group (Kunreuther and Michel-Kerjan, 2011). Regulators may restrain such a risk-management strategy. For example, legislation in Florida prohibits national groups from establishing a single-state insurer within a group. Such restrictions may hinder new market entrants and may also encourage existing companies to exit the market.

Another area where state regulators may intervene is when the insurer ties homeowners insurance to the purchase of other insurance coverage. For example, an insurer may require auto insurance as a condition to buy or renew a homeowners policy. Certain states (e.g., Alabama, New York) have barred such unfair trade practices (Alabama Department of Insurance, 2008; Gusman, 2007).

4.4. CLAIMS REGULATION (ADJUSTMENTS/SETTLEMENTS)

Hurricane claims pose a particular challenge to insurers, in part due to the large number of claims that need to be processed properly in a timely manner and in the difficult post-disaster period. Insurers employ a professional team of adjusters or contract with adjusters to help assess damage, following the established loss estimation methods. Some states also have a team of public adjusters not affiliated with insurance companies to act on behalf of the insured in claim settlements. Adjusters are required to be licensed, which involves registration with the state department of insurance, passing exams and paying license fees (NAIC, 2018). Hurricane-prone states allow adjusters to avoid licensing procedures and register with the state to perform adjustment activities for three to six months to expedite the claim settlement process in the immediate aftermath of a catastrophe. Such emergency adjustments, while crucial to help insureds rebuild their homes and businesses to reopen, may promote the unfavorable practice of insurers

contracting with less skillful adjusters instead of qualified adjusters (Klein, 1995). Nonetheless, empirical evidence to prove this practice is hard to establish.

Regulators are also concerned about quick settlement of claims—In Texas, the Insurance Code Chapter 542 sets deadlines for claims processing. However, sometimes hurricane claims have proven hard to process, specifically if it is difficult to determine whether the cause of damage was flood or wind (flood insurance is excluded from common homeowners insurance policies). Regulators tend to not intervene in the insurance claim/settlement stage unless there is a clear violation of regulations or the terms of the policy, if the insured files a complaint to the insurance department or the claim leads to litigation in court. Almost all hurricane-prone states have created a statutory law to set rules for the fair and proper conduct of contracted or public adjusters. Chapters 4101 (Insurance Adjusters) and 4102 (Public Insurance Adjusters) in the Texas Insurance Code (Title 13) specifically outline the law pertinent to regulating professionals such as adjusters.¹⁸ Some states also offer a mediation program within their department of insurance (e.g., Louisiana, Florida and Mississippi) to help insureds with claims dispute resolution. For TWIA claims, in 2011 the Texas Legislature created an ombudsman program (Coastal Outreach and Assistance Services Team, COAST) and an appraisal umpire selection process outlined in Title 28 Texas Administrative Code 5.4201 and 5.4211-5.4222.

Relatively less important catastrophic risk problems relate to marketing and distribution practices of insurers, but they may also warrant some regulation. Specifically, insurers may reduce their market and distribution activities in high-risk areas, particularly if they are explicitly constrained by the regulators to reduce risk exposure (Klein, 2003). Such limited marketing strategies may affect insurance availability. In some places, agents' commissions may be reduced

¹⁸ Similar laws exist in other Gulf Coast states. For example, in 2006 Louisiana passed Public Act 783 (the claims adjuster act). The Mississippi Public Adjuster Act, which passed in 2007, sets regulation of adjusters.

as an implicit device employed by insurers to disincentivize them from selling policies (Kunreuther and Michel-Kerjan, 2011). Such practices are potential problems that regulators watch for, and some states, including Texas, monitor to ensure that insurance is adequately represented in underserved locations.

4.5. FINANCIAL REGULATION

The aim of regulating the financial aspects of insurance businesses is to ensure their solvency and prudence in meeting certain financial obligations. Solvency regulation covers certain aspects of insurers' operations, including pricing and products, capitalization, investment, reinsurance, reserves, asset-liability matching and transactions with affiliates, as well as the level of catastrophic risks (Klein, 1995). Regulators often brace against balancing solvency and financial soundness of insurers with rising costs of insurance (affordability) and its availability to satisfy consumers in high-risk-prone areas.

Insurers are required to meet minimum standards for capital and surplus (value of assets minus liabilities) set by regulators as a cushion against unexpected increases in losses and to ensure they will continue operations. For new entrants, standards often entail fixed capital and surplus requirements for insurers. These requirements vary by states. For example, the requirements for a Texas stock insurer are \$2.5 million in capital and \$2.5 million in surplus (Texas Insurance Code Section 822.054). However, for already established companies with large risk exposure, such fixed requirements may be inadequate. Instead regulators employ minimum risk-based capital (RBC) standards developed by the NAIC. RBC evaluates insurers' risk in terms of asset risk, underwriting risk and other risks; it also generates a capital deficiency indicator that is used as a guide to mandate and authorize preventative and corrective measures in advance to avoid insolvency and other adverse impacts associated with insolvency (NAIC, 2020b). Most insurers are required to prepare

statutory financial statements in accordance with statutory accounting principles (SAP)¹⁹ and file them annually and quarterly, not only with regulators in their domiciliary state, but also with regulators in every state in which they are licensed to conduct business and with the NAIC. While the SAP uses the framework established under U.S. Generally Accepted Accounting Principles (GAAP), it is more conservative (e.g., assets are valued more conservatively and certain non-liquid assets such as furniture and fixtures are not included in calculations) and puts greater emphasis on the balance sheet and the insurer's liquidity as opposed to the income statement (NAIC 2020b). SAP standards also allow legislative and regulatory variations across the state. The RBC sets substantially improved standards relative to fixed requirements that ensure the insurer's solvency, and as of 2017 the RBC formula was modified to add the insurer's catastrophe risk to the existing six major risk components (NAIC 2017). Furthermore, RBC requirements for capital and surplus appear to be substantially lower than the capital standards that rating agencies use to rate insurers (Klein and Wang, 2009). While small differences between rating companies and regulators are natural, substantial differences raise concerns about potential deficiencies of current regulatory standards (Eling and Holzmuller, 2008). Some states, however, at their own discretion may require insurers via internal risk modelling to rigorously assess their catastrophic risks, but these requirements are not uniform across the states (Klein and Wang, 2008).

Financial regulation also covers monitoring of insurers and various regulatory interventions. As part of solvency monitoring, insurance departments across states can employ the NAIC financial information systems, including early warning systems (e.g., Insurance Regulatory Information System, the Financial Analysis and Surveillance Tracking Systems), to track down

¹⁹ In Texas, statutory financial statements are required by the Title 28 Texas Administrative Code Section 7.68 (available: [https://texreg.sos.state.tx.us/public/readtac\\$ext.TacPage?sl=R&app=9&p_dir=&p_rloc=&p_tloc=&p_ploc=&pg=1&p_tac=&ti=28&pt=1&ch=7&rl=68](https://texreg.sos.state.tx.us/public/readtac$ext.TacPage?sl=R&app=9&p_dir=&p_rloc=&p_tloc=&p_ploc=&pg=1&p_tac=&ti=28&pt=1&ch=7&rl=68))

problematic insurers and curtail insolvency risk (Klein, 2009). Accuracy in evaluating insurers' financial risks by employing static ratios while ignoring dynamic modeling of risk remains a growing concern among scientists (Cummins, Grace, and Phillips, 1999; Klein and Wang, 2009). Another important aspect of financial regulation is state intervention through guaranty associations to cover claims in case an insurer becomes insolvent. Such guaranty funds create safety nets for policyholders (Cummin, 1988; Lee, Mayers and Smith, 1997).

Identifying the level of stringency that will promote financial soundness and a diversified risk portfolio for insurers is crucial for ensuring effective insurance regulation. While it is generally accepted that more regulation distorts the market, lenient markets may also lead to greater problems (Medders et al., 2014). For example, less stringent solvency regulations may encourage more insurers to undertake higher risk exposure, which in turn may ease pressure on already existing companies to retain their exposure. However, less stringent regulation may also encourage insurers to gamble on high-risk exposure, particularly in an environment where insurers can shift large losses to other solvent insurers and taxpayers through the state insolvency guaranty association.²⁰ Such behavior increases the social cost of insurance and may also lead to moral hazards, not only among insurers but the insured as well, by encouraging concentration of risk and discouraging risk management (Harrington and Danzon, 2001).

4.6. REINSURANCE REGULATION

In the U.S., regulation of insurers and reinsurance have been intrusive (Cummins, 2007).²¹ Such heavy regulation has been detrimental to ensuring market efficiencies for not only the

²⁰ Several insurance companies in Florida have adopted this strategy, thereby indicating inadequacy of financial oversight in the state (Klein, 2008).

²¹ While EU and Bermuda markets were considered relatively less regulated (Cummins, 2007), the Solvency II framework in EU that came into force in January 2016 and recently developed capital adequacy framework for Bermuda referred to as the Bermuda Solvency Capital Requirement (BSCR) have increased the level of regulation

primary insurance but reinsurance markets, as well. Although reinsurance rates are not directly subject to regulation, regulating insurers' rates (i.e., rate suppression and compression) has an indirect impact on reinsurance operation. In states with Prior Approval Rate System, insurers are unable to adjust rates quickly in response to changing market conditions as they need to obtain rate change approval from state regulators (Klein, 1995). For primary insurers who face the rising cost of reinsurance, such rate regulatory restriction implies that they cannot pass the added reinsurance cost on to policyholders. It is thus expected that insurers will purchase less reinsurance and, to the extent that regulated premiums are not sufficient to cover their full cost, increase the probability of insolvency and perform weakly in the market (Klein and Wang, 2008).

Furthermore, state-run reinsurance and residual programs may create market inefficiencies not only for insurers but also reinsurers. As government-operated entities, they are commonly exempt from federal income taxes, allowing them to accumulate funds more rapidly than private insurers/reinsurers (Cummins, 2007). The consequence of such a tax advantage is that state-run programs compete with private reinsurers by offering reinsurance at lower prices, leading to degradations in market efficiency.²²

Another regulation that has adversely impacted reinsurance functioning is one that restricts U.S. ceding companies from receiving favorable accounting treatment (i.e., credits) for their transactions with non-U.S.-licensed or alien reinsurers.²³ Domiciled and licensed reinsurers are subject to the same regulatory rules as other licensed insurers and are also exempt from holding collateral within the U.S. for the risk they assume (NAIC 2020c). Such differential treatment for

and requirements for insurance and reinsurance in terms of capital and solvency, governance and risk management, as well as reporting and public disclosure (Stubbe, 2019; Bermuda Monetary Authority [BMA], 2020).

²² Florida Hurricane Catastrophe Fund created in 1993 in response to Hurricane Andrew provides a good illustration of how this state-run reinsurance fund distorted the reinsurance market in the state (Medders and Nicholson, 2018).

²³ Current RBC formula levies a uniform 10% charge for all reinsurance receivables regardless of the quality of reinsurers, thereby discouraging primary insurers to exercise prudence in evaluating the quality of reinsurers (NAIC 2020c).

licensed and non-licensed reinsurers may lead to several market inefficiencies (Cole and McCullough, 2008). Collateralization is expensive and raises the cost of reinsurance, which is ultimately borne by policyholders (Csiszar, 2005). This requirement may also reduce the supply of reinsurance if alien reinsurance companies choose not to deal with U.S. insurers.²⁴ The recent NAICS amendment, Credit for Reinsurance Model (2011 Amendment), allows states to reduce 100% of the collateral requirements for licensed alien reinsurers; and, more recently, the 2019 Amendments will allow state legislators to bring their credit-for-reinsurance laws into compliance with the Covered Agreements by September 2022. The Covered Agreements provide zero reinsurance collateral for reinsurers domiciled in EU and the UK and other qualified jurisdictions as specified by the NAIC (Campbell et al., 2019).

5. Homeowners vs. Commercial Lines

One notable difference between personal and commercial insurance lines is the level of risk exposure each of these lines faces. While commercial lines are generally smaller in number, they generate greater losses and are more heterogeneous in terms of losses and risk exposure than personal lines. For personal lines, accumulation risk (pooling risks together) is a bigger problem than underwriting performance (judged by loss ratio), which appears to be relatively stable for insurers (Born and Klimaszewski-Blettner, 2009). Regulatory stringency also differs between homeowners and commercial insurance. The former is more strictly regulated in terms of premiums, contract terms and policy forms, partly because homeowners insurance is less sophisticated than commercial lines. For heterogeneous exposures and losses, it is harder to set standard premiums and determine coverages. Also, commercial customers are experienced customers or represented by experienced brokers and are not in need of regulator protection as

²⁴ For further discussion on how collateralization may not be applicable to global businesses such as reinsurance, refer to Cummins, 2007.

much as homeowners (Born and Klimaszewski-Biettner, 2009). In addition, commercial consumers and, in particular, large companies have access to other risk-diversification strategies through the capital markets (e.g., they can issue catastrophe bonds; internal insurance companies). As a consequence, there is less pressure on regulators to constrain increase in premiums on commercial lines. Commercial lines also have more flexible underwriting regulations relative to personal lines (Born and Klimaszewski-Biettner, 2009). Overall, commercial insurance markets are relatively less regulated than homeowners insurance markets (Kunreuther et al., 2009; Rejda, 2008), and subsequently commercial property insurers perform better in response to unexpected catastrophes.

It also appears that risk-diversification strategies for commercial lines, in part due to a less regulated environment, allow them to fare better in the aftermath of an unexpected catastrophe. Born and Klimaszewski-Biettner (2013) showed that from 1984-2007 the average reinsurance ratio for commercial lines was 19.8% and 10.9% for homeowners lines. Data also indicated that commercial insurers were better diversified geographically and in terms of market concentrations relative to homeowners insurers. Geographic diversification, measured as the average number of states in which an insurer operates, generally has stayed constant for commercial line insurers and higher than for insurers with homeowners lines only. For the latter, geographic diversification has been declining over time (Born and Klimaszewski-Biettner, 2013).

To further understand how the severity and unexpected frequency of catastrophic events, along with regulatory stringency, affect insurers' risk-bearing behavior, Born and Klimaszewski-Biettner (2013) employed insurer-level data (both commercial and homeowners) from all U.S. states over the period 1984-2007. The authors estimated several logistic regressions to explore how the probability of an insurer's decision to completely withdraw from the market or reduce its

businesses was affected by unexpected events (both frequency as well as severity), regulatory stringency and the availability of state residual programs. The results provided strong empirical evidence that commercial line insurers kept their coverage in response to both unexpected frequency and severity of events, while homeowners insurers appeared to be more vulnerable to severe events. Rate regulations and policy cancellation bans aggravated risk-bearing decisions and reduced insurance coverage offers and, to the extent that the homeowners line is more regulated, implied more reduction of coverage offers among insurers of homeowners lines. Furthermore, state-run residual programs that offer policies at subsidized rates were shown to crowd out private insurance underwriting decisions (Born and Klimaszewski-Blettner, 2009).

6. State catastrophic insurance programs: their rationale and challenges

To insure catastrophic risks, insurers need to charge more, thereby enabling them to build up reserves, reinsure or diversify risk through financial markets to avoid insolvency. However, as discussed above, required high rates are not compatible with current state regulation policies that tend to suppress/compress them and also make it impossible for insurers to operate profitably (Klein, 2008). Furthermore, insurance regulators have to weigh in affordability and accessibility of insurance to appease their constituents against the need for financial solvency of private insurers (Klein and Wang, 2009). In addition to the many roles state regulators assume in the insurance market, states that face catastrophic disaster risks interfere with insurance markets via three type of state-sponsored insurance mechanisms: (1) residual market mechanisms; (2) state insurance or reinsurance funds; (3) state guaranty associations. We review each of them below.

6.1. RESIDUAL MARKET MECHANISMS

Many states that face catastrophic disaster risks have established state-mandated insurance programs (also referred to as residual market mechanisms, RMM) to provide insurance coverage

for properties when private insurers are generally reluctant to underwrite policies due to catastrophic risks. One important aspect of state residual programs is that as long as rates remain regulated and insurers constrained to raise premiums, there will be the need for state-backed insurance programs (Kousky and Kunreuther, 2017). Hence, rate regulatory policies directly interact with the insurance demand available through the state residual programs. Importantly, while states have more options to address catastrophic losses, they face the same difficulties as private insurers in smoothing losses over time and are not immune to the consequences of catastrophic risks (Resnick, 2007).

State residual programs cover a variety of programs, including Fair Access to Insurance Requirements (FAIR) plans, beach and windstorm plans, and hybrid programs run by two states (Florida and Louisiana)²⁵ that offer hazard-specific policies and cover other exposures such as vandalism and fires. Other state-run programs include reinsurance programs providing insurance to insurers (Kousky, 2011). Currently, Florida is the only state that provides reinsurance through a state program called the Florida Hurricane Catastrophe Fund. Despite state-level differences, these programs have many common features and face similar challenges. One notable commonality is that most of them have been growing in the last four decades. FAIR and beach plans, in particular, have experienced explosive growth in terms of both exposure value (i.e., total insured value) and total number of policies (Hartwig and Wilkinson, 2016).

For hurricane-prone states, increase in exposure value could be partially explained by the rapid population growth in coastal counties. According to U.S. Census population estimates, coastal counties in the Gulf of Mexico region, one of the fastest growing coastlines in the U.S., experienced a 24.5 percent increase in population between 2000 and 2016 (Cohen, 2018). State-

²⁵ Florida Citizens Property Insurance Corps (Florida Citizens) and Louisiana Citizens Property Insurance Corp. (Louisiana Citizens).

run residual programs have also assumed substantially more risk after Hurricane Katrina while private insurers reduced their risk concentration (McAneney et al., 2016). While these programs have surged in response to Hurricanes Andrew and Katrina (total value of exposure and number of policies grew from \$54.7 billion and 931,550 in 1990 to \$884.7 billion and 3.31 million in 2011, respectively), recent data suggests a decline in exposure value by 30 percent between 2011 and 2014 (Hartwig and Wilkinson, 2016). The decline was primarily driven by a decrease in FAIR policies and exposure, while the beach and wind pools continued to grow by 15% during this period.²⁶ According to data available from the Property Insurance Plans Services Office (PIPSO), the Texas' plan (TWIA) is the largest beach and windstorm plan, totaling 293,805 policies in 2014 (Hartwig and Wilkinson, 2016).

Kousky (2011) detailed commonalities and differences across programs in hurricane-prone states (e.g., Texas, Georgia, Florida, Alabama, Mississippi, Louisiana, North and South Carolina and Hawaii) and in California, where coverage for earthquake peril is available through the state residual program. For many, the eligibility requirement is tied to the inability of buyers to find insurance in private markets, and the overall perception of these state residual programs is that they are the insurer of last resort. The programs use premiums and earned investment income as primary sources of reserves to cover claims and rely on reinsurance and issuing bonds for large-scale losses. Past studies exploring financial analysis of wind pool plans indicated that their operating margins remained slim during low-activity hurricanes and amounted to high losses during high-frequency seasons (Hartwig and Wilkinson, 2016). For high-loss events, state regulation levies assessment of all participating insurers and policyholders and imposes a rate surcharge on policyholders, if needed. Generally, states do not assume responsibility for any losses

²⁶ Florida and Louisiana have both seen declines in policies, in part due to their efforts to depopulate their programs.

the programs may sustain beyond what can be covered by the program. However, several states have recently appropriated funds to reduce deficits in their insurance programs. All these programs were established in response to large scale events that severely impacted private insurers and forced states to step in and offer coverage (Hartwig and Wilkinson, 2016).

Because the purpose of state-run insurance mechanisms is to serve a residual portion of the market, for the most part they are designed in a way to not be preferable over or competitive with private insurers. One strategy to establish their programs as the program of last resort is pricing. Some programs (e.g., Louisiana Citizens program) impose higher rates than the rates charged in the voluntary market, ensuring that only those unable to find policies in private markets will participate. Other programs choose to adopt actuarial rates (e.g., South Carolina, Louisiana and the Texas Windstorm Insurance Association [TWIA]) and instead require customers to provide proof that they have been unable to secure insurance in the private market (Kousky, 2011). One should note that actuarial rates set by state-run programs are commonly lower than the prevailing rates in private markets, because state programs do not seek a profit, incur fewer operational expenses in most cases, and do not charge all costs in advance because they rely on debt issuances that can be repaid through industry assessments (Kousky, 2011). For example, the TWIA's 2020 rate actuarial analysis report indicated that rates had to increase by 44% for residential policies and by 49% for commercial policies to adequately correspond with actuarial risks.²⁷

Florida Citizens program is the only state program that made efforts to become competitive. While the strategies it implemented allowed the program to dominate the market, they also increased its risk exposure (Florida TaxWatch, 2010), thereby raising concerns about its financial soundness (Citizens Property Insurance Corporation Mission Task Force, 2009). For example, in

²⁷ Source: <https://www.twia.org/news-and-announcements/twia-posts-2020-rate-adequacy-analysis/>

2007, the program abandoned higher prices and program eligibility requirements, increased coverage limits and exempted properties located within 2500 feet of the coast from compliance with building codes (GAO, 2007). Several studies that examined Florida Citizens' performance suggested that the program reverse back to being an insurer of last resort by increasing rates (Citizens Property Insurance Corporation Mission Task Force, 2009). Importantly, the suggestion was to increase rates by 47% to be actuarially sound (Florida Catastrophic Storm Risk Management Center, 2009).

If risks are geographically differentiated, charging unified rates and not differentiating between types of policyholders (low- vs. high-risk) allows programs to incorporate cross-subsidy in their pricing. For example, California Earthquake Insurance averages rates by 19 zones; while not required, TWIA rates are also uniform through the 14 first-tier coastal counties (Marshall, 2018; TWIA, 2017).²⁸ The implication of such uniform rating is that it lowers the insurance rate for high-risk property owners and increases it for low-risk customers, creating the possibility that private insurance companies may cherry-pick lower-risk customers who face higher rates, thus undermining state programs (Jaffe and Russell, 2000). Some programs have made progress in shifting to more refined risk differentiation (e.g., Louisiana Citizens uses zip-code level pricing instead of parish-level rating). Others try to adopt more risk-based strategies that incorporate property structural characteristics (e.g., Mississippi Windstorm Underwriting Association, Florida Citizens).

The largest cross-subsidies to policyholders in state programs arise after an event when losses exceed claims-paying capacity and regulators allow post-event assessment of insurers participating in the program. Insurance companies often recoup this assessment by imposing a rate surcharge

²⁸ The House Bill 4409 permitted TWIA to vary rates within Tier 1 counties within specified limits (Section 36).

on all policyholders in a state (Hartwig and Wilkinson, 2016). Thus, policyholders outside the program share the underwriting costs of high-risk policyholders in the state program, creating a cross-subsidy problem. Cross-subsidies from all taxpayers in the state program may also arise when regulators give tax credits to companies to cover their assessments, or when the state appropriates general funds to help with the insurance program (Kousky, 2011). For example, in case of a deficit, Florida Citizens first assesses its policyholders (through up-front premium charges and post-event assessments), and, if this assessment is not sufficient, it then assesses policyholders outside the program for all lines of coverage.²⁹ In Mississippi, assessments are limited to property insurance premiums only. A 2015 Senate Bill (SB 900) changed the TWIA's funding structure and requires the plan to fund a 100-year storm season using the following sources: premiums and the catastrophe reserve trust fund; company assessments (\$1 billion) and bonds (\$1 billion) repaid first by TWIA policyholders and, if necessary, by all coastal policyholders³⁰; and additional funding in the form of reinsurance or other risk financing (Hartwig and Wilkinson, 2016).

Deductible and coverage limits also differ across states. For example, Florida and Georgia offer the highest residential coverage (\$2 million). Coverage limits in Texas are \$1.77 million for residential and \$4.42 million for commercial properties. Alabama has the tightest limit at \$500,000. Most of them offer catastrophic deductibles and incorporate the option for higher deductibles at reduced prices; Mississippi has the highest deductible at 20%. Lower deductibles and higher coverage increase program risk exposure (III, 2020).³¹ If premiums are adequate, low

²⁹ Some lines, such as medical malpractice, workplace, compensation and health, are exempt from assessment.

³⁰ These premium surcharges on all policyholders in catastrophe area only apply to the class 2 and class 3 public securities (Texas Insurance Code Section 2210.6132)

³¹ Florida Citizens program has been often cited as one with low deductibles and higher coverage (Medders and Nicholson, 2018).

deductibles and high coverage should not have implications for financial unsoundness of the program. With the combination of low deductibles and high coverage, however, the program may disincentivize customers to seek insurance in the voluntary market. Furthermore, higher coverage limits and lower costs may attract more high-income homeowners, who would otherwise be able to afford a more expensive private insurance policy (Kousky, 2011).

There are two basic approaches in terms of private insurer participation in the RMM: full participation model and assessment model. In the full participation model, private insurers participate either voluntarily or mandatorily (mandatory participation is most prevalent) and fully share profits and losses of the RMM. Under the assessment model structure, insurers do not share losses and profits of the RMM but are assessed post-event to help cover deficits (Klein, 2009). While some insurers are allowed to pass this assessment on to policyholders, the amount that is not allowed to pass must be funded out of their premiums and surplus (Born and Klein, 2015). This may further reduce private insurers incentives to write policies voluntarily and contribute to an increased share of the residual market. Under both models, the insurer's amount of contribution relative to RMM loss is determined by its share of the total voluntary market premiums written in the state. It is therefore expected that heavy reliance on post-event assessment may discourage private companies from writing policies in a state.

As an incentive, some state programs allow private insurers to lower their assessment requirement in exchange for writing more policies (e.g., companies in North Carolina, Alabama and Mississippi are allowed to adopt this strategy; Born and Klein, 2015). In Texas, there is no limit to the extent to which an insurer may reduce its assessment. Credits are given and loss assessments reduced if member insurers voluntarily write windstorm insurance in TWIA coverage area (TWIA, 2020). Such an incentive scheme, however, may encourage large companies to

expand their exposure and reduce their assessments and may burden smaller insurers with heavier assessments in the case of a large storm (Marlett, 2009).

6.2. STATE INSURANCE/REINSURANCE FUNDS

States can provide special insurance funds to bolster insurance coverage in their states for catastrophic disasters for which tails are very long and risks are difficult to model. For example, California and Florida have state insurance/reinsurance funds to provide catastrophic coverage. California Earthquake Authority (CEA) offers earthquake insurance directly to property owners in California (Marshall, 2018), while Florida Hurricane Catastrophe Fund (FHCF) is a state-owned reinsurance program that provides reinsurance to primary insurers in the state (Medders and Nicholson, 2018). State-run reinsurance programs have their proponents and opponents. Specifically, in the case of the FHCF, proponents argue that the program fills the gap and provides a stable source of catastrophic capacity at a lower cost. The FHCF provides reimbursements for a portion of residential property insurers' hurricane losses above the amount that is retained by the insurers. Private insurers and the state-run residual insurance program (Florida Citizens) are required to purchase reinsurance from the FHCF (Hartwig and Wilkinson, 2016). The ability to accumulate tax-favored reserves and access credits that are supported by local bonding authorities allows FHCF to reduce its costs relative to market reinsurers (Kousky, 2019). However, its rate structure could be subject to political manipulation and pressure, thereby resulting in lower rates and distorting loss control incentives (Niehaus, 2002), and may not adequately correspond to existing risk.

Opponents of the program raise the concerns that it crowds out private reinsurance and could affect taxpayers and other insurers/customers through post-event assessment, depending on its funding structure, in cases when losses are substantial. For example, while the rates are required

by law to be actuarial, insurers in the state with high exposure are allocated more coverage and are priced higher due to the exposure differences (Medders and Nicholson, 2018). The consequence of such coverage is that weakly capitalized insurers with high exposure may disproportionately benefit from the program. For example, in Florida, by statute, an insurer's reimbursement coverage is limited to its share of the \$17 billion maximum obligation (Section 215.555(1), Florida Statutes). Medders and Nicholson (2018) offered several valuable recommendations, including transferring the primary insurer's risk (e.g., eliminating coverage options, increasing cash build up to increase the FHCF's price) to private reinsurers and reducing its future reliance on debt financing (e.g., reduce the statutory limit amount).

6.3. GUARANTY ASSOCIATIONS/FUNDS

As a safety net, all U.S. states have a guaranty association/fund to cover claims arising from insolvent insurers licensed in the state (NAIC, 2020d). A common funding structure for guaranty associations is that assessments post-event are imposed on solvent insurers, and the insurers are allowed to recoup these assessments through premium increases, premium tax offsets or policy surcharges. While state guaranty funds are important, they could experience severe stress during catastrophic events if more than one insurer becomes insolvent. For example, after Hurricane Andrew, 11 insurers in Florida became insolvent (Snyder, 1993). The hurricanes of 2004 and 2005 severely disrupted insurance markets, not only in Florida but in Louisiana and Mississippi, as well (King, 2005). It is argued that post-loss assessment levied on policyholders – as a means of shifting the risk of current policyholders to future policyholders and sometimes to policyholders in other lines of business – generates negative externalities (Medders et al., 2014). With state guaranty funds and post-loss assessment structures, it is expected that in states where insurers possess a large market share outside of risky areas, those insurers may face secondary exposure to

catastrophic risk through their obligations to the state guaranty association (Kunreuther et al., 2009). Furthermore, state guaranty funds are responsible for covering claims of residents in their jurisdictions, even if the insurer is domiciled in other states (NAIC 2020d). The implication is that multistate insurers may have to shift the state-imposed insolvency cost to other states, affecting insurers and policyholders and general taxpayers. Insurers are also allowed to deduct guaranty fund assessments from the taxpayer's federal income tax and, as such, general taxpayers may also pay a share of the costs associated with an insolvent insurer failing on its claims obligations (Kunreuther et al., 2009).

Another aspect to note is that state guaranty associations provide more protection for individual buyers and small businesses than for commercial buyers. Consequently, the commercial insurance market is believed to be better disciplined because there are no insolvency guarantees (Klein and Wang, 2009).³² Notably, post-loss assessment financing structures used for many state insurance mechanisms, including guaranty associations, can create an inherent cross-subsidy, particularly when assessments are not purely risk based (e.g., when low-risk insureds pay larger post-loss assessments than high risk insureds; Newman, 2009; von Ungern-Sternberg, 2009). Cole et al. (2011) studied 25 insurers, making up 60 percent of the market in terms of premiums, exposure and number of policies, along with the post-assessment structures imposed on policyholders by Florida Citizens, Florida Hurricane Catastrophic Fund and Florida Insurance Guaranty Associations, and suggested that non-risk-based assessments do create a subsidy. This particular research indicated a primary deficiency in the post-loss assessment financing structure when assessment is not risk based and underscored the importance of understanding the impact of the subsidy on homeowners. A growing number of scholars suggest that subsidizing only targeted

³² Some commercial business is written by surplus line carriers, and there is no guaranty fund coverage for surplus line carriers (NAIC, 2020f).

segments of residents (e.g., low-income in high-risk areas who are constrained by resources) using the means-tested voucher system may be less distortive of private markets (Kunreuther et al., 2009).

While different states take different approaches to financing catastrophic risk, many of them have used some sort of post-loss assessment financing structures to maintain low rates post-incident. For example, after Hurricane Ike, a new bill (House Bill 4409)³³ passed in Texas, establishing surcharges on insureds in combination with assessments to cover post-hurricane bonds; the same bill made several changes related to TWIA's rate regulations. A 10% cap on TWIA rates set by the Texas Insurance Code Section 2210.359 remained in effect.³⁴

6.4. RESIDUAL MARKET DEPOPULATION

Some states have introduced so called depopulations programs as an incentive for private insurers to take over state insurance program policies. Florida is the number-one state that initiated a depopulation program in the mid-1990, offering a \$100 bonus per policy to new insurance companies to remove them from the Florida Citizens program, as a way to build up capital (Kousky, 2011). The companies were also required to keep policies for three years. However, many companies exited the program after three years, and the policies returned to the Citizens program (Klein, 2009). These initial efforts were ramped in the last decade (e.g., in 2006 Florida created a \$250 million incentive program that provided matching surplus notes to insurers qualifying for the program), allowing the total number of Florida Citizens policies to decline by 66% since 2012 (Hartwig and Wilkinson, 2016).

Other efforts included creating a computerized clearinghouse, allowing policyholders to find a matching insurer through the pool. The clearinghouse gives discretion to private insurers to

³³ Available online: <https://capitol.texas.gov/tlodocs/81R/billtext/html/HB04409F.HTM>

³⁴ Available online: <https://statutes.capitol.texas.gov/Docs/IN/htm/IN.2210.htm#2210.359>

decide if they would take over policies that are up for renewal or new applications accepted by Florida Citizens (Hartwig and Wilkinson, 2016). Potential problem of such choices is that private insurers may cherry-pick and choose less-risky policies from the state program.

Louisiana also made aggressive efforts toward depopulation of its state insurance program in 2007, with the target of reducing policy count to the pre-Katrina policy level (i.e., 125,000). Allocation of \$100 million funds through the Insure Louisianan Incentive Program toward grants (\$2 million - \$10 million) to insurers to take over more policies and hold them for at least five years, with at least half of the policies from coastal areas, had allowed Louisiana Citizens to reduce the number of policies by 50% to 86,645 by 2015 (Hartwig and Wilkinson, 2016).

A 2015 Senate Bill (SB 900) granted the TWIA authority to develop two voluntary depopulation programs: the Voluntary Market Depopulation Program and the Assumption Reinsurance Depopulation Program.³⁵ Formal evaluations of these programs and their effects on TWIA exposure have not yet been performed.

While the financial structure of depopulation programs across different states to cover losses involve premium revenues, surplus and investment income, reinsurance, bond issuance and ex-post assessments, because individual states assume different amounts of exposure, some are financially sounder, while others are more vulnerable. Relative financial stability of these programs partially hinges on their ability to cross-subsidize policies. Specifically, among wind pools, the smaller the area prone to high risk (or smaller the share of risky policies) in a state, post-assessment transfer of losses across all policyholders allows RMM programs to better perform financially (Hartwig and Wilkinson, 2007). The majority of insured properties in Florida are located in coastal counties; Louisiana has 8.6% of policies in coastal areas; and Texas insurers'

³⁵ See <https://www.twia.org/depopulation/>

risk exposure relative to the size of the industry is very low, at approximately 1.6% (Hartwig and Wilkinson, 2016). Such low exposure and the ability to spread assessment over unaffected policyholders, as well as relatively small exposure in terms of its state portfolio, suggest that TWIA may be better positioned to handle catastrophic risks.

Many state programs appear to be ill-prepared to handle catastrophes partly because their rates are low, coverage is expansive and participation of high-risk residents is high. For example, to cover Florida Citizens' deficit (after post-event assessments) due to massive losses from the 2005 hurricanes, the Florida legislature appropriated \$715 million in funds (spreading costs over all tax payers). To help the Mississippi Windstorm Underwriting Association, the state of Mississippi appropriated \$20 million for four years from an insurance-premium tax collected statewide (Kousky, 2011). Appropriating general revenues to help state programs with deficits or imposing taxes and other types of subsidies (e.g., tax credit for assessment of policyholders) further distorts the market and provides implicit subsidies to policyholders in risk-prone areas.

In response to growing concerns that Florida Citizens corporations would be unable to cover losses from future catastrophes, several federal-level natural catastrophe financing facilities have been proposed. One such bill introduced by Senator Bill Nelson in 2009, the Homeowners Defense Act of 2009 (S.505), proposed to establish the National Catastrophe Risk Consortium, a vehicle to allow state insurance programs to pool and transfer their catastrophic markets to capital markets through the issuance of insurance-linked securities (King, 2009).³⁶ Another proposal involved (1) establishing a federal natural catastrophe reinsurance fund to provide reinsurance to eligible state

³⁶ Within the Department of the Treasury, two types loan programs would be established for state reinsurance programs: (1) a liquidity loan to address the short-term liquidity constraint and (2) a catastrophe loan that would be available if losses exceeded 150% of the aggregate amount of premiums assessed for property and casualty insurance issued in a state over the previous 12-month period (King, 2009).

programs; (2) creating an obligation guarantee program to guarantee debt issued by state programs; and (3) providing mitigation grants for state and local governments (King, 2009).³⁷

The proponents of such federal-level natural catastrophe funding argued that the programs would stabilize the property insurance market by facilitating access to private capital for state-sponsored insurance programs and by encouraging private insurers to write in risky areas (King, 2009). It has been argued that the federal reinsurance program, assuming premiums are risk-based, would function better (Litan, 2006), reduce moral hazard issues, and improve the efficiency of private insurers with smaller losses (Cutler and Zeckhauser, 1999). Opponents, however, warned of a potential moral hazard – that is, the availability of a federal financing facility would encourage states to increase their risk exposure and to relax regulation standards (e.g., building codes) (King, 2009). Furthermore, federal reinsurance programs, experiencing political pressure, may lower rates further with implications for discouraging expansion of the private insurance market and their loss mitigation behavior (Harrington and Niehaus, 2001).

6.5. EXPERIENCE FROM OTHER COUNTRIES

It is common in many developed countries for disaster coverage to be provided through risk spreading over all households, at either a flat rate or differentiated prices. These programs operate as fully public or quasi-public mechanisms (McAneney et al., 2016; Paudel, 2012). Many argue that a system that assess everyone at differentiated prices is more equitable than one that provides a direct or indirect subsidy on insurance premiums, and it may also incentivize ex-ante mitigation (Kousky, 2019). For example, in Spain, the government provides country-wide disaster insurance and requires it to be included in all life, fire, property and motor vehicle policies. Private companies surcharge disaster premiums and transfer this portion of risk to the national government. France

³⁷ The first two functions would be established with the Department of the Treasury, while the third would be issued by the Department of Housing and Urban Development (HUD; King, 2009).

also mandates natural disaster coverage by setting uniform rates regardless of risk level and provides government-backed reinsurance for private insurers (McAneney et al., 2016). In the UK, disaster insurance is provided by the private sector. Within the structure of Flood Re, a non-profit flood pool that was established in 2016, every household is imposed a levy, which is put aside into a separate fund. Private insurers who agree to provide flood insurance can then choose to cede the flood portion of the policy to Flood Re. It is believed that this particular insurance scheme ensures affordability and availability of flood insurance across the entire country (Surminski, 2018).

In New Zealand, where earthquake peril is a concern, the government requires everybody with a fire policy to also carry earthquake insurance for which they are charged a flat rate.³⁸ In Japan, earthquake insurance is private but reinsurance is public. It is of note that premiums are differentiated by structural characteristics of buildings and locations and can be reduced for newly constructed buildings and for incorporating any resilient features (Kousky, 2019; Nguyen and Noy, 2019).

7. Insurance and Incentives

Insurance plays an important role in community disaster resilience (Hudson et al., 2020). There is growing recognition among researchers that if premiums correspond to actuarial risks and are set adequately, discounts tied to mitigation investment could provide financial incentives for risk-reduction behavior and could affect location decisions (Kunreuther, 2008). Enhanced mitigation, in turn, is likely to reduce not only the size of a claim, but also the uninsured portion of losses, minimize the below-deductible losses, and protect other invaluable possessions (Kousky, 2019).

³⁸ There are significant distributional consequences due to the flat rate structure. For example, Owen and Noy (2019) found a regressive effect of a flat rate structure in New Zealand, thereby indicating that the poor are subsidizing the rich.

For example, the National Flood Insurance Program (NFIP) incorporates a premium reduction for elevated homes (Kousky et al., 2017). Residual market mechanisms for wind hazards also offer premium discounts for wind mitigation in several states (Multihazard Mitigation Council [MMC], 2015; Office of Management and Budget [OMB], 2016). In Texas, premium discounts are available for properties that meet or exceed windstorm building codes and for buildings that implement retrofit measures (TWIA, 2018). Unfortunately, empirical research lags behind in establishing an association between premium discounts and risk mitigation behavior and in understanding the extent to which premium discount programs actually encourage new mitigation investments or simply reward existing ones.

For disaster insurance that emphasizes premium savings tied to risk migration as a best regulatory practice, it is absolutely imperative to assess how allowed savings compare with actual costs of mitigation and its cost-effectiveness to fully gauge whether this type of incentive-based program truly delivers on expectations. It is possible that premium reduction is small enough to make an investment in risk mitigation financially attractive. For example, Dixon et al. (2017) analyzed different mitigation strategies in NYC after superstorm Sandy (e.g., flood vents, raising machinery and equipment, basement infill and structural elevation), suggesting that for the majority of properties located in floodplains, such mitigation activities were not cost effective relative to available flood insurance premium discounts. Even if the mitigation investments were worthwhile, the large upfront costs associated with them may deter and discourage many to undertake them (Kousky, 2019; Kunreuther et al., 2007) unless funds are available for retrofit in the form of assistance or subsidized loans (Kunreuther, 2006).³⁹ In support of this claim, Kelly and

³⁹ For example, SBA disaster loans provide an additional amount for house retrofits, but they have been implemented on a relatively smaller scale.

Kleffner (2003) showed that individuals tend to engage in more mitigation when the cost is subsidized.

Carson et al (2013) is the only study, to the best of our knowledge, in the context of wind insurance to directly explore the relationship between self-insurance behavior and premium discounts, using data on mitigation investment funded through My Safe Florida Home (MSFH) mitigation grants. The MSFH provided funds for free home inspections and subsidized grants (dollar-to-dollar matched by the homeowners) to implement structural property improvements (Mozumder et al., 2015). While the investment was partially subsidized, the authors suggested increased investment in risk mitigation is a response to both increased insurance premiums and higher deductibles. Based on the study's research design, however, establishing causality was not direct, as such responses could well be driven by the fact that both the premiums and mitigation could be higher because of high risk exposure. Mozumder et al. (2015), using household level survey data, indicated that only one-fourth of surveyed households were willing to pay for financing MSFH after the program had expired in 2009. Consistent with past studies, income and risk perception were identified as the two primary factors for mitigation behavior among Florida households.

Although not explicitly linking hazard mitigation with premium discounts, survey-based studies have provided some empirical support for the positive association between hazard insurance and risk mitigation. For example, Petrolia et al. (2015) analyzed wind pool insurance in the Gulf states and found that wind insurance decisions were positively correlated with risk mitigation behavior. Another survey-based study from the U.S. and Germany also suggested that households with insurance were more likely to invest in hazard mitigation (Hudson et al., 2017).

Insured households also appear to have greater awareness of hazard mitigation (Thieken et al., 2006, show this evidence from Germany).

Miao and Davlasheridze (2020) have looked at this question more broadly, relating hazard mitigation behavior to community-level characteristics, including insurance take-up rates and average premiums. Specifically, examining county-level property buyouts funded through the FEMA Hazard Mitigation Grants Program across all U.S. counties, the authors found that property buyouts decreased with higher NFIP take-up rates and with lower insurance premiums, thereby suggesting that subsidized NFIP insurance may serve as an obstacle to managed retreat.

Finally, cyclicity of the insurance market may also disincentivize risk mitigation behavior. During soft cycles, when prices are low, premium reduction may not be enough to make mitigation attractive, and in a hard cycle, when the prices are high, people may completely forego purchasing the insurance (Woo, 1999).

Whether or not reduced premiums and availability of insurance incentivize development and location preferences in risk-prone areas these are important factors to consider in insurance policy design related to widespread insurance mandates and abolition of subsidized rates. This claim has often been made in relation to the NFIP; however, long-term evaluation of the program has shown very little (Cordes and Yezer, 1998; Evatt, 2000) to no empirical evidence for such an effect (Hipple et al., 2005; Wing et al., 2018). If anything, growing concern about low NFIP insurance take-up rates counters support for the claim that its availability encourages more development (Kousky, 2014).

No evidence, however, does not mean that widespread insurance mandates and abolishing premium discounts will have no effect on future land-use and development patterns. While it is beyond the scope of this research, growing empirical evidence does indicate that coastal

development has been largely due to investment in various public protective infrastructure and disaster aid programs, along with improvements in early warning and forecasting systems (Boustan et al., 2012; Burby, 2006; Suddowski and Sutter, 2005).

A large number of studies have suggested that hazard risk and cost of insurance are capitalized into housing prices. In the context of flood hazards, studies suggest homes in floodplains sell at lower prices likely due to the high risk of flood, cost of insurance, or both (e.g., Atreya and Ferreira, 2015; Atreya et al., 2013; Atreya et al., 2015; Bin and Kruse, 2006; Bin and Landry, 2013; Bin and Polasky, 2004; Bin et al., 2008; Dumm et al., 2015; Kousky, 2010; Hallstrom and Smith, 2005). In coastal areas, however, it has been challenging to separate benefits associated with coastal amenity from the dis-amenity effects of the risks of coastal hazards (Bin et al., 2008).

Specific land-use and development patterns can also be due to specific insurance program requirements. For example, NFIP regulates development and building requirements for new construction and substantial retrofits (e.g., elevation, dry flood proofing, etc.) in 100-year floodplains and in coastal areas subject to storm surge (Davlasheridze and Miao, 2019). Community Rating System (CRS) is another public program within NFIP that incentivizes public risk mitigation through premium discounts (Brody and Highfield, 2013; Brody et al., 2009; Fan and Davlasheridze, 2016; Highfield and Brody, 2013, 2017; Noonan et al., 2020; Sadiq and Noonan, 2015; Sadiq, Tyler, and Noonan, 2020; Sadiq et al. 2020a; Sadiq et al. 2020b). Studies have looked at distributional consequences of removing insurance subsidies (e.g., Bakkensen and Ma, *forthcoming*) in the context of multiple subsidies of NFIP, and at the poverty and inequality implications of the CRS program (Noonan and Sadiq, 2018). For example, Bakkensen and Ma (*forthcoming*) found heterogeneous spatial sorting in response to flood risk and specifically suggested that low-income and minority residents are more likely to sort into high-risk areas in

Florida. The implication for policy reform targeting abolition of subsidies is that it may lead to a greater concentration of low-income and minority residents in risk-prone areas as high-risk homes sell at lower prices, leading to potentially long-lasting distributional consequences for disaster vulnerability, recovery and fiscal policy (Bakkensen and Ma, *forthcoming*).

Tax incentives are another means to encourage residents to pursue mitigation measures. The size of state tax rebates should adequately correspond to cost savings from disaster relief afforded by mitigation investment. South Carolina, as part of the South Carolina's Omnibus Coastal Property Insurance Reform Act of 2007, provides tax credits (e.g., residential retrofit income tax credits; excess insurance premium tax credits) for fortification measures that make homes more storm resistant. Catastrophic Savings Accounts (CSA) are another tax-free savings tool to encourage savings toward future catastrophic expenses, including paying for insurance policy deductibles (South Carolina Department of Insurance, 2020).

The public sector can play an important role in encouraging risk mitigation behavior or restricting development in risk-prone areas through better zoning ordinances (Atoba et al., 2020; Kousky et al., 2013; Mobley et al., 2020). The federal government can also provide positive incentives to encourage loss mitigation behavior. Alternatively, the federal government can employ penalties to accomplish the same objective – penalizing areas without zoning policies by withholding certain federal aids (Kunreuther et al., 2009).

Given limited evidence of individuals' interest in mitigation measures, there is an avenue by which public and private partnerships can promote mitigation behavior. Innovative strategies that build on private-public partnerships may be crucial for enhancing disaster resilience. For example, research shows that adoption and better enforcement of building codes save a significant amount of losses and lives (Czajkowski and Done, 2014; Czajkowski and Simmons, 2014; Done et al.,

2017; Done et al., 2018; Rollins and Kinghorn, 2013; Simmons et al., 2020). Cost-effectiveness of other mitigation measures (e.g., improved warning systems, long-term mitigation and land-use planning) also indicate enhanced benefits from long-term mitigation activities relative to recovery spending (e.g., Davlasheridze et al. 2017; Kousky and Shabman, 2017).

8. The Summary of Best Regulatory Practices

Many scholars agree that catastrophic risks are insurable as long as they are priced adequately to yield reasonable profits and if creative financial ways can be found to raise the capital to cover losses (e.g., see Jaffe and Russell, 2006). However, as discussed above, practices adopted by state regulators to manage insurance markets in risk-prone areas have had significant implications for the cost and availability of property insurance. While no one model can address all challenges faced by insurance markets in different states, there are several areas in which regulations can be improved. There have been interesting discussions around modernizing and improving the insurance regulation system in the United States with an aim to developing best regulatory practices that will foster market competitiveness. The Federal Insurance Office [FIO] (2013) makes several recommendations pertinent to state-level rate regulations and loss-mitigation strategies. The objective with rate regulation is to identify the level of regulation that would encourage a competitive market environment and increase market capacity. In terms of loss mitigation, the objective is to identify a suite of regulations that would incentivize loss mitigations both by insured and insurer (e.g., incentives for mitigation tied to policy premiums) and establishing (redesigning) new (existing) mitigation measures (e.g., building codes, retrofits). While the FIO report does not explicitly suggest it, downsizing and scaling back RMMs would also enhance market competitiveness (Born and Klein, 2016).

The best practices that directly impact the supply of insurance encompass regulatory practices that promote the availability of coverage, ensure private insurers' capacity to bear catastrophic losses and encourage setting of rates commensurate with the risks (Born and Klein, 2016). The affordability considerations that underlie current regulatory intervention and tend to suppress/compress prices may be counterproductive to market development in the long-term. Below we summarize several innovations that could encourage/improve market development and structure.

Price deregulation: Scholars almost unanimously agree that full price deregulation is a way to promote market efficiency and allow insurers to effectively undertake catastrophic risk. It also appears that reinsurers are more reluctant to write reinsurance for U.S. primary insurers because their policies are considered underpriced (Cummins, 2007). Full price deregulation can, in addition, allow insurers to address capacity constraint through the increased supply of reinsurance. Furthermore, when premiums fully reflect underlying risk, private property owners are made aware of the hazards and may be encouraged to practice cost-effective risk mitigation behavior and be discouraged to develop in hazard-prone areas.

Equity and affordability: While the number one principle for market efficiency is risk-based premiums, to address affordability and equity concerns for those who live in risky areas and are unable to afford insurance or adapt otherwise (e.g., move or invest in risk mitigation), it is increasingly recognized that providing subsidies for their premiums from state or federal general public funds is preferred. This represents a less distortive alternative to artificially lowering rates and indirectly subsidizing all in risky areas through RMM rates (Born and Klimaszewski-Blettner, 2009; Kunreuther, 2006; Kunreuther and Michel-Kerjan, 2009; Kunreuther and Pauly, 2006,). Doherty et al. (2008) proposed a subsidy in the form of an insurance voucher system provided by

the state or federal government. The vouchers will reimburse a low-income homeowners for the purchase of full risk-based premium policies in hazard-prone areas. The voucher system is seen as similar to other existing federal voucher programs such as food stamps (used toward food only), low-income home energy assistance programs (for energy needs) and universal service funds (for telecommunication services).

Scaling back RMMs and state guaranty funds: As for RMMs, tightening eligibility requirements and setting adequate rates that would make RMMs noncompetitive and truly a mechanism of last resort is one of the important best practices recognized in the literature to ensure the stability of private markets. Furthermore, risk diversification through adequate reinsurance practices and promotion of take-out programs to reduce the size of RMM have also been identified as important for market efficiency (Born and Klein, 2016). Others have proposed incorporating incentives to encourage private insurers to participate in the market rather than crowding them out through subsidized residual market rates (Born and Klimaszewski-Blettner, 2009). Post-loss assessment financing structures used by RMMs and state guaranty associations create inherent cross-subsidy if post-assessments are not risk based (Newman, 2009; von Ungern-Sternberg, 2009).

Deregulating underwriting restrictions: Born and Klimaszewski-Blettner's (2009) analysis of all U.S. insurers across personal and commercial lines also suggested market deregulation in terms of other regulatory aspects (e.g., banning policy cancelations, exit restrictions, etc.) that hamper private insurers' ability to flexibly adapt their underwriting practices to changing risk. Furthermore, the authors suggest limiting state regulatory function to monitoring only.

It should be noted that particular regulatory responses are commonly triggered as a pre-emptive measure by regulators to limit market exits, constrain rate hikes and restrict insurers from

cancelling/not writing policies, all typical strategies that private insurers undertake post-catastrophe. It remains challenging, however, to evaluate whether a regulatory response has a positive, neutral or a negative impact on market adjustments. Evaluating their implications requires comparing market responses against the counterfactual where markets operate without regulations. Few past studies have attempted to determine the effect of regulation on various outcomes of market performance. For example, Born and Klein (2016) employed state-level data to estimate the effects of rate regulation (explicitly identifying states with prior rate approval systems, as reported in Appendix Table A1) and the size of the residual market mechanism on the market performance of personal and commercial property in the aftermath of so-called economically catastrophic events (defined by a loss ratio of 1.25 or greater reported by insurers in a state). The authors found evidence that the property insurers were adversely impacted (in terms of the change in number of insurers, their financial capacity, market concentration, median loss ratio and reinsurance ratio) in states with prior rate approval regulation systems and larger residual markets (Born and Klein, 2016). Notably, rate regulatory systems had no discernable effect on commercial property insurance market performance, reaffirming growing evidence that price regulation has been adopted to primarily address insurance affordability for personal property lines.

Geographic diversification of risk: Drawing upon the literature showing that the commercial property insurance market outperforms that of personal property insurers, geographic diversification of risk – the strategy that commercial line insurers commonly follow – may be the key to ensuring a more stable supply of insurance coverage in the personal property line, as well (Born and Klimaszewski-Blettner, 2009). In this regard, relaxing standards related to duplication of licensing and reporting activities of insurers operating in multiple states may promote greater risk diversification. Proponents of federal-level regulation of insurance also argue that allowing

insurers to opt for a federal charter (e.g., Optional Federal Charter, OFC) may substantially reduce the barriers to risk diversification (for details on this proposal, refer to Grace and Klein, 1999, 2008; Grace and Scott, 2009; Harrington, 2009; Harrington and Niehaus, 2003).

Enhancing access to capital: In terms of capital constraints, scholars have highlighted the importance of capital markets and establishing of private-public partnerships to help insurers (in particular for personal property lines) in the aftermath of catastrophic years. Catastrophic bonds and other risk-linked securities have gained particular traction in recent years as vehicles to allow private insurers and reinsurers to expand their risk-bearing capacities and remain solvent (Cummins, 2008; Finken and Laux, 2009). Public reinsurance is another means of supporting private insurers who experience losses during large-scale catastrophic events (Born and Klimaszewski-Blettner, 2009).

For improving access to capital, it is particularly important for U.S. insurers to get full credit for their reinsurance with non-U.S. reinsurers. In this context, regulations that are in harmony with international practices and standards are vital. Specific to greater access to reinsurance mechanisms globally, scholars agree that full elimination of the collateralization requirement of non-U.S. reinsurers is key. Revisions to the Credit for Reinsurance Model Law and Credit for Reinsurance Model Regulation adopted on June 25, 2019, fully eliminate collateral requirements for EU and UK reinsurance and for those domiciled in certain qualified jurisdictions. When fully implemented, the changes are believed to improve both the primary as well as reinsurance markets (Cummins, 2007).

Long-term homeowners insurance: Proponents of long-term insurance argue that such policies will make mitigation investment financially more attractive as opposed to annual insurance policies, as property owners will compare the large upfront cost of investment premium

discounts over 10-year or longer time periods (Jaffee, Kunreuther and Michel-Kerjan, 2008; Kunreuther and Michel-Kerjan, 2015). The policies can be fixed-price contracts (FPC) that freeze the premium amount over the period of the contract or adjustable price contracts (APC) with renewable premiums. Given the uncertainties associated with risk, however, long-term policies may pose a challenge in terms of proper pricing (this is particularly true for the FPC). Furthermore, fixed long-term premiums may not be perceived favorably by rating companies because they lock in premiums even if losses increase in the future (Doherty et al., 2008).

All-hazard insurance: All-hazard insurance is another type of alternative policy. Instead of segmenting peril, all natural disasters are covered by a single policy. Such types of disaster insurance currently operate in Spain and France, as discussed above. Because disaster risks across different perils are independent, risk diversification across hazards reduces the likelihood of large losses for insurers. Furthermore, in hurricane-prone states where separating damages by cause may become contentious (e.g., water vs. wind), all-hazard insurance may be an ideal alternative that also avoids the added cost of an adjuster to determine/assess damages. All-hazard policies naturally will be more expensive than a standard policy because they are more comprehensive, although the premiums will be differentiated across types of perils concerned with specific geographies. The large premium is one notable disadvantage of all-hazard policies and may receive substantial local resistance. Furthermore, small, single-state domiciled firms may be disadvantaged by such policies if they cannot geographically diversify the risk. Proper structuring of these types of policies is important; in particular, itemizing premiums by type of risk will alleviate confusion of some property owners who may wrongly believe that the high premiums they pay provide coverage for hazards that do not concern them (e.g., earthquake in hurricane-prone states; Doherty et al., 2008).

Hybrid policies: There have been some discussions about hybrid parametric and indemnity-based insurance policies to address the cost and speed of claims processing in the aftermath of large-scale catastrophes (King et al., 2014). Parametric policies pay a predetermined amount when an event triggers a certain parameter (e.g., wind speed reaches or exceeds certain levels). Benefits of the parametric policy are a substantial reduction in the cost of settling claims and expedited payouts. Furthermore, since the payment is not affected by the total loss, policy holders receive risk mitigation incentives and moral hazard issues are reduced. Parametric policies may also reduce the likelihood of insurance fraud, since the payments are standardized and the basis risk is independently verifiable (NAIC, 2020e). A notable drawback is that these policies establish a basis risk level, implying that they overpay if losses are lower and underpay if actual losses are greater; furthermore they do not pay if damages are incurred below the trigger parameter of the event (Kouksy, 2019). With a hybrid policy, initial payments are parametric-based to make claims settlement faster; if there is any damage in excess of the pre-determined amount, the claims adjustment process continues, ensuring that the end result is still indemnity-based (NAIC 2020e).

Coastal Wind Zone Markets: Various proposals have called for a federal wind insurance program (as a backstop or fully charged federal wind insurance program similar to NFIP) to address the complex interplay of insurance availability and affordability, along with market stability and profitability of insurers, as it eliminates various entry/exit (e.g., licensing) and operational barriers (e.g., reporting) for insurers. Others have advocated development of a private market across multiple jurisdictions that face the same risks (e.g., coastal wind zones along the Gulf and Atlantic Coasts). This proposal reduces cross-subsidies (discussed above) by shifting the risk to all residents who are subject to the same risk. The rationale for such programs also involves consistency of rules and regulations across all hurricane-prone states, allowing insurers to make

long-term commitments to capital and increase insurance availability. The role of the federal government is foreseen to be limited to oversight (e.g., underwriting aspects, including pricing) without assuming a financial role. The states' roles will be solvency regulation and providing insurance of last resort. This proposed program includes mechanisms to adjust premiums after a significant hurricane loss (increase premiums to make them actuarially fair) and in cases when losses are lower than anticipated (return excess payments to policyholders). Furthermore, tax credits based on income level and asset values will be offered to low-income residents as a way to address the affordability problem (Derig et al., 2008; Doherty et al., 2008).⁴⁰

Some scholars have proposed other mechanisms to help private insurance companies during large cataclysmic events. For example, the National Catastrophic Fund can be a financial backstop for state catastrophic funds. Insurers would deposit a portion of their revenues to this fund, which would provide reinsurance to state catastrophe funds for losses above a specified level (the threshold level of loss amount remains debatable; Kunreuther et al., 2009).

Another proposal is to charge the U.S. Treasury Department with providing federal reinsurance contracts that would be auctioned annually (e.g., see Lewis and Murdock, 1996). The level of loss that would trigger the contracts could be selected by insurers, reinsurers and state pools so as not to crowd out private coverage. Implications of these proposals for relevant stakeholders, the development of a private reinsurance market and insurance-linked securities remain open areas for research.

⁴⁰ Other proposals including establishment of a National Catastrophic Fund as a backstop for state catastrophic funds (e.g., see Doherty et al., 2008). Proponents of this proposal argue that such a fund would enable risk diversification both across perils as well as geographically, establish a relatively “cheap” reinsurance program and lower the cost of coverage (Klein, 2018).

Various instruments to promote catastrophe mitigation: Despite growing empirical evidence that wind-related losses could be substantially eliminated if appropriate structural mitigation measures are implemented by private stakeholders, interest and investment in mitigation remain low. The question then remains how to incentivize individuals, businesses and communities to mitigate so that risk is optimally managed. Current incentives tied to premium reductions and tax credits appear to be insufficient to motivate an optimal level of self-insurance/self-mitigation. Subsidizing mitigation funds via grants has proven successful; however, funds have been limited (Kelindorfer and Kunreuther, 1999; Kelly and Kleffner, 2003). Improving building code enforcements statewide, along with risk-based insurance premiums, are an important and well-noted strategies to hurricane resilience, as is increasing financial stakes for property owners (with significant “skin in the game”; McCullough et al., 2017). Furthermore, scholars have underscored the importance of promoting behavior through enhanced hazard education, literacy and outreach (Kousky and Kunreuther, 2018). In this context, communication efforts are important and, particularly development of an appropriate communication message. Kranzel et al. (2020) employed a mixed-methods approach to analyze survey data from homeowners in Florida and Alabama and identified several elicited beliefs that would promote a communication campaign. The results demonstrated that the most promising beliefs included behavioral beliefs that installation of wind-resistant roofs would protect oneself and one’s family, and normative beliefs that one’s family and community were likely to retrofit. Further research in this area is needed to better inform a hurricane-mitigation communication campaign.

In sum, insurance plays a crucial role in community resilience against disaster events and has the potential to encourage cost-effective risk mitigation behavior if rates are actuarially structured and incentives financially attractive, and resources are provided for ex-post rebuilding and

recovery. However, take-up rates for catastrophe insurance, unless mandated, have remained low. Furthermore, loss mitigation behavior when insurance is also available appears to serve as a substitute rather than complement for disaster insurance. As highlighted in this literature review, underwriting catastrophic risks has been even more challenging for private insurers due to fat tails and spatial correlation of losses, which are further compounded by requirements from regulatory and rating agencies. To remain solvent while also satisfying regulatory requirements, insurers must hold or have access to sufficient capital through reinsurance or financial markets to cover losses from catastrophic events. This requires rates to be actuarial or adjusted adequately post-event. But rates that are risk-based may exceed customers' willingness to pay for insurance. These complex issues and experience with catastrophic events have prompted the development of various government-sponsored residual market mechanisms. RMMs, while initially foreseen as insurers of last resort, have become insurers of first resort. Depopulating them and encouraging market participation have become priorities for state regulators. While several novel approaches to creating favorable incentives for insurers have been proposed, aligning them with regulatory and statutory requirements has proven to be a challenging task. Fully deregulating pricing and underwriting restrictions, along with incentivizing risk mitigation through public-private programs (e.g., building codes, information campaigns, risk communication) are a few important strategies for improving market efficiency. Several novel policy structures and government involvement with financially constrained customers to ensure premium affordability are also discussed and highlighted in this review.

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Appendix A

Table A1: Description of State Rating Laws

Type of State Rating Law	Description
Prior Approval	The insurer must file rates, rules, etc. with state regulators. Depending on the statute, the filing becomes effective when a specified waiting period elapses (if the state regulator does not take specific action on the filing, it is deemed approved automatically) or the state regulator formally approves the filing. A state regulator may disapprove a filing at any time if it is not in compliance with the law. The state regulator normally must hold a hearing to establish noncompliance.
Modified Prior Approval	This is a hybrid of "prior approval" and "file and use" laws. If the rate revision is based solely on a change in loss experience then "file and use" may apply. However, if the rate revision is based on a change in expense relationships or rate classifications, then "prior approval" may apply. A state regulator may disapprove a filing at any time if it is not in compliance with the law. The state regulator normally must hold a hearing to establish noncompliance.
Flex Rating	The insurer may increase or decrease a rate within a "flex band," or range, without approval of the state regulator. Generally, either "file and use" or "use and file" provisions apply. Generally, the insurer must file rate increases or decreases that fall outside the established "flex band" with the state regulator for approval. Typically, "prior approval" provisions apply. The "flex band" is set either by statute or by the state regulator. A state regulator may disapprove a filing at any time if it is not in compliance with the law. The state regulator normally must hold a hearing to establish noncompliance.
File and Use	The insurer must file rates, rules, etc. with the state regulator. The filing becomes effective immediately or on a future date specified by the filer. A state regulator may disapprove a filing at any time if it is not in compliance with the law. The state regulator normally must hold a hearing to establish noncompliance.
Use and File	The filing becomes effective when used. The insurer must file rates, rules, etc. with the state regulator within a specified time period after first use. A state regulator may disapprove a filing at any time if it is not in compliance with the law. The state regulator normally must hold a hearing to establish noncompliance.
State-Prescribed	The state regulator determines and promulgates the rates, classifications, forms, etc. to which all insurers must adhere. Insurers are usually permitted to deviate from state prescribed rates, classifications, forms, etc., with the approval of the state regulator.
No File/Record Maintenance	The insurer need not file rates, rules, etc. with the state regulator. Rates, rules, etc. become effective when used. The state regulator may periodically examine insurer(s) to ensure compliance with the law.

Source: Insurance Information Institute III (<https://www.iii.org/es/article/regulation-modernization>)