A MODERN ARCHITECTURE FOR RESIDENTIAL PROPERTY INSURANCE RATEMAKING

ABSTRACT

This paper argues that obsolete rating architecture is a cause of decades of documented poor financial performance of residential property insurance products. Improving rating efficiency and equity through modernization of rating and statistical plans is critical to the continued viability of the products. In particular:

- The overall rate level should reflect an appropriate provision for the cost of capital held for catastrophic events, and the cost of capital should be allocated appropriately in development of rating factors;
- The indivisible premium concept should be replaced with peril-based rating, and rating factors developed or adjusted to apply to peril-specific partial base rates;
- Catastrophe simulation and geographic coding technology, incorporating non-historical experimental data sets, should be applied to the development of base rates, territory boundaries and factors, and classification plans;
- Rating for the numerous miscellaneous exposures and coverage options, as well as maintenance of statistical plans, should be aligned with the peril rating concept.

The author develops an architecture and techniques for ratemaking which satisfy the above precepts for the Homeowners product in a hurricane-prone state. The transition from indivisible to divisible base premium facilitated by this architecture is illustrated in case study fashion, with practical implementation challenges and solutions discussed. Many ideas are transferable to ratemaking for other residential and commercial property products.

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MOTIVATIONS: THEORETICAL

The insurance industry has earned a chronically inadequate rate of return on its chief residential property line, the Homeowners product, since the 1980's. Catastrophic ("cat") events, the "toxic mold" phenomenon, the growing popularity of vicious dogs, outbreaks of sinkholes, and other root causes of loss have repeatedly surprised insurers in recent years. To date, responses have been almost exclusively reactive: underwriting restrictions, coverage limitations and sharp corrections in overall price level.

Our thesis is that the classical “indivisible premium” rating plan in common use for residential property products is a significant obstacle limiting the industry to reactive responses of questionable economic *efficiency* and actuarial *equity*. Actuaries can show strategic leadership by engineering a proactive response - the development of a modern architecture for ratemaking which improves overall rate level efficiency as well as risk classification equity. The classical plan is demonstrably obsolete, particularly in catastrophe-prone areas, and greatly hinders the ability of insurers to identify, segregate and monitor the component drivers of loss costs. Harmonious advances in technology and actuarial science now allow us to overcome the obstacles to modern rating architecture.

Specifically, these structural changes to rating plans are overdue:

- Actuarially sound prices should reflect an explicit provision for cost of capital, in addition to actual non-cat loss costs, expected cat loss costs from simulation tools ("cat models"), and underwriting expenses.
- Indivisible base premium should be replaced with several partial base premiums by peril; for example, hurricane, other wind, fire, liability/medical, and all other perils (AOP).
- Partial base premiums should be modified by distinct class and territory (geographic location) rating plans for several reasons. Property attributes affecting equitable risk classification vary significantly by peril, and the cost of capital is not generated (and should not be allocated) uniformly among perils.
- Rating for base premium adjustments and miscellaneous endorsements should be recalibrated to take advantage of the unbundling of base premiums.

Why does the classical rating plan doom insurers to poor long-run underwriting results? Recalling fundamental principles of actuarial science [1], improper insurance prices can result from two types of ratemaking failures:

1. Failure to recover all costs associated with risk transfer in the final premium (inefficiency);
2. Failure to differentiate rates for identifiable classes of risks with demonstrable differences in expected cost of risk (inequity).

Indivisible base premium in residential property insurance facilitates both failures. Two components represent the majority of the cost structure underlying the product – expected loss costs and cost of capital. In turn, these components are generated by an aggregation of individual perils insured against - the largest contributors often fire, liability, and windstorm. In recent years, it has become apparent that the loss costs and costs of capital for distinct perils are distributed in an extremely lopsided fashion or "maldistributed"[1] with respect to many classification attributes, particularly territory, As an architectural matter, indivisible base premium precludes the proper allocation of costs to class and territory, disallowing development of distinct and non-interacting class plans and rating factors based on construction features, not to mention distinct territory boundaries and rating factors. A corollary is that the recognition of the full cost of capital in overall rate level is discouraged due to an inability to spread it fairly among risks.

Now consider the consequences of failure to fairly allocate costs to class and territory by peril. Even if overall premium level generates adequate revenue to fund the losses of the diverse book of business, rating factors must apply to multiple and perhaps unrelated perils, generating unavoidable and perhaps severe premium subsidies. As some insurers improve rating plans to target the risks who are overpaying for certain perils, "adverse selection" by the affected risks will leave the insurers who fail to modernize with underpriced segments of the market, which generate poor underwriting results until overall rate level is raised. Raising the overall rate level without improving the distribution of premiums by rating factor amplifies the adverse selection, perpetuates the cycle and leads to a "death spiral" for the insurer. Cummins [2] contains a formal development of the economics of adverse selection.

The indivisible premium is a remnant of historical technology and marketing architecture. When agents were expected to quote policies in the field with a pencil and rating manual, simplicity of rating logic was paramount. The days of hand-rating are long gone in standardized personal lines products, but the rating plan based on that limitation persists. Technology is an enabler of modern rating architecture in the form of rating engines accessible from the field, as well as in geographic information systems and simulation modeling applications. Regardless of theoretical appeal, implementation of peril-specific rating would have been difficult even twenty years ago.

In addition, residential property insurance was historically marketed as "complete" coverage for the hazards inherent in the lifestyle of the typical homeowner. Today's consumers are increasingly demographically diverse and willing to choose products to fit their needs. Policy forms have evolved in response to these trends, and it is imperative that the pricing of personal lines products also evolve with the spectrum of exposures insured.

Many actuarial concepts discussed in this paper are venerable. Our contribution is to synthesize them in new ways in response to a specific challenge - the <u>transition</u> from a classical to a modern component rating architecture. We stress that once this transition is accomplished, maintenance of some aspects of the rating plan using classical actuarial methods (such as the "loss ratio" method of determining rating factors) may still be optimal. Our goal is to get the actuary across a sort of river Styx of property insurance ratemaking while ensuring that each part of the transition withstands review of, and is consistent with, canonical principles. Indeed, we feel it is critical to undertake such a modernization in order to remain true to many of our Actuarial Standards of Practice, particularly those of more recent vintage.[2] However, when we stand on

[1] The use of this term is with a respectful nod to Bailey and Simon's seminal 1959 paper on class ratemaking.
[2] We recommend a thoughtful review of ASOPs 12, 23, 29, 30, and particularly 38 and 39, both before and after reading this paper. Such a review should go a long way to convince the practicing actuary that our motivations are consistent with upholding these Standards of Practice.

the other side, we plan to look back and recognize some of our architecture as embodying potentially long-lasting innovations in actuarial techniques.

MOTIVATIONS: PUBLIC POLICY AND PRODUCT CHANGES

Notwithstanding theoretical motivations, necessity is the mother of invention. This paper may also be read as a case study of the actuarial response to a pricing challenge manifested in public policy. The State of Florida passed into law a statewide Unified Florida Building Code (FBC) which supersedes all local codes for buildings permitted after March 1, 2002. One goal of the FBC is to improve the resistance of new construction to windstorm losses by specifying robust fixtures and construction techniques to be used, in accordance with the recommendations of scientists and engineers. The code is heavily geography-dependent, differentiating among many elements based on the wind speed "zone" in which the site is located. In particular, properties located in the "120-mph" (in a 100-year event) and above wind zones must be built with significant levels of resistance to wind. Zones are (generally) concentric boundaries defined by the standards of ASCE 7-98 (see Figure 1).[3]

The insurance industry strongly supported the FBC, and its enabling legislation contained a quid pro quo - that insurers would develop class plans to provide rate differentials for devices which demonstrably mitigate windstorm losses, whether such devices were included on new construction or extant on, or retrofitted onto, existing structures. The Florida Office of Insurance Regulation (OIR) commissioned a public domain study from Applied Research Associates, Inc. (ARA) which developed a mitigation class plan containing benchmark class factors for various combinations of construction fixtures and techniques [3], and an analogous study was conducted by Applied Insurance Research, Inc. (AIR) in support of a mitigation class plan filed by Insurance Services Office, Inc. (ISO). The deadline for individual companies to make rate filings to implement a mitigation class plan was February 28, 2003.

This mandate is the death knell for indivisible premium rating plans in Florida. Our research shows that the maldistribution of loss and capital costs by territory and peril makes such a lack of rating resolution intolerable in the presence of a windstorm mitigation class plan. The hurricane “share” of all-perils loss costs varies between 20% and 75% by county, and the fire share varies between 5% and 35%. No compact set of actuarially sound class factors would be workable against such a variable premium base. In parallel, it is also a great improvement to target the existing Public Protection Class (PPC) factors to the proper fire premium base.

The classical design has been tolerated by the insurance industry and its advisory organizations for too long, probably because the magnitude of the errors is manageable in areas of the United States where the distribution of loss costs is more geographically consistent and the contribution of catastrophic events to the aggregate loss costs is moderate. In Florida, the mitigation class plan is a catalyst for the development of base rates and rating factors by peril, as well as the redefinition of territories using GIS mapping software and the extension of catastrophe modeling technology into windstorm class and territory ratemaking. However, the concepts are applicable

[3] The exception to this statement is along parts of the Florida Panhandle, where the political influence of home-builder associations caused a "one mile from the coast" rule to delineate areas where 120-mph standards for building materials are to apply. Examining Figure 1, the areas excepted comprise most of several west Florida counties.

to Homeowners pricing in other geographic areas, and more generally to other property insurance pricing exercises.

Public policy also influences emerging non-catastrophic causes of loss. Statutory coverage mandates and resistance to coverage restrictions in states with "prior approval" policy form regulation have contributed to the skyrocketing portion of policy loss costs associated with sinkhole claims in Florida and toxic mold claims in Texas and elsewhere. Florida statutes require sinkhole coverage and severely restrict claim settlement options, resulting in frequent total or near-total losses after moderate settling and cracking occurs in the residential structure. While "mold" is only a cause of loss as a result of another covered peril, the loss adjustment expenses and risk of large judgments have been well documented.

This paper is not about specific emerging perils; the point is that having the ability to segregate base premiums allows us to “quarantine” the loss costs associated with these perils at an earlier statistical stage. Pricing must keep up with the ever-expanding coverage in the property insurance product.

MOTIVATIONS: TECHNOLOGY AND CATASTROPHE MODELING

It is now settled actuarial science that actual losses from cat events over short experience periods should be replaced in ratemaking data by long-run expected cat losses derived from a simulation tool and the insurer's expected exposures. See Clark [4] for an excellent fundamental justification for building cat models to replace historical cat losses. In addition, several authors have tackled aspects of the problem of incorporating simulated cat losses into the overall rate level and rating factor calculations, notably Walters and Morin [5] and Burger et al. [6].[4]

A few features of cat models[5] are particularly relevant and we exploit them in populating our rating architecture:

1. They are peril-specific - one model may be used for hurricanes, another for severe thunderstorms (including tornado and hailstorm), and yet another for earthquake analysis. It is thus natural to segregate covered perils for ratemaking in such a way that the cat model can be used to build the rates for each peril separately and adequately.

2. Cat models are fundamentally exposure rating tools - loss costs can be generated from any set of relevant data, whether actual or experimental. Scenarios can be contrived and tested to develop rating factors, reducing the need for complex normalizations of experience data.

3. Some vendors offer models which output the complete empirical distribution of event losses. From this, annual losses are easily aggregated. Therefore, in addition to expected losses, we can generate moments, percentiles, and more sophisticated risk metrics for any modeled property (whether real or experimental) or aggregation thereof. These metrics

[4] For the reader unfamiliar with cat models, we recommend a thorough perusal of these references, as we will not repeat their descriptions of the design and operation of cat models nor their justifications for the use of modeled losses in ratemaking. However, our treatment of base rate and rating factor development is generally consistent with previous literature and often builds upon concepts formalized by these authors.

[5] All simulated cat losses used in this paper were derived from the CLASIC/2® catastrophe models for Atlantic Hurricane and U.S. Severe Thunderstorm ("other wind"), products of Applied Insurance Research, Inc.

are critical in deriving proxies for cost of capital and allocating risky expected losses to class and territory.

4. Every property is "geo-coded" with exact longitude and latitude, allowing us to place "pins" on maps and analyze statistics from any geographic aggregation we wish. Optimal territory boundaries with respect to gradients in loss and capital costs can be quickly identified with GIS software and scenario testing. This contrasts with the limitations of ZIP code experienced by some earlier authors.

We leverage each of these key attributes of the simulation tools in the course of our case study. The advancement of modeling science and related technology is the enabler of much of the work to follow.

OVERALL RATE LEVEL CHANGES

We aim to present a complete study of ratemaking for residential property lines, not simply a description of modern enhancements. Accordingly, we begin with a discussion of the development of overall rate level changes. Along the way, we point out components which will be targeted by our detailed rating architecture.

A comprehensive description of classical overall rate level indications for Homeowners insurance in a pre-catastrophe modeling environment is contained in Homan [7], and a concise, thorough review of basic techniques in McClenahan [8]. We use the following data to develop the indicated change in rate levels:

- Five accident years of direct paid and case-incurred losses and "defense and cost containment" (D&CC) expenses, organized by calendar year (development age), with cat losses identified;
- Five calendar years of direct written and earned premiums, and the historical rate tables necessary to bring them to present rate levels using the extension-of-exposures technique;
- Five calendar years of direct earned exposures (house-years and total values insured or "TVI");
- Three calendar years of underwriting expenses, including "adjusting & other" expenses (A&OE) associated with claim administration, allocated to category and line of business by the accounting function;
- Modeled expected cat losses by line of business, produced by a simulation tool from exposures in-force as of a given date;
- The latest calendar year's ceded catastrophe reinsurance premiums;
- Various Annual Statement data required to generate a regulated profit provision.

Exhibit 1 shows the development of the indicated overall rate level change. The formula[6] is:

[6] Our general convention is to let capital letters represent quantities in dollars (or dollars per policy) and lowercase letters represent factors or ratios to premium. Greek letters represent relativities or constants. Carets ($\wedge$) represent modeled amounts.

$$\Delta = \frac{x + f + f_R}{1 - v} - 1 \qquad (1)$$

where:

x = the weighted average experience ratio;

f = the fixed (not varying directly with premium) underwriting expense ratio to direct premium[7];

f_R = the fixed non-loss reinsurance costs (premium in excess of modeled expected losses), expressed as a ratio to direct premium;

v = the variable expense rate per dollar of direct premium, which includes the profit provision calculated in accordance with regulations[8] and treated as a variable expense rate.

The derivation of each component of the overall rate level change will be discussed in turn, using an analysis for the hypothetical A-Florida Insurance Company as our pedagogical device.[9]

Average Experience Ratio

The weighted average experience ratio is the "dot" or inner product of the vector of experience ratios for each calendar/accident year and a vector of selected weights. In Exhibit 1, we reflect typical judgments about the relationship of credibility to age of experience period in our weight selections.

The annual experience ratios themselves are developed as:

$$x_i = \frac{L \times l \times t_L \times (1+u) + \hat{C} \times (1+u_C) \times t_C}{P \times \delta \times t_P} \qquad (2)$$

where:

L = losses plus D&CC, excluding cat losses for modeled perils;

l = loss development factor to ultimate;

t_L = selected loss cost (pure premium) trend factor;

u = loading for A&OE as a proportion to losses;

$\hat{C}$ = modeled expected annual cat losses;

u_C = the expected ratio of loss adjustment expenses (LAE, which includes D&CC <u>and</u> A&OE) to losses for catastrophic claims;

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[7] Some actuaries include a trend adjustment in the expected future fixed expense ratio to reflect inflation of underwriting expense elements.

[8] Florida statutes prescribe a profit load calculation very similar to the Calendar Year Investment Income Offset Method described by Robbin [9], with the assumed "fair" profit at 5% of premium. An economically "fair" profit provision would compensate the insurer for a variety of business risks, well documented in actuarial literature. The statutory load considers only time value of money on reserves held; we load the catastrophe cost of capital elsewhere in the fair premium. Other valid risks potentially compensated by the profit load are not treated in this paper.

[9] As the reader follows through several exhibits, note that we have tried to let numbers "tie" within and across exhibits as much as possible, for tutorial purposes, as we construct our example. However, the numbers used are not necessarily representative of actual data or benchmarks for individual companies nor the industry as a whole.

t_C = exposure de-trend factor for modeled cat losses;

P = direct collected earned premiums including any expense fees;

δ = an on-level factor to restate premiums as if earned at present rate levels;

t_P = selected premium (per earned house-year) trend factor.

Losses might be paid or case-incurred, as long as the development factor is estimated on the same basis. We will not review the estimation of development factors, though we used the canonical chain-ladder method.

The loss cost trend factor and premium trend factors reflect expected changes in economic conditions making the expected losses and premiums per exposure unit in the prospective period different than that observed in the experience period. To estimate these factors, we compile calendar quarter earned house-years, earned TVI, earned premiums, and paid losses plus D&CC for twenty or more consecutive quarters as shown in Exhibit 2. Time indices for each quarter are aligned as the regressor variable. The earned rate (premium per house-year) is the basis for premium trend and the loss cost (paid losses per house-year) is the basis for loss trend. The trend in earned house-years itself will be used in the de-trending of cat losses later.

We fit an exponential regression line to each response variable. The exponential coefficient in each equation is the least-squares best fit annual change. Two, three, four, and five-year domains are fitted and examined, and a representative annual change selected for each series. The trend period is the power to which the annual change is raised to derive the final trend factor for each experience period, and is determined as the number of years between the midpoint of the experience period and the midpoint of the anticipated effective period of the proposed rates. Exponentiating the annual change for the trend period provides the final trend factor, which is carried to Exhibit 1.

The volume of exposures underlying every item in formula (2) (for an individual experience year) should be the same. This is why loss cost (per policy) trends and earned rate trends are used to adjust the losses and premiums in each experience ratio. Accordingly, the de-trend factor for modeled cat losses is necessary to state the expected cat losses on the same volume of exposures as is underlying the approximate midpoint of each experience period. By nature, cat models produce losses given in-force exposures as of a predetermined (but presumably recent) date. Due to run-time, data storage, and labor costs, it is impractical to repeatedly simulate losses using in-force exposures from several historical years. As an alternative, the selected annual change in earned house-years from Exhibit 2 is raised to a negative power representing the trend period between the in-force date used in the cat model and the midpoint of each experience period to derive a de-trend factor. The factor is applied to the single modeled expected loss estimate to get the cat losses which are loaded into each period shown on Exhibit 1.[10]

Note that the match between the attributes of excluded actual cat losses and modeled expected cat losses should be as close as possible for actuarially efficient ratemaking. Claims departments are often responsible for coding individual claims as "catastrophic", and there is generally no

[10]The de-trended cat losses are not then trended forward to the midpoint of the effective period because we assume the modeled loss per exposure unit for cat perils is not inflationary. Annual updates to models reflect the latest meteorological and scientific knowledge but do not generally indicate a structural need for trend.

mandate for consistency with the basis used for simulated cat losses. For example, if modeled hurricane losses reflect only landfalling hurricanes, but the claims unit designates weak, bypassing tropical storms as the basis for many "cat" claims received during a season, the excluded losses are broader than the simulated losses which replace them, making overall rate level indications inadequate. Actuaries should be vigilant and proactive in setting parameters for cat loss coding with respect to:

1. Event definitions (example: hurricane versus tropical storm)
2. Time periods (example: 72 hours over which losses are eligible for "cat" treatment)
3. Geographic areas affected (example: areas subject to government warnings)
4. Lines of business (example: exclusion of liability losses from "cat" eligibility)

It is wise to consider the associated definitions in company reinsurance treaties as an example when developing parameters for cat loss reporting.

The expected ratio of LAE to losses for catastrophes will depend heavily on how the insurer's claims department handles these events. Use of mobile claims centers and contracting of outside adjusters may affect the assumed ratio. Historical data on specific past events can be used as a guide in some cases; we have found that the ratio is very low (because the losses in the denominator are high, not because adjusting catastrophic claims is cheap) when the insurer's own claims personnel are the bulk of the adjusting corps. Hence, we omitted a provision for catastrophic LAE from the example for simplicity.

The collected premium can be placed on-level by either the parallelogram method or the extension-of-exposures method discussed in Homan [7], though the latter is of great help when it comes to estimation of rating factors. If the parallelogram method is used, the factor for each experience period will be derived explicitly from knowledge of overall rate changes and effective dates thereof, as detailed in McClenahan [8]; if the extension method is used, the raw premium data must be linked to all necessary categorical variables (class, territory, etc.) used in ratemaking and complete sets of historical rate tables or "ratebooks" must be available to compute the premium for each policy "as if" it were calculated on the current ratebook. Then the factor in the formula is implicitly the ratio of on-level to collected direct earned premium. Neither method will be discussed in detail here.

Underwriting and Adjusting Expense Ratios

Once the experience ratios are determined with formula (2), we must consider underwriting and adjusting expenses, reinsurance costs, and profit. Exhibit 3 shows an analysis of expense provisions. Recent calendar year underwriting expense ratios for each component:

- Commissions and brokerage;
- Other acquisition expenses;
- General (overhead) expenses;
- Premium taxes (which must be shown separately in some states);
- Other taxes, licenses and fees;

are used to estimate future expected expense ratios. It is tempting to select the multi-year average, but trends in expense ratios often reflect structural changes in finance or operations and must be given some credence in the selection of future ratios.

An assumption must also be made about the proportion of each component which varies directly with the premium charged. Commissions and most taxes and fees are assessed as percentages of net premium and thus treated as 100% variable. General expenses are almost exclusively allocated amounts of fixed overhead amounts and a 100% fixed assumption is usually appropriate. Other acquisition expenses include some fixed administrative costs, but also the cost of field inspections and policy-specific costs which may vary with premium size. We assume 50% of expenses in this category are fixed. Underwriting expense ratios are usually expressed to direct written premium, as they are almost fully incurred prior to policy inception.

Fixed underwriting expenses "by line" actually reflect accounting department allocations of companywide expenses to line of business. We strongly encourage actuaries to review the allocation procedures and judge whether the allocation basis accurately captures the true expenses associated with the line, especially in the presence of historical cat events. Often a premium-based allocation (the preference of most accountants) will be sufficient. For catastrophe reinsurance costs, this method will not be accurate, as discussed below.

A caution is in order about bulk assessments from residential property residual markets and guaranty funds, usually found in the "other taxes, licenses and fees" category. In some states, these assessments can be recouped over a given time period from policyholders via a premium surcharge. If the company chooses to surcharge, assessments should be removed from the expenses used for ratemaking to avoid redundant recovery of the cost. If recoupment is not allowed, a different problem arises - in the absence of a cat event in the historical three-year period, a tax provision which includes no residual market deficits will be inadequate in the long term. The annual expected value of assessments is material to the expense ratio despite a “lucky” zero over a short term. The same arguments which urge consideration of expected direct catastrophe losses in ratemaking should convince the actuary that the company's share of long-term expected residual market deficits should be considered in expenses in ratemaking. Failure to do so will harm profitability in the same fashion as would ignorance of the long-term impact of cat losses.

Adjusting and other expenses are usually related to the sum of paid losses and D&CC, rather than premiums. Since these amounts are generally line-specific rather than allocated companywide amounts, the calendar year ratios fluctuate more than those for underwriting expenses and the long-term average should drive the selection unless emerging causes of loss (such as mold, which involves extensive pre-settlement scientific testing) are driving a structural change in claim adjustment expenses.

Cost of Capital

The cost of capital held to protect the insurer against infrequent catastrophic events which produce losses far in excess of the long-term average for the peril must be considered in ratemaking. The held capital may be internally generated, borrowed from investors, or "rented" from reinsurers. Most insurers capitalize their cat risk using a combination of sources, with the largest often being reinsurance. Reinsurance may be available from private sources, which include a market-determined cost of capital in their premium, and/or public sources, which generally do not. Musulin and Rollins [10] contains a description and comparison of private and public property cat reinsurance options in Florida and a breakdown of the reinsurance premium as follows:

$$P_R = \hat{C} - R(\hat{C}) + \theta + T \qquad (3)$$

where:

$\hat{C}$ = expected direct cat losses (i.e. modeled gross annual losses);

$R(\hat{C})$ = expected net retained cat losses (determined by reinsurance program design);

θ = charge for cost of capital (a.k.a. reinsurance risk load);

T = transaction costs (such as brokerage and reinsurer administrative expenses).

A spectrum of approaches exist for efficiently reflecting the cost of catastrophic events in ratemaking, such as:

1. Treatment of the entire reinsurance premium (appropriately allocated to line) as a fixed expense in ratemaking and consideration of only non-cat and retained cat losses in the loss portion of the experience ratio. This method would be most appropriate for a heavily reinsured company to which differentiation of other rating factors according to modeled losses was not important. It has the advantage of not requiring detailed cat model output.
2. Loading of simulated expected direct cat losses in place of actual cat losses in the numerator of the experience ratio, and adjustment of those losses for a cost of capital charge calculated directly from assumptions, with no tie to the empirical market-determined cost of capital. This method might be required for an entity which has no benchmarks, such as an insurer which funds catastrophes solely from internal capital or a rating advisory organization.
3. A blended method, where the loss portion of simulated catastrophe costs is reflected directly in the experience ratio, and the cost of capital portion is treated as a fixed expense reflecting the market charge indicated by the non-loss portion of reinsurance costs. This is the method we use, so that $f_R = (\theta+T)/P$.

Homan [11] uses the first approach in his treatment of reinsurance costs in property ratemaking, and Rollins [12] has contrasted the relative strengths and weaknesses of the three approaches.

We already included the total direct expected cat losses in the overall rate level change by removing actual cat losses and adding modeled gross annual losses to each year's experience ratio. A provision for non-loss reinsurance costs, in order to provide for all costs associated with risk transfer, should consist of the reinsurance premium, less expected ceded cat losses, as a ratio to direct premium, or

$$f_R = \frac{P_R - (\hat{C} - R(\hat{C}))}{P} \qquad (4)$$

Since θ and T in formula (3) are not observed directly, this is the practical formula for the total non-loss portion of reinsurance costs.[11]

In Exhibit 4, we derive the fixed reinsurance cost provision from typical data. Direct earned premiums for the line, the portion subject to the cat reinsurance program, modeled gross annual losses, and actual cat reinsurance premiums ceded to various sources are compiled. The reinsured portion of modeled losses is derived by subtracting the retention (often based on subject premium) and the losses not covered due to coinsurance features of the treaty (typically 5% of losses above the retention). The actual ceded premium is normally significantly larger than this amount, and the difference represents cost of capital and transaction costs. For the overall rate level indication, we express the fixed reinsurance costs as a ratio to direct earned premium. In addition, it is useful later to think of these costs as a load to the gross ceded losses or "capacity charge" per dollar of expected loss. The fixed cost provision is carried to Exhibit 1.

Note that the ceded premiums are specific to the line of business under review. In practice, ceded cat reinsurance premiums are rarely specified by line, only in aggregate. The actuary must assist accountants in allocating the ceded premiums to line of business. Exhibit 5 provides an example. Direct earned premiums by line are compiled, with the property portion extracted for (currently) "indivisible" premium lines of business. This becomes the subject premium for most cat reinsurance programs. The portion due to property perils must be estimated from loss cost data. The actual all-lines ceded premium is allocated to line based on the modeled gross annual losses, separable by line from catastrophe simulation output, rather than a direct premium measure. The direct premium, subject premium, and allocated ceded premium for the line under review are carried to Exhibit 4.[12]

STRUCTURE OF FAIR PREMIUM

Derivation of Fair Premium Components

Given the components of overall rate level, our next task is to design a rate structure which collects a fair premium through a combination of charges. When partial base rates vary by peril, yet some fixed expenses (the reinsurance provision) are not allocated equally to peril, the classic ratemaking formulas need some careful modification.

The overall rate level change is developed using the loss ratio ratemaking method. In contrast, the new base rates and rating factors are developed from loss costs. This is necessary because each base rate and relativity is new and peril-specific, and cannot be expressed as a change to a previous factor, yet conversion to premium rates and rating factors is necessary for pricing. Note that "loss ratio" ratemaking (which produces the indicated changes to existing base rates needed to reconcile the indicated overall rate level change with the expected rate level impact of the rate and rating factor changes) is not incompatible with divisible premiums, once the modern plan is

[11] The astute reader will note that our "blended" formula is actually incomplete. There is no cost of capital levied on the internal capital held for retained catastrophic losses. In a heavily reinsured company, we can ignore this part of the capital charge for simplicity of presentation. Obviously, the formula cost of capital for an insurer which retained all losses and built a risk load into rates directly would not be zero. Our presentation assumes that the bulk of cat losses are ceded and that the associated cost of capital is revealed by the market.

[12] In Florida, the public reinsurer develops participating primary insurers' ceded premiums directly from exposure rather than in aggregate. Therefore, there is no need to allocate the public cat reinsurance premium.

in place and divisible premium statistics are used to do periodic rate reviews. It is, however, incompatible with the transition from indivisible to divisible premium.

In the proposed rating plan, premiums are levied in three parts:

- *Base rates* by peril, which cover raw loss costs (and fixed reinsurance costs where necessary), "loaded" for variable underwriting expenses and profit;
- *Rating factors* by peril, which adjust each base rate for risk class and territory differences in expected costs;
- A single policy *expense fee* (to cover all fixed underwriting expenses other than reinsurance).

Recall the classic formula for policy-level fair premium, expanded to separate non-loss reinsurance costs from other expenses not varying with direct premium:

$$P = X + F + F_R + vP \quad (5)$$

where P represents fair premium dollars, X is the expected loss cost, F represents the fixed underwriting expense dollars associated with the policy, and F_R represents the associated fixed reinsurance cost dollars. Since we choose to structure our rating plan so that the fair premium is collected via a combination of base rate (B) and expense fee (E):

$$P = B + E \qquad (6)$$

solving for P in formula (5) and setting it equal to (6) yields:

$$\frac{X + F_R}{1 - v} + \frac{F}{1 - v} = B + E$$

This formula suggests a natural decomposition, designating base rates to cover losses and fixed reinsurance costs, and expense fee to cover only fixed underwriting expenses, so that:

$$B = \frac{X + F_R}{1 - v} \qquad (7)$$

$$E = \frac{F}{1 - v} \qquad (8)$$

In developing base rates for non-modeled perils, we determine X directly from experience data. For modeled perils, we determine it from the model output. Later, we will make and justify a choice to recover all fixed reinsurance costs in the base rate for the hurricane peril. We determine F_R from the reinsurance data described above. Finally, we recover all fixed underwriting expenses in the policy expense fee, using:

$$E = f \times \overline{P} \qquad (9)$$

where $\overline{P}$ is the average premium per policy from experience data.

The decomposition of fair premium may affect rating factors as well, depending upon actuarial assumptions. Class rating factors by peril are derived from class loss cost relativities, which in turn are determined from experience data or model output. Assume a loss cost relativity is α, so that the class loss cost is:

$$X' = \alpha X$$

If fixed reinsurance costs are included in the base rate and not increased or reduced in proportion to the expected loss cost for the class, then the indicated class rate is:

$$B' = \frac{X' + F_R}{1 - v}$$

per formula (7). Substituting for X', the ratio of the class to base rate (a.k.a. the correct class factor) is:

$$\rho = \frac{B'}{B} = \frac{\alpha X + F_R}{X + F_R} \qquad (10)$$

as the variable expense ratio cancels out of the quotient.

Note that in cases where:

1. We choose not to recover a portion of fixed reinsurance costs in the base rate for the peril, or;
2. We assume that fixed reinsurance costs allocated to the class vary in proportion to class loss costs;

the formula reduces to α and the loss cost relativity is the correct premium relativity. Though non-loss reinsurance costs were assumed "fixed" for the overall rate level calculation, the assumption about whether they should be treated as fixed by class or territory is crucial for derivation of the proper rating factors. Our choice to recover all non-loss reinsurance costs in the hurricane base rate means that the classical formula for rating factors will apply for non-hurricane perils. For the hurricane peril, we will show an example of class (mitigation) factors calculated using the non-proportional assumption for these costs, and territory factors calculated using a modified proportional assumption for these costs. Also note that the formula can be expressed using an expected loss ratio and fixed reinsurance cost ratio to unmodified premiums (for the peril in question), since the premium dollars cancel out of both X and F_R.

Basic rating logic for the proposed structure is outlined in Appendix A. The rates and factors shown are for purposes of example only and do not have any particular significance. The derivation of base rates and various rating factors follows for each peril:

- Fire
- Hurricane
- Other Wind (non-hurricane windstorm, including tornado and hail)
- Liability/Medical
- All other perils (AOP)

Total "key" premium and total base premium are the sum of the key and base premiums, respectively, for each of the five components. Key premium (retaining the terminology used in the classical plan) represents the actuarially sound rate for first-dollar coverage on a risk of a base amount of insurance. Base premium is key premium adjusted for:

- The total value insured relative to the base amount, and

- The chosen deductible.

The choice of base amounts and deductibles is discussed later. Each component is rated for territory and most for class[13], and non-liability components are rated for value insured and deductible as well. The general total base premium formula reflecting N different perils is:

$$P = \left(\sum_{i=1}^{N} B_i \times \rho_i \times \tau_i \times k_i \times d_i\right) + E \qquad (11)$$

where

B = base rate;

ρ = class factor;

τ = territory factor;

k = key factor (for non-liability perils);

d = deductible factor (for non-liability perils);

E = expense fee.

Once total base premium is determined, the application of various charges and credits (primarily for coverage modifications) results in "adjusted base premium" which is comparable to that in the classical rating plan. However, the existence of component partial base premiums allows credits and charges to apply to only the components of base premium judged actuarially relevant, with appropriate modifications to the percentage charges and credits. Adjustments to base premium will be discussed further below.

Implications of Fair Premium Structure

Let us review some actuarial and note some practical advantages of peril-specific base premiums, all of which contribute to a more sustainably competitive pricing of individual risks in a 21st-century property insurance environment.

1. Fixed (non-loss) reinsurance costs can be allocated appropriately by peril to specific base rates and rating factors generating the cost of business..
2. The share of actuarially sound base premiums by peril may be highly geography-dependent. Class and territory rating factors should be calibrated to the expected experience differentials for individual perils and applied as such.
3. Territory boundaries should reflect loss cost gradients, which are heterogeneous by peril – distance to coast drives those for hurricane, other geographic features drive those for non-hurricane windstorm, and political boundaries may drive those for other perils. Peril-specific development of territory boundaries allows more accurate rating factors by peril.
4. The existing construction types used in rating are primarily designed for differentiating fire danger, and the relative wind damageability inherent in these classes overlaps with an

[13] This is a general term, encompassing the construction/protection factor (Fire), increased limits factor (Liability), and mitigation factor (Hurricane).

explicit windstorm mitigation class plan. Base premium separation allows targeting of classification features to the perils they affect.

5. We show later that amount of insurance ("key factor") curves and the loss distributions for deductible factors differ greatly by peril. Peril-specific rating allows proper differentiation of base premiums by value insured and deductible amount.

6. Percentage deductibles are (at this time) specific to the hurricane peril in Florida, due largely to statutory mandates to offer flat deductibles. The current rating plan must adjust for flat dollar/percent deductible combinations through a complex set of tables.

7. The hurricane portion of premium must be reported separately by territory per regulatory instruction in Florida.[14] Currently, this is typically done via a complex set of extraction factors by territory.

8. Actuarially sound hurricane rates must be determined with the help of catastrophe simulation models, facilitated by separation of this peril in the rating plan.

9. Proposed mitigation credits in all industrial/engineering studies done to date are calculated as a percentage of windstorm premium. A crucial assumption about the wind portion of base rates would be necessary to convert them for usage with the current rating plan.

10. Experience data on "other wind" (tornado, hail, straight-line wind) events is sparse and of low credibility for ratemaking, but a catastrophe simulation model can assist in determining the peril-specific rates.

11. Liability peril-specific rates allow the application of benchmark increased limits factors (which assume liability-only premium) rather than the dollar charges used in some current rating plans.

12. Liability premium should be separated for any loss reserving, as well as ratemaking and most management reporting exercises.

13. Many endorsements and some base premium adjustments change peril-specific exposures, and the charges or credits for these should be calibrated to the appropriate portion of the base rates.

In summary, key and base premiums will be determined by peril and added together to determine the total key and base premium. Each partial base premium will be calculated with a peril-specific partial base rate, territory factor, class factor, key (amount of insurance) factor, and deductible factor. This modernization of the rating plan streamlines many aspects of property insurance ratemaking.

DEFINITIONS FOR RATEMAKING

Territory Boundary Definitions

Appropriate territory definitions are a critical companion to peril-specific rating. Given a (Cartesian) surface or geographic map where loss costs are expressed as a function of latitude and longitude, we assert that risk classification principles [13] imply that territory definitions

[14] Rule 4-170.014(12) of the Florida Administrative Code.

should correspond to loss cost gradients (contours on the map). Previous authors have explored the use of loss cost gradients and GIS software to define territories, but their approaches have generally been based on data organized at the ZIP code level [14, 15].[15] Unfortunately, the public purpose of ZIP codes is such that they do not represent a sufficiently granular starting point for the analysis of hurricane loss potential.[16] The basic problem in property insurance is that loss cost gradients may vary widely by peril, and in fact the direction of the gradient for one peril may frequently be opposite that for another. In plain English, the contour maps by peril may not "match up" very well.

In Florida, there is significant conflict among meteorological indications, as well as conflict between meteorological and political boundaries. Modeled hurricane loss cost gradients largely reflect proximity to the coastline, meaning the optimal set of territories would make a contour map of the state look somewhat like an onion, with concentric closed polygons. In addition, the loss costs in the southern latitudes are much higher given the same distance to coast. Figure 2 maps modeled expected annual hurricane loss costs by land survey "section" defined by the Public Land Survey System - a unit of one square mile. The data set is weighted equally in each section, as explained below.

In contrast, modeled loss costs for other wind do not follow the geographical pattern of those for hurricane. In fact, they tend to be negatively correlated with the hurricane indications in similar groups of sections. Figure 3 maps the modeled other wind loss costs by section on the same data set.

Loss cost gradients for AOP and liability rating largely reflect demographics, though meteorological and geological phenomena significantly impact sinkhole and lightning losses. On the liability side, urban areas tend to be more litigious, and on the property side, urban areas may be more prone to theft and vandalism losses. Traditional (and ISO) territory boundaries for the classical rating plan were derived primarily from municipality and county lines. These lines may serve as sales territories as well. In short, for actuarial and practical reasons, political lines may still have a place in a modern territory rating system.

For the fire peril, two sets of geographic factors may apply - a construction/PPC factor and a territory rating factor. A solid argument can be made for the elimination of territory factors in fire once construction/PPC factors are redefined to apply to the fire-only partial base rate. On the other hand, regional or demographic differences in loss costs may persist even after adjusting for the level of fire protection by area. In our case study, we found that there was enough variation in fire hazards among territories to continue the use of a territory rating factor in addition to the construction/PPC factor.

All peril-specific actuarial considerations must be weighed in promulgating revised territory definitions. In addition, practical considerations favor having a single set of boundaries, and those boundaries being determined by landmarks (such as major roads and bodies of water) which are recognizable to salespeople and consumers. In summary, we determine territory boundaries as the intersection of all of the following geographic data sets:

[15] To be fair, Kozlowski and Mathewson advocated the use of square-mile loss densities given that the data is available.

[16] ZIP codes are based on urban demographics and tend to be convex polygons rather than thin "strips" parallel to coastlines, which is the general pattern of hurricane loss cost gradients.

1. Actuarially defined contours reflecting loss cost gradients by peril (particularly for hurricane) and convenient landmarks (roads, bodies of water, etc.) which are located close to the modeled contours;
2. Classical (existing) company territory definitions, which segregate barrier islands and some coastal areas;
3. ISO territory definitions (which generally follow county lines, with some municipalities and a few barrier islands separated);
4. Existing county lines.

Consideration of existing company territory boundaries is extremely important for the processes of transitioning individual policy/location records to the new lines.. A one-to-many relationship between each existing territory and the new territories allows a simple "lookup" rather than a geo-coding exercise in policy management systems. Likewise, consideration of existing advisory organization lines is valuable for implementing statistical reporting under the modern rating architecture.

In our study, overlaying all of the listed data sets geographically produced 187 new distinct territories.[17] Figure 4 maps a possible set of proposed territory definitions.

Analysis of loss cost gradients for non-hurricane perils indicated that no significant actuarial advantage (i.e. "bright line" gradients in loss costs) was to be gained by rating at a level more resolved than county. Therefore, the remainder of the paper shows rating factors which vary at the county level for non-hurricane perils and the territory level for hurricane perils.

Definition of Base Structure

Any base rate for property insurance reflects an assumption about the "base" structure insured. For non-modeled perils, this is important because all rating factors are keyed to the base house. For modeled perils, the definition helps incorporate public classification studies and build territory factors.

First, base values insured by policy form for the calculation of key factors are:

Form	Base Value	Coverage
HO-2	$100,000	A (building)
HO-3	$100,000	A
HO-4	$10,000	C (contents)
HO-6	$10,000	C
HO-9	$100,000	A
MH-2	$20,000	A
MH-3	$20,000	A

These values are generally consistent with those used by advisory organizations such as ISO.

[17] To facilitate coding and statistical conversion, our existing three-digit codes are redefined as the county code (01-67) plus a third digit of 1 for the territory closest to the coast, followed by 2, 3, ... further inland, or 0 for a county which contains only one territory.

Other base attributes, most following industry norms, are as follows:

- Base deductible is a flat $500 for all perils other than hurricane.
- Base deductible for hurricane is 2% of the Coverage A amount, in keeping with the Florida practice of percent rather than flat dollar deductibles for hurricane. This also aligns our rating plan with the public domain studies promulgating class factors for mitigation attributes.
- Base liability limit is $100,000 and medical payments limit is $1,000.
- Base fire protection class (PPC) is 9 (on the ISO scale of 1 to 10)[18].
- Base construction type (for fire premium) is frame.
- There is no base territory - the territory factors for hurricane, other wind, liability, and AOP are expressed and balanced relative to the statewide average of 1.00.

In the rating factor analyses for fire, AOP, and liability discussed below, actual experience data is used to develop indicated factors and various adjustments are made when it is necessary to bring experience to a "base class" level for a particular attribute.

In contrast, the rating factors for modeled perils are determined from an experimental data set consisting of hypothetical "base" structures placed around the state. We built an input data set containing one base structure in the geographic centroid (or as close as possible on land) of every square mile section of the state - 55,930 modeled locations in all. This is similar to, but much more extensive than, the approach taken by ARA in their public domain study. Base house attributes are as follows:

- HO-3 policy form insured for all perils;
- $100,000 coverage A, coverages B/C/D at 10%/50%/20% of A (respectively);
- A $500 other wind and a 2% hurricane deductible;
- Frame construction type;
- Gable roof attached with clips and covered by standard shingles;
- A garage with unreinforced door and no other opening protection (i.e. storm shutters).

In other words, the base house is of base rating values and "unmitigated" with respect to hurricane damage, roughly as defined in the ARA study.[19]

It is essential to use experimental data sets for rating factor development for modeled perils for several reasons. Actual exposure data generally reflects vastly different property profiles by region. These maldistributions extend to nearly every rating variable - average total value insured, average windstorm mitigation and fire protection level, average deductible amount, and others. Hurricane or other wind modeled relative loss costs generated from these lopsided exposure profiles would be so biased as to be nearly useless.

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[18] Most companies and ISO use 3 as the base; our departure reflects the predominantly rural demographic profile of our policyholders.

[19] In a parallel study for mobile-homeowners, an analogous experimental data set was built for a mobile home with MH-3 policy form, $20,000 coverage A and associated standard relationships for coverages B/C/D, and a "mobile home" construction type with no mitigation devices.

A related problem is that of "missing" exposure. In the extreme case, the lack of exposure in a new, more refined coastal territory could result in an indication of a zero rating factor as a zero loss cost for the region is produced by the model. Alternatively, much of the existing exposure in coastal territories could be written on an "ex-wind" basis, whereby the hurricane peril is excluded from the policy. If the exclusions are noted in the data supplied to the model, the same problem will result. In short, when the territory boundaries are redefined, it is essential to consider the full spectrum of possible exposures in geographical rating factors. This is possible only with a contrived data set.

BASE RATES AND EXPENSE FEES

Recalling formulae (7) and (8), we build base rates and expense fees from loss costs, fixed (non-loss) reinsurance costs, and fixed underwriting expenses, all expressed in dollars per policy, then loaded for variable expenses and profit. In turn, these components are determined from cat models (for hurricane and other wind perils), historical loss and exposure data and distributions (for non-modeled perils), and the breakdowns of underwriting and reinsurance expenses used in the overall rate level change calculations.

Exhibit 6 shows how base rates are constructed for modeled perils. First, the fixed reinsurance costs for the homeowners line of business are allocated to policy form on the basis of the product of the latest year's actual distribution of exposure (earned house-years) by policy and the known base coverage amount, or "earned TVI at base value insured". The indicated loading in the base rate is just the ratio of allocated fixed reinsurance costs to earned house-years (policies).

To obtain the loss portion of the base rate, the cat model is run against the experimental data sets and the simulated expected gross annual losses are recorded for every location. Location results are aggregated statewide to obtain the overall average loss for the base structure in a season.[20] The final base rate for hurricane, by policy form, is the loaded sum of the loss cost and fixed reinsurance cost. Recall we have chosen to allocate all non-loss reinsurance costs to the hurricane peril, so the other wind base rate by form is just the loaded loss cost.

The analogous base rates for non-modeled perils are based on historical data and developed on Exhibit 7. When using the loss cost ratemaking method along with historical property exposure data, several distributional adjustments may be necessary. For the fire peril, the average underlying key factor (a function of TVI) and average underlying construction/PPC factor are likely highly divergent by policy form. The exposure base, the denominator of the loss cost, is multiplied by the average underlying factor in the <u>proposed</u> rate structure (for each maldistributed rating factor) to restate it at a "base class" level for determining the base rate. Similar adjustments apply for average underlying limits in the base rate for liability and average

[20] Model results are less credible for HO-4 (renters) and HO-6 (condominium unit-owners) policy forms. Worse, our book of business has very low volume in these forms. We chose to proportionally reduce the modeled loss cost for the site-built homeowners forms, based on the ratio of the sum of base coverage A/B/C/D amounts for the forms, to derive a reasonable hurricane loss cost for HO-4 and HO-6 forms. Specifically, our HO-4 policy provides a $10,000 base for contents coverage, no coverage for structures, and "loss of use" coverage of 20% of the contents coverage, while the HO-3 provides a $100,000 base amount for dwelling coverage, 10% of the dwelling amount for other structures, 50% of the dwelling amount for contents, and 20% of the dwelling amount for loss of use. The ratio of total modeled coverage between these two forms is therefore (10+2)/(100+10+50+20), or about 6.7%. This assumes the same average damageability ratios over all coverages.

underlying TVI in the AOP base rate. The adjusted loss cost must still be loaded for variable expenses and profit, of course.

The need for distributional adjustments to the loss cost based on proposed rating factors means that these rating factors must be determined before the final base rates are. This is necessary for an efficient and equitable rate structure when rates are developed from the ground up. Later, we show that we achieve adequate revenue under the modern rating plan by "solving for" the base rate which matches indicated overall rate level to estimated rate impact.

Expense fees by policy form are developed on Exhibit 8. The ratio of the latest year's earned premiums (including such fees) to earned house-years represents an average premium per policy. The fixed expense ratio is applied to this value, and loaded to obtain the indicated fee. In practice, round numbers are often selected for expense fees and they are often set equal for similar policy forms.

TERRITORY AND CLASS RATING FACTORS

In the basic rating logic, territory factors apply to every peril. In addition, class factors apply to fire (construction/protection) and hurricane (mitigation), and increased limits factors adjust the liability premium. Base premiums for each non-liability peril reflect coverage adjustments for amount of insurance and amount of (or percentage) deductible.

Territory Factors – Modeled Perils

Exhibit 9 presents one method of determining hurricane territory rating factors which incorporate an allocation of fixed reinsurance costs. Most actuarial techniques for the development of rating factors use only the mean loss cost to modify the base rate. We use the modeled mean loss costs by territory to modify the loss portion of the base rate, and the <u>standard deviation</u> of these loss costs to modify the fixed reinsurance cost portion of the base rate.

Recalling formula (7), we can denote F_R as the fixed (non-loss) reinsurance expense dollars per policy. The bulk of non-loss reinsurance costs reflect some measure of risk as perceived by the reinsurer. Many risk metrics (as functions of the possible loss outcomes on a portfolio of policies) exist, and it is beyond the scope of this paper to capture the essence of the (considerable) actuarial debate over the best metric for reinsurance premium development. We make an assumption which is simple and squares with observations of the global reinsurance market:

$$F_R = K \times S_L \quad (12)$$

where

S_L = the standard deviation of the modeled annual losses - readily available by location or in geographical aggregate from the cat model;

K = an empirical scale factor which relates the volatility in modeled losses to the actual non-loss ceded reinsurance premium.

In other words, we assume that reinsurers charge us for cost of capital in proportion to the standard deviation of our annual losses. While reinsurance pricing models tend to be proprietary, there is long-standing support in both actuarial literature [16] and market practice to brand this assumption reasonable.

We choose the scale K_i identically for each territory so that the exposure-weighted F_R by territory, based on S_L, balances to the aggregate F_R derived on Exhibit 4 (expressed per unit of losses). The success of the technique does not require this choice - the scale factor could be set lower in some territories and higher in others to reflect second-order assumptions about the capacity charges levied by reinsurers in different areas.

The modeled number of exposures (essentially a land-area weight given the construction of our experimental data sets), modeled (mean) loss cost, and modeled standard deviation of losses are collected for locations falling in each proposed territory. Note that the overall modeled loss cost is the exposure-weighted average by territory, but the aggregate standard deviation is not additive - it must be collected directly from the model output. By design, the allocated fixed reinsurance costs, reflecting the scale factor, do average (exposure-weighted) to the aggregate fixed costs derived in the overall rate level indication.

The sum of the modeled loss cost and fixed reinsurance cost for each territory is the basis for the cost relativity to the statewide average. This relativity is the theoretical territory factor. In practice, we allow for a tempering of the indicated rating factor toward unity due to competitive or regulatory pressure. We do not refer to this as "credibility weighting" because the modeled loss costs are fully credible in a convergent hurricane model.[21] The tempering is a non-actuarial exercise. If it is present, the resulting factors must be rebalanced to unity.

The techniques may be applied in an identical fashion to experimental data sets for both homeowners and mobile home forms. In our study, we found that the statewide range of territory factors was slightly wider for mobile homes.

Though loss and fixed reinsurance costs must both be considered in all rating factors for the hurricane peril, formula (10) does not apply directly when this technique is used because:

- The rates are balanced to the statewide average of unity, so there is no base territory to which credits and debits are expressed;
- The fixed reinsurance costs are allocated directly in the calculation of the territory factors using the standard deviation of modeled losses.

An adjustment to loss cost relativities may be necessary when mitigation class factors are developed later.

The territory factors for the other wind peril are developed using identical experimental data sets, with the exception of lowering the base deductible to $500. The same basic technique is applied to the model output, with the deletion of the allocation of fixed reinsurance costs - the modeled mean loss cost relativities are the sole basis for the (possibly tempered and rebalanced) territory factors. We feel the advent of simulation models for other wind offers us the opportunity to

[21] The Florida Commission on Hurricane Loss Projection Methodology, an agency charged with certifying the validity of catastrophe models used in rate filings in the state, uses a standard by which modeled mean loss costs must "converge" within a certain tolerance at the ZIP code level. The simulation size required for convergence can be very large (50,000 years in the case of our model).

exorcise the last vestiges of the classical ISO "excess wind procedure" and its brethren from ratemaking for infrequent catastrophic events.[22]

Territory Factors – Non-Modeled Perils

Standard one-way actuarial techniques are applied to the problem of setting territory rating factors for AOP, liability, and fire (if desired) from historical experience. Exhibit 10 shows an analysis of AOP territory factors for completeness.

In a loss ratio ratemaking approach, the actuarially correct inner product used to balance the average statewide factor to unity would be that of:

- Adjusted relative loss ratios (losses divided by premiums stated at present level and adjusted to "base" or statewide average territory level) by territory, and
- A weighting vector of earned premiums (on present base territory level) by territory.

In the loss cost approach used in our study, the appropriate weight becomes whatever exposure base is used to calculate relative loss costs. We have chosen earned total value insured as the base (one unit of earned TVI = one house insured for $1,000 for one year), so it is used both to calculate relative loss costs and to balance the statewide average territory factors to unity.

We apply classical (limited-fluctuation) credibility to the relative loss costs, again using earned TVI as the base, to obtain final indicated factors. Many other credibility techniques could be applied, but a survey of them is beyond the scope of this paper. The full credibility standard V_f is chosen by judgment, and the credibility for a single territory is

$$Z_i = \sqrt{\frac{V_i}{V_f}} \qquad (13)$$

Again, it is possible that selected territory factors may differ from indications for non-actuarial reasons. The selected territory factors are rebalanced to a statewide average of unity using the weighting discussed above.

Depending on claim volume, territory factors for the liability peril may be set using regional aggregations of territories. Alternatively, regional loss cost relativities might serve as the complement of credibility for territory-level relativities. In fact, these regions do not have to be geographically contiguous if liability trends tend to follow city and suburban demographics. In any case, the same techniques are applicable except that loss data should also be converted to basic limits to avoid demographic bias.

Class Factors – Hurricane (Mitigation)

Property insurance has always been rated by type of construction, but construction rating attributes were historically designed to rate the predominant peril of fire. The blunt distinction between frame and masonry wall construction was often deemed sufficient. As hurricane has replaced fire as the cause of loss underlying the plurality of the base premium in some states,

[22] See Burger et al. [6] for an excellent contrasting description of the use of cat models for hurricane and an excess wind procedure for other wind.

construction class plans should evolve accordingly. The modern rating architecture should include class plans based on distinct construction attributes for both fire and hurricane perils.

In hurricane, we refer to a "mitigation" class plan as it focuses on fixtures, techniques and devices specifically designed (and often retrofitted to the home after initial construction) to reduce such losses. As discussed earlier, Florida statutes now enumerate several devices which must be considered in the development of the class plan. The public domain ARA study is also required reading for those seeking to understand the rationale for the choice of devices which serve as elements of the class plan. The study found that the following devices significantly reduce hurricane losses and should be treated as "primary rating factors":

- *Roof shape* (gable, hip, flat, and others)
- *Roof covering* (shingles compliant with FBC, shingles not compliant with FBC, tile, metal, and others)
- *Secondary water resistance* of roof (present in the form of taped or sprayed sealant, or not)
- *Roof to wall* connection (toe nails, clips, hurricane wraps of single or double layers)
- *Roof deck attachment* method (four categories based on nail size and spacing)
- *Opening protection* (engineered storm shutters, non-engineered attachments such as anchored plywood, or none at all)

The study noted several additional attributes which reduce hurricane losses enough to be treated as "secondary rating factors":

- Opening protection *coverage* (windows only or all openings including doors and garage doors)
- *Gable end bracing* (present or not)
- *Wall construction* (the traditional fire class variable, frame or masonry)
- *Wall to foundation restraints* (present or not)

An actuarially interesting result of the study is that the reductions in expected loss cost for various combinations of devices turn out to be highly interactive, meaning that the class factors cannot be set for individual devices and multiplied or added across all devices present to determine the appropriate comprehensive class factor. Instead, we need a multi-dimensional table of modeled primary rating factors for each combination such as the one shown in Exhibit 11.[23] The indicated reductions in loss costs for the various combinations also depend upon the terrain category (i.e. flat, swampy, hilly) associated with the property location. ARA divided the state into two basic terrain categories which they denoted "B" and "C". We chose to map the terrain category definitions shown in the study to our proposed territory structure, designating each entire territory as one category to facilitate the determination of class factors from the tables without additional geo-coding.

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[23] Exhibit 11 shows the actual factors promulgated in the ARA study, relative to a base structure which is largely unmitigated and carries a 2% hurricane deductible.

Given the raw loss cost relativities, the final class factors must still embody a key actuarial assumption. When the mean loss cost is reduced (relative to the unmitigated base structure) for a house by application of mitigation devices, should its allocated portion of fixed reinsurance costs be reduced as well? If so, should it be reduced in proportion to the mean or should the reduction be tempered? Recall that formula (12) assumes that fixed reinsurance costs are proportional to the standard deviation of modeled losses. Even if we believe this assumption is valid at the individual risk level, it is entirely possible that a reduction in mean losses could decrease S_L less than proportionally, or even increase it. Alternatively, other seemingly intuitive assumptions - for example, that the coefficient of variation of modeled losses would remain constant when a mitigation regime were applied - would lead to a fully proportional reduction in fixed reinsurance costs (and therefore class factors which are identical to the raw loss cost relativities).

Under the assumption that non-loss reinsurance costs are truly "fixed" even in the presence of mitigation, the class factors may be derived from the loss cost relativities using formula (10), where α is the relative loss cost, X is the permissible loss ratio from Exhibit 1, and F_R is the fixed reinsurance cost ratio from the same exhibit. For example, a loss cost reduction of 20% for a device, along with a permissible loss ratio of 65% and a fixed reinsurance cost ratio of 10% would lead to a class factor of

$$\rho = \frac{(1-20\%)\times 65\% + 10\%}{65\% + 10\%} = .827\ .$$

In addition to the key issue of reductions in fixed reinsurance costs, the public domain studies have been silent on several important issues for ratemaking:

- Should this mitigation class plan apply to losses from other wind (non-hurricane storms containing tornadoes, hail, and severe straight-line wind)? If not this plan, what about a modified alternative? Other wind causes of loss were not considered.
- Should this mitigation class plan apply equally to owners, renters, and condominium policy forms? It stands to reason that the factors should be modified when contents coverage is the predominant exposure under the policy. Yet little guidance was provided in the studies.
- How should mitigation class plans be modified for commercial construction exposures?
- How should mitigation experience data from actual catastrophic events, as they are occasionally experienced, be assimilated into the class factors? It would be hubristic indeed to assume that mitigation devices and combinations thereof will perform exactly as modeled when we observe the effects of a real hurricane. To the extent they do not, what is the actuarially appropriate credibility for the vital data from actual events in future class factors?

In summary, actuaries and their scientific partners have a long way to go in developing comprehensive mitigation class plans for the relevant perils. To the extent we do not ask all the right questions, unpalatable answers may be forced upon our industry.[24]

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[24] Regulators in Florida have already encouraged blanket application of the class factors for residential structures to HO-4 and HO-6 policies and other wind base rates.

Class Factors – Fire (Construction/PPC)

In the classical rating plan, class factors are targeted at the fire peril and two attributes of residential structures: the resistance of the structure to fire damage, and the level of fire protection afforded by the community in which the structure is located. These two attributes are highly interactive - masonry construction, which is more fire resistive, is more common in suburban environments where fire hydrants are prevalent and fire stations plentiful. Therefore, rating factors are developed using "two-way" actuarial analysis, as detailed by many contributors to actuarial literature.

We have not broken new technical ground in our study - fire peril experience data is used along with a two-way "minimum bias" procedure to develop sound construction/PPC factors for the modern rating plan. We have included no exhibits on this topic, but do wish to quickly point out some empirical results associated with a peril-specific analysis:

- The "spread" of construction/protection class factors is much wider when only the fire peril experience is considered in the analysis, as losses for other perils are not part of the experience base. These losses, which do not vary significantly by fire rating attributes, serve as ballast dampening the construction/protection class factors toward unity in the classical plan. This result confirms one of the stated advantages of the modern rating plan - greater rating resolution for non-catastrophic perils.
- Significant differentials in loss experience are found for individual (ISO) protection classes 4, 5, and 6, prompting us to develop separate factors for these classes. Most insurers combine classes 1-5 or 1-6 and use the same rating factor in classical rating plans.
- Fire experience for hybrid construction types such as brick veneer (over frame) and "hardi-plank" siding varies significantly from that for either full frame or full masonry construction. We chose to expand the classical "frame vs. masonry" construction class distinction to include an intermediate rating class for these hybrid types.

KEY, DEDUCTIBLE, AND LIMIT FACTORS

As Appendix A shows, the modification of base rates for territory and class produces partial key premiums by peril. The key premiums are further modified for attributes reflecting the volume of coverage provided, via key factors, deductible factors, and increased limit factors (for liability), to obtain partial base premiums. It turns out that the incongruities in the loss distributions for fire, AOP, and modeled perils are significant enough to warrant separate development of key and deductible factors for each peril. In addition, the presence of percentage deductibles for hurricane requires a separate set of deductible factors.

Key Factors - Non-Modeled Perils

The reflection of value insured is probably the single most important rating factor in pricing property insurance. Given its critical importance, it is one of the most under-represented topics in the actuarial literature. In the course of our research, we were frustrated to find little guidance on techniques for developing key factors from experience data for even an indivisible premium, and absolutely none on key factor relationships for distinct perils when rated separately. Most papers on homeowners pricing do not treat the subject at all. Homan [7] provides a clever frequency/severity approach for an all-perils development, but his reliance on industrywide loss cost distributions for the complement of credibility is not helpful when no analogous complement is available by peril.[25] In summary, we are caught between the "rock" of low credibility of experience data by peril within small ranges of insured value, and the "hard place" of no suitable complement of credibility in the form of larger-scale studies.

In response, we developed an approach for AOP and fire perils based on accumulations of experience data at successive levels of value insured. It reflects the value of experience data while facilitating smoothing of the indicated loss costs to produce tables which square with actuarial theory.

Exhibit 12 shows the development for the fire peril. Five calendar years of experience is segregated by $5,000 ranges of (coverage A only) TVI. First, the average classical all-perils key factor for the midpoint of the range is shown for reference, along with the earned house-years and paid fire losses (with D&CC). Second, we accumulate the exposure and losses for all TVI ranges up to and including the current range, and calculate the cumulative loss cost.

Why accumulate? Theoretically, the key factor represents the loss cost at a given (incremental) TVI range relative to the loss cost at the base value, but the loss cost series for individual TVI ranges is simply too volatile to use directly. Instead, we use the more stable cumulative loss cost series to mark selected cumulative loss costs at "target" points (generally every $25,000 of TVI), and calculate the implied incremental loss cost in the target range by decomposing the cumulative value as follows.

The known cumulative losses can be represented as the sum of a series of incremental loss costs times incremental exposure in each TVI range up to the current one:

$$L_k = \overline{\lambda}_k \overline{W}_k = \lambda_1 W_1 + \ldots + \lambda_k W_k$$

where:

λ_i = the incremental loss cost in each range (i=1, 2, ..., k);

W_i = the exposure weight in each range;

and bars above indicate cumulative totals for ranges "up through" an amount. Then we solve for the incremental loss cost for the current range (denoted by k) from the cumulative totals and the exposure in the current range:

$$\lambda_k = \frac{\overline{\lambda}_k \overline{W}_k - \overline{\lambda}_{(k-1)} \overline{W}_{(k-1)}}{W_k} \qquad (14)$$

Once the implied key factors are found for each of the target ranges, we interpolate linearly between every two target points to find the key factor for the $5,000 ranges in between.

When selecting cumulative loss costs at target points, we must be careful to keep the implied marginal key factor (difference between key factors for successive $5,000 ranges) between the theoretical lower and upper bounds of:

[25] Homan also includes a treatment of fixed expenses, which is not necessary when an explicit expense fee is charged as it is in our fair premium structure.

- Zero (meaning no additional losses are expected despite the increase in policy limit) and
- .05 (meaning all losses are total and will "burn through" the additional policy limit of 5% of the basic limit in a linear fashion).[26]

This is a non-trivial exercise requiring some trial and error. Exhibit 12 shows a reasonable curve given the credibility of some actual data and the theoretical limitations. Also, the factor for "each additional $5,000" beyond $250,000 primarily reflects the marginal factor in the last target interval.

The effects of fire protection, construction, and average TVI overlap severely in the rating plan. Higher-valued homes tend to be of masonry construction and located in well-protected suburban areas. Accordingly, for the fire peril we adjusted the exposure amounts to ameliorate this distortion to the raw incremental and cumulative loss costs. Specifically, we divided out the proposed construction/PPC rating factor from each exposure record in the statistical data to get a loss cost stated "on base class".

Key Factors - Modeled Perils

In catastrophe simulation models, the result for each simulated event at each location is typically the "mean damage ratio", a value representing the damage as a proportion of the value of the structure(s) insured. The value of the structure is given as a parameter by the user of the model and the mean damage ratio is applied to it to generate the modeled losses. Put another way, in the models there is an assumption of independence between the mean damage ratio for the structure and its insured value. Most insurers make blanket (as opposed to policy-level) assumptions about insurance-to-value when populating an exposure data set for simulation, which proportionally affect the modeled cat loss costs for pricing purposes.

Assuming the values insured reported to the model are reflective of sufficient insurance to value, this attribute of cat models implies that the key factor table is linear with respect to TVI for the modeled perils. The hurricane base premium for a given $200,000 house is twice that for an identical $100,000 house. A further discussion of the appropriateness of this assumption appears in the ISO [17] filing to partition wind base premiums, as part of their statutory compliance filing of the Florida mitigation class plan. Note the ISO key premiums are nearly linear for the wind peril.

To some, the assumption may appear to be an unacceptable oversimplification and a weakness of using simulated catastrophe losses in pricing. For a heavily reinsured company, the argument over whether the key factor table should be driven by the linearity of modeled loss costs is largely academic. Market reinsurance costs are increasingly driven by the distribution of modeled losses, and the retailer of insurance must reflect its "wholesale" cost for each risk, as charged by the reinsurer, to avoid economically irrational underwriting.

We apply a linear scale of key factors for both hurricane and other wind perils. The key factors vary by policy form only because the base value insured differs by form. In Florida, one practical effect of the separation of key factors by peril is higher hurricane rates for high-valued homes. These homes were significantly subsidized by application of sub-linear key factors to indivisible premium, of which a plurality (if not a majority) is typically hurricane premium.

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[26] Recall that we defined the base structure as one of $100,000 TVI.

Deductible Factors - Non-Modeled Perils

Unlike key factors based on the aggregate loss cost distribution, deductible factors depend solely upon the loss severity distribution. An excellent review of general deductible pricing theory appears in Hogg and Klugman [18], and we assume familiarity with the "loss elimination ratio" (LER) as the kernel of the deductible rating factor. Our study provides strong evidence that the LER profile varies greatly by peril. In addition, one might expect that the LERs should vary significantly across many other rating factors, such as value insured, territory, and class. In order to maintain manageable rating logic, we have allowed flat dollar deductible factors to vary by peril and TVI range, and by territory only for modeled perils.

The deductible factors for non-modeled perils are developed directly from five years of individual claim data. Flat dollar deductibles ($500, $1,000, and $2,500) are the only options for non-modeled perils, in contrast with the percent (of coverage A TVI) deductibles offered for the hurricane peril and discussed below.[27] Each existing claim is stated on a "ground-up" basis by adding back the deductible amount associated with the claim.[28] The net of deductible claim amount is determined for each claim under each flat deductible option. The sum of all claims valued at each deductible option is compared to the ground-up losses to determine the empirical LER for each deductible amount. Then the deductible rating factor for each non-base deductible is calculated as

$$d_i = \frac{1 - LER_d}{1 - LER_{Base}} \qquad (15)$$

or the ratio of the losses retained (not eliminated) at the target deductible to those retained at the base deductible (of $500 in our study).

The factors resulting from this calculation depend heavily on the underlying exposure (TVI) distribution of the empirical data, since the amounts of total losses vary by claim but the flat amount does not.[29] Actuarial theory tells us that the LER for the same deductible option and the same underlying (unlimited) loss distribution will be smaller as the average TVI (policy limit) increases. Further, the relationship between the LERs for two (small amount) deductible options should be dampened as both options represent an ever-smaller portion of increasing TVI. This implies a two-way consistency test for deductible factors:

1. The selected factor for a given TVI range should (obviously) decrease as the deductible increases, and

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[27] There is no theoretical reason percent deductibles by peril cannot be priced from experience data. In fact, we could argue that percent deductibles are actuarially superior for all perils because they "inflate" with the value insured and therefore with the corresponding the loss severity distribution, a big help in preserving the loss elimination ratios underlying the rating factors. The resulting factors become obsolete over time much more slowly. Though state statutes tend to restrict deductible options depending upon TVI, at least one Florida insurer has recently introduced an all-perils percent deductible.

[28] This does not solve the "missing claims" problem of losses not exceeding the actual deductible which "would have been filed" if the deductible were smaller. We have ignored this distortion.

[29] We divided the data into TVI ranges which produced a credible and approximately equal amount of earned house-years in each range.

2. The selected factors for a given deductible should converge toward unity as the TVI range increases.[30]

When this process is compared for multiple perils, we expect the loss distribution for perils which tend to result in more total losses (such as fire) to imply smaller LERs at all deductibles, and therefore deductible factors closer to unity, than those implied by a peril producing more partial losses (such as AOP). Therefore, across multiple perils we can add a third consistency test:

3. The selected factor for a given TVI range and deductible option should be closer to unity for the more "severe" peril (the one with the more right-skewed distribution of loss amounts).

Exhibit 13 shows representative LERs and selected deductible factors which reflect all three tests.

Deductible Factors – Modeled Perils

Percent deductibles applicable only to the hurricane peril are the rule in Florida. They were originally introduced as an innovative way to reduce loss exposure without nonrenewals in the market turbulence following Hurricane Andrew in 1992. In lieu of experience data, we use the cat model to determine hurricane deductible factors by scenario testing over several model runs on the same experimental data sets, with only the deductible option changed in each scenario. Specifically, we replace the base 2% deductible with each of the other deductible options (in our study, 0.5%, 1% and 5%) and repeatedly run the model to determine the simulated loss elimination ratio.

Catastrophe simulation science indicates that the shape, as well as the scale, of hurricane loss distributions varies widely by territory in the Gulf Coast. In fact, areas with high average hurricane loss costs also tend to have a greater frequency of severe storms which produce more near-total property losses. Ideal hurricane deductible factors should therefore vary by territory. In consideration of maintaining manageable rating logic, we examine the scale (expected annual loss costs by territory) of the hurricane loss distribution by territory from the experimental base data set and divide the territory set into Low (less than $400 per year), Medium ($400-$599), High ($600-$1,099), and Extreme ($1,100 and over) hurricane intensity zones. The boundaries are determined by judgment, and intended to include a reasonable number of modeled locations in each zone - though most modeled points are in the Low zone, the higher-intensity zones must be segregated to produce reasonably accurate factors. The modeled losses are aggregated under each scenario in each zone, the relativities to the modeled losses at the base deductible are computed, and deductible factors selected. Exhibit 14 shows the results.

When using the model to price flat dollar deductibles as a modification to the base rate for a percent deductible, the problem of exogenous values insured pops up again, in a different disguise. Any flat amount represents a constant percentage of a single experimental base value insured, no matter what the choice. For example, the modeled losses, and therefore the loss elimination ratio, for a $500 deductible scenario will be identical to those for a 0.5% deductible

[30] Whether they start above or below unity is determined by the base deductible.

scenario when the base value is $100,000.[31] The actual deductible factor charged in rating, even for the hurricane peril, should depend upon the empirical TVI distribution of the insurer's book, and indeed the TVI of each property. By design, this is not considered in our experimental data set.

We did not resolve "the" proper way to differentiate flat dollar hurricane deductible factors by TVI range, but settled on an adjustment to a "base" scenario (that for the 0.5% deductible, which is equivalent a flat $500 deductible for the majority of units in the experimental data set). The implied relative loss cost for AOP perils by value range, shown on Exhibit 13, is the ratio of the complement of the loss elimination ratios in each range; the calculation is analogous to formula (15), but relates TVI ranges rather than deductible amounts. We select a relativity, then apply it to the modeled 0.5% deductible factors by zone to produce $500 flat deductible factors which vary by both TVI range and zone. For example:

Low zone, under $75,000: $$1.17 \approx \frac{(1-25.0\%)}{(1-20.4\%)} \times 1.23$$

Medium zone, $225,000 and over: $$1.26 \approx \frac{(1-14.7\%)}{(1-20.4\%)} \times 1.18$$

and so on. The end result is a reasonable consideration of both value insured and territory loss distributions in the pricing of hurricane flat dollar deductibles. The calculation could be repeated for other flat deductible options.

The deductible factors for other wind, where only flat dollar deductibles are offered, are calculated using exactly the same procedure and modeled scenario testing, except that we chose not to differentiate the factors by zone. This simplifies the process by removing one dimension from the matrix of rating factors. Catastrophe simulation science indicates that other wind aggregate loss costs are driven by expected event frequency and that the shape of the severity distribution of individual severe thunderstorm events is not as critically different by territory. Further, other wind is a much smaller portion of overall base premium in Florida, leading us to waive this adjustment.

Limit Factors - Liability/Medical

This paper breaks no ground with respect to the actuarial techniques for calculating limit factors for the liability peril (Coverage E), but there are still advantages to divisible base premium. Limit factors are often based on benchmarks obtained from the voluminous databases and advanced loss distribution analysis provided by advisory organizations such as ISO. With distinct liability base premium, we have an opportunity to move away from the cumbersome additive charges commonly used in residential property insurance and develop multiplicative limit factors for liability base rates with appropriate reference to industrywide data. The modern rating logic includes a liability base rate modified by a multiplicative factor.

[31] This is true assuming that the model contains a "static" event set which is applied to every location. Some models build a "secondary uncertainty" randomization component into the analysis, which means the modeled losses for the same scenario on the same event set will still differ somewhat every time the model is run.

Medical payments coverage (Coverage F) is such a small part of the overall base premium that we chose to simply add the base rate to that for liability (after modification by the limit factor) and allow for the existing additive medical limit factors. Application of multiplicative factors to medical might even result in premium changes of less than one dollar, which is not practically desirable in most systems.

ADJUSTMENTS TO BASE PREMIUM

Many adjustments (charges and credits) are made to the base premium to determine a final homeowners policy premium, even without the presence of specific endorsements. We highlight some of these adjustments and show that the modern rating architecture allows several improvements:

- Some adjustments may be recalculated as a modification to an appropriate subset of the total base premium rather than a blanket modification of premium for possibly impertinent perils;
- Some adjustments for excluded perils may be accomplished by partial or total elimination of a portion of the base premium, simplifying the rating logic.

Exhibit 15 shows how charges and credits are recalibrated to a smaller premium base when changes must be revenue-neutral in aggregate. We tabulate the statewide distribution of base premium by peril and policy form, then simply divide the current credit or charge by the proportion of the proposed premium base represented by the components to which the credit or charge is targeted, to make the modification factor appropriate for the smaller base. Of course, the actuary may determine that larger or smaller revenue effects are indicated and use experience data to adjust the charges and credits in line with indications, provided the expected revenue gain or loss is acknowledged as an off-balance in the determination of overall rate level impact.

Some examples of actuarially sensible changes to adjustments to base premium are:

- *Wind and hail exclusion* may be accomplished by simply eliminating the base premium for hurricane and other wind in the total base premium calculation. Tabular factors formerly used for this purpose may be eliminated, streamlining rating logic.
- *Superior construction and storm shutter credits* may be eliminated, as they are superseded by the comprehensive windstorm mitigation class plan.
- The *seasonal occupancy charge* may be adjusted to apply to the (AOP + fire + liability) base premium, if we believe that the wind resistance of the structure does not depend on occupancy.
- The *protective devices credit* for smoke and burglar alarm combinations may be adjusted to apply to (AOP + fire) base premium.
- The *age of home credit* may be adjusted to apply to the (AOP + fire) base premium, or eliminated with the advent of fire and hurricane class plans.
- The *town/row house charge* may be adjusted to apply to the (AOP + fire) base premium.
- The *replacement cost provisions charge* for "guaranteed replacement cost" endorsements may be adjusted to apply to the non-liability base premium.

IMPLEMENTATION ISSUES

The move to a modern rating architecture for residential property insurance affects many non-actuarial functional areas within an insurer, including:

- Operations (programming, policy management, statistical reporting)
- External affairs (filings, regulatory relations)
- Marketing (sales force, customer service training, competitive analysis)

Several specific items and issues with actuarial overtones which tend to have cross-functional impacts are discussed below.

Measurement of Overall Rate Level Impact

Most rate reviews proceed in three major steps:

1. Examine the indicated overall rate level change;
2. Determine base rates and rating factors (and rating logic as necessary);
3. Assess the overall rate level impact of the selected rate structure and reconcile it with the indicated overall change.

Step 3 is extremely important to both internal and external stakeholders in the insurance economy as well as to the actuary charged with maintaining profitability. It may be accomplished at several levels of granularity. When only a few base rates and rating factors are changing and there are no significant changes to the rating logic, "aggregate" estimates of the overall impact may be sufficient. The extreme case would be a single change to a base rate which applies to all policyholders, in which case we could state with actuarial certainty the overall impact without analyzing the effect at the policy level. When the rating logic and territory definitions are completely redesigned and each base rate, class and territory rate table is developed from first principles, we find ourselves at the other extreme. The overall rate level impact must be measured by re-rating every existing policy on the proposed rate structure.

The actuary must be prepared to build tools which compare "before and after" premiums for each existing policyholder and which can be run iteratively in a timely fashion. Again, technology is the enabler allowing us to extract high-quality data and execute rating logic quickly to measure rate impacts in this fashion. As the impacts are compared against the indications, the most efficient technique for iterative adjustment is a "flat factor" applied to the base rates by policy form.[32] In our study, we did not vary the flat factor by peril, which has the effect of preserving the overall distribution of base premium.

[32] As a regulatory matter, some states require rate indications developed by policy form - in this milieu, the flat factor applied to the indicated base rates to achieve the overall indication should also vary by form.

Competitive and Residual Market Analysis

Even a policy-level measurement of static overall rate level impact is still insufficient to indicate the likely "second-order" or dynamic effect on overall premium and policy volume (as prices incent consumer actions) and distributions by policy form, territory and class. Yet this is actually the effect of greater magnitude to the profitability and growth of the insurer in the long run. When all the insurers competing in a market have similar rate structures and the market is relatively stable, the effect of an overall rate level change which does not displace many existing customers differently than the overall average may perhaps be measured with ignorance of dynamic competitive effects. When an insurer makes a market-leading change to a modern rating architecture, the likely competitive effects must be examined in advance and monitored closely as the architecture is rolled out. Returning to Cummins [2] will remind the reader of how critically certain market attributes can affect the possibility of adverse selection against the insurer.

On the flip side, a modern rating plan is one of the few ways to gain a sustainable competitive advantage in the market without a significant investment in operational scale and surplus capacity. Further, marketing and underwriting restrictions should be comprehensively reviewed and aligned with the rating plan once it is implemented. Historical restrictions which reflected rate adequacy considerations in particular territories and classes may be rethought as the marketing plan is revisited. In summary, a more refined rating plan should allow for some additional growth given a constant surplus base.

The regulators (and possibly industrial sources) in many states collect proposed premiums for standard "rating examples" (a.k.a. "risk profiles"), which are most often publicly available. These rate comparisons may also include the residual market rate from the insurer of last resort if there is one. The actuary can compile such comparisons as a leading indicator of changes in competitive position, at least for "typical" risks. Regulators may be interested in the proposed position of the insurer against public (residual market) as well as private competitors, depending on the level of political pressure against raising residual market rates to maintain minimal competition with the private market.[33] Exhibit 16 shows an example of a rate comparison which might be useful. The actuary should encourage all stakeholders to keep in mind several distortions inherent in rate comparisons:

- Comparing an individual insurer's proposed rates to the competition's current rates may produce a false sense of competitive position when rate levels are rapidly rising or falling industry-wide, due to the natural time lag between successive filings. Emerging causes of loss, capacity problems affecting reinsurance prices, and other phenomena may not yet be reflected in the current (i.e. the last filed) rates of competitors or the residual market.
- Comparisons are often based on the "average" rate for a particular county or wider geographic region. The average may be weighted by an exposure distribution which does reflect that of the insurer, or it may not be weighted at all - a simple arithmetic average using one rating example for each territory within the area. The insurer implementing more refined territory definitions than its competitors produces an average for coastal

[33] In Florida, the residual market rates are set based on the highest premium reported by the top twenty private insurers (as ranked by premium market share) for a given rating example in each county, which focuses regulatory attention more directly on the differential between an insurer's proposed rates and those for the residual market in the same geographic area.

areas which is most likely skewed upward in this case, because of its removal of inland subsidies to coastal business in a more refined hurricane territory structure. The example for a small coastal territory, perhaps even one in which the insurer has no current business, gets equal weight with the inland example from a much wider land area and more populated area and the high coastal rate drives the average.

Rate Dislocations and Transition Planning

As critical as it is to understand the proposed rating plan's competitive impact on the ability to write new business in each territory, it is just as important to manage customer retention when many existing insureds likely face significant rate changes for the same reason. First, the actuary can inform the marketing and sales force by geographic area in a comprehensive fashion. Figure 5 shows an example of a "pin map" which delineates the proposed territory boundaries and contains a color-coded pin for each existing insured location. The colors indicate the spectrum of rate changes which will be experienced by each location.

Second, serious consideration should be given to a transition plan which caps annual swings in premium to a maximum and minimum percent value, phasing in the premium change for those subject to severe rate dislocations. There is a legitimate actuarial debate as to whether such plans are inherently unfairly discriminatory, as new business and renewals would be charged different rates for an identical risk. A complete discussion of the economics and public policy associated with such plans is beyond our scope, though we note that "swing limits", capping changes in rating factors in spite of credibility-weighted indications, are used throughout many accepted rating plans in most lines of insurance. No matter what, the practical business advantages of a phasing-in of premium changes for existing insureds cannot be overlooked.

It sounds simple to implement such a plan, but the devil is in the details of how the premium subject to transition is calculated and carried forward from year to year. Basic logic for a plan which caps annual premium increases might be as follows:

1. Calculate P_0, the premium on current rates at the current TVI. P includes premium for miscellaneous coverages and endorsements, but does <u>not</u> include expense fees. Premium for endorsements added during the current term is restated as full-term premium on current rates.
2. Calculate P_1, the premium on <u>proposed</u> rates at the <u>current</u> TVI, for the standard policy coverages and only endorsements which are effective <u>before</u> the renewal date (i.e. on an "apples to apples" basis whereby premium for new additional coverages is not compared against current premium totals). P_1 also excludes expense fees.
3. The premium change factor is the ratio of the premium on proposed rates to premium on current rates less unity:

$$H = \frac{P_1}{P_0} - 1 \qquad (16)$$

4. If the premium change factor exceeds M, the selected maximum premium increase, let transition factor

$$T_0 = \frac{M}{H} \qquad (17)$$

5. Multiply each peril partial base premium by T_0 in development of final policy premium. Store T_0 with policy statistics. At the next renewal, update the transition factor by multiplying by the maximum premium increase, limiting it to unity:

$$T_1 = Min(T_0 \times M, 1.00) \qquad (18)$$

6. Repeat the adjustment of base premium and storage of T_i for as many periods as necessary until it is 1.00.

It is straightforward to modify this algorithm to accommodate a transition plan which limits both premium increases and decreases for individual policyholders.

Steps 1 and 2 should indicate that there are many exposures such as endorsements and "inflation guard" (which provides automatic annual increases in TVI to keep pace with replacement cost inflation) of which the treatment should be carefully specified in designing any transition logic. Just as important is a cost-benefit analysis of the revenue loss expected from the transition plan, at least in the first year. We recommend Figure 5 be reproduced to show the rate impacts net of the transition plan, and a granular analysis of premiums on proposed rates, by policy, with and without the transition plan to aggregate the revenue impact companywide and by territory. This is the only reliable way to assess the plan's impact.

Miscellaneous Rates, Endorsements, and Operational Impacts

Most miscellaneous coverages are rated using key premium as the base. Recall that this is the fair premium for the class and territory, but reflecting a given base coverage amount and deductible. Simply changing "key premium" to "total key premium" (the sum of the key premiums by peril) will allow migration of much of the rating logic for endorsements in a sound manner. However, rates per $1,000 of coverage and flat dollar charges should be thoroughly reviewed to assess their adequacy as the overall rate level and its distribution by peril shift under the modern rating plan.

The basic rating logic may be of primary concern to the actuary, but the policy services, programming, statistical reporting, and manual writing personnel will spend most of their time dealing with its effect on the adjustments to base premium and the miscellaneous rules and endorsements available in the residential property program. The actuary should be prepared to invest significant time and effort in assisting these vital stakeholders in modifying the other processes downstream which are impacted by the changes in basic rating logic.

CONCLUSION

Whether due to necessity or strategy, insurers can improve the stability and adequacy of overall rate level as well as the actuarial equity of individual policy rates by investing in a modern rating architecture for residential property insurance. Elements of the modern rating plan may include:

- Proper use of simulated losses for catastrophic perils in overall rate level, territory and class rating;

- A fair premium structure which is aligned with the need for appropriate consideration of expected losses, fixed and variable underwriting expenses, and costs of capital by peril;
- Base premiums divisible by peril and subject to distinct classification and territory rating plans;
- Refinement of corresponding territory definitions;
- Introduction of new class plans targeted to individual perils formerly not class rated;
- Coverage modification (amount of insurance, deductible and limit) factors which reflect differing loss distributions by peril and appropriate assumptions about the loss cost distribution of catastrophic events;
- Rating logic for adjustments to base premium and miscellaneous endorsement premiums which is targeted to the perils affected by such modifications of the policy and consistent with the logic for base premium determination.

In addition, many practical considerations apply as the modern rating architecture progresses from actuarial theory to operational reality within the organization and economic and competitive position in the outside market. The actuary should take an active role in addressing each issue.

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