CHAPTER 6

Climate Change Impacts on Insurance in Florida

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Climate change presents added risks as well as related opportunities for the insurance industry and financial sector. Implications must be evaluated for property, casualty and life insurance industry segments as well as for the financial sector more broadly. While climate change exacerbates the existing volatility of these markets, it also inherently creates opportunities for product development. Florida is a unique contributor to both the risk and opportunity since the state is the world's largest insured catastrophe region. The state of Florida itself is heavily leveraged as insurer for much of the cost of extreme weather in the form of hurricanes and other tropical storms. Unlike other insurance risk bearers, however, this state cost of risk cannot be offset by commensurate market opportunity. Increased volatility in insurance, reinsurance, and capital markets are all challenges for Florida, with potentially adverse collateral effects on residual insurance market pressures, policyholder assessments, state debt, and tax strategies. Insurance industry initiatives, to the extent they are successful, can have a balancing effect on these challenges.

Key Messages

- The potential for substantial changes in the climate make the risk assessment, underwriting, and pricing of insurance and insurance-linked securities more complex.
- Catastrophe loss models incorporate scientific assumptions about climate change into the risk assessment capabilities for multiple disaster perils, including hurricane, flood, and wildfire, among others.
- Insurers and reinsurers are at the forefront of research regarding the effects of climate and climate change on future loss costs, loss uncertainty, and opportunity.
- Florida is and will continue to be one of the world's largest insured, catastrophe markets, and as such is highly vulnerable to changes in the climate as well as changes in the markets for protecting against financial risk.
- It is especially important for Florida and Floridians to implement smart ways of adapting to climate change and its effects in order to protect our economic sustainability.

Keywords

Disaster risk; Catastrophes; Insurance; Reinsurance; Economic loss; Risk reduction; Insurability

Introduction

During recent decades, natural catastrophes as well as man-made disasters have posed a rising threat to societies and the world economy. In 2015 alone, there were 353 recorded catastrophe events worldwide, resulting in estimated total economic losses of $92 billion (Swiss Re 2016) Of these events, 198 were deemed natural catastrophes, the most

ever recorded in a single year, with estimated overall losses of $80 billion (Swiss Re 2016). A continuation of changes in environmental factors is expected to have an upward effect on the magnitude as well as on the geography of future loss events. The private (re)insurance sector recognizes climate change as a factor in strategic planning for the future of the business as major reinsurers, insurers, and industry consortiums are placing substantial resources on research and development to respond appropriately to the emerging changes in risk.

This chapter provides an overview of the possible insurance impacts of such changes. The implications for insurance and more specifically insurance in Florida are potentially far-reaching and are subject to several important, but often little understood, aspects of the marketplace for risk and Florida's place in it.

Beginning with Hurricane Andrew in 1992, Florida has been at the forefront of discussions related to natural catastrophes and insurance markets. Florida's geographic, or physical, exposure to catastrophic weather, especially in the form of tropical windstorms, is clear and is discussed thoroughly in other chapters. Socioeconomic factors directly influence Florida's level of economic losses resulting from catastrophic events. Florida's increasing overall population, the increasing migration of its population to coastal areas, and the rise in total insured property values at risk in these areas combine to substantially increase Florida's concentration of insurance exposure to catastrophes.

The population of Florida in 2015 is estimated at approximately 20 million, according to the U.S. Census Bureau, making it the third most populated state in the nation behind California and Texas. This represents a drastic increase since 1950 when there were a mere 2.8 million inhabitants. Even just since 1980, Florida's overall population has doubled. Furthermore, while the nation's 673 coastal counties make up only 17% of the U.S. land area they account for 55% of the nation's population (AIR Worldwide 2013; U.S. Census Bureau 2010). Florida serves to highlight this trend, with 61 of its 67 counties listed as coastal by the National Oceanic and Atmospheric Administration (NOAA), comprising over 75% of the state's total population (NOAA 2013).

Exacerbating the risk, Florida construction values have risen sharply during this period of time as well (Florida Catastrophic Storm Risk Management Center 2011). A portion of this rise is easily explained by the need for housing stock as the population has risen. But two additional factors have contributed to the rise. Individual property values have risen, even after adjusting for inflation (Florida Catastrophic Storm Risk Management Center 2011). Land values have risen as populations (and thus demand for land) have risen. And newer homeowners who either ignore the disaster risk, or can affordably insure against it, have built homes more expensive to construct than the typical Florida home of the 1950s and 1960s (Florida Catastrophic Storm Risk Management Center).

Businesses and commercial real estate have flocked to Florida since the 1960s as the state grew as a tourism economy with low taxes. Florida also has a high density of property insurance coverage, with most houses protected against windstorm losses and about one-third insured

against floods (Florida Catastrophic Storm Risk Management Center 2011). Indeed, it was estimated that in 2012 nearly 80% of insured real estate assets in Florida were located in coastal counties (AIR Worldwide 2013). This represents $2.86 trillion of insured residential and commercial exposure located in Florida coastal areas. The exposure of Florida to natural hazards, particularly tropical storms, along with the state's high level of insurance penetration combine to make Florida arguably the world's greatest insured natural catastrophe region.

Not surprisingly, and for the reasons given, the cost to insurers of Florida weather catastrophes has risen far faster than inflation during the past 30 years (Kunreuther et. al. 2012). These factors will continue to have a major impact on the level of insured losses from natural catastrophes. Given the growing concentration of exposure on both the Atlantic and Gulf coasts of the state, future disaster events would be likely to inflict significant property damage and business interruption losses on Florida even without changing environmental conditions. And Florida's insurers can be expected to foot much of the bill.

Assessing the potential impacts of climate change on insurance is complex, and depends on the temporal and spatial scales over which one is concerned, the entities of interest, judgment criteria, and the desired level of certainty. Moreover, climate change—given its potential for systemic impact—can dramatically alter the risk management landscape more broadly than just insurance. We are challenged to understand climate change in a world where all climates contain a spectrum of extremes and related catastrophes. This spectrum can be quite broad with no easily discernable trends (Muir-Wood 2016). It is in such a world the insurance sector attempts to find long-term profitability (private sector) and financial stability (public sector).

This chapter addresses potential impacts of climate change on insurance within the framework of how healthy insurance markets function. The first section is comprised of a broad conversation on the insurance and financial markets, their functions and roles, as well as their financial volatility and problems. Second is a discussion of why and how governments serve as public insurers or as sponsors of insuring entities. In the third section, the chapter addresses the assessment of the risk, both from an insurance standpoint and a climate change perspective. Fourth, insurance underwriting and pricing are examined, followed by a fifth section on the potential financial impacts of climate changes. The sixth and last section examines recent and current efforts—both public and private—to abate the financial impacts of potential climate changes.

The Insurance and Financial Markets

The American insurance market is generally robust, competitive, and innovative. Citizens expect insurance to be available and affordable for a wide range of risks. Floridians are no exception. One could argue Floridians have higher than average expectations of their insurance. It has been asserted the growth of Florida since 1960 is attributable primarily to two factors: air conditioning

and affordable property insurance (Florida Catastrophic Storm Risk Management Center 2011). Whether the statement is true, it is undeniable that Floridians have come to depend on both for quality of life purposes. The dependence on affordable insurance is a factor that takes on increasing pressure as insured losses increase. It is important then to discuss how this market for risk financing works in order to understand how it may be impacted by climate change.

Functioning Insurance Markets

Private insurance markets function well only if necessary conditions are met. Private insurers generally only insure pure risks, meaning risks that do not include any speculative "upside outcome" for the person or entity facing the risk (i.e., risks wherein only loss or status quo are possible). Beyond this first condition, however, six additional characteristics of a risk are critical to making it ideally insurable in the private market (Rejda 2011).

First, there should be a large number of roughly similar (although not necessarily identical) individual risk exposures subject to the same peril or group of perils. For instance, a large number of masonry dwellings subject to hurricane exposure can be grouped together (pooled) for purposes of providing property insurance on them. This enables an insurer to predict losses, with reasonable accuracy, based on the law of large numbers and to spread loss costs over all insureds in the group.

Second, losses should be accidental, or unintentional, in nature, so that the insured cannot affect the probability that a loss will occur. The law of large numbers is based on the random occurrence of events. Prediction of future loss experience may be highly inaccurate if intentional, or otherwise nonrandom, losses occur.

Third, losses should be determinable and measurable, meaning the loss should be definite as to cause, time, place and amount. The basic purpose of this requirement is to enable an insurer to determine if a loss is covered, and if it is, how much should be paid.

Fourth, losses should not be catastrophic. This means that a large portion of exposed units should not incur losses at the same time. Although insurers ideally wish to avoid all catastrophic losses, practicably most natural catastrophes are covered and reinsurance is purchased to limit the insurer's catastrophe potential.

Fifth, the chance of loss must be calculable, both in terms of frequency and severity. Some losses are difficult to insure because the chance of loss cannot be accurately estimated, and the potential for a catastrophic loss is present.

Sixth, the premium must be economically feasible, meaning the insured must be able to afford the premium. To have an economically feasible premium, the chance of loss must be relatively low.

When individual exposures are independent and numerous, and losses are accidental in nature, they become more predictable than if these conditions are not met. An insurer can compute actuarial projections of the probability of such losses sufficient to assess the premium

it must charge to be able to insure the risk. So long as the premium (based on the fair price of the risk) is not infeasible for insureds to pay, a market for insuring such risks can function well.

Insurance in theory is supposed to be an *ex ante* financial instrument, where insurers over time build up capital to use for paying damages that occur later. But today, the vast majority of property insurance policies carry 12-month terms. Thus, insurers strongly prefer risks that can be pooled over a short period of time (i.e., the law of large numbers works over multiple exposure units in one short term period rather than requiring a long term average for statistical accuracy) so that one year's premiums cover one year's losses. Furthermore, insurance pricing is optimized by competitive markets, so that each insured pays the cost of adding that insured to the risk pool and no insurer can survive in the short term by underpricing the expected true cost of the risk.

Insurance in practice has a tradition of serving as a risk averse financial instrument and particularly averse to catastrophe losses and potential. Because of this, insurers are prone to restrict contract terms as they raise prices of their products and services whenever and wherever catastrophic loss potential is estimated to exist. Regulation—self-regulation, industry regulation and public regulation—with an interest in long-term stability and availability serves to temper the propensity to behave in wholly reactionary fashion to climate extremes, catastrophic losses and climate change.

The Role of Insurance within the Financial Markets

Insurance is a specialty sector of the financial markets where, as previously mentioned, pure risks are the focus. Because these risks inherently should provide no opportunity for financial gain by the insured, profitability for the insurer is contingent on accurate information for every risk insured and the ability to convert this information into pricing that adequately and fairly represents the risk the insurer takes.

The reinsurance market serves as back stop to losses from the insurance market. Most reinsurance aggregates risks (by books of exposure units subject to similar perils) for which insurers have already obtained credible information on each individual risk (by exposure unit). Buying reinsurance, insurers can take on larger and more volatile risks than would otherwise be financial feasible as reinsurance not only spreads losses across its insurer clients (through its pricing scheme) but also infuses additional capital that indirectly increases insurers' financial capacity to bear large losses (Rejda 2011; Kunreuther et. al. 2012).

The broader capital markets play a role as well in two ways: first, these markets may participate directly in risks and losses through insurance-linked securities (ILS), which are available to large investors; and second, they may participate indirectly as investors infuse capital into publicly traded insurers and reinsurers as well as investment funds.

Volatility and Market Problems

Based on the preceding requirements of an ideally insurable risk, even with participation by reinsurers and ILS investors, private insurance markets struggle to provide sufficient coverage to meet society's needs for some risks (Klein and Kleindorfer 2003; Cummins 2006; Medders, Nyce and Karl 2013). These risks—commonly called extreme or catastrophic risks—are uninsurable through conventional insurance markets because they defy the conditions private markets require for operation. Insurance markets can face problems in providing coverage for truly large events; the size and rarity of insured events can make them difficult to predict. Losses may be intentional (as in terror attacks) or affected by trends that render losses nonrandom. The infrequency of large loss insured events may also require risk pooling across several time periods for insurers to expect to break even. In the case of catastrophic risk, private insurers may not be able to adequately address the information problems they encounter in attempts to price and underwrite. Where they are able to arrive at rates in which they have confidence, buyers may have insufficient income to afford to pay (Skipper and Kwon 2007). And financial markets can be disrupted when an extremely large insured loss occurs, complicating the rebuilding of capital after a large payout.

Markets that include high potential for catastrophic insurance industry losses are prone to a variety of market problems. Private insurers may choose to decrease market exposure, and thus decrease capacity in the highest-risk zones. For example, Cummins (2006) states, "Insurance markets tend to respond adversely to mega-catastrophes. They respond to large events ... by restricting the supply of insurance and raising the price of the limited coverage available." The Florida property insurance market experienced such market problems in 1993 after Hurricane Andrew and again in 2006, on the heels of the brutal 2004-2005 hurricane seasons. In both market years, reinsurers restricted reinsurance supply to insurers thus creating a cascading effect on property insurance availability, especially for homeowners and commercial residential property owners.

In Florida, given the size of the catastrophe risk as well as its volatility, the availability of private capital to support catastrophic windstorm exposure is contingent upon regulatory and legislative directives intended to ease market pressures and stabilize pricing. Negative externalities, and ultimately market failures, can result from insurance rate suppression (regulatory decreases in the price ceiling) within this catastrophe-prone market.[1] Public policy considerations in the state, however, have in recent years dictated suppressed pricing and subsidized coverage, rather than having each insured necessarily pay the fair cost (based on the law of large numbers) of being added to the risk pool (Medders et.al. 2013).

In a state such as Florida, where development of the built environment has revolved around population and business (particularly tourism) growth, it makes sense the political economy

[1] Insurance rate regulation has three purposes: ensure adequate rates, ensure non-excessive rates and ensure rates are not unfairly discriminatory. Protection against insurance rate inadequacy is critical since it reduces the likelihood that an insurer will not have sufficient funds from premiums collected to pay claims.

would will people to continue to live and work in certain geographic areas where there are high risks, however infrequent the losses may be. Thus, in addition to restricting the competitive environment within the private insurance market, the state chose to develop a residual market for property insurance and reinsurance as well, with implications for the private insurance industry.

It is important to note that climate extremes and losses due to climate change may be felt most quickly and strongly by the reinsurance sector and the public insurance markets since these are the "back stops" for exposures, risks and losses determined extreme, catastrophic or otherwise difficult to insure. It therefore makes sense to begin a Florida-centered discussion of insurance participation with its residual (public) market for insurance.

State of Florida and Federal Government as Florida "Insurers"

Based on the principles for well-functioning insurance markets, government plans would ideally use risk-based premiums in setting the price charged for each individual risk and not offer subsidies in setting the premiums on individual risks (at the least not subsidize the riskiest locations). To do otherwise is to actively induce people to put themselves in harm's way. Such subsidies also risk crowding out any potential private market initiatives. Of course, to follow this advice, the government must have the will to reject requests to provide special help to affected industries and/or regions.

A review of government programs providing coverage for extreme or catastrophic events shows that these programs do not function like insurance; where premiums are charged, they may be explicitly subsidized or set based on incomplete measures of the risks involved, resulting in an implicit subsidy (Cummins 2006; Grace and Klein 2009). There may not even be a clear statutory intent to subsidize coverage. The government's insurance commitment may extend over multiple time periods, allowing the government to recoup past losses through future premiums or other revenues. The federal government may provide back-up coverage financed not through premiums paid by insureds but through general government revenues. In short, these programs bear less resemblance to insurance than to targeted public spending or risk management programs aimed at meeting the government's responsibilities of providing economic security and economic stabilization (Kunreuther et.al. 2012).

The Florida homeowners insurance market consists of a unique combination of private and residual insurers grappling with increasing demand- and supply-side economic pressures in the face of high-density development near high-risk coastlines. Insurance for Florida's residential property insurance market includes both private insurers and several quasi-governmental property insurance mechanisms. In 1970 the Florida Windstorm Underwriting Association (FWUA) was enacted by the Florida Legislature to offer "wind only" coverage in Monroe County and the Florida Keys. The FWUA was gradually expanded to provide wind coverage in 29 of Florida's coastal counties. Since this initial attempt to provide a public policy response to

catastrophic windstorm risk, three entities have evolved with expressly different purposes: Citizens Property Insurance Corporation, the Florida Hurricane Catastrophe Fund and the Florida Insurance Guaranty Association. These statewide programs are backed implicitly by the State of Florida itself, although none of the programs has explicit backing. Flood insurance has not historically been provided by the private insurance market but rather has been covered under a Federal program, the National Flood Insurance Program. (Florida Catastrophic Storm Risk Management Center 2011).

Citizens Property Insurance Corporation[2]

After Hurricane Andrew in 1992, the Florida Legislature met in a special session to address problems in the residential insurance market. Several insurers had become insolvent, and others were concerned about increased insolvency risks. The Legislature addressed the need for residential property insurance policies that provided "full" (multi-peril) coverage rather than wind-only policies offered by the FWUA. The Florida Residential Property and Casualty Joint Underwriting Association (FRPCJUA) or (JUA) was created in 1992, and later combined with the residual market mechanism that insured commercial residential or condominium and apartment buildings (the Florida Property Casualty Joint Underwriting Association).

The Florida Legislature merged the FWUA with the FRPCJUA, creating Citizens Property Insurance Corporation (Citizens) effective August 1, 2002. Citizens has three distinct accounts; the Personal Lines Account, the Commercial Lines Account, and the Coastal (formerly High-Risk) Account. Citizens has policies available to cover multiple perils (excluding flood and other perils considered uninsurable), the wind peril only, and multiple perils excluding wind.

When Citizens experiences a financial deficit due to losses, it may levy assessments. These assessments are not only against its policyholders but also against the policyholders of private insurers in almost all lines of property-casualty insurance in Florida.

The Florida Hurricane Catastrophe Fund[3]

The Florida Hurricane Catastrophe Fund (FHCF) was created by the Florida Legislature in 1993 to provide additional insurance capacity and help stabilize the property insurance market in Florida (Fla. Stat. s. 215.555(1)). The FHCF provides reimbursement for a portion of a property insurer's hurricane losses above the amount retained by the insurers. Insurers enter into contracts with the FHCF and pay a premium. The FHCF is able to accumulate premium payments on a tax- free basis as it is exempt from federal income taxation. Except for certain exemptions, all admitted insurers writing residential property insurance in Florida, including Citizens Property

[2] All information here was adapted from Florida Catastrophic Storm Risk Management Center, 2011.
[3] Ibid.

Insurance Corporation, are required by Section 215.555, Florida Statutes, to obtain FHCF reimbursement coverage.

In the event that the FHCF's losses exceed its surplus, the FHCF is authorized to collect assessments on policyholders in almost all lines of property-casualty insurance. The amount of coverage available from the FHCF, the cost of the coverage, and the potential assessments are significant factors in the state of the insurance market. The maximum obligation of the FHCF for a given contract year is specified by statute. The current maximum is $17 billion. Each insurer's reimbursement coverage is limited to its share of the $17 billion maximum obligation.

Because for now the FHCF coverage is for one peril only—hurricane. And because reimbursements are made for direct losses only, not for indirect losses associated with claims payments (such as attorney fees), the FHCF loss experience is a fairly simple barometer for the level of pure losses generated by one type of extreme climate event. The possibility of increases in event intensity due to climate changes means the capacity of the FHCF will continue to be under pressure to stabilize the Florida residential property insurance market.

Florida Insurance Guaranty Association[4]

The Florida Insurance Guaranty Association (FIGA) was created by the Florida Legislature in 1970 to address concerns about the adverse effects of insolvent insurers. Its specific purpose is to "provide a mechanism for the payment of covered claims under certain insurance policies to avoid excessive delay in payment and to avoid financial loss to claimants or policyholders because of the insolvency of an insurer." (Section 631.51(1), F.S.) Thus, FIGA is the state entity that pays the claims of insolvent insurers and has the ability to assess in the event of insolvencies related to catastrophic storms. FIGA does not accumulate funds in advance of an insurer's insolvency, but similar to Citizens and the FHCF, it obtains funds through pro-rata assessments levied by the Office of Insurance Regulation on insurers subject to assessment. Its use is limited primarily to protecting the state's policyholders against potential insolvencies of private insurers since the public insurers—Citizens and FHCF—as discussed above have their own respective assessment capabilities in the event of large losses.

National Flood Insurance Program

The private insurance market, through its standard homeowners policy, generally does not pay for flood losses due to the market failures concerns previously discussed. The lack of private insurance availability led to government intervention. In 1968, Congress created the National Flood Insurance Program (NFIP) to help provide a means for property owners to financially protect themselves from water loss (Kunreuther and Michel-Kerjan 2012). The NFIP offers flood insurance to homeowners, renters, and business owners if their community participates in the

[4] Ibid.

NFIP. Participating communities agree to adopt and enforce ordinances that meet or exceed the Federal Emergency Management Agency (FEMA) requirements to reduce the risk of flooding.

Floods are the most common and most destructive natural disaster in the United States. Ninety percent of all natural disasters involve flooding, and all 50 states have experienced floods or flash floods in the past five years (NAIC 2016). In 2014, global sea level was 2.6 inches above the 1993 average and continues to rise at a rate of about one-eighth of an inch per year (NOAA 2017). Higher sea levels mean that deadly and destructive storm surges push farther inland than they once did, which also means more frequent nuisance flooding. Nuisance flooding is estimated to be from 300 percent to 900 percent more frequent within U.S. coastal communities than it was just 50 years ago (NOAA 2017). Furthermore, rising sea levels threaten the integrity of infrastructure—roads, bridges, ports, utility plants, sewage treatment plants, etc.

Since Hurricane Katrina, the NFIP has been in a financial deficit state. Super Storm Sandy increased the deficit substantially. According to the Government Accountability Office, the NFIP "likely will not generate sufficient revenues to repay the billions of dollars borrowed from the Department of the Treasury to cover claims from the 2005 and 2012 hurricanes or potential claims related to future catastrophic losses. This lack of sufficient revenue highlights what have been structural weaknesses in how the program is funded."

The losses generated by the NFIP to date, as well as the potential for future losses, leave the federal government and taxpayers in a highly exposed financial state. The Biggert-Waters Flood Insurance Reform Act of 2012 (Biggert-Waters Act) extended the NFIP for five years and contained provisions to help strengthen the financial solvency of the program, including phasing out almost all discounted insurance premiums (for example, subsidized premiums). The extent to which its changes would have reduced NFIP's financial exposure is unclear since in 2014 the Homeowner Flood Insurance Affordability Act of 2014 was enacted, which reinstated some premium subsidies and slowed some premium rate increases that were included in the Biggert-Waters Act.

The maximum elevation above sea level in Florida is less than 400 feet (NOAA 2017). There are over 2 million flood insurance policies in effect in Florida, representing more than one-third of the approximate 5.6 million policies nationally (OIR 2016). Because of the relative importance of flood insurance in Florida, the state's response to the potential effects of the Biggert-Waters Act was negative and strongly so. Florida Insurance Commissioner, Kevin McCarty, issued a press release in spring of 2013 warning homeowners of the expected price increases that would be taking effect in fall of that year (OIR 2016). Florida Governor, Rick Scott, wrote an open letter to Florida's U.S. Senators Nelson and Rubio in the fall of 2013, urging them to resist the Biggert-Waters Act changes. Also in the fall of 2013, the Florida Office of Insurance Regulation (OIR) issued an informational memorandum to insurance companies interested in writing private flood insurance to serve as an alternative to the NFIP (OIR 2016). As of year-end 2016, there were five private insurers writing both primary and excess-of-NFIP insurance coverage, six offering

primary policies only, four offering excess policies only, and one writing surplus flood insurance to homeowners in the state of Florida (OIR 2016).

Risk Assessment

Given insurance market problems and public policy pressures that can arise in catastrophe-prone regions, along with the critical importance of information to a well-functioning insurance market, members of the insurance industry have been paying attention to changes in environmental factors and the science of climate change for years. Yet it remains a challenge to take concrete measures to address climate change. One reason is because the there is pressure to price for profitability each policy period (usually a year) insurers are under pressure to focus on what may happen in the short term than about the impacts of climate change that will likely occur over the long term. Nevertheless, insurers are increasingly asked by regulators and rating agencies to explain what they are doing to manage the risk of climate change (Climate Working Group 2012).

Traditionally, insurers relied on historical loss data to assess their property risks. As losses from atmospheric perils such as windstorms and flood grew in the 1980s and 1990s, however, insurers began to develop and use catastrophe loss models that are based on simulation analysis. These models take into account expert assumptions about present and future events as well as historic data. Catastrophe models can either be stochastic, randomly generating loss events based on data inputs, or deterministic, running loss event scenarios. Both types of catastrophe models can be utilized to inform insurers about the possible effects of the climate and weather patterns on insured losses. Concerns about climate change effects on loss expectations has increased the demand for quantification of risk and uncertainty and so has increased the demand for use of these models (Climate Working Group 2012).

Physical Risk Effects and Catastrophe Loss Models

Catastrophe loss models inherently reflect the climate since they are by definition models meant to represent reality. For example, flood models estimate storm surge losses based on today's sea levels, not those of 50 or 100 years ago. As the models are updated, they capture the most recent seasons of activity. So whatever impact a climate change has had to date is in essence already present in the models.

Estimation of losses is key to modeling for insurance purposes. Catastrophe models produce not only estimates of average annual losses, but also probable maximum loss (PML) and tail value at risk (TVaR). The modeled 100-year PML represents a 1% (1 in 100) chance losses will reach a particular value or greater, based on an exceedance probability curve (in turn based on thousands of simulated loss years). It is easy to forget, however, that the "or greater" part of the sentence is important; statistically, the probability that losses will be much greater is significant. Estimation of the TVaR becomes critical to understanding the risk profile of insurable events for

low-probability loss levels. The catastrophe TVaR, similar to value-at-risk measurements for other applications, estimates the average amount of loss expected above a critical loss level—in the catastrophe modeling, above the PML. These calculations are particularly critical to pricing reinsurance and ILS products.

All of Florida is exposed to hurricane events, so the markets require PML estimates that include the entire state as well specific books of business individual insurers may underwrite. Not surprisingly, Florida has the highest estimates of any state. Table 6.1 below indicates estimates of Florida PMLs for 2016, at 0.4%, 1%, and 2% probabilities.

Table 6.1. Probable Maximum Loss Estimates for the State of Florida Due to 2016 Hurricanes.

Return Period (in Years)	Critical Probability	Aggregate Gross PML (in Billions)
250	0.004	$80.6
100	0.01	$53.9
50	0.02	$36.0

Interpretation: A one-in-hundred loss year (associated with a one% probability) would produce estimated $53.9 billion or greater in gross loss to all Florida residential policyholders, including loss adjustment expenses. Source: State of Florida Financial Services Commission 2016b.

Table 6.1 indicates a 0.4% likelihood that insured residential policyholders in Florida would experience at least $80.6 billion in hurricane wind losses, given what the catastrophe model(s) utilized are assuming about climate effects to date. These modeled results are based on wind losses only since flood losses are primarily covered by the NFIP, not the private insurance market or Citizens. Even without further environmental changes that exacerbate loss events and losses, hurricanes clearly pose an enormous risk to the state. If considering hurricane-related flood and other categories of loss not related to hurricanes, the Florida PMLs are substantially higher. Future environmental changes would impact the estimates as well, although it is not yet clear precisely how, or by how much.

Climate-Sensitive Modeling

Several commercial loss modelers offer “climate conditioned” stochastic models and deterministic models that presume extreme disaster scenarios (Climate Working Group 2012). In order to develop scientific scenarios showing the long-term impacts from climate change, the potential paths for development of environmental changes must be fed into the models. A global community of scientists investigate the potential impacts of climate change on the frequency and intensity of natural disasters. For instance, the Fifth Assessment Report of the United Nations Intergovernmental Panel on Climate Change (IPCC) is the expectation that hydroclimatic intensity will be exacerbated by continuing climate change (Niehörster et. al. 2013). This means that regions that are already humid today will become even more humid, and areas that are dry today will become even drier (and in some cases warmer too). Such a trend can have a significant impact on agriculture and forestry and also increase the frequency of extreme hydroclimatic

events, such as long heatwaves and periods of drought.[5] More specific to catastrophe events, the frequency of hurricane activity in the Atlantic basin may stay constant, or even decrease, while storm intensity may increase. Climate model results for extratropical cyclones, or winter storms, show a similar pattern. Floods, on the other hand, may increase both in number and intensity (Niehörster et. al. 2013).

But there is significant uncertainty in understanding relationships between various climate signals and the frequency of occurrence of natural disasters, especially where regional-scale expectations are concerned. There is a wide scientific consensus that climate variability may increase, but the current climate is already highly variable—witness the 10-year absence of Florida hurricane landfalls. Because the natural climate variability is so large, detecting a clear signal due to climate change remains a challenge. Given all the natural fluctuations in the climate, it could take decades before establishing whether the frequency of extreme conditions is increasing. The main problem is the rarity of extreme events and a lack of data about them. That alone makes it difficult to assess the situation.

Two recent studies show the danger of jumping to conclusions in the short term about long-term climate effects. In these studies, researchers looked at hurricanes and tornadoes, in turn, and found that if the same number of housing units had been built at the time, then the then the amount of damage caused by storms actually would have decreased to today rather than increased. The first study discovered the most damaging single hurricane would have been the Great Miami hurricane of 1926, followed by Katrina in 2005, and two hurricanes in Galveston, Texas in 1900 and 1915 (Pielke et.al. 2008). The report did not find any trend in increasing intensity in hurricanes. The second study conducted an analysis of 56,457 tornadoes since 1950, and showed that if the same number of housing units had existed over the past six decades, there would be a decreasing trend in tornado loss damages between 1950 and today (Simmons et.al. 2013). These efforts to replicate past weather patterns and events yield results that counter the notion of increasing extreme events. But more such studies are needed. Once past weather patterns can be modeled consistently, they can then be used to more confidently forecast future patterns. For (re)insurers, a prudent approach is to use scenario testing (via deterministic event models) in addition to stochastic models to evaluate climate impacts.

Model Volatility and Technological Changes

Volatility in loss estimation, especially PML and TVaR estimation, has been a driver in the changing and updating of model assumptions as new data and scientifically validated approaches are discovered.[6] Catastrophe models increasingly emphasize their consideration of the inherent

[5] For instance, the IPCC indicates Florida and the Southeast U.S. are expected to experience lengthier heatwaves in the foreseeable future than in the past.

[6] The variability in modeled loss outcomes is a well-known challenge in the insurance markets. In fact, the State of Florida has a public commission, the Florida Commission on Hurricane Loss Projection

uncertainty in loss outcomes. This consideration is critical to capturing the true loss potential from an event and must address both primary and secondary uncertainty concerns. Primary uncertainty lies in the random event generation (i.e., the factors impact probability of an event), while secondary uncertainty lies in estimation of event intensity, damage and financial loss. Representing the full distribution of potential event outcomes reduces bias in loss estimates. For reinsurance and ILS instruments, model developments in this area are critical for events resulting in mean modeled losses that lie near the trigger point of a transaction. Credible consideration of the full range of potential loss outcomes from the event reduces the worst form secondary uncertainty can take—that the loss potential to the transaction would be underestimated (Guin 2016).

Today's catastrophe models can express model uncertainty both probabilistically (through expert assumptions and sophisticated simulation testing) and deterministically (through extensive "what if" scenario testing). Different models may achieve these tail values using different methodologies, and each methodology has drawbacks that contribute to model risk. Nevertheless, they provide important tools for gaining information about the tail and the tail risk profile.

Vast improvements in computing power and underlying risk information have resulted in considerable refinement of catastrophe loss modeling as well. Increased resolution, specification and online platforms have made the use of models faster and friendlier and the modeled outcomes increasingly informed. Also affording additional improvements in the modeling environment are the technologies that allow for real-time event and loss information as well as predictive analytics. High-performance computing has made many catastrophe modeling advances possible, particularly on the predictive analytics front. Predictive analytics are concerned with determining whether an event will occur as opposed to estimating losses over a specified time period. As a potential market disruptor, predictive analytics may also alter what is offered in the catastrophe finance market. For now, the technologies at a minimum improve the intelligence with which insurance operates in a volatile environment.

(Re)insurers can use updated information from the models for core business – risk selection and pricing – improvements as well as for better investment decisions. Risk selection, commonly referred to as underwriting, is the process of evaluating whatever is potentially insured (properties, businesses, people, etc.) for the perils to which they are exposed and the hazards to which they are susceptible (Rejda 2011).

The Special Case of Flood Risk Assessment

While private catastrophe risk modelers have been working diligently on the assessment of U.S. wind risk and other perils, they have been slower to develop models that assess flood risk. This

Methodology, which reviews the reasonableness of model assumptions and the modeling process of commercial models before they can be used in Florida to set residential property insurance rates.

relative slowness by commercial modelers to tackle flood risk assessment is attributable to at least two important factors, both of which are market driven. First, the fact that the NFIP has been the virtually exclusive insurer of U.S. flood risk for 50 years and so there has previously been little or no demand by private insurers for commercial risk modelers to spend resources to develop flood models. Second, the NFIP is already aided by the FEMA Risk Mapping, Assessment and Planning. FEMA identifies flood hazards, assesses flood risks, and partners with states and communities to provide accurate flood hazard and risk data to guide them to mitigation actions. FEMA flood hazard mapping is the basis of NFIP regulations and flood insurance requirements (FEMA 2017).

As FEMA and the NFIP struggle to update flood maps, the flood mapping process and flood insurance rates to more accurately reflect the risk, and as private insurers indicate interest in writing U.S. flood insurance coverage, commercial catastrophe risk modelers have increasingly begun to pursue the modeling of U.S. flood risk. An indication of the uptake in research and development by modelers in this area is the fact that three commercial modelers have invited the Florida Commission on Hurricane Loss Projection Methodology (Modeling Commission) professional team to review their flood modeling efforts on site in 2017 (SBA 2017). The Modeling Commission began to develop standards for acceptability of flood models in 2014.

Meanwhile, FEMA is simultaneously making strides to improve its flood risk assessment structure and processes. The Technical Mapping Advisory Council is a federal advisory committee established to review and make recommendations to FEMA on matters related to the national flood mapping program authorized under the Biggert-Waters Act. The Technical Mapping Advisory Council is charged with reviewing the national flood mapping process and making recommendations to FEMA regarding flood mapping as well as the "impacts of climate sciences and future conditions and how they may be incorporated into the mapping program" (FEMA 2016). In a June 2016 report issued by Technical Mapping Advisory Council, it is clear the group is prioritizing structural and process improvements in existing FEMA mapping, and then will focus more heavily on the potential for climate change effects on the maps.

Scientific researchers outside of the modeling industry and FEMA have been specifically looking at sea level rise as a contributor to past and future flooding. While such research does not directly attempt to tie the sea level rise directly to insured loss amounts, the (re)insurance industry can incorporate the estimates generated from this research into their internal financial models to estimate the potential impact of future flooding due to sea level rise.

Underwriting and Pricing Impacts

Underwriting is the first line of defense an insurer has to protect its profitability. Proper underwriting results in books of business that are not only insurable, but are pooled according to the risk each brings to the company. Thus, proper pricing of each risk pool of similarly-exposed

units, is contingent on proper underwriting as well as on the quality of information used directly for rate and premium calculations.

If insurers fail to respond to changes in the risks they have selected, negative externalities almost certainly occur. Two negative externalities are especially dangerous to profitability—moral hazard and adverse selection (Rejda 2011). Moral hazard occurs when those with insurance can influence the chance of loss by taking on more risk than they would in the absence of insurance. Adverse selection occurs when those at higher risk of loss are more likely to seek coverage, or seek more coverage, than those at a lower risk.

The insurance industry has a long history of modifying underwriting guidelines, tightening contract terms and parsing out classes of risk more granularly so as to accurately reflect expected losses whenever risk and/ or market conditions change unfavorably. If climate change is expected or observed to change the loss landscape, it is in insurers' best interests to respond with changes in the risk transfer landscape.

Multiple Lines of Insurance Impacted

Natural disasters can destroy homes, cars, businesses and crops, leading to an increase in the number and severity of property-casualty insurance claims in multiple lines of coverage—residential, commercial, auto, business interruption, crime and more. Environmental changes that lead to larger losses therefore impact multiple property-casualty insurance lines as well.

The potential issue of liability under law for the consequences of climate change has not been tested adequately but the risk is real. Attempts by individuals and groups of people to sue industrial groups have so far generally failed (Niehörster 2013). Thus far, there has been no case that has really tested whether and how liability claims based on the consequences of climate change would be settled. The insurance industry, however, follows trends in court decisions, and responds to case precedent with changes in their business decisions.

Furthermore, climate change is not just a property and liability issue. It also has potential ramifications for consumers' health. Poor air quality can lead to an increase in the number of people with asthma, which can also lead to an increase in health insurance claims.

Have insurers in some parts of the country stopped offering certain types of insurance coverage or limited the types of coverage they offer, based on sustained rises in their loss costs? Yes. And still more have charged higher insurance premiums that are often unaffordable for consumers (Kunreuther and Michel-Kerjan 2012). As a result, some consumers buy policies that do not provide as much coverage as they need, while others go without insurance. But to what extent are these market decisions based on climate change?

Effects on Underwriting, Terms, and Prices

Insurance is the only product in the world that is sold before the cost of producing the "goods" is known with certainty. Thus, insurers are inherently in the business of information. The better

the information, the better the business decision. In a marketplace of changing dynamics, insurers are confronted daily with new information and must cull it for credibility and reliability before incorporating it into business operations. And if good business were not enough reason to proceed cautiously, regulatory scrutiny over underwriting and pricing requires judicious treatment of information.

If insurers were to review the current scientific information for decision purposes, it would be difficult to respond confidentially from an underwriting and pricing standpoint. For instance, the IPCC relays information that could justify either increasing or decreasing increasing premiums. The IPCC has for years cautioned about an increase in heat waves, torrential rains and floods. According to a recent IPCC report, however, there may be fewer cold weather disasters and storms in the future in some places.[7]

It is currently difficult, given the current state of climate science and catastrophe models, to take the output of climate-sensitive models and apply them directly to insurance pricing. Direct application, however, is not necessary for capture of climate change information. Indeed, insurers do not need to take "climate change," per se, into account at all. If probable loss, frequency, and/ or severity are changing, they do not have to be labeled as climate changes for insurers to respond appropriately. Even times of heightened extreme weather activity do not change industry fundamentals: to assess the risk based on the current modeling assumptions and price it accordingly.

From an underwriting perspective, expect to see increasing granularity and fragmentation. Granularity is the extent to which insurers drill down within a risk pool to the individual exposure unit for purposes of deciding insurability and contract terms (Florida Catastrophic Storm Risk Management Center 2011). The more they drill down the more risk pools they create, and the smaller the pools get, all else the same. In the extreme, residential property insurers could drill down to a point where each house is its own risk pool. The problem with this is insurers would not be able to use the law of large numbers to accurately determine expected losses. Realistically, they can only get as granular as makes statistical and financial sense. Fragmentation is another way in which insurers can respond to changes in its risks, and/ or the marketplace. This refers to comparing risk pools holistically, according to risk as well as customer preferences, and providing different products, services and contract terms to different market segments, or fragments, based on multiple profitability factors (Swiss Re 2016).

The property insurance business in Florida is already underwritten, and priced, more granularly than in most other regions. The catastrophe loss models used by insurers all, to one degree or another, utilize global positioning satellite (GPS) data to precisely locate homes and businesses, and build vulnerability curves into the modeling process to incorporate information

[7] On the whole, it seems likely that insurance premiums for houses and buildings in flood-prone coastal regions will rise, based on current flood models. On the other hand, because of the complex impacts of climate change, risks (and premiums) may fall in other areas. There is evidence, for example, that snowmelt-driven springtime floods will become less frequent in the future.

about property improvements that are known to affect susceptibility to perils and hazards. Market fragmentation is occurring, too, albeit more at the reinsurance than primary insurance level. Primary insurers are limited by the Florida OIR as to how much they can incorporate differences in customer preferences into their underwriting and pricing algorithms. Reinsurers, not limited directly by the same rules, can utilize profitability analytics to fragment the insurance base to optimize expected underwriting profits and capital allocation decisions.

The insurance industry appears to be taking a watchful approach to environmental change. Reinsurers, who write policies that help insurance companies pay catastrophic claims, may not be anxious about short-term loss impacts of environmental changes since insurers and reinsurers can deal with that year to year by raising prices following catastrophic events. What they are likely more concerned about is that if risks become too big, they may become incalculable, and thus uninsurable. For instance, if sea levels continue to rise in some regions then properties, or even entire cities, on those affected coasts could become uninsurable at some point.

Underwriting and pricing are complicated for events that are low-frequency and catastrophic. A significant portion of the complexity is driven by political pressures. Regulators, legislators and other public policymakers are under tremendous pressure, particularly in the months that follow extreme loss events, to ensure insurance is both available and affordable for their constituents. Insurers do not make underwriting and pricing decisions in a vacuum; they must conform to the regulations and legislation to which their lines of business are subject. Regulators and legislators, in turn, desire a healthy insurance market. To the extent private insurers cannot provide sufficient insurance capacity profitably, policymakers are under pressure to utilize the state insurance entities at a minimum for insurance availability, and may also use them for insurance affordability (Medders et al. 2013).

In the state of Florida, if environmental changes produce more extreme loss events, Citizens' policyholder count will likely rise as private insurer profits get squeezed (at a time when Citizens would likely be facing large claims payouts itself). The FHCF will be under pressure to increase its capacity (and thus its financial liability). The adverse financial impacts on the state of Florida could be substantial.

State of Florida Financial Impacts

The ability of Florida's state-sponsored insurance entities (residual insurers)—Citizens, FHCF and FIGA—to pay losses is vital to the state's ability to respond adequately to weather disasters.

Due to the magnitude and volatility of catastrophic losses, it is virtually impossible to finance all of the potential losses in any single time period. This leaves two options: prefund all potential losses or utilize some form of post-loss funding. The state of Florida has chosen to finance a significant portion of its catastrophic risk exposure through post-loss assessments. In Florida,

these assessments are levied on most property-casualty insurance policyholders by the state's residual insurers (Florida Catastrophic Storm Risk Management Center 2011).

Citizens Financial Impacts and Policyholder Assessments

Citizens is smaller than it was five years ago due to multiple factors. A decade of no Florida-landfalling hurricanes and an influx of ILS capital combined to soften the Florida property reinsurance and primary insurance markets. Plus, a vigorous Citizens depopulation program intentionally reduced Citizens' market share.

Annually, Citizens reports its aggregate PMLs, potential assessments, and financing options to the state of Florida (Florida Financial Services Commission 2016a). Largely due to Citizens' reduced policyholder base, a 100-year (one% likelihood) or 50-year return period (two% likelihood) in 2016 would result in no financial shortfall. A 250-year return period (0.4% likelihood) would, however, result in an estimated shortfall, an amount in excess of $2.8 billion (Florida Financial Services Commission, 2016a).

Based on the 2016 estimated Citizens policyholder base and combining the effects on the Personal Lines Account, the Commercial Lines Account, and the Coastal Account, under a one-in-250-year loss scenario, there would be an estimated one-time Citizens policyholder surcharge of $136 million (15% surcharge) during the first year, an estimated one-time assessment of non-policyholders of $799 million (2%), and an estimated emergency assessment of nearly $1.9 billion, with estimated annual assessment of $122 million, representing a 0.3% assessment (Florida Financial Services Commission 2016a).[8]

The insurance impact of environmental changes in the short-term are inherently embedded as much as is practicable in these estimates. Long-term changes are not necessarily embedded in the modeling used to arrive at these numbers. Suffice to say if in the long-term catastrophic losses are substantially higher than estimated today, the effect on Citizens could be substantial. Higher losses, resulting in higher assessment potential over an almost-certainly-higher policyholder base are the likely results. Since assessments are subject to a maximum percentage, however, there is a limit to the direct financial impact on Citizens. What then the impact on the FHCF and FIGA?

FHCF Financial Impacts and Policyholder Assessments[9]

Once an FHCF-participating insurer's hurricane losses exceed its share of the aggregate industry retention (deductible), it triggers FHCF coverage.[10] The claims-paying resources of the FHCF

[8] These numbers assume annual assessment for 30 years using an interest rate of 5%.

[9] Discussion of the FHCF estimates is based on Financial Services Commission 2016b and the Florida Catastrophic Storm Risk Management Center.

[10] An insurer's FHCF reimbursement coverage is triggered after it meets its retention (the functional equivalent of a deductible). For the contract year that began on June 1, 2015 and ends on May 31, 2016, the aggregate retention for all participating insurers is $6.9 billion. Aggregate retention for the contract year beginning on June 1, 2016 is projected to be $7.0 billion.

include cash available from current and past accumulation of reimbursement premiums and investment income[11]; proceeds from pre-event financing and post-event debt; and risk transfer (reinsurance and ILS) recoverables.[12] Cash is used before any of the other claims-paying resources are used. Pre-event debt is repaid from FHCF investment income. In situations involving large losses that must be paid quickly the FHCF would likely attempt to use post-event bonds to finance its reimbursement payments to participating insurers based on the losses generated by the hurricane or hurricanes. As stated earlier in the chapter, these bonds would be repaid using emergency assessments.

Post-event debt is repaid from emergency assessments on most Florida property and casualty premiums of both admitted and non-admitted lines of business (the exceptions are workers' compensation, medical malpractice, accident and health, and federal flood insurance). Post-event resources could also include funds from assessments levied without the issuance of post-event debt. The maximum assessment percentage is 6% with respect to any one contract year's losses and 10% with respect to all contract years' losses combined. No such post-event debt is outstanding as of the date of this writing; there are currently no assessments.

Similar to Citizens, the FHCF reports annually its aggregate PMLs, potential assessments, and financing options. Table 6.2 shows the estimated annual assessment impact from various hurricane loss scenarios for 2016.

Table 6.2. Potential FHCF assessment impact of PML scenarios.

Return Time (in Years)	Potential Post-Event Bonding (in Millions)	Annual Assessment (in Millions)	Annual Assessment %
250	$3,146	$205	0.50%
100	$2,593	$169	0.41%
50	$429	$28	0.07%

Interpretation: Based on a one-in-100 loss year (associated with a 1% probability) would produce estimated $53.9 billion or greater in gross loss, the bond financing need is estimated at $3,146 in order to make insurer reimbursement payments. (Assumes annual assessment for 30 years using an interest rate of 5% and an assessment base of $40.9 million.) Source: State of Florida Financial Services Commission 2016b.

As with Citizens, if in the long-term catastrophic losses are substantially higher than estimated today, the FHCF would face additional financial pressures with limited claims-payment sources, thus likely placing a larger share of the financing burden ultimately on Florida policyholders. Although the FHCF has no statutory obligation to pay after its financial resources are exhausted, and thus insurers could be left without full reimbursement for their losses, it is not likely Florida policymakers would allow such an outcome. First, without reimbursement, many Florida property insurers would be unable to meet their claims liabilities and would face

[11] The FHCF is projected to collect $1.2 billion in reimbursement premium, net of expenses, mitigation and debt service, for the 2016-2017 contract year and the total projected cash balance as of December 31, 2016 is $13.8 billion.

[12] The FHCF purchased $1 billion of reinsurance for the first time ever for the 2015 season. No such risk transfer products are in place for the 2016 season.

bankruptcy. Second, although the primary purpose of Florida's third state-sponsored insurance entity, FIGA, is to pay claims in the event private insurers cannot, it is not intended or financially prepared to backstop the private insurance industry in the event of a disaster (or set of disasters) so large it impairs a large portion of the industry.

FIGA Financial Impacts and Policyholder Assessments[13]

FIGA does not accumulate funds in advance of an insurance company's insolvency. Therefore, when a company insolvency occurs, FIGA must obtain the funds it needs through pro-rata assessments levied by the Office of Insurance Regulation on insurance companies subject to assessment.[14] These insurers must then recoup the cost through their policyholders. Depending on the number and size of property insurance companies that become insolvent following future hurricane strikes (or other disasters) in Florida, FIGA may need to levy its own FIGA Regular Assessments and FIGA Emergency Assessments to meet its hurricane claims payment obligations under Florida law.

FIGA has three separate accounts (Section 631.55(2), Florida Statutes): (1) the automobile liability account; (2) the automobile physical damage account; and (3) the account for all other insurance required to be part of FIGA. Only insurers writing business in the lines of insurance included in the account in which the insolvent company was writing business can be assessed. The "all other" account is relevant since it includes the property insurance lines of business.

FIGA has three sources of income to pay claims other than through assessments: distributions from estates in receivership, recoveries from the FHCF and investment income. It can be assumed that in a worst-case weather loss year, FHCF recoveries may not be forthcoming and investment income may be negative. Clearly, FIGA operates in a cascading-effect environment with the other two state insurance entities. If they are under extreme financial pressure, FIGA, by its very definition is under financial pressure as well in attempting to pay claims.

This third leg of the state's residual insurance stool receives the least attention, at least publicly, for the financial risk it represents to insurance policyholder, state government and Florida taxpayers. Assessments are a quasi-tax on insurance policyholders. But there also exists the risk of direct taxation implications of extreme weather.

Florida Taxpayer Financial Impacts

The state of Florida total tax revenues were nearly $33 billion for 2012 (Unites States Census Bureau 2015). It is notable that at the state's current taxation level, state tax income would hardly be adequate to pay the gross losses of a one-in-50-year storm (or set of storms) in a single year,

[13] Discussion of FIGA impacts is based largely on review of FIGA 2016 and on the work of the Florida Catastrophic Storm Risk Management Center.

[14] Insurance companies may be required to pay these assessments in as little as 30 days.

which is estimated at $36 billion, according to FHCF figures (Financial Services Commission 2016b).

In a worst-case year, without any special consideration for climate-related losses, weather-related losses could leave the state in a financially awkward position. Without a "nuclear briefcase" (aka a financial plan for a worst-case situation), the state would be left with potentially few options. These involve a combination of maximum policyholder assessments along with issuing debt, necessitating the likely imposition of additional other taxes at a time when the taxpayer income base would be necessarily impaired already, due to the non-tax financial burdens resulting from the event(s).

Maximum assessments could increase policyholder premiums by up to 75%. Putting this into perspective, Florida homeowners already pay the highest homeowners insurance premiums, on average, in the nation, at over $1,100 per year (based on annually-updated data from the National Association of Insurance Commissioners). State of Florida workers today pay no state income tax. Arguably, Florida's growth and economic vitality have come to depend on the appeal of the zero individual income tax. The state would virtually be forced to tax the business and tourism base more heavily to make up the shortfall—a risky option. In some worst-worst case scenarios, Florida could face wide-scale population emigration, sustaining a heavy loss of its tax base.

Better for the state is to find ways to avert the possibility of such a crisis and/ or promote insurance industry efforts to do so. The balance of this chapter discusses insurance innovations and initiatives underway, designed in part to reduce the insurance risks of environmental changes.

NFIP Financial Impacts

Storm surge will be exacerbated by sea level rise, and the impacts of increases in storm surge will be felt long before the effects of static sea level rise in Florida (Florida Oceans and Coastal Council 2010). The estimates of climate change on Florida insurance markets and taxpayers provided above have not included flood at all, much less the potential increases in flood losses due to sea level rise. Flood loss estimates due to sea level rise have not been released by catastrophe modelers although we know modeler efforts are underway to build models that generate such estimates.

We must not forget Florida is the NFIP's largest coverage region, representing one-third of the program's insurance policies. Even if we set aside increases in tropical storm-related loss potential, the threat of sea level rise to Florida is sufficient to exacerbate the financial challenges the NFIP already faces. Based on NOAA's four global mean sea level rise scenarios—Low, Intermediate Low, Intermediate High and High—state, regional, county and municipal area planners can estimate the impact of sea level rise on a particular locality and its population (NOAA 2016). The Tampa Bay Climate Science Advisory Panel recently completed a study of these scenarios and concluded that the Tampa Bay region might experience sea level rise between 0.5 to 2.5 feet by 2050 (Hillsborough City-County Planning Commission 2016). This is

especially important information given pockets of the Hillsborough-Tampa Bay area would have been especially hard hit by the effects of Biggert-Waters on NFIP flood insurance rates (OIR 2016).

When considering the potential combined impact of the NFIP's existing financial distress, the changes in technical mapping taking place within FEMA and the potential for significant sea level rise within the next 20-50 years, it is difficult to imagine a financially healthy NFIP unless the program is entirely revamped, and frankly, is not available or affordable to all Florida property owners.

Mitigation and Risk Transfer Solutions

The insurance-reinsurance sector does not exactly have a reputation for innovation, but this does not mean insurers and reinsurers are not innovative. As discussed earlier in the chapter, insurers must proceed with caution to protect their financial solvency and their policyholders' exposures. Innovation must be well researched and vetted before (re)insurers move forward on significantly new or altered products or pricing techniques. But there are several risk transfer solutions underway that can help to mitigate catastrophe risk.

Closing the Protection Gap

Insurance penetration in Florida is high, both in raw terms and relative to most other regions in the world. The simplest insurance solution to reduce the relative risk faced by Florida is to close the insurance gap. Much of the world is underinsured, according to the world's leading reinsurers (Swiss Re 2015). Meanwhile, the U.S. is heavily insured, and Florida is the arguably the most heavily insured of all relative to its catastrophe potential (Swiss Re 2015; Kunreuther et.al. 2012). Fig. 6.1 indicates, for instance, 45% of North America catastrophe losses in 2013 were insured while only 5% of Asia's were insured. The percentages were even lower for South America and Africa, at 1% insured losses each.

Fortification, Building Standards, and Zoning

Insurability requires accidental, unforeseen losses and a feasible insurance price. If real estate development is unlimited and/ or building standards are lax, many property owners are not likely able to afford the premiums to insure their properties. Florida boasts among the best building codes in the U.S. and the world.[15] Although the state's record on fortification of existing building stock is spotty, it is a world leader in property fortification. The insurance sector supports responsible building and zoning through risk-based pricing.

[15] The Insurance Institute for Business and Home Safety (IBHS) reported in 2013 and 2015 their rankings of U.S. Gulf and Atlantic Coastal states by strength of building code and effectiveness of building code enforcement. According to IBHS, Florida ranked 1st in 2013 and 2nd (behind Virginia) in 2015.

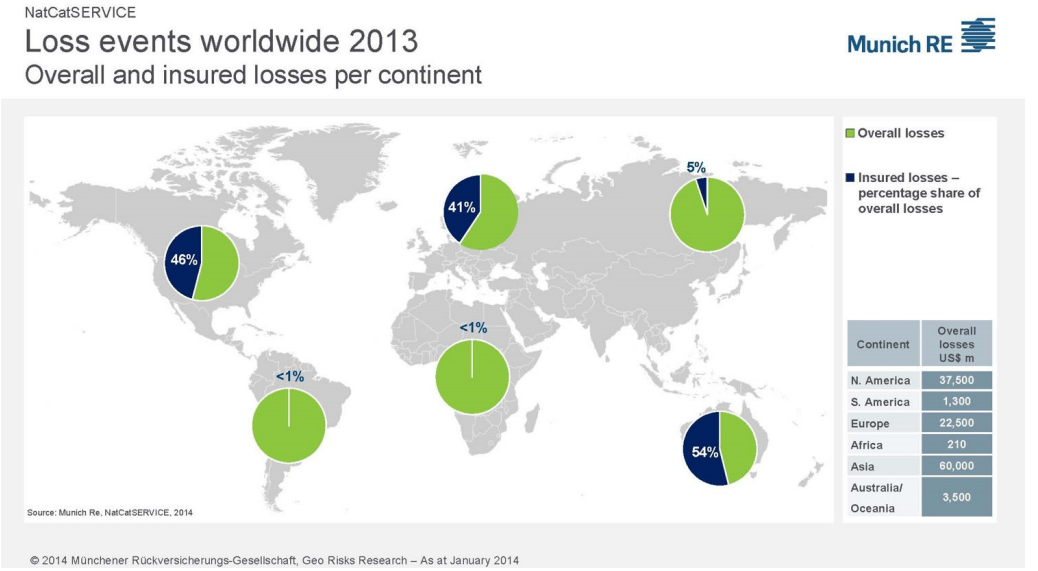

Figure 6.1. The best measures to close the gap address the root causes of underinsurance.

Mandatory Insurance Programs

In the U.S., including Florida, insurance is often mandated, either directly by statute or indirectly by lenders who require insurance in lieu of collateral for obtaining needed financing (Kunreuther et al. 2012). U.S. residential and commercial properties, if financed, must be insured, with few exceptions. Given Florida's high property and construction values, the state's asset base is a volatile insurance and reinsurance risk. Mandating insurance for properties in other regions would help to spread the risk.

Microinsurance

The property protection gap is exacerbated by poverty and lack of insurance availability in other regions of the world. Microinsurance can come in many forms, but is basically community-based insurance provided to individuals and businesses with such small financials they do not ordinarily meet the financial minimums for profitability (Swiss Re 2015).

Parametric Insurance

Insurance payout triggers and benefits that are based on parameter indexes, such as wind speeds, temperatures, or industry-level loss amounts. Because it does not require historical loss data or current loss measurement to determine claims payouts or premiums, index-based insurance has the advantage of simplicity over traditional indemnity-based insurance.

Other Innovative Reinsurance Solutions

(Re)insurance for Renewables

Insurance makes possible the growth in use of new economic developments, including new technologies, by providing protection against loss (Skipper and Kwon 2007). A challenge for insurers posed by new technologies is that there are no long-term statistics on loss experience, which is the most important factor for risk assessment. Thus, insurers closely monitor the development of new technologies so as to understand and assume new risks. In this way, insurers who are first movers make an important contribution to removing barriers to the use of new types of technology for investors and operators. Reinsurance companies are at the forefront of encouraging (or discouraging, in some cases) new renewables technologies, such as wind energy, hydroelectric, biofuel, and geothermal power. Besides this, insurers can provide further insurance solutions that help protect the environment, such as low-cost policies for climate-friendly vehicles.

Holistic Earnings and Capital Protection Covers

Insurers and corporations can efficiently combine multiple risks and/ or interdependent triggers so long as the joint costs of these is less than the sum of their separate costs. In so doing, overall costs of catastrophes to both the insured and the insurer are reduced.

Parametric Solutions

Discussed previously, these index-based insurance solutions can be used to enhance the insurability of any difficult-to-insure risk (London School of Economics and Political Science 2015; Swiss Re 2016).

Integrated Reinsurance and ILS Programs

When the sheer size of a risk is challenging, increasingly, panels of reinsurers combine their capital with alternative sources of capital (ILS) to fund upper layers of potential losses on a collaborative, integrated basis.

Retrospective Covers

These programs allow insurers to transfer the risk of liabilities from past underwriting years, and are especially helpful to insurers who face potentially significant but unknown long-tail losses and need to release capacity to underwrite new business.[16]

[16] Long-tail losses are any losses that tend to be slow to develop over time.

Industry Initiatives

In 2016, the World Economic Forum declared "failure of climate change mitigation and adaptation" as a top five global-level risk facing the world over the next 10 years, based on the collective judgment of 742 surveyed experts and decision makers drawn from business, academia, civil society, and the public sector (World Economic Forum 2016). Extreme weather events, water crises, food crises, and profound social instability round out the "top 5" list and can be linked directly to climate risks. The insurance industry and its regulators, as participators in the Forum's Global Risk Survey, clearly recognizes the gravity of climate change as a potential global economic game changer. Insurers have led initiatives like reducing greenhouse-gas emissions, increasing their use of renewable energy, and being more energy efficient.

(Re)insurance Industry Research Efforts

The insurance industry is aware of possible catastrophic ramifications of environmental changes. It responds to the risk potential by undertaking research initiatives, apart from its direct risk transfer innovations. Reinsurers, such as Munich Re, Renaissance Re and Swiss Re, have invested in human capital to aid in finding answers to the scientific questions and discover solutions. These companies are among the several that have hired in-house mathematicians, scientists and legal counsel to help problem solve new risks before the risks emerge as trends. Industry groups are active in the research as well. For instance, the Casualty Actuarial Society, Canadian Institute of Actuaries, Society of Actuaries, and the American Academy of Actuaries' Property/Casualty Extreme Events Committee have responded to climate risks by collaboratively commissioning committees to recommend, support, and perform research on climate change and assess the potential risk management implications for the insurance industry.

Regulatory Research Efforts

The FEMA, Technical Mapping Advisory Council, and NFIP research efforts were mentioned earlier in this chapter. It is incumbent upon regulators and policy makers to understand and respond to the threat of sea level rise and increased storm surge that may arise from climate change and result in greater flood losses. Recognizing the need to account for any potential effect climate-driven risks might have on the marketplace and the availability and affordability of insurance, state insurance regulators and other stakeholders are undertaking their own separate research efforts. The National Association of Insurance Commissioners (NAIC) has a working group on climate risk. The objectives of the group are to review risk management efforts by insurers regarding the effects of climate change and investigate the use of modeling by insurers and reinsurers regarding climate change impacts.

The NAIC adopted the Insurer Climate Risk Disclosure Survey (survey) in 2010. The survey is comprised of eight questions that assess insurer strategy and preparedness in the areas of investment, mitigation, financial solvency (risk management), emissions/carbon footprint and engaging consumers. The survey results provide trends, vulnerabilities and best practices related to insurers' response to climate change. Disclosure allows policymakers to gain an insight into needed public policy changes.

The NAIC also adopted revisions to the 2013 Financial Condition Examiners Handbook at the end of 2012. These revisions incorporated risk-focused examination questions that provide examiners with needed guidance on what questions to ask insurers regarding any potential impact of climate change on solvency. They were specifically designed to help examiners identify unmitigated risks and to provide a framework for them when examining such risks and their impact on how an insurer invests its assets and prices its products. The participating states for the latest reporting year include California, Connecticut, Minnesota, New Mexico, New York, and Washington.

Florida Mitigation and Adaptation

Given Florida's susceptibility to natural disasters from wind and water, it is wise for Florida to take the potential catastrophe threats of climate change seriously. Climate change mitigation and adaptation opportunities for Florida are covered thoroughly in another chapter. Nevertheless, it is worthwhile to address the issue here, even if only briefly.

Mitigation of potential losses via capacity restrictions on public insurance entities (e.g., Citizens and FHCF) is critical as is adaptation to loss patterns. There is also increasing pressure to harden shorelines and implement engineering strategies to protect structures and infrastructure from loss.

The Hillsborough City-County Planning Commission is an example of a local government effort to be informed about the potential risks and consider adaptation efforts that may reduce the financial (and other) impacts of sea level rise. The group's 2016 report points out the most at-risk areas as well as the at-risk populations with discussion about the need for infrastructure improvements and modifications to adapt to the looming threat. For instance, the report indicate more than 80 percent of the affected area is publicly owned and thus is both 1) critically important for the local government to address directly; and 2) within the local government's control to practice adaptation methods, such as coastal retreat, to reduce the future impact of sea level rise on the public budget.

The Florida Oceans and Coastal Council (2010) similarly has evaluated potential impacts of sea level rise on areas of Florida and has reported on opportunities for mitigation and adaptation. One example in this report is that almost 60% of the land along the U.S. Atlantic Coast that is one meter or less above sea level is expected to be developed, and less than 10% has been set aside for conservation. In addition to hardening shorelines and fortifying structures, a strategy of

coastal retreat from key high risk locales may be a wise course of action with catastrophe risk management as well as conservation benefits.

Conclusion

As this chapter has discussed, the potential for climate change as risk is real. Some of these risks are insurable today but may become uninsurable over the long term unless sufficiently mitigated. Low-frequency, high-severity events, within feasible financial limits, generally are considered the most ideally insurable, but insurability also presumes such events occur randomly. The non-randomness issue must be addressed before insurers and reinsurers can fully capitalize on related opportunities for the insurance industry and financial sector. Systemic environmental effects that could have implications must be evaluated for property, casualty and life insurance industry segments as well as for the capital markets.

While potentially risky consequences of changes in the climate exacerbate the baseline volatility of the financial sector, they also inherently create opportunities for insurers, reinsurers and other "investors in risk" to develop new products and services. Florida is a unique contributor to both the risk and opportunity since the state is the world's largest insured catastrophe region. The state of Florida itself is heavily leveraged as pseudo-insurer for much of the cost of its extreme weather exposure. Unlike private insurers, however, Florida's cost of bearing risk has no market opportunity offsets. Increased volatility in insurance, reinsurance and capital markets are all challenges for Florida, with potentially adverse collateral effects on residual insurance market pressures, policyholder assessments, and taxation. Insurance industry risk transfer solutions and research initiatives, are especially important to the state in balancing the need for reliant economic development with insurance availability and life safety.

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