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Chapter 6: Insurance industry

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Introduction

This chapter provides an overview of the private insurance industry's key role in developing flexible climate change adaptation pathways by transferring and mitigating risk. It also provides a discussion of climate change–related risk and adaptation from the standpoint of the property and casualty insurance industry, both in general and specific to New York City. This perspective, while not inclusive of all viewpoints, is pertinent to discussions of risk, particularly given the New York City Panel on Climate Change (NPCC)'s risk management approach to Flexible Adaptation Pathways. Insurance industry tools and risk experience, on the one hand, and the work of government adaptation planners and decision makers, on the other, can be mutually supportive.

6.1. Background

The insurance industry and climate change–related risks

The insurance industry is often referred to as the "canary in the coal mine" in discussions of climate change. Current research indicates that as climate change impacts become evident, both hurricane and nor'easter frequency and intensity will change (see Climate Risk Information (CRI), Appendix A). Any increase in the frequency or intensity of weather-related catastrophic events will increase insurance risk and directly affect property and casualty premiums. Thus, the insurance industry follows closely the scientific research on the likelihood of changes in frequency and intensity of these storms as a result of climate change.

Currently, a major driver of natural catastrophe losses globally is weather-related extreme events (Fig. 6.1), with large contributions from North Atlantic tropical cyclones and European winter storms. Together with sea level rise, these storms could result in significantly higher insured and economic losses in the future if, as is expected, climate change results in more intense storms that hit densely populated coastal areas.

Recently, climate-related events, such as extreme flooding in the United Kingdom, heat waves in France, and prolonged drought in the southwestern United States, have also caused concern among insurers. Projected future changes in the underlying climate system will also affect the life and health insurance industries, as changes in precipitation and temperature globally will shift the distribution of infectious diseases.

Many insurance companies recognize the scientific consensus that climate change is already occurring and anthropogenic activities, such as combustion of fossil fuels and tropical deforestation, are having a discernible influence on global climate. While it is not possible to attribute individual weather-related catastrophes, such as Hurricane Katrina, to anthropogenically induced climate change,

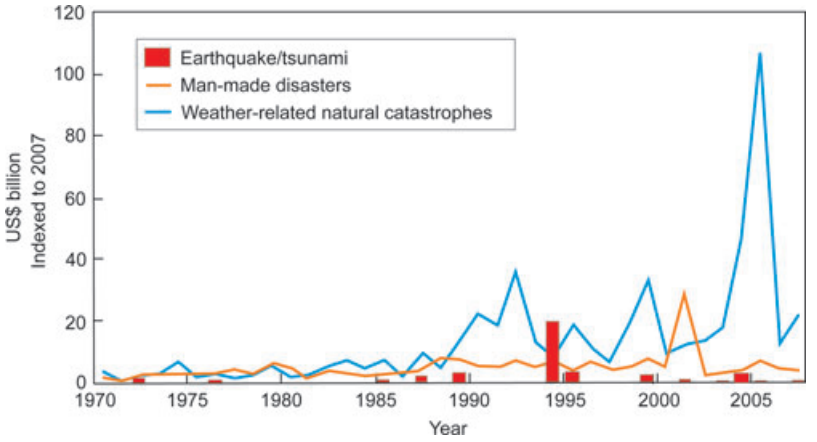

Figure 6.1. Insured global catastrophe losses, 1970–2007.
Source: Swiss Re Sigma 1/08.

the Intergovernmental Panel on Climate Change (IPCC) and other scientific assessments have identified relationships between climate change and changes in the frequency or severity of extreme events (IPCC, 2007).

For New York City, the primary near-term risk from weather-related disasters is coastal flooding from nor'easters, powerful coastal storms occurring during the autumn and winter months. Historical nor'easters have reached intensities comparable to category 1 or 2 hurricanes on the Saffir-Simpson scale. These extratropical cyclones bring hurricane-like conditions: strong winds, storm surge, and beach erosion. Significant damage to New York City and the surrounding metropolitan area has already occurred in the past. The nor'easter of December 1992 demonstrated the susceptibility of the New York City infrastructure to flooding and storm surge. Over $1 billion of damage occurred in New York City, the transit system of lower Manhattan was inundated, and the highest storm surge since modern record keeping was recorded at the Battery. In the future, storm surges from nor'easters and hurricanes will be exacerbated by already ongoing sea level rise.

Role of insurance in transferring and reducing risk

Insurance and reinsurance transfer risk from an individual policyholder or primary insurance provider to a larger risk-sharing community. The insurance company facilitates this transfer of risk among insured individuals in a way that attempts to be equitable and cost-effective for customers while maintaining solvency and shareholder value for the company. Premiums are set to represent an insured's contribution to the overall shared risk; therefore, to be equitable, those with greater risk should pay higher premiums than those who contribute less to the overall risk. The insurance industry studies risk in actuarial terms, meaning that the mathematical and statistical traits of each risk are carefully monitored. The risk absorbed by the insurance industry is reduced by basing the terms and conditions of insurance policies on actuarially derived premiums and deductibles or by limiting coverage based on risk. Furthermore, private insurance companies are not required by law to write in high-risk areas and will cease to offer coverage in an area deemed high risk.

On the basis of actuarial principles, a property at higher risk from weather-related events will pay more for insurance than a property located in an area or built with recognizably reduced exposure to weather-related risk. For example, properties located in designated flood plains or hurricane zones generally pay higher premiums than those elsewhere. Thus, increased weather-related risks will lead to higher rates, higher deductibles, and limited coverage, providing incentives for adaptation or risk reducing measures. The insurance company might stipulate measures that could be undertaken to reduce risks and associated premium costs, such as building retrofits, stricter new building codes, and location of structures. Furthermore, the risk

landscape will change, as coastlines shift due to sea level rise and the severity and frequency of individual hurricanes and extratropical cyclones fluctuates. As discussed in Chapter 3 and the CRI (Appendix A), climate hazards likely to increase include severe floods, intense precipitation events, and extreme heat. These changing climate hazards and their associated impacts will directly influence insurance risk and premiums.

As an integral part of underwriting, insurance companies factor in historical weather and climate patterns in insurance industry catastrophe models. These are computer models, which combine statistics, mathematics, physical science, and economics to assess the financial risk posed by wind, earthquake, flood, and other perils. Past patterns are the basis for assumptions made about the current probabilities of catastrophic events within these models, which use computer-assisted calculations to estimate the losses likely to be sustained by a portfolio of properties due to a catastrophic event.

Unique risks of climate change

Climate change poses a unique risk-related challenge. Because of the inertia of the climate system and long lifetimes of key greenhouse gases (GHGs), there are multidecadal lags in the climate system. (For a fuller discussion, see Chapter 3 of this volume.) These lags make it challenging to project the timing and magnitude of climate change impacts far into the future. Furthermore, future GHG emissions paths are difficult to predict, yet these emissions scenarios also have a major influence on the magnitude and timing of future climate change impacts. Thus, there is a timing mismatch between insurance policies that are generally written for 1 year (3 years at most) and climate change impacts that are projected with large uncertainty for decades in the future.

At this time, insurance companies do not have enough information to form a basis for raising premiums today to reserve for possible future increases in climate change–related risk. Insurance premiums will rise on a sustained basis only after impacts of increased GHGs are clearly in place.

In the meantime, valuable time that could be spent implementing adaptation measures may be lost. Therefore, to address this significant lag, local and/or federal governments have a role in promoting adaptation measures. They can do so through stricter building codes, land-use planning regulations, and strengthening of ecosystems in anticipation of future climate change impacts (see Chapter 5 and Climate Protection Levels (CPL) Appendix C).

Insurance executives often intone that climate change poses both risks and opportunities for the insurance industry—but the point bears repeating. Balancing the climate hazards discussed in this report are new business opportunities. The need to mitigate GHG emissions and create a "low carbon" economy leads to opportunities to provide new or expanded insurance and risk management products to help deploy technological solutions, such as renewable energy, low carbon fuels, carbon capture and storage (i.e., trapping and sequestering the GHGs from burning fossil fuels), energy efficiency, and sustainable land-use and forestry practices. These measures are relevant to a discussion of adaptation because they will reduce GHG emissions and thus contribute to lessening the potential scope of adaptation actions by helping to avoid the worst impacts of climate change in the long term. In addition, some of these mitigation measures, especially in the land-use and forestry sector, may also themselves contribute to climate change adaptation as well.

6.2 Importance of the insurance market in climate change adaptation

There are several ways in which the private insurance market can contribute to climate change adaptation. It can:

- Help maintain long-term insurability and provide incentives for adaptation through risk-based premium pricing;
- Use insurance risk-evaluation tools (e.g., catastrophe models) to help policy makers and adaptation planners better understand and assess the financial implications of climate change;
- Encourage or spearhead research aimed at focusing output from the global climate models to be more useful to insurance underwriters and adaptation planners;
- Support government adaptation efforts; and
- Provide educational information on climate change–related risks and increase awareness among customers.

Public sector insurance

To survive, insurance providers need to charge accurate, risk-based premiums so that property owners who build or own property in high-hazard areas will bear the costs of their actual risks. Whether private or public, insurance pools that underestimate risks or use subsidies to mask the true cost associated with risk are not sustainable, at least not from an insurance perspective. Public insurance options, such as those currently practiced in the United States, are not always actuarially sound. These underfunded state solutions promote up-front affordability, but they also encourage risky—and potentially expensive—economic activity.

There are several examples in the United States of government-run insurance pools that do not set premiums at an actuarially sound, risk-based level, thereby jeopardizing the long-term sustainability of the insurance coverage. Two of them are the State of Florida's Citizens Property Insurance Corporation and the National Flood Insurance Program (NFIP). Although the New York State shows no signs of initiating a state-run insurance pool, the case of Florida illustrates the challenges of maintaining a private insurance market in a shifting risk landscape.

In Florida, following 2005, the year of Hurricane Katrina and several other major hurricanes, catastrophe models and other analytical studies indicated that higher premiums were in order. However, Florida regulators, in the belief that they were promoting affordable insurance and fairness to owners of Florida coastal properties, set a cap on the premium rates that could be charged. Insurance companies, deciding that they could not be profitable at the prescribed rates, began pulling out of the market. The state government then relied on a state-funded plan to provide insurance for properties that private carriers would not cover.

The public plan, known as the Citizens Property Insurance Corporation (Citizens), is now the largest homeowners' insurance company in the state, with 1.3 million policies, many of which are located in areas at high risk of hurricanes. The state of Florida is presently $2.3 billion in debt, so paying out claims is likely to be difficult in the event of a major catastrophe, resulting in claims greater than what Citizens can pay out. The state is now weighing options, including raising the premiums on Citizens' property-holders by as much as 10% a year, to encourage policyholders to switch to private insurance carriers.

It appears that some of the Florida coastal property owners have been temporarily shielded from paying to insure for the true risks from major hurricanes.[1] Instead of discouraging development of vulnerable coastal areas, the insurance encourages development where the risk is highest. This situation has a considerable economic cost, not to mention threatening fiscal trouble for the state in the event of a large loss.

A second example where the government has affected the pricing of the private insurance market, and thus may be failing to signal to property owners the true cost of ownership, is the NFIP, which is in debt because of flood claims from the recent hurricanes. As of 2009, the NFIP was $19.2 billion in debt to the U.S. Treasury.

The NFIP has been in place since 1968 to provide flood insurance in locations where private insurance is not available and to decrease federal disaster relief outlays by offering flood insurance at reduced rates. For the first 37 years, the program paid out approximately $10 billion in claims, in total. However, in 2005, claims were $21 billion primarily due to Hurricanes Dennis, Katrina, Rita, and Wilma. Now, Congress is facing the task of reforming the NFIP to manage the debt and keep the program in tact. The concern is that even a restructured NFIP may continue to allow homeowners to purchase insurance at a price that does not include the full extent of flood risk, thus signaling the ongoing and increasing challenge of coastal land-use planning in high-risk flood zones.

Use of catastrophe models for climate change adaptation planning

Some of the standard insurance industry tools for risk evaluation can help climate change adaptation planners, particularly the industry's loss valuation, or catastrophe models. Currently, underwriters use catastrophe models as one of several tools to guide them in setting insurance premiums for the near term (e.g., the upcoming year); the models can also be used to estimate financial losses from projected future increases in frequency or severity of climate change–related catastrophes. Some modeling groups are already doing this.

What are catastrophe models?

Catastrophe models combine statistical and deterministic methods to estimate the economic losses for insured properties in a specific location from a variety of natural catastrophes. They use a wide range of information to generate potential losses from natural catastrophes (hurricanes, tornadoes, earthquakes, winter storms, and floods), and the probability of these losses occurring. The insurance industry uses catastrophe models as tools to assess the risks posed by natural catastrophes and to help determine insurance rates and coverage in specific locations for the next year.

Catastrophe models consist of four modules: event, hazard, vulnerability, and financial analysis.[2]

- The **Event Module** describes the occurrence of the extreme events and their locations. It is used to provide an accurate representation of the probability of occurrence of all events likely to cause damage at any given location;
- The **Hazard Module** incorporates the intensity of the events at each location;
- The **Vulnerability Module** calculates the damage at a given location for each event in the event module; and
- The **Financial Analysis Module** utilizes insured value and policy terms, such as deductibles, inurings, and limits and applies these to exposures at specific locations to calculate the insured loss for insurance company portfolios.

The event and hazard modules incorporate all the potential events and their magnitudes that might occur at each location. The input regarding the distribution of these events is based on historical data, such as the National Hurricane Center Best Track data, a 159-year archive of all tropical cyclone tracks in the North Atlantic.

The vulnerability module combines event and hazard module output with data on building quality, age, construction materials, building type, occupancy type, and other factors through the use of vulnerability functions—equations that prescribe the degree of damage associated with the event parameters. This module assesses how badly each location is damaged in an event. Vulnerability curves are developed through a combination of engineering modeling, observed building behavior in actual historical events, and experimental observations, such as wind tunnel experiments.

The financial module combines the damage generated by the vulnerability module with the coverage terms of the insured locations to calculate total and insured losses for insurance companies. Calculated losses are mostly property losses but also include business interruption and building contents.

The final output of a catastrophe model is the Loss Frequency Curve (LFC), which summarizes the loss potential. The reliability of the LFCs depends on the reliability of the individual modules and their interrelationships. The expected occurrence of hazards included in catastrophe models is based on the premise that an adequate statistical profile of catastrophic events can be derived from historical data, and that the near-future behavior of these events can be estimated from these data. Since statistically significant climate change impacts related to disaster frequencies are, for the most part, not discernible in recent data, trends related to climate change are weak at best in most current catastrophe models.

How can catastrophe models help adaptation planners, and what are their limitations?

The insurance industry's models can be adapted to assess potential losses from natural catastrophes in the future when climate change impacts become more evident. For example, the frequency and intensity of hurricanes, rain storms, floods, and winter storms in catastrophe models can be increased, under specific assumptions, to simulate climate change forecasts; possible economic losses based on these forecasts can then be calculated. The economic losses can be based on current data or on estimates of the future value and characteristics of properties in specific areas. Using current property value and characteristics data to project the impacts of future climate change losses provides a valuation benchmark based on today's property characteristics and valuations. However, these current financial values and physical vulnerabilities will almost certainly change with time.

The benefit of catastrophe models lies in providing a basis and an approach for evaluating what future losses might be, on the basis of certain assumptions about climate change impacts. They can give policy makers a chance to consider "what if"

scenarios, which can be useful for adaptation planning purposes. However, given the typically high degree of uncertainty in timing and extent of the future climate change impacts, it is difficult to use the loss valuation results based on future climate change scenarios to make concrete adaptation investments without having better guidance on the probability and timing of these scenarios.

What is required from global climate models?

Changes in the fundamental climate state can potentially result in historical data becoming obsolete and not representative of current atmospheric and oceanic patterns. Therefore, insurers and vendor companies might become increasingly reliant on global climate models to develop realistic and relevant hazard sets for catastrophe models. Global climate models, as described in Chapter 3, directly incorporate fluid dynamics, thermodynamics, and atmospheric physics to provide long-term projections of the average climate conditions, such as surface air temperature, sea surface temperature, sea-ice extent, and precipitation distribution. The output of the climate models consists of forecasts of climate parameters, such as average land and sea surface temperatures and precipitation. These are long-term means for the coming decades and are usually spatial averages covering large geographic areas.

While improving in resolution, current climate models are too coarse to simulate the subgrid scale processes that drive some extreme events, such as the severe storms and flooding, that are needed for the insurance industry catastrophe models. Some of the uncertainty in global climate models is related to lack of understanding of basic scientific relationships, such as the dynamics of melting of land ice sheets. Research, to better understand such processes, is warranted.

The climate model forecasts also come with large uncertainties associated with underlying assumptions, including future GHG emissions pathways, economic trends, and political developments in regard to global action on climate change mitigation.

Given the current lack of near-term (1- to 3-year) forecasts, dearth of geographic detail due to coarse resolution, and large associated uncertainties, the climate models need to be improved so as to be more useful for the insurance industry in their future underwriting activities and for adaptation planning in general.

As climate models improve and their resolution increases, nearer-term forecasts for smaller geographic regions with reduced uncertainty may be possible, which will assist insurance underwritings as well as adaptation planning. There is presently an intense international focus on climate model improvement, which will help to increase the usefulness of climate model results for underwriters and adaptation planners.

Role of government

Public–private cooperation is important for a comprehensive plan of climate change adaptation. There are several ways in which local, state, and federal governments can play a role in supporting the private insurance market and the public good. State regulators can support long-term insurability of property by working with the insurance industry to maintain a private insurance market with risk-based premiums.

Government at local, state, or federal levels could mandate adaptation measures, such as stricter construction standards (new or retrofit) for buildings and infrastructure; include climate change risk in land-use planning through zoning restrictions and other measures; strengthen or restore ecosystems; and implement other adaptation initiatives in high-risk areas, even before the full price signals that will come from private insurance are evident. All of this can contribute to Flexible Adaptation Pathways. Since these measures can reduce climate related risks, they can help maintain insurability and contribute to lower private insurance premiums. In both the near and long term, government financial help, if required, might take the form of financial aid to subsidize low-income home owners that require retrofits or other adaptation measures.

The public sector can also support the adaptation process by helping to determine the level and types of protection needed for current and anticipated climate change risk, by funding global observation and data collection systems, such as National Oceanic and Atmospheric Administration (NOAA)'s ocean observation network as well as regional and local monitoring programs and by contributing to advances in global climate models. This research can lead to better understanding of the key scientific

processes that affect forecasts of climate change and associated impacts. The private sector could work with governments at all levels and provide information regarding its data priorities and needs that would benefit all stakeholders.

In addition, the government at all levels could develop public education programs to increase awareness of and provide protection from increased risk of natural weather-related catastrophes.

6.3 Scope of risk and other considerations in the New York City area

While commercial, residential, and private industrial property are not within the scope of the NYC Climate Change Adaptation Task Force, understanding the scope of climate change impacts on all properties in the New York City metropolitan area is important since the privately insured parties who own and manage these assets contribute to the New York City tax base and rely directly on the city's infrastructure.

Catastrophic losses include not only property damage, but also losses from business interruption following a catastrophic event. For example, almost half (45%) of the insured losses from Hurricane Katrina resulted from business interruption following the disaster, while 55% of the losses were related to property damage (Olsen *et al*., 2009). Thus, understanding the full scope of risk in the New York City metropolitan area is key to providing needed information for the city's adaptation planning.

Exposure in the New York City metro area

While the primary near-term risk for New York City is storm surge from intense nor'easters, which will be exacerbated by sea level rise, the city is also susceptible to hurricanes. The Insurance Information Institute estimates that if a storm as strong as the "Long Island Express," the Category 3 hurricane that made landfall in Long Island in September 1938, arrived today and struck approximately 50 miles to the west in downtown New York City and northern New Jersey, insured property losses could be as high as $110 billion. This would be close to three times the insured losses caused by Hurricane Katrina. The future loss potential could continue to grow because of further development in the city. Losses to the total economy could exceed $200 billion, resulting from secondary impacts, such as business interruption loss.[3]

Table 6.1. Insured natural catastrophe estimates in New York—2009 as-if losses

Storm	2009 Estimate
Hurricane Gloria 1985	$885 million
Hurricane Bob 1991	$400 million
December 1992 nor'easter	$715 million
March 1993 Superstorm	$320 million
Blizzard of 1996	$175 million
President's Day Storm 2003	$27 million

Source: ISO/PCS; AIR Worldwide, RMS, Eqecat; Insurance Information Institute inflation adjustments.

Fortunately, the New York metropolitan area has been spared a direct hit from a hurricane comparable to the Long Island Express since 1938. However, to quote the former director of the National Hurricane Center, Max Mayfield, in his 2006 testimony before a Senate subcommittee[4]: "It is not a question of *if* a major hurricane will strike the New York area, but *when*." The possibility of a direct hurricane strike is a very real one; damage totals in the region from Hurricane Gloria (1985) and Hurricane Bob (1991) were less significant owing to their landfall timing. Both hurricanes came ashore during low astronomical tides, resulting in smaller storm surges.

The absence of industry insurance record keeping prior to 1950 prevents a more precise estimation of the loss occurring from a storm the size and intensity of the Long Island Express if it were to occur today. However, it is possible to estimate what the industry losses from past events occurring in 1950 and onward would be today after accounting for population growth, inflation, changes in wealth, and insurance penetration. Property Claims Services, a branch of the Insurance Service Office in Jersey City, NJ, maintains a database of United States catastrophic-insured losses by state and type. The database is maintained in U.S. dollars of the year of occurrence. By applying the techniques of Collins and Lowe (2001) and Pielke *et al*. (2008), which take into account the aforementioned variables, the estimated ("as-if") present cost of repeats of historical hurricanes and nor'easters are calculated. Some notable extreme events are listed in Table 6.1.

While the numbers above do not compare to the insured losses generated by Hurricane Katrina, all

losses exceed $20 million, and most of them are in excess of $300 million. This is representative only of insured losses; typically, economic losses are at least twice the insured losses. Therefore, the occurrence today of at least three of the events listed above (Hurricane Gloria and Bob and the December '92 nor'easter) could result in economic losses in excess of $1 billion in the New York metropolitan area.

Given expected climate change impacts and growth projections, the loss potential in New York City is even higher than adjusted historical data might indicate. A recent Organisation for Economic Co-operation and Development (OECD) report gives a sense of how much is at stake. Among 136 port cities around the world, New York is among the top 10 in terms of population exposed to coastal flooding, and second only to Miami in terms of assets exposed to coastal flooding.[7] One estimate of sea level rise during the 21st century finds that approximately 2,000,000 people in about 740,000 households would be affected for a moderate increase in sea level in greater New York City.[8] Furthermore, some 272,000 buildings, 461 miles of major highways, 88 emergency service facilities, and 80 healthcare facilities would also be impacted under this scenario. Under a more extreme, business-as-usual emissions scenario, the population in New York threatened by sea level rise doubles.[9] Furthermore, the asset value exposed to sea level rise increases nearly seven times, from $320 billion USD to $2.5 trillion USD. Risk associated with coastal flooding because of sea level rise is not the only aspect focused on in the OECD report; the impact of hurricanes and nor'easters are considered as well. A simple normalized wind damage index is calculated on the basis of population and asset value, and currently, New York is second only to Toyko in its present day wind damage potential rating.

In 2007, the total value of privately insured coastal properties in New York State, all of which are located in New York City and Long Island, was more than $2.3 trillion. This represents 62% of the value of all privately insured properties in New York State. This is an estimate of the cost to replace structures and their contents, including additional living expenses and business interruption coverage, for all residential and commercial property in the state that is insured.[10]

While these figures may seem large, they do not include the uninsured property in New York City, including some of the critical city infrastructure. The Port Authority of NY/NJ, the MTA, and the New York State Thruway Authority (which manages the Tappan Zee Bridge) do carry some insurance provided by private insurance companies. However, the value and replacement cost of New York City infrastructure is unknown, owing to its highly complex nature and uniqueness. Therefore, traditional underwriting practices are difficult to apply, and the coverage is not necessarily sufficient to cover the full cost or even a major part of the cost to replace the infrastructure, cover potential damages, or cover all the indirect costs, such as the cost of lost business. Consequently, the vast majority becomes "self-insured" by the city. Furthermore, much of the infrastructure insurance provided by private insurers includes large "self-insured retention" levels, meaning that the property owner (the city in many cases) is responsible for paying out a large amount upfront if there is damage to a piece of infrastructure, before private insurance applies.

While much of the city infrastructure is uninsured or potentially uninsurable by the private sector, the businesses and residents that pay taxes are insured through ordinary private insurance policies. New York City adaptation efforts will need to consider properties owned by the taxpayer base as well as those related to the city's critical infrastructure. Communication, commuting, and utilities are important to the city's economic structure, as are the residences and businesses providing the tax revenue.

In addition to adaptation for the critical infrastructure, citywide strategies to protect private property can be initiated, including revisions to building and zoning laws for new construction, renovations, and retrofits.

How the private insurance industry can assist New York City's flexible adaptation plans

As previously discussed, there are several ways in which the insurance industry can help with climate change adaptation. These are:

- Help maintain long-term insurability and provide incentives for adaptation through risk-based premium pricing;
- Use insurance risk-evaluation tools (catastrophe models) to help policy makers and adaptation planners better understand and assess the financial implications of climate change;
- Encourage or spearhead research aimed at improving global climate model results to be more

useful to insurance underwriters and adaptation planners;
- Support government adaptation efforts; and
- Provide educational information on climate change–related risks and increase awareness on the topic among customers.

Specifically for New York City, while much of the value of infrastructure is self-insured, many taxpayers who own and operate commercial buildings and live in the area turn to the private insurance market. Damages to real property as well as business interruption losses of these insured properties will affect the city's tax revenues and infrastructure. Adaptation measures for these properties can be included in the New York City climate change planning, and the private insurance market has a role to play in providing risk management policies for these commercial, industrial, and residential owners.

The insurance industry can provide insights into the expected economic losses that the city infrastructure will potentially suffer under different climate change scenarios. The output of catastrophe models includes loss estimates for a market portfolio, a collection of insured properties that is representative of the risks, and exposures in the New York City area. A market portfolio of current New York City estimated infrastructure values can be used as inputs to catastrophe models to calculate the estimated economic losses for future climate change scenarios.

The insurance industry can aid the adaptation planning process of New York City by providing additional information based on its own analysis. Furthermore, the industry can support regulations that reduce weather-related risks, such as changing zoning requirements, enhancing building codes, and protecting natural ecosystems. The benefits of regulatory changes will be immediate; weather-related risks today will be reduced, stabilizing or decreasing insurance premiums.

6.4 Research on climate change, underwriting, and adaptation planning

Research undertaken by the insurance industry

Led by the European insurance and reinsurance[11] companies, many regions covered by the global insurance industry, including Europe, North America, and parts of Asia, have been aware of the significance of climate change for some time and have funded or engaged in a significant amount of related research.

Along with Lloyd's, AIG was a lead funder and an organizer of a series of two Catastrophe Modeling Forums convened by the Center for Health and the Global Environment at Harvard Medical School and the Insurance Information Institute (I.I.I.) in October 2007. Additional funding was provided by ACE, Allstate, Guy Carpenter, Travelers, and MunichRe America. The forums brought together leading meteorologists, catastrophe modelers, and representatives of insurance, reinsurance, and brokerage companies to discuss how to approach incorporating climate change risk in the catastrophe modeling process. A summary report on the two forums, along with papers and slide presentations, can be found on the I.I.I. website at http://www.iii.org/cmf/.

Swiss Re has produced several reports related to climate change risks including:

- "Climate Change Futures: Health, Ecological and Economic Dimensions" http://www.climatechangefutures.org/pdf/CCF_Report_Final_10.27.pdf;
- "Climate Change Risks and Opportunities" http://www.swissre.com/resources/c981a000462ff1898450d4300190b89f-Klimaaenderung_en.pdf; and
- Several brochures related to increased risks of natural catastrophes, one of which on "Natural Catastrophes and Re-insurance" http://www.swissre.com/resources/15a16b80462fc16c83aed3300190b89f-Nat_Cat_en.pdf.

Global trade and business could see a dramatic impact from climate change according to the report:

> "*Climate Change and Security: Risks and Opportunities for Business*," issued jointly by Lloyd's and the International Institute for Strategic Studies in 2009 http://www.lloyds.com/NR/rdonlyres/0C6F0662-5B98-49E1-A2242D3E830947B6/0/Climatechangeandsecurity_200904.pdf.

AIG and Travelers contributed financial support and, along with several other insurance companies, participated in the Resil-ient Coasts project of the H. John Heinz III Center for Science, Economics, and the Environment, resulting in a set of principles to guide coastal community resilience and climate

change adaptation in light of more intense hurricanes and other weather related disasters:

http://www.heinzctr.org/publications/PDF/Resilient_Coasts_Blueprint_Final.pdf.

Willis Research Network recently sponsored an Insurers' Summit at Princeton University on major hurricanes in the Northeast, which featured discussions and presentation on climate change risks. It was attended by almost 300 scientists, academics, and insurance professionals from around the world. Presentations and the agenda from the summit can be found at:

http://www.willisresearchnetwork.com/Lists/Publications/DispForm.aspx?ID=51.

Other major insurers, reinsurers, and vendor companies, such as Lloyds, Munich Re, RMS, Zurich, AIR, and EQECat, have also published climate change–related research. A compendium of articles and research papers covering the insurance industry's climate change activities can be found in "From Risk to Opportunity 2008: Insurers Responses to Climate Change," a report commissioned by Ceres and authored by Evan Mills, PhD. This report can be found at www.ceres.org/Document.Doc?id=417.

Further research and data collection required

In some cases, adaptation strategies will require investments to reduce vulnerabilities and manage risk. Rigorous assessments of adaptation strategies are needed to support funding for these investments. Coastal climate change risk results in part from past, current, and future choices about commercial and residential development in shoreline areas. Calculation of future risks is uncertain due to the inherent uncertainty associated with the onset and impact of climate change. This makes effective adaptation planning challenging and emphasizes the need for development of Flexible Adaptation Pathways. Better quantification of future climate change requires advancing scientific understanding and developing the methodologies necessary to refine climate model forecasts and to make them more useful for adaptation and insurance underwriting. This has been identified as a priority in the last two IPCC Assessment Reports (IPCC, 2001, 2007) and is currently the subject of extensive study.

Over time, global climate models will become more skillful in the projection of regional climate and extreme events. This effort is already underway through a recently initiated Climate Prediction Project. The project arose out of a world-modeling summit held by the World Climate Research Programme to develop a strategy to revolutionize prediction of climate to address global climate change, particularly at regional scales.[12] The Bulletin of the American Meteorological Society recently published a paper outlining efforts to advance global climate models, data collection efforts, and other research needed to help adaptation planning.[13]

Improving scientific understanding of physical relationships and methodologies to reduce uncertainty would prove of great help to the insurance industry. As described in Chapter 3, current estimates of sea level rise, for example, have uncertainties both in terms of timing and extent, creating risks associated with making costly and time-sensitive investments on these forecasts. These uncertainties may delay implementation of adaptation plans or lead planners to address only the higher-probability, lower-impact scenarios. Consequently in the case of sea level rise, as one example, the relationship between rising temperatures and ice-sheet melting needs to be better understood.

Increased funding at the national level to enhance observational data collection, from both remote and *in situ* sources, is important to improve data quality. Also important is identifying areas where physical relationships are not adequately understood or monitored over the temporal and spatial scales required for climate forecasts. The Tropical Ocean-Global Atmosphere (TOGA) program is an excellent example of this. Numerous monitoring devices were deployed by NASA in the early 1980s, and the oceanic data this monitoring network provide have been invaluable in increasing the understanding of basic oceanic processes and characteristics. As programs like TOGA are developed and implemented, the number of observations will increase, along with the understanding of climate change needed for the insurance industry. Indicators and monitoring specifically needed for the New York City region are described in Chapter 7.

Tools that can help translate expected climate change into localized impacts on the built and natural environment are also needed. Current flood, shoreline, and inundation maps, used for

land-use and infrastructure planning and mortgage due diligence, do not accurately reflect current risks, let alone future risks, posing significant challenges for adaptation. In the case of sea level rise, the development and dissemination of high-definition, digital flood and coastal maps, based on assessment of data from LIDAR[14] surveys and other data-gathering techniques, are essential. These maps could be created to include a variety of scenarios for potential future sea level increases.

Other research topics include:

- Understanding correlations across hazards (for example, between heat waves and drought);
- Developing a coordinated and comprehensive catalog of storms;
- Projecting shorter-term (<10 years) climate change risk; and
- Producing Monte Carlo simulations of physically based models of tropical cyclones (TCs), from "birth-to-death," generated for thousands of years of synthetic TCs.

Funding of this research at the national level is a top priority, as it is a critical step in implementing risk reduction strategies. Additionally, attempts to address nearer-term risks need to be designed to be adapted as our understanding of climate change impacts improves. This is fundamental to the concept of Flexible Adaptation Pathways.

6.5 Reducing greenhouse gas emissions: new opportunities for the insurance industry

While climate trends create underwriting challenges, they also present a unique set of business opportunities. Consumers and businesses globally are responding—either voluntarily or under obligation—to the need to reduce GHG emissions, and insurance companies are offering products and services to help their clients achieve lower emission targets. These products and services support reductions in GHG emissions, thereby ultimately contributing to long-term climate change mitigation (see Chapter 2, Risk management).

The importance of reducing GHG emissions now and as quickly as possible cannot be underestimated as a way to support effective adaptation efforts. At the end of the century under a business-as-usual emissions scenario of 1.5% growth per annum in CO_2 emissions, the concentration of CO_2 in the atmosphere is projected to reach 750 parts per million (ppm). This can be contrasted with an emissions scenario designed to achieve a stabilization of 450 ppm concentration of CO_2 in 2100. The difference in adaptation measures required to protect life and property in a 750 ppm CO_2 world versus a 450 ppm CO_2 world is clearly significant and is a function of emissions levels over the course of the century. The insurance industry is in a position to help the world transition to a lower carbon economy and thus support a reduction in adaptation measures that would be required in a world with a higher GHG emissions path.

Ceres, a national network of investors, environmental organizations, and other public interest groups working to address sustainability issues, such as climate change, publishes an annual report[15] outlining the climate change mitigation-related products and services launched by the insurance industry. The 2008 report has 50% more such products and services than the 2007 report, which itself showed a tremendous increase over 2006. Products include insurance coverage for green buildings, renewable energy, carbon capture and storage, and carbon trading. While most of the innovations are in Europe, where GHG emissions are already regulated, the report shows a significant increase in the number of U.S. firms introducing climate change mitigation-related products.

Some of the most common climate change mitigation-related insurance products, and those that have been on the market a number of years, include: products tailored to the renewable energy markets providing insurance and risk management for all aspects of renewable energy deployment from construction to delivery, insurance for "green" buildings (e.g., insurance specifically tailored for green buildings or to encourage property owners to upgrade to green building specifications in the event of a loss) and pay-as-you-drive insurance that provides a financial incentive for driving less.

Innovative insurance companies are now beginning to offer products that have been discussed for many years but have not been available until recently, such as director, officer and professional liability products to protect officers and board members against climate change litigation, products that address the risks specific to carbon capture and

storage and products to insure the deployment and operation of electric vehicles.

Insurance companies are also investing in businesses that are developing and offering low- and no-carbon technologies and driving improvements in climate science that will help governments better understand and prepare for future risks. Furthermore, an increasing number of insurance companies are getting involved in the carbon markets, both in carbon trading, in offering insurance to protect buyers of carbon credits against seller insolvency, and carbon credit delivery insurance, for both the purchaser and supplier of credits. There are also products that bundle carbon credits along with the coverage, such as carbon neutral auto policies.

Many of these products and services will lead to reductions in GHG emissions, ultimately contributing to long-term climate change mitigation and reduced adaptation requirements. Most of them are designed to help clients adjust to living in a carbon-constrained world.

6.6 Conclusions and recommendations

Among other industries, the insurance industry has a unique stake in the issue of climate change because increased climate change–related risk in the future will change its underwriting practices, possibly causing premiums to rise and limiting the insurability of properties.

Historically, the private insurance industry with risk-based pricing of premiums has helped spur risk reduction measures through financial incentives (e.g., insurance premiums that are lower and coverage that is more complete if there is less risk associated with a particular property).

However, because of lags in the climate system and the long-term nature of the climate change, the impacts of the buildup of GHGs are either not felt immediately or are experienced at low levels, but are projected to become evident and more acute in the future. Thus, future climate change impacts built into the climate system are only partially present today, and it is not yet feasible to reflect these impacts in the current pricing of insurance premiums.

The state and local governments can help by working with the insurance industry to maintain a private insurance market while supporting both near-term and long-term insurability through mandating risk mitigation measures sooner rather than later, such as stricter building codes, more restrictive zoning regulation and protection, and restoration of critical coastal and other ecosystems, that can help protect properties from future catastrophic events.

Government can help by funding improvements in data collection, for example collection of data on changes in ocean temperatures and acidity, and contributing to improvements in global climate models and basic research to better understand physical relationships that will lessen the uncertainty in the climate models. To help adaptation planners and insurance industry underwriters, climate modelers can focus on producing estimates of climate change impacts with shorter time frames and on smaller geographical scales and on conducting research to better understand some of the critical physical impacts of increased atmospheric and ocean temperatures, such as the potential for rapid breakup of the polar ice sheets.

Insurance industry risk assessment tools, catastrophe models, can be adapted to help the city of New York assess likely economic costs of catastrophic events under various future climate change scenarios.

Tools that can help translate expected climate change into localizesd impacts on the built and natural environment are also needed. The development and dissemination of high-definition, digital flood, and coastal maps are high priorities. These maps could be created to include a variety of scenarios for potential future sea level increases.

In addition, the insurance industry can foster deployment of new technologies to reduce greenhouse emissions and support the emerging carbon market as part of core business offerings. These products and services will lead to a reduction in GHG emissions, ultimately contributing to long-term risk reduction and alleviating the need for the most drastic adaptation measures.

Examples of potential insurance measures related to adaptation

New York City and New York State governments

- Enact stricter building codes, land-use planning regulations, and strengthening of ecosystems;

- Work with the insurance industry to maintain a private insurance market with risk-based premiums;
- Where appropriate, provide financial aid to subsidize low-income homeowners for retrofits and other adaptation measures; and
- Develop public education programs to increase awareness of climate change risks, establish climate change adaptation plans to protect public infrastructure, and assess the need for common adaptation measures, such as seawalls;

Private sector

- Work with governments at all levels and provide information regarding its data priorities and needs;
- Help maintain long-term insurability, and provide incentives for adaptation through risk-based premium pricing;
- Use insurance risk-evaluation tools (catastrophe models) to help policy makers and adaptation planners better understand and assess the financial implications of climate change;
- Encourage or spearhead research aimed at improving global climate model results to be more useful to insurance underwriters and adaptation planners;
- Support government adaptation efforts;
- Provide educational information on climate change–related risks, and increase awareness on the topic among customers;
- Supply risk information about the city's large uninsured properties for New York City climate change planning, as well as providing risk management policies for these commercial, industrial, and residential owners;
- Provide insights into the expected economic losses that the city infrastructure will potentially suffer under different climate change scenarios; and
- Provide additional information based on its own analysis, and support regulations that reduce weather-related risks, such as changes in zoning requirements and building codes (see CPL Appendix C) and protection of natural ecosystems.

The federal government

- Support research on climate models and emissions scenarios to make them more useful for the insurance industry and other adaptation stakeholders;
- Fund observation and data collection systems, such as NOAA's ocean observation network at the global scale and contribute to advances in global climate models; and
- Encourage the creation of tools that can help translate expected climate change into localized impacts on the built and natural environment.

Further issues

- More understanding of correlations are needed across hazards (for example, between heat waves and drought);
- Development of coordinated and comprehensive catalogs of tropical and extratropical cyclones; and
- Shorter-term (<10 years) projections of climate change risk.

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Endnotes, references, and further reading

[1]"Home Insurers Canceling in East" New York Times October 16, 2007, by Paul Vitello and "Florida, insurance leaders seek ways to lessen risk posed by Citizens," South Florida Sun-Sentinel.com, January 4, 2009, by Julie Patel.

[2]The modules listed here describe the categories used by the catastrophe modeling company RMS. Other models, while they use similar methods, may use slightly different categories. For example, Swiss Re's reinsurance group combines the event and hazard modules into a single hazard module and includes in addition, value and insurance conditions modules.

[3]"Taken by Surprise" Risk Management September 2007 by Daniel Pimlott but the referenced figure is from III; and "Insurers plan for hurricanes in

local forecast; Industry sets out to raise awareness," Richard Newman, The Record, July 20, 2006.

[4]Max Mayfield, then Director of the National Hurricane Center, May 24, 2006, at an oversight hearing of the Senate Commerce, Science Transportation Subcommittee on Disaster Prevention and Prediction, on "2006 Hurricane Season and At-Risk Cities."

[5]Douglas J. Collins and Stephen P. Lowe (2001): A Macro Validation Set for US Hurricane Models http://www.casact.org/pubs/forum/01wforum/01wf217.pdf.

[6]Roger A. Pielke, Jr., Joel Gratz, Christopher W. Landsea, Douglas Collins, Mark A. Saunders, and Rade Musulin (2005): Normalized Hurricane Damage in the United States: 1900–2005. Natural Hazards Rev. Volume 9, Issue 1, pp. 29–42 (February 2008).

[7]Source: R.J. Nicholls *et al.*, Ranking Port Cities with High Exposure and Vulnerability to Climate Extremes, OECD, November 2008.

[8]Source: J. Friedman, NYC Emergency Management Office.

[9]Nicholls, R. J. *et al.* (2008), "Ranking Port Cities with High Exposure and Vulnerability to Climate Extremes: Exposure Estimates," OECD Environment Working Papers, No. 1, OECD publishing, © OECD. doi:10.1787/011766488208.

[10]Value and definition from AIR Worldwide Corporation report "The Coastline at Risk: 2008 Update to the Estimated Insured Value of U.S. Coastal Properties," June 11, 2008. This includes the full insured property value in the following counties: Bronx, Kings, Nassau, Nassau, New York, Queens, Richmond, Suffolk.

[11]Reinsurers are insurance companies that specialize in insuring the "primary" insurance companies that provide risk management services to individuals and businesses. Reinsurers tend to devote more resources to a thorough scientific study of a variety of risks, serving as a knowledge resource for the primary insurers.

[12]"Revolution in Climate Prediction is Both Necessary and Possible" by J. Shulka *et al.* Bulletin of the American Meteorological Society, February 2009.

[13]"Lessons Learned from the IPCC: Scientific Developments Needed to Understand, Predict and Respond to Climate Change" by Sarah J. Doherty *et al.*, Bulletin of the American Meteorological Society, April 2009, pp 497–513.

[14]Light Detection and Ranging (LIDAR) is a remote sensing system used to collect topographic data. This technology is used to document topographic changes along shorelines.

[15]Evan Mills, "From Risk to Opportunity: Insurer Responses to Climate Change," A Ceres Report, April 2009.

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