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FINANCIAL SERVICES

Quantifying Uncertainty in Technical Reserves

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Introduction

Regulators, rating agencies, and other stakeholders are paying greater attention than ever to uncertainties in technical reserve estimates. A widespread and rapid movement akin to a "paradigm shift" has already become evident at many levels—from increased popularity of, or in some cases increased need for, stochastic approaches to analyzing insurance risks to recent global developments and thought leadership as outlined in the Exposure Draft *Measurements of Liabilities for Insurance Contracts: Current Estimates and Risk Margins* by the International Actuarial Association ad hoc Risk Margin Working Group. This Exposure Draft is playing a vital role concurrent with the International Association of Insurance Supervisors (IAIS) and the International Accounting Standards Board (IASB) on the latest issues regarding reserve uncertainty.

The majority of liabilities for non-life insurance companies comprise technical reserves, and the uncertainty involved in estimating these liabilities means they pose considerable risk. Adverse reserve runoff has directly contributed to major insurance company downfalls over the years—downfalls that have negatively affected shareholders, policyholders, company employees, and even other insurance companies that may have helped in the bail-out process.

A company's reserves are at best only an estimate of payments to be made in the future for outstanding claims, and variation exists in any estimate of the technical reserve. Although this uncertainty affects management, investor, and regulator decisions—and has the potential to greatly affect financial reporting results and solvency—the nature and extent of this uncertainty is generally not well understood by decision makers. For example, financial statement reporting requires that a single number represent the technical reserve. While potential investors or regulators generally recognize that this single number may be subject to change over time, the magnitude of potential variation is generally not identified or quantified in an informative way.

This white paper discusses some of the more significant pressures facing non-life insurance companies in this environment (see Figure 1). It also explores some of the sophisticated approaches for quantifying reserve uncertainty as well as the impact that numerous issues (e.g., data availability, consideration of operational changes) may have on the ability to appropriately quantify such uncertainty. It discusses the importance of attempting to quantify reserve uncertainty now, focusing on the use of stochastic models while emphasizing the practical issues that must be considered, including changes in operations and exposures and changes in reinsurance structure. This paper acknowledges that although undertaking a stochastic modeling endeavor is quite difficult, such efforts can help non-life insurance companies manage reserve risk and build value in their businesses. A better understanding of claims uncertainty will help allow for enhanced transparency with stakeholders, including more thorough disclosures on technical reserves in response to regulatory requirements as well as a greater understanding of the impact of product offerings on capital and on financial results.

Figure 1: Reserve Uncertainty Is at the Core of Many Issues

Source: KPMG International, 2007

Questions Senior Management Should Be Asking

1. Why is measuring uncertainty important?
2. What has been done to measure uncertainty by line of business? In the aggregate?
3. How will quantifying uncertainty help us manage our business?
4. Will reserve uncertainty affect the company’s share price? The company’s rating?
5. What data are necessary to measure uncertainty?
6. Does this change the reserving process?
7. Is there an appropriate level of governance around the reserving process?
8. How do we handle diversification and correlation?
9. Does the modeling of uncertainty reflect economic reality?
10. What is the “right” model for our business?

Understanding the Issues

A number of internal and external pressures are driving today's increased focus on reserve uncertainty. Use of non-stochastic, or deterministic, reserving approaches alone is increasingly found to be insufficient in capturing and portraying a full picture on reserve uncertainty. Deterministic-type "reasonableness tests" such as sensitivity analyses on key model inputs and scenario analyses on different sets of assumptions have been, and still are, some of the popular and commonly accepted means in providing management an indication of the extent of uncertainty in the deterministically determined reserve estimates. But these alone seldom provide management with the much-needed strategic advantage of a more advanced understanding of uncertainty in probabilistic terms. From a compliance standpoint, many regulatory bodies have begun expressing interest in how insurance companies determine technical reserve estimates and the level of confidence a stakeholder should have in the estimates. Regulators' interest lies in the risk related to both earnings and overall solvency:

- In the United States, the Securities Exchange Commission (SEC) increasingly requests additional disclosures regarding reserve uncertainty. SEC comment letters are seeking more explanation from insurance companies on the uncertainties surrounding the technical reserves, including potential financial statement impacts; for example, the SEC has explicitly requested disclosures of a company's range of reasonable reserve estimates.
- The Australian Prudential Regulatory Authority already requires that technical reserves as reported on the financial statement be determined as the present value of a central estimate, with risk margin added to yield the present value liability at a 75 percent confidence level. This calculation incorporates the time value of money along with a 75 percent probability that reserves will be sufficient to cover the loss and loss expense obligations of the company as of the financial statement date.
- The impending regulatory guidance of Phase II of International Financial Reporting Standards (IFRS) continues this thrust, similarly requiring the present value of a central estimate with an explicit additional margin that market participants would require for bearing the risk.

The concept of risk measurement relative to technical reserves and its impact on capital adequacy has an element of compliance in Europe's Solvency II initiative as well as rating agency interest. Technical reserves are the most variable elements of a non-life insurance company's balance sheet, and as such, have direct bearing on capital. Under Solvency II, the market value of reserves will be based on the expected present value of future cash flows, but will include a market value margin that meets the objectives of either transferring the portfolio to a third party or recapitalizing the company to ensure a proper run-off scenario.

Beyond compliance, however, are implications for senior management, boards of directors, and other interested parties. The quantification of uncertainty relative to reserving risk impacts not only regulatory capital but also economic capital, a mechanism by which companies are measuring the risks of their businesses. A strong risk governance process—including reserving risk governance, especially for non-life insurance companies—allows for better recognition of the uncertainties inherent in claims liabilities. Robust governance also enables informed decision making and enhanced transparency with internal and external audiences.

In addition to regulatory matters, other practical issues arise with respect to understanding uncertainty. A company considering a merger or acquisition, for example, could place itself in a stronger negotiating position if it has quantitative evidence regarding the target's reserve amounts at varying levels of probability. Reinsurance strategy may be seen as two-fold, depending on whether a company is assuming claims into its risk portfolio or whether it is purchasing outwards reinsurance as part of a risk mitigation strategy.

The issues associated with inwards reinsurance are similar to those for primary business—including the attendant financial reporting, capital adequacy, and disclosure issues—although the amount of uncertainty associated with assumed reinsurance is even greater and more challenging to capture than that for primary business. Meanwhile, outwards reinsurance provides the possibility for a company to cede the more volatile parts of its business. Thus, a more informed approach to understanding the volatility can lead to a more efficient risk mitigation strategy.

Risk mitigation is also critical for a company pursuing asset liability matching strategies or securitization. If, for example, assets are to be matched appropriately with liabilities, management needs to understand the probabilities associated with various reserve levels along with their cash flow implications. If one considers securitizing a liability, that too requires an understanding of whether the vehicle for securitization is matched appropriately with the risk that is being managed.

The claims process is exceedingly complex—essentially the result of an arbitrary occurrence coupled with any number of internal and external influences on the ultimate disposition of the claim. The goal is to determine the central reserve estimate along with a distribution that quantifies the uncertainty that is inherent in the estimate. Over time, deterministic approaches—where historical data are used to project expected results without regard to the probabilities associated with underlying assumptions—have been popular due to their ease of explanation and application. Yet these approaches have been criticized for their inability to sufficiently capture the random nature of the claims process.

Stochastic approaches, on the other hand, do allow for the random nature of the claims process, using a statistical model to describe the underlying assumptions. With advances in technology allowing for manipulation and simulation of large and complicated sets of data, the use of stochastic modeling is on the rise. These approaches are more sophisticated than deterministic techniques, but much remains unknown about modeling such a unique process. While an abundance of research literature has been published on the subject of reserve uncertainty and different approaches to stochastic modeling, the reader can easily be lost in the theoretical complexities and the pursuit of technical niceties and end up with little insight into what is happening in the actual business. In practice, there is seldom a single correct approach but rather a range of reasonable approaches; therefore, the key lies in striking the correct balance between ensuring technical soundness in the modeling and recognizing the practical issues or fallacies that may indeed invalidate any model.

The next few sections address these issues.

Interpreting Uncertainty

When determining a reserve estimate, one is predicting the future, so no matter what reserve is calculated, it will never be exactly right. But just how accurate or inaccurate will that estimate prove to be? A variety of sources of uncertainty exist, such as:

- **Random nature of claims**. A company's exposure to claims is uncertain as are the number, size, and timing of any such claims.
- **Data elements**. The available data may or may not be appropriate for projecting the future. Ideally, data should be segregated into homogenous and credible cohorts for projection purposes, but the ideal does not always exist. Even if segregation is possible, the act of segregating data requires judgments that might not be appropriate in a given situation, and historical data may not be indicative of future experience.
- **Model risk**. The model being used for projection may or may not provide a reasonable mechanism for explaining the claims process.
- **Other risks**. Many internal and external forces may influence the claims process. For example, changes in the underlying exposure to loss due to changing policy limits or changing reinsurance terms could affect the reserve, as could socio-economic factors such as unemployment rates or inflation. In a sense these "other risks" could be considered "model risk" as they may not be adequately captured in the projection process. (This issue is discussed further in the section entitled "White Noise" on page 15.)
- **Historical data**. The actual claims amounts shown in standard "loss triangles" encompass historical uncertainty. The variability of the estimated claim amount related to the "true" value of the distribution that is being measured—using a given measurement methodology—indicates the estimation error. However, future claims amounts will also have variance—that is, the projected value for each future claim amount depends on the possible future outcomes. This future variability is captured in the process error. Both types of error must be considered to adequately capture reserve uncertainty (see Figure 2).

Figure 2: Estimation Error and Process Error

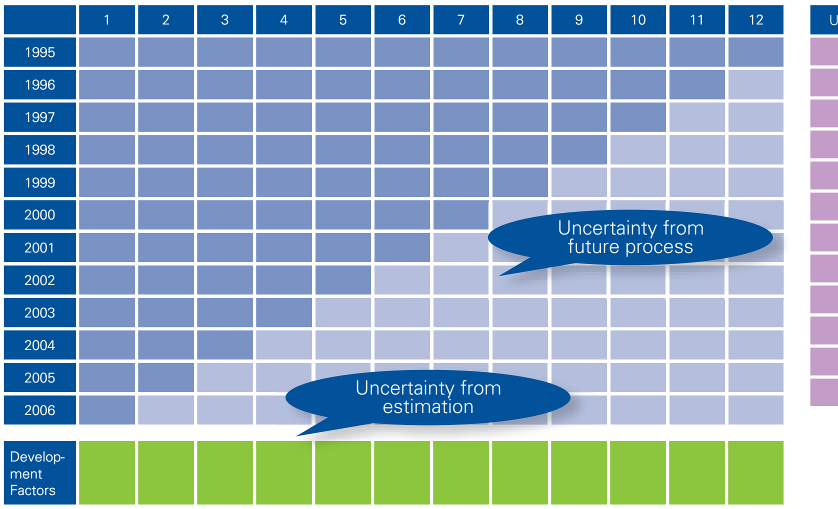


Figure 2 depicts a loss triangle as of December 31, 2006. The historical data are represented by the medium-blue cells while the ultimate claims amounts estimated from a development factor estimation methodology are shown in the column of purple cells. The uncertainty associated with the purple cells is a combination of the estimation approach (green cells) and inherent volatility of future outcomes (light-blue cells).

Source: KPMG International, 2007

Assessing Uncertainty

As discussed below, a number of important components must be considered in assessments of uncertainty.

The Significance of Data

The basis of a quality assessment of reserve uncertainty—regardless of the modeling undertaken—is quality data. As with any reserving exercise, the goal is to be able to segregate claims into reasonably homogenous and credible data sets, but the relative level of data aggregation could be quite high or quite granular, down to the individual claim details. There are numerous decisions to be made, any of which may affect the interpretation of uncertainty. Evaluation interval (e.g., annual or quarterly) is one such segregation decision wherein annual intervals might seem appropriate but might mask important seasonality influences on the claims development.

The impact of reinsurance is another such decision: data net of reinsurance might appear to be a stable measurement, but depending on the reinsurance structure over time, the use of net data rather than gross and ceded data could mask uncertainty that should be captured. A particularly important example is the treatment of "extraordinary" claims, such as catastrophe losses. Often, large losses are treated separately from the "regular" claims during the reserve estimation process. This treatment reduces variability, but determining a reasonable threshold for splitting extraordinary from regular claims is a challenge. For each data decision, management must consider whether the segregation allows for more accurate quantification or simply hides variability that should be recognized.

At the analytic level, such granular decisions have direct bearing on the methods that can be used and the output that can be obtained. At the highest level, management should recognize that the quantity and quality of data have direct bearing on the reliability of results used in reporting and decision making.

Stochastic Approaches

The main approach to stochastic modeling of technical reserves is the fitting of a statistical model to the data to describe the underlying claims process. One can examine how well the model fits the historical data and determine if modifications are necessary. The outcomes of such modeling are a measure of past variability and a distribution to be used to measure future variability. The result is a probability distribution showing reserve outcomes at varying probabilities or confidence levels. The distribution produces a range of possible outcomes, not the range of reasonable outcomes that stakeholders might wish to evaluate for financial reporting, capital adequacy, or strategic decision making. Management must interpret the results in light of the intended purposes of the modeling.

Several stochastic reserving methods are gaining ground, including an approach developed by Dr. Thomas Mack as well as "bootstrapping," factorials, and a number of generalized linear or other statistical models (see References for background material on page 19). The illustrations used in the remainder of this white paper focus on the Mack and bootstrapping methods using U.S. industry information.

Figures 3, 4, and 5 illustrate the central estimates and standard deviations associated with application of the Mack and bootstrapping methods to homeowners, commercial motor, and workers' compensation claims payment data, respectively. Due to the credibility gained by examining aggregated industry data, the claims process appears to be fairly stable. The central reserve estimates of each method are reasonably consistent and the errors or standard deviations, relative to the reserves, are quite low. (Such a result would not be expected for more detailed segmentations of business.) The increase in percentage error as the accident year matures is due to the smaller volume of claims still open in older time periods, with the potential for random "white noise" to have a more significant impact on results.

Figure 3: Homeowners U.S. Industry Stochastic Outputs

Accident Year	Mack Method				Bootstrap Method*			
	Ultimate	Reserve	Error	% Error	Ultimate	Reserve	Error	% Error
1996	21,430,948	-	-	0.0%	21,430,948	-	-	0.0%
1997	16,709,712	12,268	7,077	57.7%	16,709,755	12,311	22,016	178.8%
1998	20,520,842	32,918	11,254	34.2%	20,520,330	32,406	35,850	110.6%
1999	21,094,145	57,170	13,419	23.5%	21,094,082	57,107	45,577	79.8%
2000	25,059,680	131,283	27,412	20.9%	25,059,022	130,625	67,648	51.8%
2001	28,805,081	298,606	45,545	15.3%	28,802,744	296,269	99,880	33.7%
2002	25,475,597	528,242	54,964	10.4%	25,472,828	525,473	128,090	24.4%
2003	27,033,384	1,073,903	88,958	8.3%	27,028,717	1,069,236	181,236	17.0%
2004	30,170,646	2,348,894	168,281	7.2%	30,166,699	2,344,947	268,655	11.5%
2005	33,943,504	9,933,875	857,819	8.6%	33,953,188	9,943,559	598,599	6.0%
Total	250,243,539	14,417,159	899,435	6.2%	250,238,312	14,411,932	791,197	5.5%

*Note: 1,000 Simulations

Source: KPMG International, 2007

Figure 4: Commercial Motor U.S. Industry Stochastic Outputs

Accident Year	Mack Method				Bootstrap Method*			
	Ultimate	Reserve	Error	% Error	Ultimate	Reserve	Error	% Error
1996	9,699,471	28,952	-	0.0%	9,670,519	-	-	0.0%
1997	10,197,376	65,918	17,087	25.9%	10,166,995	35,537	17,074	48.0%
1998	10,473,152	141,606	24,662	17.4%	10,441,996	110,450	28,236	25.6%
1999	11,094,052	242,995	32,499	13.4%	11,061,234	210,177	37,808	18.0%
2000	11,347,414	480,722	38,741	8.1%	11,314,429	447,737	53,784	12.0%
2001	10,921,222	907,954	88,521	9.7%	10,889,171	875,903	73,591	8.4%
2002	10,365,177	1,722,918	96,926	5.6%	10,333,779	1,691,520	103,310	6.1%
2003	10,195,575	3,165,720	136,267	4.3%	10,166,055	3,136,200	149,937	4.8%
2004	10,293,768	5,351,220	210,013	3.9%	10,257,799	5,315,251	222,383	4.2%
2005	10,573,375	8,138,580	295,053	3.6%	10,559,285	8,124,490	350,439	4.3%
Total	105,160,583	20,246,586	480,472	2.4%	104,861,262	19,947,265	521,682	2.6%

*Note: 1,000 Simulations

Source: KPMG International, 2007

Figure 5: Workers' Compensation U.S. Industry Stochastic Outputs

Accident Year	Mack Method				Bootstrap Method*			
	Ultimate	Reserve	Error	% Error	Ultimate	Reserve	Error	% Error
1996	15,224,627	234,348	-	0.0%	14,990,279	-	-	0.0%
1997	16,388,373	510,743	212	0.0%	16,140,766	263,136	91,000	34.6%
1998	17,823,981	862,489	4,113	0.5%	17,556,189	594,697	130,084	21.9%
1999	17,891,183	1,278,684	82,107	6.4%	17,622,577	1,010,078	165,373	16.4%
2000	19,140,327	1,953,318	95,203	4.9%	18,852,718	1,665,709	206,249	12.4%
2001	18,803,232	2,620,555	164,684	6.3%	18,519,526	2,336,849	245,527	10.5%
2002	17,396,828	3,408,877	289,574	8.5%	17,137,280	3,149,329	283,501	9.0%
2003	17,193,386	5,012,199	322,456	6.4%	16,932,221	4,751,034	352,466	7.4%
2004	17,855,457	8,251,081	376,116	4.6%	17,600,781	7,996,405	507,764	6.3%
2005	19,504,913	14,745,641	878,361	6.0%	19,203,884	14,444,612	960,152	6.6%
Total	177,222,307	38,877,935	1,194,390	3.1%	174,556,221	36,211,849	1,530,232	4.2%

*Note: 1,000 Simulations

Source: KPMG International, 2007

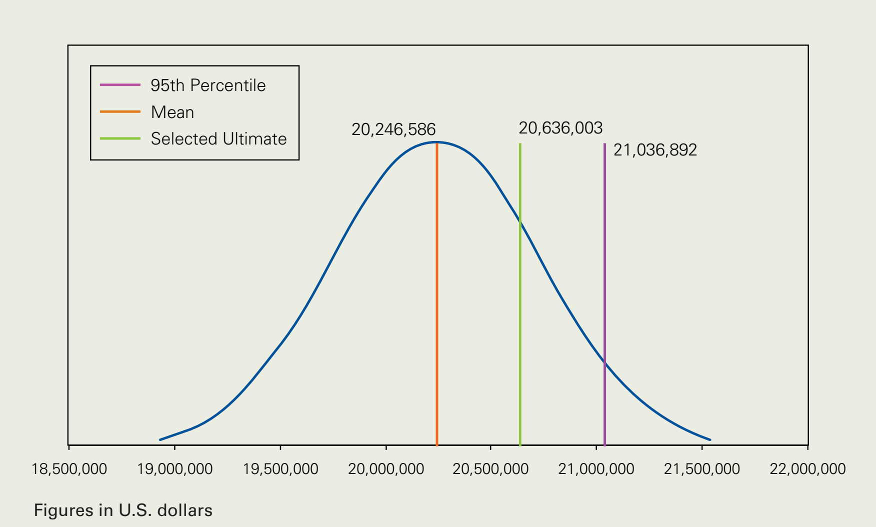
Figure 6 illustrates the probability density function associated with industry commercial motor data; the probability density function shows the probability that a random variable—in this case the future incremental payments, or the technical reserves—will equal a given value. This graph illustrates the statistical mean of the distribution and the reserve level at the 95th percentile or confidence level, that level at which there is a 95 percent chance the true reserve amount will not exceed the estimate. Also shown is the user's selected central estimate of the technical reserve.

The cumulative distribution function accumulates the probabilities so that the random variable amounts are shown with cumulative probabilities ranging from 0 percent to 100 percent. An example for homeowners' data is shown in Figure 7.

The behavior of different types of random variables can often be described by similar probability distributions, and while claims experience generally defies one's ability to easily fit it to a particular distribution, a handful of distributions have commonly been used in attempting to describe the claims process. These include the normal, lognormal, and gamma distributions; each has somewhat different characteristics, notably in regard to the severity of loss in the "tail," the higher percentiles of the distribution.

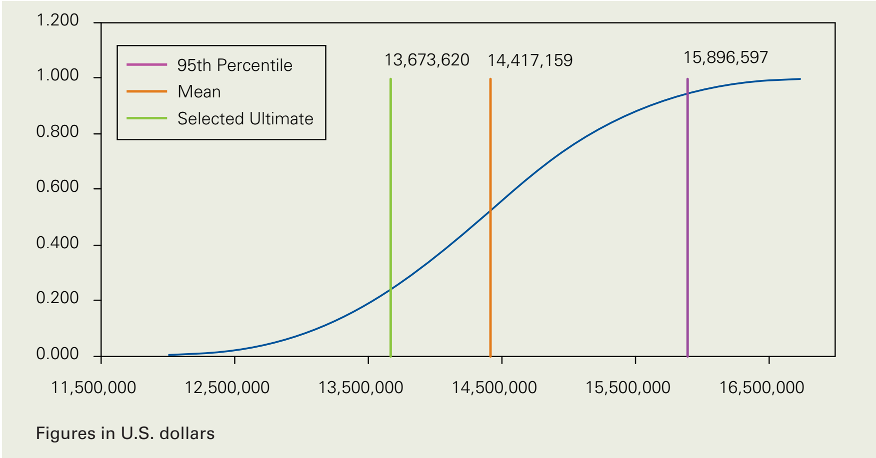
Figures 8 and 9 provide the probability density and cumulative distribution functions, respectively, associated with industry workers' compensation reserves using a lognormal distribution. One can see that the stability resulting from a large volume of data produces a rather narrow range even for a line of business that is typically considered difficult to analyze. With such stability, in this instance, the lognormal distribution approaches the shape of a normal distribution. For a more volatile block of business, the lognormal would predict more severe outcomes for higher confidence levels.

Figure 6: Commercial Motor: Mack Paid—Normal Distribution of Reserves



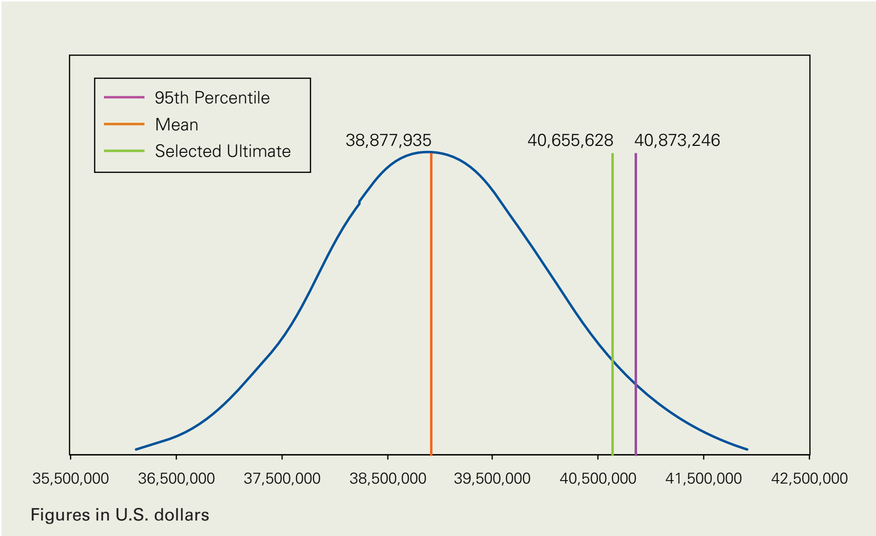
Source: KPMG International, 2007

Figure 7: Homeowners: Mack Paid—Normal Distribution of Reserves



Source: KPMG International, 2007

Figure 8: Workers' Compensation: Mack Paid—Lognormal Distribution of Reserves



Source: KPMG International, 2007

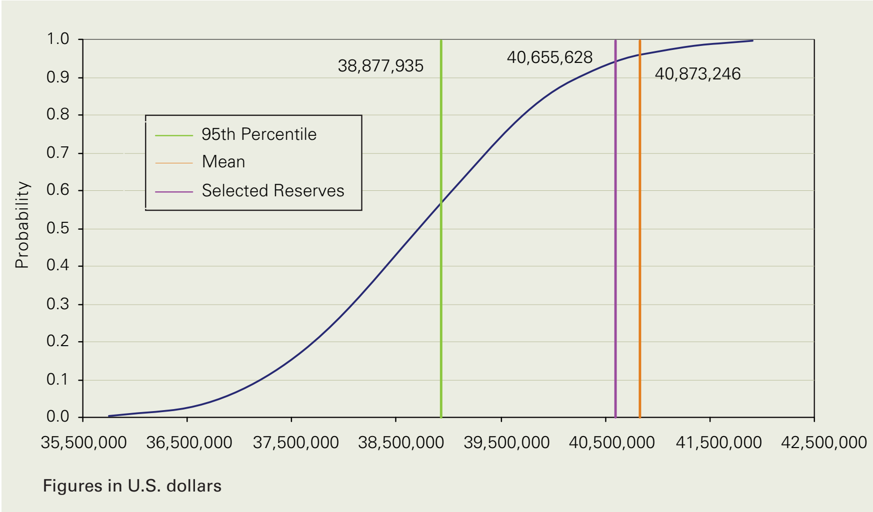
These graphs showcase the possible outcomes around a statistical mean assuming a specifically modeled distribution. This result is not the same as a range of reasonable low and high technical reserve estimates that might be obtained by asking a number of actuaries to each provide a "central" estimate. Management should consider results such as these in assessing the risk associated with a specific booked reserve or in determining the impact of a new product on capital.

Depending on the nature of the claims to which the company is exposed, the central estimate would likely fall somewhere near the statistical mean of the distribution. For example, with a relatively stable line of business, the estimate might fall somewhere near the 50th percentile of the distribution, while for a low frequency, high severity line of business, the estimate could be skewed comparatively higher in the distribution. If the reserve estimation process occurs separately from the quantification of uncertainty, inconsistencies between the central estimate and statistical mean could be the unintended consequence.

Figures 8 and 9 illustrate a potential issue that could arise if one calculates a central reserve estimate in a vacuum without consideration of reserve uncertainty as measured by statistical modeling. In this workers' compensation example, the paid claims experience for the current accident year may be significantly lower than expected, resulting in an unrealistically low reserve estimate for that year. In such a case, it would be appropriate to select a higher technical reserve using alternative methodologies or assumptions, resulting in a more reasonable estimate. Therefore, this inconsistency might be valid, though it does point to the need to understand, and not just accept, the results of any reserving exercise.

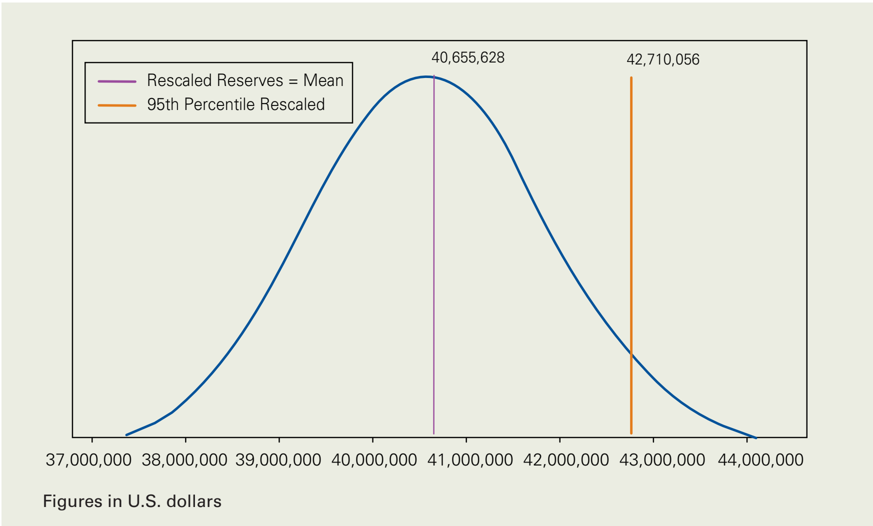
Figure 10 illustrates the workers' compensation example with the technical reserves at each confidence level rescaled so the central estimate reserve is now equivalent to the statistical mean.

Figure 9: Workers' Compensation: Mack Paid—Lognormal Distribution of Reserves



Source: KPMG International, 2007

Figure 10: Workers' Compensation: Mack Paid—Lognormal Reserves Rescaled



Source: KPMG International, 2007

Depending on the issues at hand when quantifying reserve uncertainty, different areas of the resulting distribution will be of interest. For example, for financial statement reporting, management may choose to focus on the middle of the distribution, where the central estimate of reserves will be located. Figure 11 illustrates the commercial motor industry data of Figure 6, with the technical reserves at each confidence level rescaled so the central estimate reserve is now equivalent to the statistical mean.

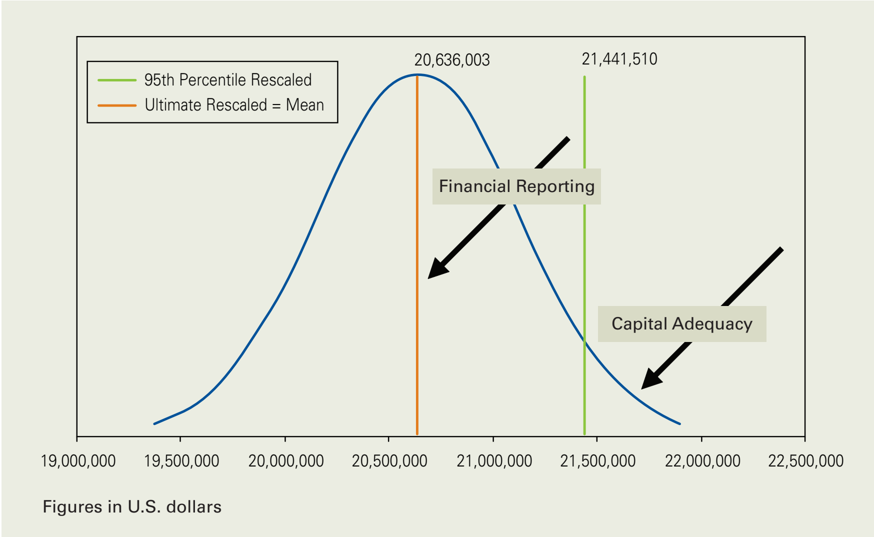
Management may wish to focus on the mean of approximately US$20.6 million when reporting reserves. On the other hand, if capital adequacy is under consideration, technical reserves in the "tail" of the distribution, which shows the most severe of possible outcomes, will be of more value. From a compliance standpoint, for example, both Australian and U.K. regulatory guidance necessitate that only capital at a level greater than the 99.5 percent confidence level may be released.

Diagnostic tests are useful for determining whether the modeling results are valid. For the random variable being modeled, in this case loss development factors, a pictorial depiction of the residual errors between actual and modeled development factors can provide clues on the effectiveness of the model. In general when observing residual errors, one would expect to see no bias; rather, the residuals would randomly center around zero error. Further investigation is required if any biases are observed—with, for example, errors always greater than zero or with a cyclical trend above and below zero.

In Figure 12, each plotted point represents an error term—namely, the difference between an actual observation of claims payment and an expected amount, standardized to the expectation. Each column of points represents one calendar year of experience, and the red line represents the average error based on sample points.

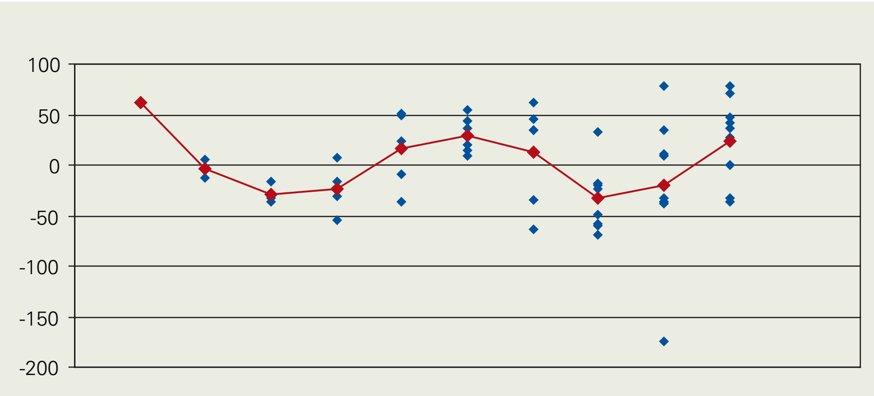
In this example, representing commercial motor experience, the movement in average errors from year to year suggests a cyclical trend in calendar year development. The cyclical nature is apparent but mild, as the standardized residuals cycle within a relatively small band. While the output from stochastic modeling indicates that the reserves are actually quite stable, this trend could be the result of external market influences or changes in the philosophy applied to settling claims over time. The model may not be appropriate for explaining the claims process, or the data may contain biases that should be removed prior to analysis. As always, caution is necessary when modifying data to help ensure that any adjustments that might dampen variability are truly warranted. Any conclusions reached

Figure 11: Commercial Motor: Mack Paid—Loss Reserves Rescaled



Source: KPMG International, 2007

Figure 12: Standardized Residuals by Diagonals



Source: KPMG International, 2007

should be made within the context of the scale of the errors and qualitative information regarding both internal and external influences on the business.

Applying Sensitivity Testing and Scenario Analysis

Supplementing the stochastic results with sensitivity testing and scenario analysis can be useful to management. A range of reasonable reserve outcomes can be created using various optimistic and pessimistic underlying assumptions and inputs in reserving methodologies. In so doing, the underlying assumptions are not treated as random variables but rather can be used as a set of comparison points against the stochastic results. If reasonably optimistic and pessimistic assumptions produce estimates that are consistent with the bulk of the distribution, then some comfort can be taken that the statistical distribution is grounded in reality. Alternatively, working backward from the stochastic modeling, management can consider whether realistic scenarios support the statistical findings. If not, modifications in the modeling may be indicated. In this way, practical knowledge and statistical rigor interact to provide the most complete information possible to the analyst and to management.

Statistical modeling represents improvement over the ad hoc approaches the industry has used in the past to measure uncertainty. For example, statistical modeling provides explicit recognition of both probabilities associated with and relative magnitudes of the technical reserves. Yet no statistical model currently available can capture reserve uncertainty perfectly. In Australia, the challenge of determining an appropriate statistical distribution with which to model claims uncertainty is considered one of the most difficult aspects of complying with financial reporting requirements. Even with the advances in computing power, the claims process is highly complex, and there are no guarantees that historical experience will be a valid guide to future experience. A balance between complexity and understandability is an important goal. The more random variables to model and the more sophisticated the modeling technique, the greater the risk that the methodology becomes a "black box"—understandable to the analysts but to no one else. If stakeholders cannot understand how the outcomes are achieved, the modeling becomes suspect no matter how impressive the results.

Interpretation of Results

Interpreting results of stochastic modeling is always difficult. Many distributions could be valid but not all will be considered in the modeling. As discussed previously, the distribution will reflect the range of outcomes rather than the range of reasonable estimates, but what if the particular distribution has not considered a relevant element of the claims process that should have been modeled?

Even when a distribution of reserve estimates is developed, it can only serve as a guide for drawing conclusions on reserve uncertainty. Management must consider a number of questions in selecting the parameters to be used for financial reporting disclosures on the overall uncertainty associated with the reported reserves. For example, does the 65 percent confidence level represent an appropriate upper boundary or is the 90 percent confidence level better? Does the decision on what to disclose depend on what reserve segment is under discussion? How is the impact of diversification and correlation considered in the findings? All of these questions require judgment coupled with an understanding of the nuances and practicalities surrounding the underlying business.

Consider an insurance company that has been writing commercial motor liability policies with policy limits of US$1 million for a number of years, and the claims experience has been relatively stable. With such stability, the historical data may fit a statistical model very well, with results that appear realistic. However, consider also that the company recently began offering policy limits of US$2 million instead of US$1 million, as shown in Figure 13. If the analyst accepts the statistical modeling results and does not know of the doubling of exposures in the current year, the quantified uncertainty will be inaccurate. The true variability has now increased relative to history.

Similarly, consider the situation where policyholder deductibles are increasing incrementally over time, as illustrated in Figure 13. The insurance company will find itself with very different relative variability when covering claims associated with 2006 than it had when covering claims associated with 2003. Interpreting the results of stochastic testing when the exposure is changing over time can be particularly difficult.

Figure 13: Changes in Exposures

	Example 1 Policy Limits Offered	*Example 2* Average Deductible
2003	1,000,000	100,000
2004	1,000,000	150,000
2005	1,000,000	200,000
2006	2,000,000	250,000

Source: KPMG International, 2007

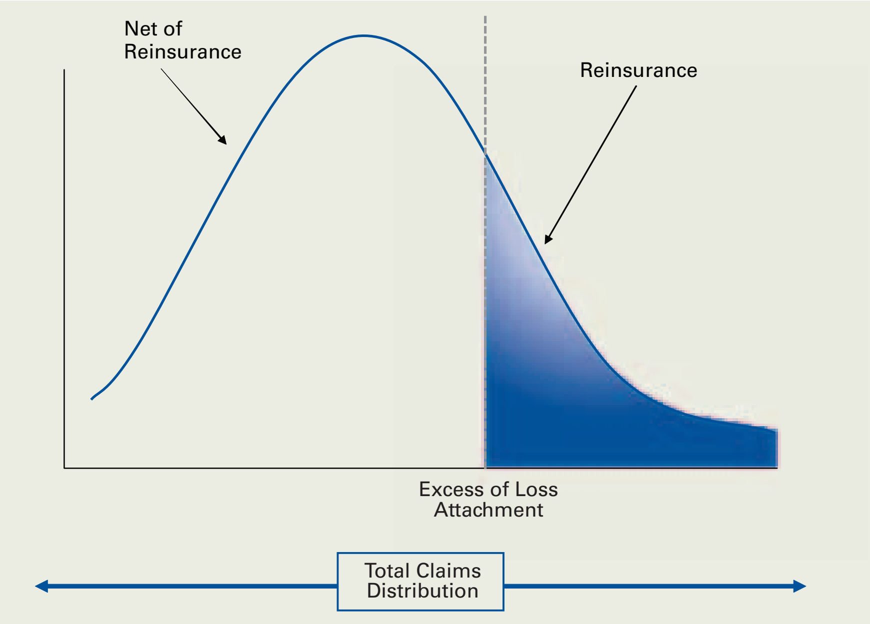
The important issue is to evaluate the potential effect of exposure changes on the underlying uncertainty. Premiums are often used by insurance companies as proxies for exposures, but examining changes in premiums alone—without considering the effects of pricing impacts—will not provide the needed information for evaluation. Therefore, premium levels are of limited use in understanding the underlying business—the key to drawing conclusions related to the quantification of uncertainty.

Reinsurance is another significant issue that warrants careful consideration. A logical approach to quantifying uncertainty might be to analyze the uncertainty for data gross of reinsurance, with subsequent application of reinsurance treaty terms for the appropriate years, to ultimately yield a measure of uncertainty on a net of reinsurance basis. Since reinsurance terms can change frequently, producing situations not unlike the changing policy limits and deductibles illustrated above, such an approach has the benefit of explicit consideration of the exposure changes.

However, what if only data net of reinsurance is available? Some may argue that this measurement is preferable, especially if treaty terms have been consistent over time, as net data should naturally exhibit less volatility than gross data, perhaps making the results more straightforward. Yet this approach will also require interpretation. For example, a particular origin year of claims may be subject to reinsurance that begins providing coverage in excess of a 75 percent loss ratio; on a net basis, that origin year will exhibit the true variability underlying that type of business until the reinsurance coverage begins. At that point, net variability drops to zero, a result that may be unexpected if the analysis does not anticipate the reinsurance.

Conversely, consider a block of business subject to a loss ratio corridor with coverage attaching in excess of a 75 percent loss ratio and depleting once a 90 percent loss ratio is reached. No variability will be seen as long as the claims experience indicates a loss ratio within the reinsured corridor, but once that reinsurance is exhausted, uncertainty returns. Without an understanding of the reinsurance terms and the associated timing of claims experience, erroneous conclusions could be drawn about the relative uncertainty associated with net experience.

Figure 14: Claims Distribution — Primary vs. Excess



Source: KPMG International, 2007

Figure 14 illustrates the total claims distribution associated with a block of business.

The total distribution is further segregated between the portion of the distribution associated with the primary claims, limited to an excess of loss retention, and the portion associated with the excess claims. It should be possible to quantify the uncertainty for the limited claims and the uncertainty for the excess claims, with the aggregation of those quantities equaling the uncertainty for the total distribution. However, both the limited claims and the excess claims have their own distributions that are most likely not the same size or shape as the total distribution. The limited claims should theoretically exhibit less variability and the excess claims more variability than the total.

These factors come into play when determining the fair market value of a block of claims—if, for example, an excess of loss reinsurance contract is being priced. If only the variability for the total distribution is taken into account in the pricing, the price will likely not be sufficient to cover the potential for upward development on an excess basis. The concept expands to any fair value exercise as may occur when considering a merger or acquisition or in securitizing a block of business; understanding the uncertainty associated with the business being valued allows for an estimate that reflects economic reality.

Diversification Benefits

Generally, stochastic modeling would be applied to each individual line of business due to the benefits associated with working with homogeneous data sets. Each line of business written by an insurance company contributes its own risk profile to the overall business. However, aggregation is required to understand the overall uncertainty associated with the reserves. In fact, the aggregation of multiple lines of business with varying levels of risk should result in a more stable, less risky portfolio than that of each individual line of business. Since the underlying claims distributions of each line of business are likely not 100 percent dependent on each other, the most optimistic or pessimistic situation for one line of business will not be exactly the same as for other lines of business. This is the diversification benefit, similar to that for stock portfolios.

From an insurance perspective, motor liability claims for bodily injury and property damage will likely be highly related, as an auto accident has high potential for causing damage to both the vehicle and the people involved in the accident. On the other hand, workers' compensation and homeowners claims, for example, may not necessarily be related; the events that would result in claims and the influences on claims development are just not similar enough to draw such a conclusion for these two lines of business.

The measure of the relationship between any two given lines of business is known as its correlation; mathematically the correlation coefficient ranges between -1 (perfect negative correlation) and 1 (perfect positive correlation), with 0 representing no correlation, or complete independence.

Figure 15 depicts a sample correlation matrix.

Figure 15: Sample Correlation Matrix

Line of Business	A	B	C
A	1.00		
B	.60	1.00	
C	.25	-0.90	1.00

Source: KPMG International, 2007

In practice, the assignment of correlation tends to be judgmental, resulting in rounded numbers representing the correlation between two lines, such as those seen in Figure 15. The judgments are based on qualitative assessment of the underlying characteristics of the given lines.

Taking the example of combining two lines of business, A and B, the standard deviation of the aggregated distribution, reflecting the overall uncertainty, will equal:

$$StdDev_{A+B} = \sqrt{Var_A + Var_B + 2 \times StdDev_A \times StdDev_B \times \rho}$$

where StdDev is the Standard Deviation, Var is the Variance, and ρ is the Correlation Coefficient.

Ignoring correlation and the corresponding benefits of diversification would result in an inaccurate picture of the true risk associated with an insurance company's total liabilities. However, the measurement of correlation is extremely difficult, especially when a number of lines of business must be considered. Consequently, this element remains one of the least understood relative to treating claims experience as random processes.

One possible solution to quantifying diversification is to apply the stochastic modeling to all lines of business combined rather than to each individual line of business. This approach avoids the need to determine correlation coefficients for each combination of lines and to translate that into an overall measure of variability. However, determining a reasonable claims distribution at the aggregate level may be even more difficult than determining the claims distribution for every line. The various correlations among lines of business will have an impact on the overall claims experience, likely in ways that are unclear. Such aggregation could even diversify away all variability. Assuming all risks are alike and therefore are additive is also another key weakness and may lead to misleading results. Once again, great care is necessary in interpreting the results from such an approach.

Currently there are many ways of modeling the diversification effects on uncertainty from different lines of business and risk sources. These methods include, but are not limited to, more standard methods such as a simple total variance calculation involving correlation matrices, ranging to more advanced methods such as copula modeling and Tail Value at Risk measures to capture tail dependencies at high probabilities of sufficiency, and to Dynamic Financial Analysis models, which include models on asset performances and their interactions with the company's liabilities. Some of these advanced methods are already in use in some parts of the world.

Allocation Considerations

The quantified benefit of having a diversified portfolio, by its very nature, is not specific to a line of business or segment. Rather, it represents the overall benefit associated with such diversification. Therefore, tension arises in relation to financial reporting when the business is required to report results on a line-of-business or segment basis. Getting to this level of detail calls for examining the various percentiles associated with each line of business, segment, or origin year and making assumptions about the level of diversification, and then allocating the benefit to each line of business, segment, or origin year. This approach results at best in an artificial allocation. The economic reality is that the diversification benefit exists at an aggregate level, providing some offset to the total technical reserves. Therefore, reflecting it as an asset or a contra-liability may be appropriate. Accounting guidance does not allow for such treatment, but as international reporting standards move more toward fair value concepts, this technical consideration is worthy of future exploration.

In addition to the diversification benefit, numerous practical situations could arise where allocation becomes an issue, depending on the manner in which the modeling of uncertainty is performed. For example, if uncertainty is quantified using underwriting year data, reflecting both earned and unearned portions of exposure, but results are necessary only on the earned portion—as is often the case for financial reporting—the translation of the overall uncertainty to earned and unearned uncertainty levels will require allocation. The same is true when

considering analyses gross and net of reinsurance, as discussed previously. Both of these situations have been cited as particularly challenging in Australia, where quantifying uncertainty is already in practice.

Instances may exist where management may want to understand the variability associated with different seasons in the claims cycle or the variability surrounding claims that have already been reported relative to claims that have occurred but have not yet been reported. In all likelihood, analyses to quantify uncertainty will not be performed at such a granular level, in which case allocation again becomes an important consideration.

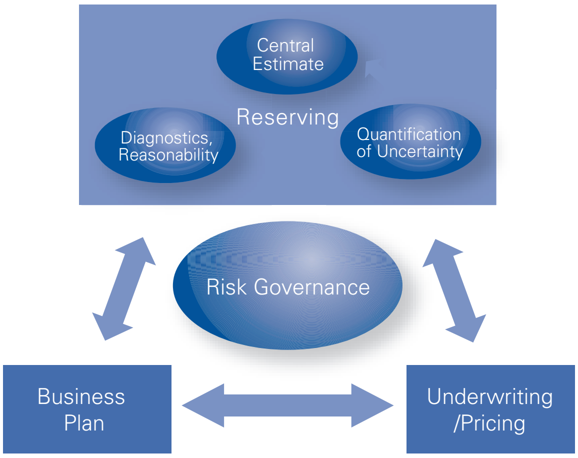
White Noise

If it were possible to know the exact model for the claims process, technical reserve estimation would not be so significant an issue. With all the variables affecting the claims process, the analyst can only overlay a presumed model onto as many random variables as seem appropriate and test to see if the model appears to capture those variables in a meaningful way. To a certain extent, refining the model by increasing the number of random variables should help to minimize the estimation error and reduce uncertainty, yet there is always a certain amount of variability—"white noise"—that cannot be explained.

On an operational level, balance is needed between the costs associated with attempting to realize the best model and the benefits achieved from such attempts. In theory, the research needed to develop a "perfect" model would serve to increase confidence in the results generated relative to technical reserve estimates and their associated uncertainty. However, from a practical perspective, any number of resource limitations would serve to constrain that research. How much investment is appropriate in improving a model that will never be able to explain all variability? The answer lies in the purpose for the modeling. With a reasonable working model, increasing the random variables subject to the modeling will likely have little impact on the results in the middle of the distribution but significant impact in the "tail." Thus, if solvency issues are paramount—as is the case in Europe with Solvency II and IFRS Phase II as well as in any capital exercise regardless of regulatory requirements—the investment in developing a model that can minimize tail error should be considered worthwhile.

The Control Cycle

Figure 16: Risk Governance and the Reserving Cycle



Source: KPMG International, 2007

Within an insurance company, the reserving process is clearly linked to the underwriting and business planning processes. The governance in place around these key processes will help determine how effectively the entity operates. As illustrated in Figure 16, the reserve process should encompass a continuous cycle of estimating both the central estimate and a measure of uncertainty, all with an eye toward reasonability checks.

The stochastic approach discussed here allows for explicit consideration of the random nature of the claims process. Estimation of the probabilities actually associated with technical reserves allows for a clear assessment of, and better appreciation of, the risks being taken within the operations. Such consideration of risk can, in turn, lead to increasingly transparent and informed decision making regarding product development, underwriting guidelines, risk mitigation strategies, and planned financial results.

A crucial aspect of the governance surrounding the reserve process is the monitoring of results over time to help ensure that stochastic reserving is viable and adding value. Hindsight is one technique that can be employed to determine if the model being used is in fact useful. Similar to comparing actual experience with the experience expected from the central estimate to determine if the latter is reasonable, the analyst can determine if the claims distribution surrounding the central estimate is reasonable. For example, if the model yields a reserve estimate of X at the 90th percentile of the distribution, but in looking at the actual data, in reality X appears to be more likely than not, then the model is not effective at capturing the claims distribution.

The concept of back-testing the modeled experience with actual experience with the benefit of hindsight can be useful here. To illustrate the concept of making use of hindsight, a simplistic example of a possible test is to take a triangle of data where the final claims amounts for the oldest years are already known, pretend that the oldest data elements are unknown, and use the model to project the outcomes. The quality of fit on the oldest data elements will be an indicator of the model's usefulness. Figure 17 on page 17 illustrates the output of two models applied to commercial motor data, where the claims payments for time periods 7–10 are already known. A comparison of the expected incremental payments to the actual payments shows that Model 2 is much more effective than Model 1. From a quantitative standpoint, the magnitude of the standardized residuals bears out this result as well. In practice, this particular method may or may not be appropriate as any observed results will be subject to other forces, but the benefits of applying this principle are clear.

Another monitoring device is to observe the standard errors of the distributions over time—for a line of business, segment, or particular set of accident years—to determine if the relative volatility is changing as expected. For example, the standard error for a set of accident years should decrease over time as the experience matures. However, for a segment of business in a steady state, where old claims are settling out and new exposures are being added from year to year, the standard error would be expected to be stable over time. Through such observations, the analyst can determine if the model outputs are sensible.

Once a model has been sufficiently tested and shown to provide reasonable results, it should serve as a baseline going forward. Additional inputs should not change the outputs materially. Unexpected swings in uncertainty would warrant further investigation to determine, for example, whether the underlying exposures have changed.

Figure 17: Commercial Motor Liability Hindsight Test of Models

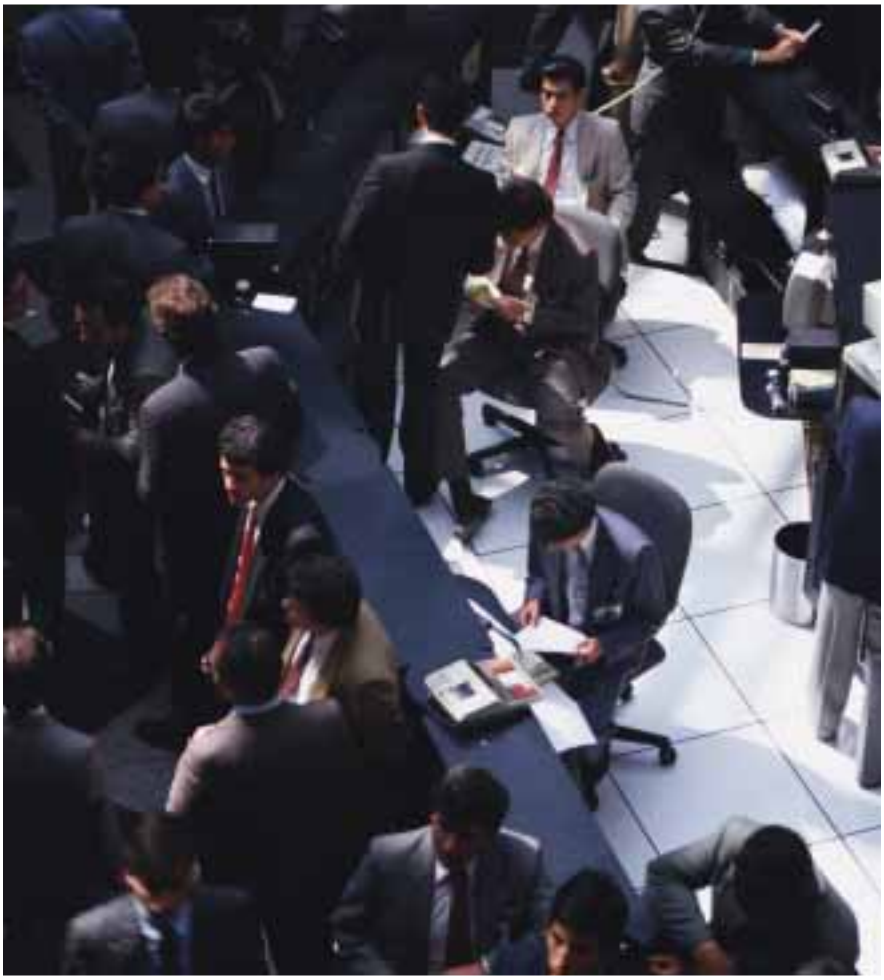
	Model # 1				Model # 2			
Actual Incremental Payments	7	8	9	10	7	8	9	10
1996	214,000	64,000	59,000	34,000	214,000	64,000	59,000	34,000
1997	198,000	88,000	82,000		198,000	88,000	82,000	
1998	196,000	102,000			196,000	102,000		
1999	240,000				240,000			
2000								
2001								
2002								
2003								
2004								
2005								
Expected Incremental Payments	7	8	9	10	7	8	9	10
1996	364,000	189,000	19,000	-	198,000	81,000	68,000	34,000
1997	381,000	198,000	20,000		209,000	85,000	72,000	
1998	390,000	203,000			214,000	88,000		
1999	417,000				227,000			
2000								
2001								
2002								
2003								
2004								
2005								
Standardized Residuals	7	8	9	10	7	8	9	10
1996	(248.62)	(287.53)	290.19	-	35.96	(59.73)	(34.51)	-
1997	(296.48)	(247.21)	438.41		(24.06)	10.29	37.27	
1998	(310.65)	(224.17)			(38.91)	47.19		
1999	(274.10)				27.29			
2000								
2001								
2002								
2003								
2004								
2005								

Source: KPMG International, 2007

Conclusion

The market issues that face non-life insurance companies require that stakeholders receive more and better risk information than has been available in the past. Reserving risk is one of the largest risks facing non-life insurance companies, underscoring the critical importance of sophisticated methodologies for measuring the uncertainty surrounding technical reserves.

Whether goals are compliance oriented, such as robust disclosures for financial reporting, or strategic, such as the ability to determine what products to continue offering to customers, the quantification of uncertainty provides the necessary information. As evidenced by the widespread international developments on this issue of reserve uncertainty, the recent rise in global as well as local attention is only going to intensify in the future. Rather than remaining reactive and accepting the risk of a delayed or incomplete grasp of the technical and practical issues on reserve uncertainty, a superior response may be to develop expert knowledge and convert opportunities to achieve strategic advantage.



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