Issues in the Regulatory Acceptance of Computer Modeling for Property Insurance Ratemaking

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Introduction

New ideas and technologies that challenge accepted notions of reality have usually met with controversy proportional to the degree of change they represent. This has certainly been the case recently in the property insurance market, where a technological revolution has occurred, triggered by the development of sophisticated computer models capable of simulating insured losses in catastrophic events. These models allowed a far more sophisticated analysis of the insurance process. The models indicated that the historically accepted methodologies used to develop insurance rates and solvency tests may have been severely flawed. The new data suggests that current rate levels in high risk areas may be grossly inadequate and past estimates of probable maximum loss may have been dangerously over optimistic.

If correct, the new estimates of catastrophe loss potential will have profound effects on the public, including: how much their insurance costs, how their coverage is structured, how their homes are constructed, and where they are able to live. Some consumers may be forced to engage in expensive retrofitting activities or face a decline in the value of their properties. Banks may experience an increase in risk on their mortgage portfolios. Home builders may see tougher building codes and restrictions on development in some areas. Legislators may see increased demand for public funding of catastrophe losses to ease the shock of free market reactions.

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Given these effects, it is not surprising that there has been a tremendous amount of debate surrounding the application of computer modeling to the insurance process. The situation has been exacerbated by the mind numbing complexity and proprietary components of the models. Understandably, regulators have been very cautious about allowing their use. However, models have gained widespread acceptance in the insurance and financial communities. The inability of regulators and insurers to reach a consensus on their use in property ratemaking is a major driver of the availability crisis facing property insurance consumers in high risk areas.

The Traditional Property Ratemaking Process

It is difficult to understand why models have indicated such radically different answers than more traditional methods without first examining how actuaries developed rates for insurance products with catastrophic exposures before models. The older methodologies were developed in an era with very limited computer technology and databases that were often little more than statewide aggregations of losses by year. One of the most popular, the *excess wind procedure*, will be briefly discussed below.

Statewide loss data was accumulated by year and separated into wind and non-wind components. A ratio of wind to non-wind losses was calculated for each year over a long time period. If in any year this ratio exceeded a threshold value (perhaps two standard deviations above the mean), the "excess" losses were removed from the five-year experience base used in the filing and averaged over a much longer period. An "excess wind factor", reflecting long term average ratios of excess wind to normal losses, was calculated. This factor was then weighted with a regional factor reflecting many similar states and applied to normal capped losses to yield an estimate of total expected losses in an "average" year. The objective was to smooth rate indications and avoid rate fluctuation.

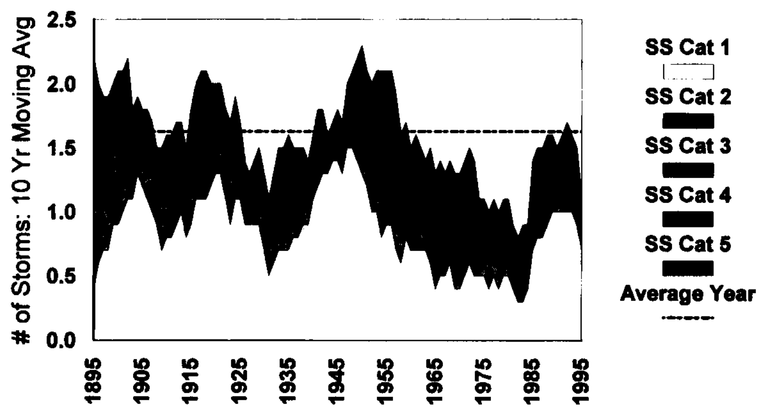
The method makes several assumptions about the 20–30 year period used in the "excess" calculation:

- Catastrophic activity was "normal;"
- Population demographics were stable;
- Insured losses by peril were stable;
- Changes in coverage or construction practices did not affect the ratio of wind to non-wind losses.

Each of these assumptions was by periods in the 20–30 year period ending in the late 1980s.

Figure 1 is a ten year moving average of the number of hurricanes that made landfall in the United States by category from 1885 to present. The data is also shown in Figure 2 as a series of maps covering 25 year intervals from 1895 to 1995. Clearly, the frequency, location, and intensity of land falling hurricanes vary over time, making any methodology which relies on relatively short experience periods highly suspect. The period from 1960 to 1987 was abnormally "quiet."

FIGURE 1
Hurricane Landfall by Intensity
1885 thru 1995



Source: Colorado State University Department of Atmospheric Science

The second key assumption is that population demographics remain stable over time. To illustrate the problem a violation of this assumption may cause, assume that in 1970 there was one inland risk for every coastal risk, and that each inland risk generated $1 of non-wind loss and each coastal risk generated $1 of wind loss, so the wind to non-wind ratio would be 1:1. If in 1995 there are two coastal risks for every inland risk, we would expect the wind to non-wind ratio to change to 2:1. However, if we still applied the historical 1:1 ratio to non-wind losses to estimate wind losses, the resulting rate level would be inadequate.

Figures 3 and 4 show that this assumption has also been violated in recent years. Coastal areas, particularly in Florida, are growing at a relatively faster pace than inland areas. Figure 3 shows the United States' population change by county, while Figure 4 is a summary of population change by region.

The third assumption is that the proportion of insured losses by peril is stable. To illustrate, suppose that from 1960–1995 the quality of fire protection improved substantially as State X urbanized. One would expect that, all else being equal, the ratio of wind to non-wind (i.e. fire) losses would increase over time as better fire protection lowers fire losses, but does not affect wind losses. Overall, the level of fire protection has increased since 1970.

Finally, property insurance coverages and building practices have changed significantly. Coverage shifted from actual cash value to replacement cost, contents limits increased, some policies offered "guaranteed replacement cost", and many additional coverages were added.[1] Changes in construction techniques have been dramatic. Newer styles offer much better wiring and energy efficiency (the former likely improving fire loss ratios), but their degree of wind resistance has been debatable. While it is difficult to quantify the effect of these changes on the accuracy of the excess wind procedure, there is no question that historical data must be viewed with caution.

To summarize, experience-based techniques were subject to several critical biases that appear to have combined to yield large underestimates of loss potential in the period immediately preceding the advent of computer models.

1. Examples include coverage for water leakage, debris removal, and food spoilage.

FIGURE 2A
US Atlantic Coast Hurricane Landfalls: 1895 to 1920

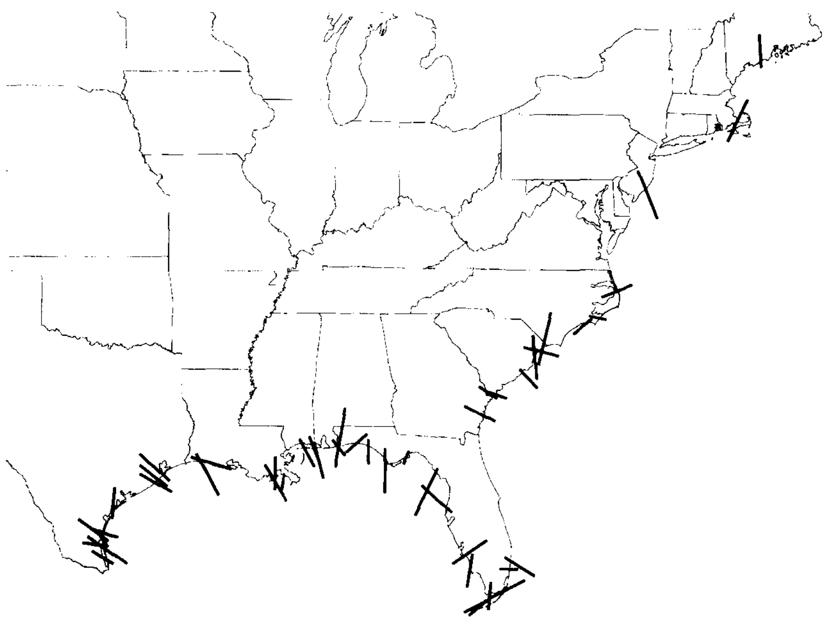


FIGURE 2B
US Atlantic Coast Hurricane Landfalls: 1920 to 1945

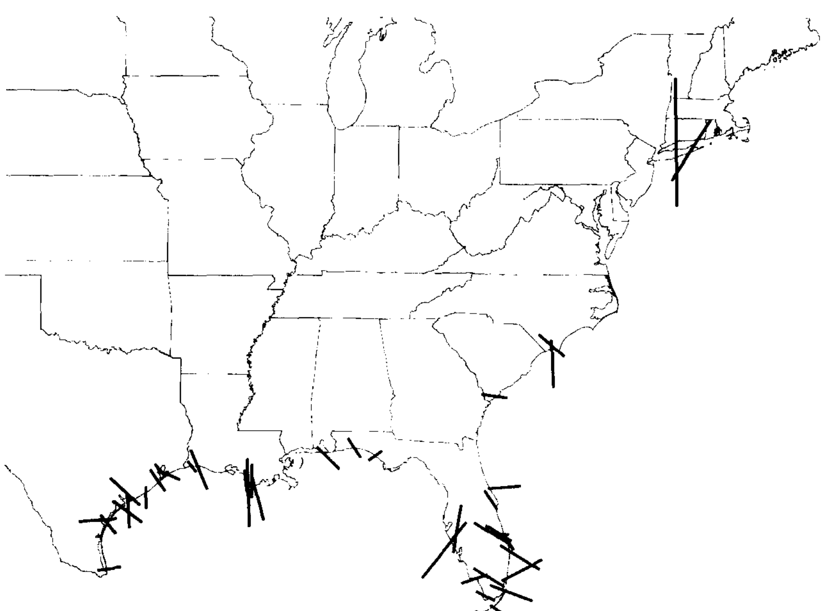


FIGURE 2C
US Atlantic Coast Hurricane Landfalls: 1945 to 1970

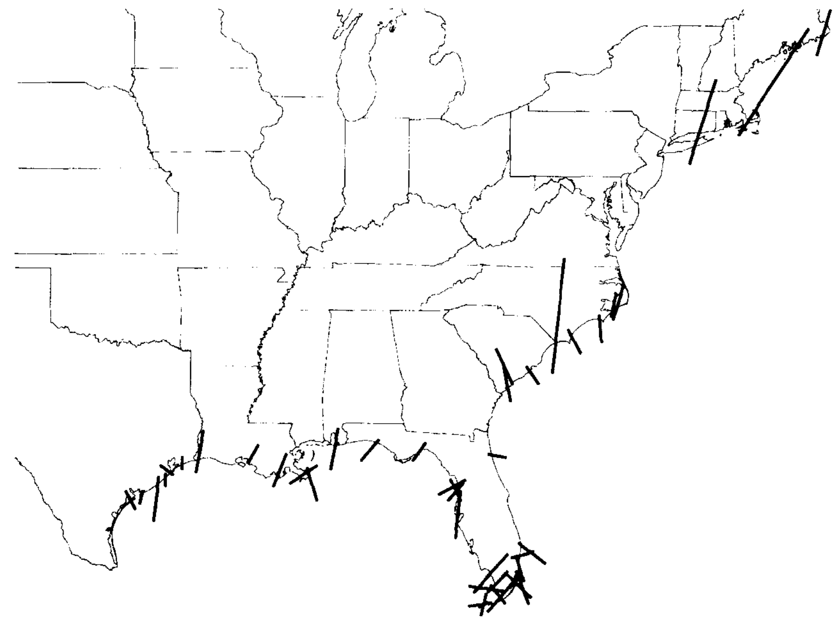


FIGURE 2D
US Atlantic Coast Hurricane Landfalls: 1970 to 1995

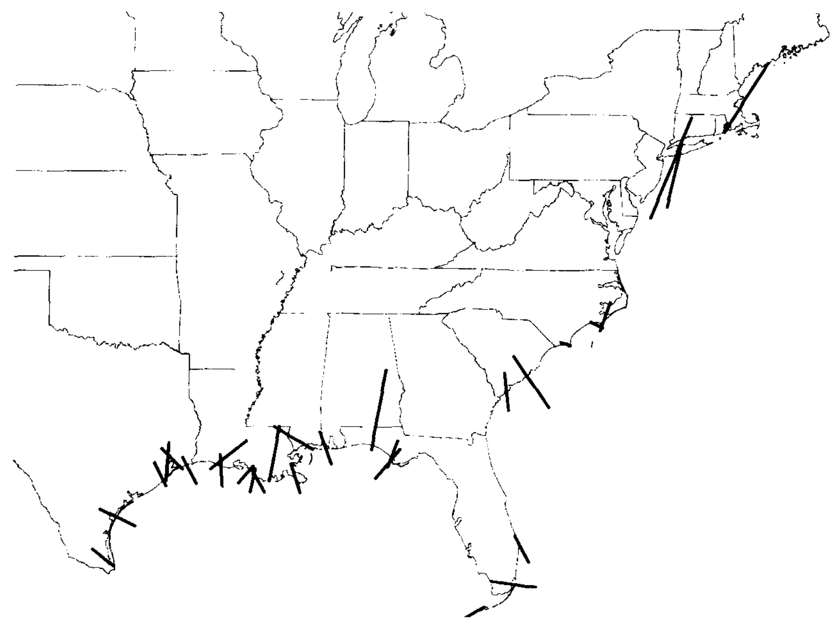
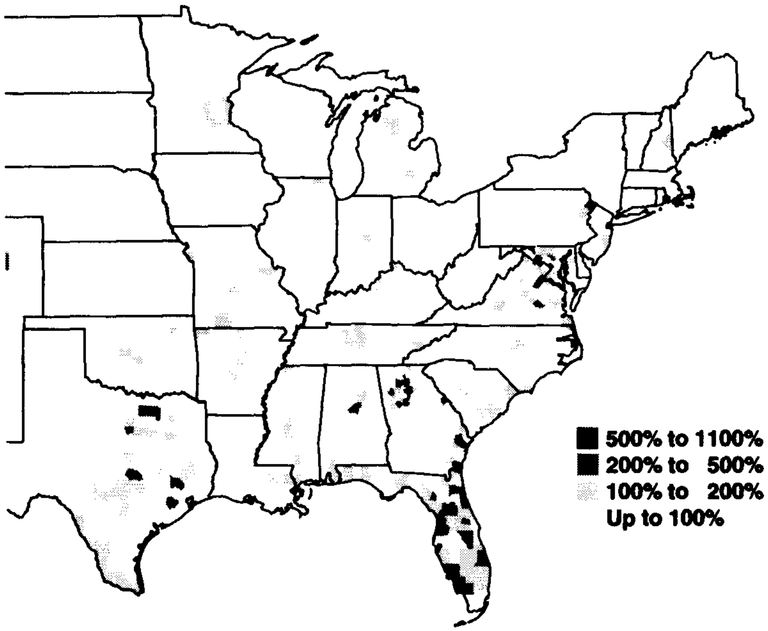


FIGURE 3
Population Change by County
1970 thru mid-1995 (US Census Bureau)

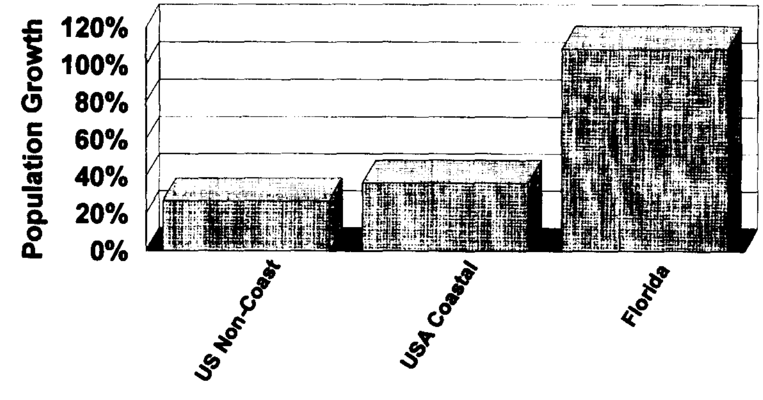


Source: US Census Bureau

As an illustration of the magnitude of the pricing errors that occurred, consider the case of Florida property insurance in the years before Hurricane Andrew. In 1992, the Insurance Service Office calculated an excess wind factor of 1.14 for Florida Homeowners coverage, which would have generated approximately $80 million in catastrophe premiums for the entire Florida insurance industry annually.[2] Current modeled estimates of the needed revenue for catastrophes are 10 to 15 times that amount.

2. This figure is developed as follows: Total Homeowners premium volume was approximately $1 billion. Assuming an expected loss ratio of 65 percent, this yields $650 million in loss cost, which equals normal losses times 1.14. Thus, normal losses were $570 million, leaving $80 million for "excess" catastrophe losses. While this calculation is a crude approximation of a very complicated ratemaking process, it serves to illustrate the magnitude of the pricing error.

FIGURE 4
US Population Change: 1970–1995



Source: US Census Bureau

According to A.M. Best, Florida consumers paid approximately $2.7 billion in insurance premiums in 1992 for all property lines of business. The insurance industry incurred 94 cents in direct losses and expenses for every dollar of direct premium earned on Florida property business from 1988–1991, a period in which there were *no hurricanes*. In order to break even on underwriting operations, only six cents of every dollar were available for hurricane losses, or about $160 million per year. Hurricane Andrew generated insured losses of more than $16 billion. At $160 million/year, it would take more than 100 years just to pay for Andrew, assuming no other catastrophic storms in the interim.

Techniques for estimating single event losses and needed capitalization levels were not much better. Many underwriters used multiples of statewide premiums to estimate loss potential. Regulators assumed that insurers had to maintain 25 cents of capital for every dollar of premium. Such rules of thumb were proven to be inadequate by the catastrophes of the early 1990s, where many companies experienced losses many times the probable maximum losses (PMLs) estimated by traditional methods.

Traditional methods also provided little information on several other factors critical to insurance operations and public policy planning. Since they were based on state or regional databases, little information was available by territory, construction, deductible, etc. The effects of new coverages or construction techniques could not be quantified. Estimates of probabilities associated with various sized loss events, needed to assess the financial solidity of insurers, were unavailable.

Despite these major shortcomings, the excess wind procedure was one of the best techniques available in the past. It is still used effectively in many circumstances where its base assumptions are not violated, such as for determining loads for non-hurricane wind losses in situations with more stable demographics.

The Development of Computer Models

Improving loss forecasts required the development of methods that were less susceptible to the types of biases noted above and which provided increased clarity in understanding individual risk loss exposure. A modeling process, similar to that used in many major economic and scientific applications throughout our society,[3] appeared to be a promising approach. Models would allow long term seismic and/or weather information to be integrated with current demographic data, construction practices, and insurance coverage forms. Advances in computer technology and easy access to weather and census databases made such an effort feasible in the 1980s, and several firms developed catastrophe models.

The details of how models are constructed and used by insurers is beyond the scope of this paper, but several other authors have addressed this issue (Kozlowski and Mathewson, 1995). The models represented a radical departure from the traditional experience based way of looking at things, and introduced several problems that insurers and regulators had difficulty with. The traditional method had

3. Examples include models used for weather forecasts, econometric analysis, governmental budget projections, demographic studies, medical research, and aircraft design.

the advantage of using insurer loss data and mathematical calculations that could be easily verified. Simulation models, on the other hand, posed the following challenges:

- The raw insurance data for modeling was often *exposure* (amount of coverage), which, unlike premiums or losses, was not reported in financial statements or other externally verifiable sources;
- The raw data was often sent to the modeling company in policy level detail and processed in the modeler's proprietary computer program, making it difficult to follow the calculations in the manner the traditional methods had allowed;
- The seismic or meteorological simulations and damage functions at the core of the models are extremely complex and difficult to follow without extensive technical expertise.

Thus, the traditional regulatory review process had a difficult time evaluating model reasonableness absent an extensive and highly technical review by a team of experts in the fields of meteorology, seismology, computer science, engineering, etc. Compounding this problem is the natural inclination of the model developers to resist open publication of material they consider to be trade secrets.

Insurers as Consumers

Many insurers found themselves on the "consumer" end of the modeling process long before they attempted to use models in their interactions with regulators. The first major users of modeling technology were reinsurers, who focused on estimating probable maximum losses and pricing unregulated reinsurance products. Firms performing financial ratings of insurers, such as A.M. Best, also came to rely on models to evaluate insurer exposure to catastrophic loss.

Most members of the financial community accepted modeling technology with relatively little controversy as it evolved over the years. Notably absent were debates over "black boxes" and proprietary information, despite the often painful consequences for company management of the modelers' message (higher reinsurance costs, lower profitability, forced reductions in exposure, pressure on financial ratings, etc.).

Several factors explain this phenomenon:

- The modeling process represented a clear technological improvement over the available alternatives;
- Modeling was not wholly foreign to insurers. Similar techniques had been used for years to perform economic forecasts used in investment decisions, for example;
- Insurers had the benefit of a competitive environment for modeling services;
- Insurers lacked the type of safety net available to individual consumers in the form of government-sponsored programs such as "Windpools," leaving them little choice but to accept the use of the techniques favored by their reinsurers and investors or face a loss of reinsurance or equity capital.

Consumer Effects

With or without regulatory acceptance, models will have major effects on consumers. Models have become standard tools for reinsurers,[4] financial analysts, and rating agencies. They have a fiduciary responsibility to use the best information available, regardless of its acceptability to regulators in the rate filings of primary insurers. If primary companies and regulators are unable to reach a consensus on their use (implicitly or explicitly), a sharp contraction in availability of coverage for "high risk" insureds from private sources and an expansion of coverage provided through quasi-governmental entities financed through assessments and/or public debt are likely.

Assuming, however, that primary insurers and regulators will eventually solve the problems that are currently inhibiting the use of models in primary ratemaking, what are the likely effects on consumers?

There is no doubt that in the short run there will be disruptions to some consumers as prices and coverages are brought more closely

4. The major state sponsored reinsurer, the Florida Hurricane Catastrophe Fund, develops rates using a model.

into line with revised estimates of loss potential. It is not accurate to say that all, or even most, consumers will be worse off under insurance prices developed using models. More focused pricing will lead to consumers paying prices more aligned with risk. Low risk consumers will benefit directly. High risk consumers will experience powerful financial incentives to mitigate losses. In the long run, consumers will adjust to the new economic realities, and aggregate losses should decline as risky behavior is discouraged. A strong argument can be made that inaccurate pricing of insurance products has produced undesirable results of over development in high risk areas and inadequate incentives for mitigation.

If public policy planners decide that the effects on high risk consumers are unacceptable, they may choose to cushion the effect by subsidizing them through residual markets and/or by making public sources of capital available. Before doing so, however, public policy planners should carefully analyze the true consumer effects of implementing prices based on models. Consider the case of the Florida Windstorm Underwriting Association (FWUA). The FWUA offers wind only coverage in high risk coastal areas of Florida. It had historically relied on extended coverage (EC) loss costs derived from ISO data before the use of models.

In 1996, the FWUA calculated indicated rates using a catastrophe model. The indications were for several hundred percent rate increases in many areas, which caused a great deal of concern among public officials. A closer examination of the data, however, showed the true effect to be less frightening. A risk with a $113,000 Coverage A in coastal Dade County indicated an increase of 533 percent, from $15 per month to $95 per month. However, the rate for non-wind coverage was unaffected at $71, so the total property insurance premium change was from $86 to $166, an increase of 93 percent. Most consumers pay their insurance premiums through an escrow account, which would include a mortgage payment and property taxes of $1,050. Thus, the total monthly house payment would increase from $1,136 to $1,215, or 7.0 percent, less than that generated by a one point change in the interest rate on an adjustable mortgage.

Perhaps the most significant consumer effect of modeling will be a far more focused assessment of individual policyholder loss potential. Since traditional methods depended on large volumes of data to generate the stability needed for ratemaking, they were generally capable of a "rating resolution" of entire states or even groups of states. Modeling, on the other hand, uses statistical techniques to achieve stability, offering the prospect of a "rating resolution" of zip code, construction type, or even individual property.

Achieving a better estimate of loss exposures unique to the individual property owner promises many benefits to the consumer:

- *Comprehensibility of Prices.* Identifying characteristics that represent higher exposure to loss will help consumers better understand, and control, insurance costs.
- *Rational Behavior.* When the cost of a good reflects its economically correct long term price, consumers will take that cost into account and act accordingly.
- *Fair Pricing.* More accurate information will reduce subsidies and reward consumers who engage in loss mitigation.
- *Reduced Information Risk.* Investors demand higher returns to compensate for uncertainty. Improved information will reduce this risk and lead to lower prices and/or greater availability.
- *Stable Pricing.* Since models use long term seismic or weather data and all available information on the risk to develop loss estimates, they should be less susceptible to variation than other methods.

Regulatory Effects

The emergence of catastrophe models has led to a number of problems for regulators. While a few regulators have refused to approve filings using models at all, most have attempted to work with insurers to reach rate levels more consistent with model indications.

Most of the public focus on the modeling issue has come from the ratemaking process. Less publicized, but equally important, is the potential for regulators to significantly improve solvency monitoring tools. While rate increases place an immediate, but usually manageable, burden on many consumers, insolvencies in the aftermath of catastrophes can result in reduced or delayed claim payments, significant financial hardship, assessments, and possible bond issues. All of these effects were felt in Florida in the aftermath of Hurricane Andrew, when twelve companies went insolvent, leaving more than $400 million of unpaid claims. This exceeded the resources of the guaranty association, forcing a special bond issue that resulted in assessments passed on to consumers over many years. Many more companies were impaired by Andrew and would have been insolvent but for infusions of capital from parents and affiliates.

Models offer regulators vastly improved tools for assessing financial solidity, though their use in this setting may make it difficult to deny their use in ratemaking. The Florida Department of Insurance requires two model runs in order for new companies to qualify to take blocks of policies out of the Florida Residential Property Casualty Joint Underwriting Association.

Can the Proprietary Information Hurdle Be Overcome?

Aside from the understandable resistance to new methodologies that overturn established ways of analysis, the biggest obstacle to regulatory acceptance of models has been their proprietary elements. Modelers are naturally reluctant to openly publish their trade secrets, leading some to characterize models as "black boxes" impervious to public scrutiny. Often lost in this debate is the fundamental question of whether fully disclosing the contents of the models is necessary for their validation and whether or not such disclosure would be of much practical use, given the models' high degree of complexity.

Modelers are aware of the need to provide information to validate their products to both their clients and regulators, and have cooperated in several organized efforts to develop model review and validation standards. Many modelers would concede that much more could be done to explain the assumptions and sensitivities of their models. Regulators, too, must be proactive in establishing a clear process for model validation, which might include:

- Developing familiarity with the technical background of models;
- Defining a clear process and specifying policies related to the use of models in ratemaking;

- Making reasonable efforts, within the constraints of state open records or "sunshine" laws, to safeguard legitimate trade secret information.

Many have argued that models can be externally validated without the need for full disclosure of their inner workings. Such a process might involve tests such as:

- Comparison of predicted wind fields in a series of simulated storms vs. those actually observed in recent events;
- Comparison of statistics such as mean minimum barometric pressure, mean wind speed, or number of storms of certain categories for a large number of simulated events vs. actual historical averages;
- Comparison of relative damage estimates by type of structure to actual observed damage in recent storms;
- Comparison of predicted losses for individual events to actual insurer losses.

Care needs to be exercised when making extrapolations from individual events to long term average losses. For example, if a model overestimates the actual loss for a single loss event by 20 percent, it is not clear that the model's estimate of mean losses for thousands of storms would be similarly biased. One would expect individual storm losses to vary from predicted levels, but such errors should cancel out over many simulations.

Florida Commission of Hurricane Loss Projection Methodology—A Useful Model?

In 1995, Florida embarked on an ambitious project to objectively evaluate modeling technology and overcome the proprietary information conundrum. The Florida Commission of Hurricane Loss Projection Methodology was created. The Commission consisted of twelve individuals representing various disciplines, including computer science, meteorology, engineering, actuarial science, the consumer advocate, and the Insurance Department. It was placed in the

State Board of Administration, which is responsible for the administration of the state pension funds and the Florida Hurricane Catastrophe Fund. The enabling legislation creating the commission says:

> The Legislature recognizes the need for expert evaluation of computer models and other recently developed or improved actuarial methodologies for projecting hurricane losses, in order to resolve conflicts among actuarial professionals, and in order to provide both immediate and continuing improvement in the sophistication of actuarial methods used to set rates charged to consumers.

The Commission has held scores of meetings since its inception and thoroughly evaluated the leading models. It designed a series of test data sets which modelers ran and submitted to the Commission. It operates under the Florida government in the sunshine law, which presented a challenge in protecting proprietary information examined by the Commission. The problem was solved by assembling a team of outside experts who made on-site visits to the modeling companies and evaluated various technical aspects of the models. These individuals were able to share their findings with the Commission without divulging detailed trade secret information.

The Commission adopted a series of standards and model specifications in July 1996.

Modelers were offered the opportunity to respond to those standards. The modelers will make presentations to the Commission to argue that models meet the standard, and the Commission will then vote to determine whether the model is acceptable to the Commission. The models approved by the Commission will be deemed admissible and relevant in rate filings with the Department of Insurance and also in any other administrative or judicial proceeding associated with that.

Can Models be Manipulated?

Some have expressed concern that unscrupulous insurers could manipulate the models to inflate loss estimates. Certainly, such manipulation is possible, as it would be with any of a number of other reports made to regulatory authorities. A key issue is whether the modeler or the insurer controls the model code. If it is the modeler, then the opportunity for manipulation is significantly reduced and is focused on the insurer's data reported to the modeler and any insurer specific assumptions (unique coverages, etc.) that prompted the modeler to alter its standard product.

There are, however, several powerful disincentives for insurers to manipulate model results to the detriment of policyholders. Most obviously, if rates are inflated the insurer faces the prospect of losing customers to competitors using more reasonable estimates. Some would argue that a lack of competition in high risk areas weakens this constraint. Even so, it would be against an insurer's self interest to inflate estimates. The model is usually used within the insurance organization for several purposes, including the assignment of financial ratings and reinsurance evaluation. Inflated loss estimates would put downward pressure on financial ratings and increase the need for and cost of reinsurance, depressing earnings and adversely affecting the stock price of publicly traded companies.

Several safeguards have been suggested to reduce the risk of manipulation:

- Require a legal affidavit attesting that the user has not manipulated the assumptions.
- Require a formal opinion from the modeler on the proper execution of the model when run by the insurer.
- Modelers could provide regulators with rate ranges that reflect geographic, building structure, and deductible options.

Issues for States Without Major Catastrophe Exposures

Regulators in states not prone to catastrophic events have a vital interest in the outcome of the debate on the use of models. If rates do not reflect expected loss in high risk areas, it is likely that growth will be higher and mitigation incentives inadequate, increasing long term overall losses. The inevitable availability problems will increase pressures for national solutions to the catastrophe crisis that may expose their citizens to increased taxes or insurance costs. Finally, the financial difficulties of national insurers after a large catastrophe could result in market disruptions throughout the country.

Conclusions

Catastrophe modeling is a relatively young science. Models are evolving and far from perfect. However, they are substantially better than any available alternatives. Limitations in methodologies used in the past led to a host of serious problems and a need for painful adjustments to new realities.

Regulators and insurers need to work together to build a consensus on how to price insurance products and how to improve the public acceptance of this new technology. Failure to do so will expose consumers to availability shortages, continuing market disruptions, and degraded claims paying ability. The consumer effect of models is not all negative, and in fact models may be a great benefit to consumers in the long run by improving the accuracy of pricing and thereby empowering consumers to make intelligent economic decisions about where they live and how they build their homes.

References

Kozlowski, Ronald and Stuart Mathewson, 1995. "Measuring and Managing Catastrophe Risk," *Journal of Actuarial Practice*, Vol. 3(2):211.