



Jointly Sponsored Research Project:

Enterprise Risk Management for Property-Casualty Insurance

Companies

Authors: Shaun Wang, Robert Faber

August 1, 2006

Table of Contents

About the authors

Acknowledgment

Part 1: A Theoretical Framework for ERM

1.1 Definitions of ERM

1.2 Risk Dynamics & Theory of ERM

1.3 ERM as the Brain and Nerve System for an Enterprise

1.4 Guides to ERM Implementation

Part 2. Risk Dynamics within Property-Casualty Insurance Companies

Part 3. Empirical Findings on Widely Used Risk Models

3.1 Diversification Benefit or Penalty

3.2. Model Risk or Lack of Information?

3.3 Could Rating Agency Actions Have Been More Timely?

Part 4. Examples of Effective Risk Models

4.1 Enterprise-Level: Market Competition

4.2 Enterprise-Level: Risk Capital

4.3 Segment-Level: Risk Valuation

Part 5. Summary & Conclusion

References

About the authors:

Dr. Shaun Wang is Executive Director/CEO of ERM Institute International, Ltd., and Director of Actuarial Science Program in the Department of Risk Management and Insurance at Georgia State University's Robinson College of Business. He had previously worked for seven years at SCOR Reinsurance Company, and held academic positions at the University of Waterloo and Beijing University's Guanghua School of Management. He was the leader for the 2002-3 Bowles Symposiums and on the Organizing Committee for the Chicago ERM Symposiums in 2004-2006. He has published extensively on the quantification and measurement of risk and his research has won several international awards. He is Editor for ASTIN Bulletin (the Journal of the International Actuarial Association). He holds a Bachelor degree in mathematics from Beijing University and a Doctoral degree in statistics from the University of Waterloo. He is a Fellow of the Casualty Actuarial Society and Member of the American Academies of Actuaries.

Mr. Robert Faber is President and CEO of Risk Lighthouse, Inc, a research and advisory firm. Mr. Faber comes with over 30 years of insurance industry experience. He served as the Chief Underwriting Officer at Allstate Reinsurance (1986-96), and subsequently at SCOR Reinsurance (1997-2004). He was accountable for both the underwriting and pricing functions for a book of business aggregating over US\$400,000,000 in premium annually, with wide ranging lines of business and market segments (including both personal and commercial, property and liability insurance, small regional to large national companies). In this capacity, he worked with over one hundred clients in the design and application of their reinsurance program.

Acknowledgment:

This research project is jointly sponsored by the Casualty Actuarial Society, the ERM Institute International, Ltd., and the Joint SOA/CAS Risk Management Section.

The authors would like to thank several professionals for providing many helpful comments, including Michael Belfatti, Mary Ellen Coggins, Barry Franklin, Richard Goldfarb, Roger Hayne, David Ingram, John Kollar, John Kulik, Joseph Marker, Jim Rech, and Trent Vaughn. In particular, John Kollar provided leadership in overseeing the project and Michael Belfatti offered very stimulating discussions. Their suggestions significantly improved the presentation of this report. Of course, any errors remain the responsibility of the authors.

Esther Yang participated in developing the ERM theoretical framework. David Wolfe and Bo Yu provided assistance with the data analysis. Their assistances are greatly appreciated.

Disclaimer: The opinions expressed in this project report do not necessarily represent official positions taken by the sponsoring organizations (CAS, ERM-II, and SOA).

Part 1: A Theoretical Framework for ERM

1.1 Definitions of ERM

The term “enterprise risk management” (ERM) represents a holistic approach to managing risks that an enterprise faces in the rapidly changing business environment. Although risk management techniques have been practiced by sensible business firms for years, the field of ERM has only recently gained widespread attention from the business and academic community – and it is now emerging as a new discipline. As an evolving discipline, ERM means different things to different people depending on their professional training, their job functions, and the types of risks to which they are exposed. We will now review some popular definitions of ERM, followed by a presentation of our definition.

COSO Definition: The Committee of Sponsoring Organizations (COSO) defines enterprise risk management as “a process, effected by an entity’s board of directors, management and other personnel, applied in strategy setting and across the enterprise, designed to identify potential events that may affect the entity, and manage risk to be within its risk appetite, to provide reasonable assurance of entity objectives.”

The COSO framework emphasizes rightly that risk management starts at the board level (at the center of corporate governance). It also recognizes the importance of internal controls and organizational infrastructure for carrying out the risk management functions. While the COSO framework has made big footprints in the field of ERM, it has drawn heavy criticism for its bias toward risk control, audit, and avoidance.

CAS Definition: The Casualty Actuarial Society (CAS) developed the following definition: “ERM is the process by which organizations in all industries assess, control, exploit, finance, and monitor risks from all sources for the purpose of increasing the organization’s short and long term value to its stakeholders.” The CAS definition

represents a scientific attempt to emphasize both the threats and the opportunities created by business and financial risk.

S&P Definition:

Rating agencies now often include an ERM evaluation as part of their rating review of an insurance company. According to David Ingram (2006), Standard and Poor's will evaluate ERM quality in five areas:

1. Risk Management Culture
2. Risk Controls
3. Emerging Risk Management
4. Risk and Economic Capital Models
5. Strategic Risk Management

The S&P defines excellence in ERM as follows: “[An] insurer has extremely strong capabilities to consistently identify, measure, and manage risk exposures and losses within the company’s predetermined tolerance guidelines. There is consistent evidence of the enterprise’s practice of optimizing risk-adjusted returns. Risk and risk management are always important considerations in the insurer’s corporate decision-making.”

Our Definition of ERM

Traditionally, risk management is viewed as the management and control of downside risk. We want to set the record straight: the ultimate goal of ERM concerns not only value preservation, but also value creation. Even casual observers of economics see that the engines for value creation are well-run enterprises and a healthy economic system. A large part of shareholder value emanates from franchise value, which is directly tied to the effectiveness of the organization.

An *enterprise* exists to fulfill its established purposes for its stakeholders, by taking on projects and interacting with external and internal clients. (Here, “enterprise” is used in a very broad sense – for example, a firm, a public entity, or an industry sector.) In the process of selecting and implementing projects, the enterprise must interact with various players in its operating environment, deal with internal organizational issues,

anticipate and respond to changes in its operating environment, and face unknown factors and uncertain outcomes.

An enterprise always sits within the *big universe* that consists of 1) infinitely many potential *projects* with associated risks and opportunities, 2) external *players* including customers and competitors, and 3) external financial and economic *forces* in the broader social and political environment. The firm's risk portfolio may significantly differ from that of the big Universe, depending on the activities the firm engages in, how the firm conducts such activities, and how it interacts with the big Universe.

For example, the insurance business is like a huge risk warehouse. Most risks originate in the big universe (e.g., natural catastrophe, pandemic, interest rate changes), which are beyond the control of the insurance company. However, at the company level, a firm can decide which risk segments or market segments in which to assume exposure. Furthermore, at the desk underwriting level, underwriting and pricing decisions can significantly alter the risk profile for the company.

In physics/engineering language, we use “*risk dynamics*” to refer to the interactions of forces and players within and outside the enterprise. There are often multiple risk dynamics at work. From time to time, some risk dynamics may dominate others in influencing the behaviors of the enterprise. The confluence of various risk dynamics and their interactions collectively define a system of risk dynamics for the enterprise.

We define enterprise risk management as the discipline of *studying the risk dynamics of the enterprise, the interactions of internal /external players and forces, and how players' actions (including the risk management practices) influence the behaviors of the risk dynamics, with the ultimate goal of improving the performance and resiliency of the system.*

Studies of risk dynamics should start with an analysis of the business model of the enterprise, followed by an identification of the scope of business operations, including the impact of constraints imposed by regulators and rating agencies. Moreover, such studies must measure the sensitivity to external and internal forces, and formulate business or risk strategies to interact with the various forces.

The reference points for studies of risk dynamics should be the *objectives* and *risk appetite* of the enterprise, and the operating room (parameters) as constrained by financial resources, business expertise, and regulatory and accounting rules. It is in light of threats to objectives of the enterprise that risks are to be identified, evaluated, and prioritized. Aligning with the firm's objectives helps make risk management context specific and relevant.

ERM for insurance companies must be considered with regard to a fundamental difference from other industries. The insurance product is a promise to pay (assuming someone else's risk for a fee), whereas other industries primarily manage risks that are relevant to a particular business process.

1.2 Risk Dynamics & Theory of ERM

We present five principles of risk dynamics that collectively form a theoretical basis of enterprise risk management.

Principle #1: Risk dynamics exist as objective *states of nature*, of which we can gain more knowledge through experience, insights, and modeling of internal forces within the system.

Without a deep understanding of the risk dynamics, the nature of uncertainty may appear to be “pure volatility”. This may entice people to engage in naïve risk taking under the banner of diversification. The chance of success for a risk strategy directly depends upon the depth of knowledge about the risk dynamics.

The more complex the risk dynamics, the more critical it is to have subject experts to perform the risk assessment and diagnosis. For very complex risk dynamics (e.g., such as insurance business), a simple check-box type of auditing will fail to identify some major business risks.

A major challenge of ERM is to understand the various forces within risk dynamics, to measure and predict the strength and the direction of the forces, and to form a disciplined approach to react to them (avoid, divert, or manage the forces).

For many firms, regulatory decrees, rating agency actions and accounting rules are powerful forces that impact the operations of the enterprise. For instance, regulators and rating agencies often draw the boundaries of the operating room for insurance companies. The system of risk dynamics can only operate normally within its operating room, and may experience a “crash” if it approaches the boundaries of the operating room as drawn by regulators and rating agencies.

Principle #2: An enterprise has multiple risk dynamics at multiple levels with multiple forces. To gain an overall picture we need to understand the interactions of risk dynamics at different levels and to reconcile the multiple perspectives.

Firstly, there are local risk dynamics that are *inherent* to the business operations. To understand the local risk dynamics, we have to zoom in to examine the local forces. Such forces include competitive forces in the local market and local culture.

Secondly, at the macro-level (segment level and company level), there are bigger forces that are impacting the whole sector or whole enterprise, e.g. interest rate environment, market competition, etc. Such risks would be difficult to identify at the individual risk level. Only at the macro level can we properly track correlated risks (e.g. the asset risk concentration and catastrophic risk accumulation).

In running an enterprise, it is essential to recognize both global and local views: Without inputs from the field, any development of business strategy lacks a solid footing; while the strategic directions are set at the company level, the success and failure of the strategy depends on the local business execution.

Principle #3: Market valuations and internal valuations are among the major forces impacting the dynamics of the enterprise. A big part of ERM is to study the dynamics of external market valuations and their impact on the assets and liabilities of the enterprise, and to use internal valuations to influence the behaviors of the enterprise.

The manifestations of risk dynamics are often “changes in value”. After all, the main objective of an enterprise is to maximize value for its stakeholders. There is an old saying that “valuation is king”. For an enterprise, most of its risks (both upside and downside) are measured by their economic impacts. Many real-world decisions are driven by differences in valuation and accounting systems.

The outcomes of market valuations directly impact the values of assets and liabilities of an enterprise. Today, very few firms can afford not to pay close attention to the impacts of external market valuation. Market valuations are becoming an even stronger force with the adoption of fair value accounting by the International Accounting Standard Board. To better cope with the volatility of market valuations, firms need to enhance their asset-liability management practices. On the other hand, stakeholders need to understand that market valuations often exhibit short-term volatility due to the specifics of their own valuation dynamics at the time; market valuations may not be the best indicators for the long term (given the inherent business cycles and the long-term forces of mean-reversion). In other words, stakeholders need to be mindful of long-term valuations to complement the market valuations.

Principle #4: Properly constructed risk metrics and valuation models can shed light on the behavior of risk dynamics, and are powerful forces and essential tools for taking a

structured and disciplined approach that aligns business strategy with the process, people, technology and knowledge in the organization.

As an integral part of ERM, firms need to develop risk metrics and internal risk capital models and use them as effective tools to guide the business activities. Every effort should be made to develop risk metrics and build models at different levels to utilize different information. This makes the coordination and harmonization among various measures and models a critical factor for success.

For example, the exercise of tracking and counting aggregate risk exposure enables the firm to track areas of high concentration of risk. Also, segment analysis can shed light on various risk-return prospects. Indeed, in financial portfolio management, segment allocation can explain a majority part of the differences in performance.

The purposes of risk valuation models are i) to assess the firm's risk profile, capital needs, and ii) to help direct efficient allocation of resources.

We can think a firm as an internal economy. An assessment of resources (available capital and human expertise) can help determine the scope its economic activities. With its limited resources, a firm must consciously make strategic resource allocation decisions – from business planning, through prioritization of expenditures, to accounting and performance metrics. Business units are operating under their own local constraints and objectives (which may not be fully-aligned with company strategic directives), and are competing with each other for allocated resources within the company.

For many financial institutions, economic risk capital has become a common “currency” to facilitate an internal economy within the firm. Companies should be encouraged to develop such economic risk capital models. However, the real challenge is to ensure that the economic capital figures reflect the multiple risk dynamics impacting the enterprise.

Principle #5: Actions taken by key participants within risk dynamics (e.g., insurance company executives, underwriters and actuaries, rating agencies and regulators) can exert great influence on the behaviors of these risk dynamics.

A deeper understanding of the risk dynamics requires us to examine closely the psychological and behavioral characteristics of various players, as well as their interactions with each other and with the various forces of the risk dynamics.

Within an enterprise, there are risks embedded in every business decision, whether the decisions are made by an individual or group of individuals. Most decisions (big or small) are made under incomplete or inaccurate information. Delayed information (or feedback) can also create a source for making wrong decisions. There might be mismatch of expertise, or misaligned incentives that can distort the decision-making.

Management decisions and actions (including the ERM framework itself), as well as frontline underwriting and pricing decisions, can impact the enterprise's system of risk dynamics, and can strengthen or weaken the system performance and resiliency. Any systematic approach can bring about unintended consequences. Using a specific risk model itself also creates "model risk" and "methodology risk".

Market Valuation Dynamics

On the one hand, market valuation is a powerful force that impacts the risk dynamics for an enterprise. On the other hand, by applying the risk dynamics concept to market valuation, we quickly come to the realization that external to the enterprise, market valuations have their own valuation dynamics.

It is enlightening to examine the dynamics of market valuation: how market valuation fluctuates under the forces of supply and demand, how market valuations behave in a non-liquid high bid-ask spread environment, how a bubbling market valuation can generate a real wealth effect for individuals and corporations as long as "the balloon"

does not burst. As examples of the destructive forces due to the dynamics of market valuation, we have seen how big money flows quickly changed the valuation of a local currency and a specific sector (e.g. the 1997 Asia financial crisis, the recent valuation surge and ebb in the Iceland).

Here we quote a comment on the commodities and housing bubble by Warren Buffett at the 2006 Berkshire-Hathaway Shareholder meeting: “At the beginning, it is driven by fundamentals, then speculation takes over. As the old saying goes, what the wise man does in the beginning, fools do in the end. With any asset class that has a big move, first the fundamentals attract speculation, then the speculation becomes dominant. Once a price history develops, and people hear that their neighbor made a lot of money on something, impulse takes over, and we’re seeing that in commodities and housing...”

Most of today’s financial economics textbooks are concerned about the equilibrium state or arbitrage-free valuation. In reality, any state of equilibrium exists only momentarily and “change is the only constant”. The endless debates about the efficient market hypothesis are just simply two perspectives of the same market valuation dynamics.

We have stated some characteristics of risk dynamics using physical/engineering language. However, it is even more enlightening to move up to the next level and treat an enterprise as analogous to a living being. This can help us gain additional insights about an ERM framework, since a living being demonstrates great capability in processing complex signals, sorting out the themes of complex issues, and taking the most efficient approach.

1.3 ERM as the Brain and Nerve System for an Enterprise

It is instructive to think of an ERM framework as the brain and nerve system for the enterprise.

Management Information: A biological being uses all of its senses and instincts to gather information about the external environment (where dangers and opportunities are constantly unfolding). It is essential to a firm's survival that management pick out vital signals so as to be responsive to the external environment.

A strategic management information system is essential for management to make the right decisions. In addition to data on risk exposures and positions, general information (e.g. the state of market competition and phase of the business cycle) is extremely valuable.

Nowadays, many companies suffer from the syndrome of “too much data, too little information”; this syndrome is often a result of not knowing the various sources for gleaning management information.

Among infinitely many risks and opportunities, ERM should facilitate the identification and prioritization of dominant risks that pose a threat to the firm, and major opportunities that fall in line with the strategic directions of the firm. Some of the risks may be spectacular by themselves (e.g. a volcano eruption in a remote part of the world) but have little relevance to a specific enterprise. Using physical terms, relevance is inversely related to distance. If a planet comes to collide with earth's path in 200 years, the event's relevance will grow as the time-to-collision gets smaller.

Feedback Loop: An important capability of a living being lies in its ability to interact and respond to feedbacks. The ERM system should enable a prompt feedback loop from business managers, and should put into place a mechanism for responding with corrective actions.

Although there are totally unexpected events, many risks come into play after early-warning signals. Corporations often ignore these signals because they lack mechanisms for heeding them. Unfortunately, the signal to stop eating is slightly delayed in the body, causing weight gain and perhaps obesity. We shall see that same delayed signal exists in some insurers or lines of business.

Coordination & Harmony: The health of a living being is demonstrated through the harmonious coordination of various parts of its body. Risk integration is not just mechanically lumping together various body parts (business units), but is about coordinated functions of all major body parts (business units) working toward the overriding goals of the firm. It is a magic that coordination can bring about a higher level “living being”.

ERM is also a science of balancing different forces that co-exist in risk dynamics. Severe imbalance of the forces will stall the growth of the system, resulting in instability, disruption, and even failure. Using the U.S. legal system as an example, some argue that the over-emphasis of individual rights may hurt the well-being of the society.

So far we have used physical and biological analogies to illustrate what ERM represents. Now we proceed to apply our theoretical framework to the implementation of ERM.

1.4 Guides to ERM Implementation

ERM Organization

Regardless of the size and complexity of the enterprise, the management element of ERM ultimately boils down to actions by individual players in various roles. It is a necessary first step to establish clear roles and responsibilities for the key players – namely the board, senior management, risk owners and internal auditors.

The firm's board of directors must clearly drive the ERM effort. The board defines the firm's risk appetite and the risk tolerance, and defines the scope of the projects and business activities. Management should also establish the organizational and functional risk governance structure. To make risk management an integral part of business decision-making, the risk owners must monitor the actions of the business managers.

The firm should identify a risk champion, an individual designated to lead the ERM effort and to drive it through the organization, so that the risk process can become institutionalized. Such risk champion often carries the title of Chief Risk Officer. Other viable candidates include the Chief Financial Officer, Head of ERM, Vice President of Business Planning, among others. In property-casualty insurance, this risk champion must clearly understand the processes of underwriting, pricing, claims handling, loss reserving and investment, as well as how they interact, in the context of market competition and regulatory constraints.

The risk champion needs to play a role as advocate and internal consultant. This will help create a positive energy (a partnership relationship rather than adverse tension) between business managers and the risk management function. The risk champion should help to articulate the firm's risk appetite and strategy to various stakeholders, help determine how the risk information is to be gathered, identify risk owners, and help coordinate people and processes and the integration of data system capabilities.

The risk champion should ensure that the ERM process brings about the following outcomes:

- A transparent account of the firm's business model, including strategy, objectives, risk appetite and risk tolerances.
- A method for identifying, assessing, analyzing, and measuring the key business risks in an organization.
- A set of risk valuation models for various risk dynamics

- An open forum for discussing an organization’s risk capabilities, such as where it stands in terms of strategy, people, processes, technology and knowledge.

All key business managers need to take part in the ERM process and assume ownership of risks. Only when the business managers have accepted the ownership of risks can we say that the ERM process has been institutionalized.

Cost-benefit Assessment: The ambition of risk analysis should be weighed on the balance of costs and benefits. The initial ERM framework should focus on the areas that can yield the largest benefits without over-consuming the firm’s limited resources. To help quantify the cost-benefit of ERM, a company can maintain two sets of valuations, under strategies before and after implementing ERM.

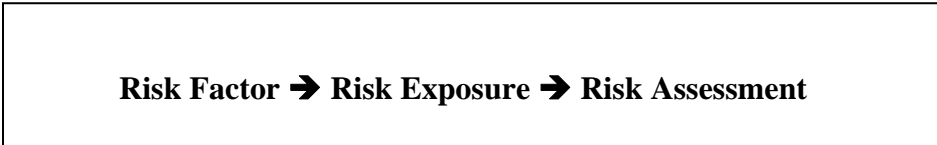
The rollout of the ERM process also has many elements (organizational aspects, risk assessment and measurement, communicational aspects, etc). Over-emphasis of any one element can make the whole process “ill”.

Development of Risk Valuation Models

As an essential tool for implementing ERM, the firm should develop risk valuation models guided by an understanding of the risk dynamics. Both *risk assessment* and *risk measurement* are integral parts of the development of risk valuation models.

Risk Assessment: This is the enterprise’s sensitivity to the risk factor. This requires knowledge of the enterprise’s total risk exposure accumulation and how it is affected by identified risk factors.

A key ingredient of any risk valuation model is the sensitivity analysis:



Current risk assessment focuses more on the likelihood than on the sensitivity. From the risk dynamics viewpoint, it is essential to quantify the sensitivity to the risk factors. Financial institutions have well-developed analytical models to quantify the sensitivity to market risk factors. These models may provide useful insights for insurer risk modeling as well, suggesting a way to model individual risks in grouping, especially given that they may be impacted by the same risk factors.

Correlation modeling and stress testing: One should also bear in mind that, under extreme circumstances (or when the system is under stress), the risk dynamics may start to exhibit a very different behavior. This is where the conventional linear correlation structure normally breaks down in analyzing extreme events.

In developing risk valuation models, we need to first map out different levels of the business segmentation (including segmentation of business by profit centers or risk characteristics) and different time horizons. It is quite normal to have different models producing different indications, given the different perspectives and utilizations of different information. The key is to let the different models to talk to each other. This also highlights the need for establishing some robust benchmarks (to control the model risks).

We can then proceed to develop risk valuation models for various levels/aspects of business operation and different time horizons:

- 1) At the company level, the risk valuation model should reflect the drivers of market valuation of the firm, as well as firm's strategic risk appetite, short-term and long-term goals. At the company level, the risk valuation model should capture the sensitivity to macro-level forces.
- 2) At the business unit level or segment level, the risk valuation model should reflect local business dynamics and local regulatory constraints. Risk valuations by segment enable us to focus rightly on the impact of systematic risks on a book of business. We would miss this key perspective if we analyzed the outcomes on an individual risk basis.

- 3) At the product level, the risk valuation model must consider detailed product features and design.

We can also build risk valuation models for various risk types: market risk, credit risk, interest rate risk, competition risk, loss development risk, etc.

The risk valuation models at various levels of the organization and different risk types should interact so as to guide business units to work together to achieve the company's overall objectives. Higher level risk valuation should flow down as overlay (backdrop) for the risk valuations at business unit level and product level, but not replace them. Lower level valuation models should provide a feedback loop to higher level valuation models. For instance, the outcomes of risk-return valuation by product lines will be used as input for resource allocation at the company-level valuation. The balancing act of conflicting forces should be left to the highest-level decision-making as possible. However, operational units must understand their role in this balancing, and the impact of their actions in the balancing.

We should always keep in mind that while risk dynamics refers to objective states of nature, a risk valuation model refers to our subjective evaluations, from a particular perspective and time horizon. The risk valuation models themselves introduce an additional source of "model risk", and proper care must be given in their development and applications. Below are some principles for developing and applying risk valuation models in a company's enterprise risk management:

- i. *Integrated Valuation.* The risk valuation model should provide an integrated view of the risks associated with the whole business decision process (underwriting, pricing, reserving, accounting, and claims handling functions). This integrated view should also apply to a cost-benefit assessment of installing any particular risk valuation model. We should always give preference to the practicality of the valuation model rather than an

- unnecessarily complex mathematical construct.
- ii. *Forward-Looking.* The risk valuation model should be forward-looking and capture the major opportunities and potential pitfalls. With past experience as a reference, it is essential to obtain forward-looking information such as underwriting cycle, market competition (players coming in or exiting the market), new developments in the regulatory and legal environment, etc.
 - iii. *Model Robustness & Benchmarking:* To gain credibility among business managers, it is essential to have robustness in the models. One way to achieve robustness is to first establish some benchmark as the base and allow limited deviations from the benchmark.
 - iv. *Understanding.* Decision-makers at all levels in the organization need to have an understanding of the relevant risk valuation model, its key drivers, and the information output.
 - v. *Commitment.* Like any corporate program, a sophisticated risk valuation model will only work effectively if the management is willing to be committed to the results.
 - vi. *Monitoring of Behaviors.* To minimize unintended consequences, we should closely monitor the impacts that the risk valuation models might have on people's behaviors.

To minimize the model risk and opportunity for bias, the model should utilize as many objective metrics as possible, and should facilitate reconciliation of different sources of information. The less reliable is the estimation of something, the more important scenario testing and maximum downside valuation become. Models should be constantly critiqued (even criticized) relative to their demonstrated explanatory power. There should be controls related to revising/updating the model.

Part 2. Risk Dynamics within Property-Casualty Insurance Companies

Using the ERM Theoretical Framework as developed in Part 1, we now describe the system of risk dynamics for property-casualty insurers.

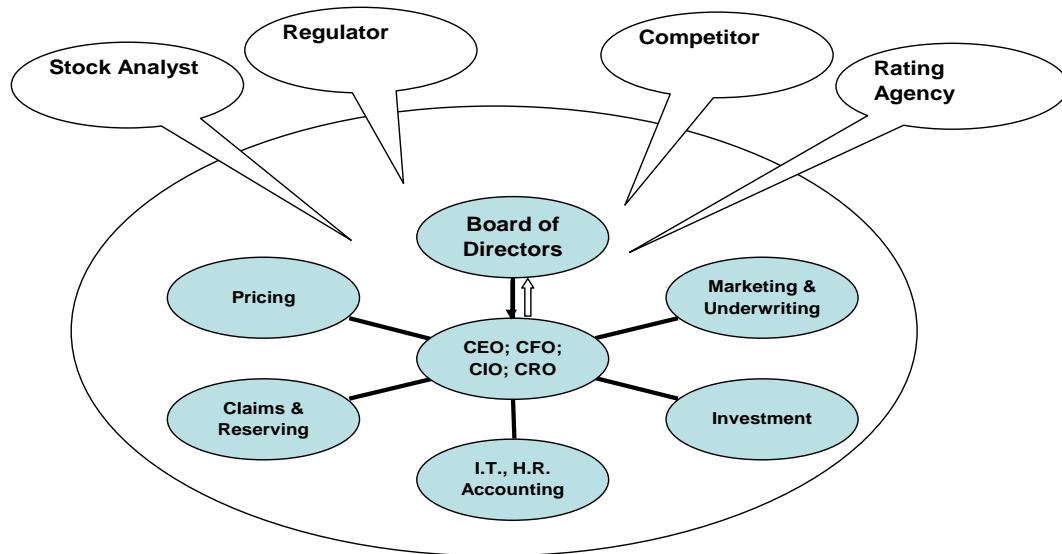
Projects:

Property-casualty insurers are risk warehouses: they engage in writing, pricing, and serving insurance contracts that cover property and liability risks for individual households (personal lines) and organizations (commercial lines). Insurance contracts are promises of contingent payments, with the costs unknown until many years down the road. The risk-intensive nature of insurance business makes the risk dynamics very different from other sectors (such as manufacturing, processing, or consulting services).

Players:

We model a property-casualty insurer as a system of risk dynamics that consists of many external and internal players. The internal players include board of directors, the CEO/CFO, underwriters, and actuaries, who are making strategic, marketing, risk selection, pricing and reserving decisions, respectively. The external players include regulators, rating agencies, competitors, investors, agents, brokers, and policyholders. The internal and external players can influence or interact with each other.

Figure 2.1 External and Internal Players for a Property-Casualty Insurer



Each player makes decisions based on information available to him/her. The set of available information can differ among the various players. Even if the players have exactly the same information set, they might construe its meanings differently according to their own perspectives and incentives. Rating agencies and regulators look at a company from outside while trying to determine its relative financial strength. Management of insurance companies should know more about their own risk exposures; but management may only partially disclose this information to rating agencies, regulators and reinsurers.

External Players:

- Rating agencies and regulators (and to some extent accounting standard setters) have considerable influence on an insurance company's operation. Unfavorable rating or regulatory actions can drive away customers and push a company off the cliff.
- Stock analysts might put pressure on insurance company executives to focus excessively on quarterly earnings and revenue growth.

- Competitive market pressure: the price-cutting actions by the competitors can pressure insurance executives to respond by lowering the price to retain/defend market share. The force of market competition at times can be brutal and disruptive.

Internal Players:

- The board of directors and senior management make strategic decisions on the lines of business and market segments to write insurance, set targets for growth and profitability, and influence underwriting discipline and risk management culture across the firm.
- Marketing and underwriting pursue a book of business with specific loss characteristics. Their performances are often tied to “top-line” revenue given the long delay in seeing final results. They may or may not get to see the ultimate financial result on their book of business.
- Actuaries analyze historical data and estimate trends to determine future rates for insurance policies. There are constant tensions between marketing and pricing, since the ability of selling insurance policies is inversely related to the level of pricing.
- The claims department handles individual claims. The philosophy and practice of the claim department directly impacts the loss levels, defense costs, case reserves, and the timing of settlements and loss payments.
- The investment department is guided by the firm’s investment policy and asset-liability management strategy.

Forces: The above players in conjunction with external shocks (natural, such as earthquakes, wind storms, global warming; societal, such as claim inflation and legal environment) form different forces that impact the system.

External Forces:

- Actions by competitors cause downward pricing pressure and coverage expansion;

- Uncertainty of future costs contributes to overly-optimistic and occasionally overly-pessimistic pricing and underwriting decisions;
- Rating agencies and regulatory rules and requirements, accounting rules (such as fair value accounting and rules for risk transfer testing) may impact how insurance companies run their business
- Economic variables such as interest rates, exchange rates and medical cost inflation
- Fluctuations in asset value due to market risk and credit risk events
- Shock losses due to natural and human catastrophes

Internal Forces:

- Internal forces: shareholders expectations create forces on income and return targets; marketing and underwriting staffs create forces on revenue growth, etc.
- Strong incentives on top-line revenue (premium) growth can create a bias toward under pricing.
- Inherent uncertainty due to delayed claim reporting and lack of understanding of the loss drivers for the business being accepted.
- Inherent uncertainty associated with the risk selection process, pricing model, claims handling practice, reserving practice, and investment practices

While many external forces are outside the control of the company, the internal forces and how they interact with external forces are often within the control of the company. For instance, occurrences of natural catastrophes are outside the control of a company, but a company has a great deal of control over its net portfolio position.

To see which forces have historically caused system failure (insurer insolvencies), we can refer to the famous report -- "Failed Promises: Insurance Company Insolvencies." This report documented the following major causes (drivers) of insurance failure:

- Under-reserving

- Under-pricing
- Unsupervised Delegation of Underwriting Authority
- Rapid Expansion (especially into unfamiliar markets)
- Misuse of Reinsurance, extensive and complex reinsurance arrangements
- Mismanagement (fraud, false reports, reckless management, incompetence, greed and self-dealing)

An A.M. Best study of insolvencies from 1969 to 2002 documented similar findings: the leading cause of collapse was inadequate reserves for claims, which accounted for more than 37 percent of impairments among the 562 insolvencies studied. In some years, inadequate reserves accounted for an even higher percentage. Rapid growth also played a major role, accounting for 17.3 percent of failures over the period studied, particularly during soft markets.

Reserves are the single largest liability and the most “uncertain” item on the balance-sheet; adverse development can have a huge impact on the financial standing (in terms of capital position). Using the risk dynamics concept, under reserving is more of a consequence, rather than a cause. Adverse reserve development is often a manifestation of under-pricing at the contract inception, caused by market competitive pressure and/or underestimation (e.g. unexpectedly high claim inflation). Adverse reserve developments are inevitable when under-priced contracts were booked as if they were written at adequately-priced levels. It can be viewed as only a reporter of the calamity that took place several years ago. After all, the pricing and underwriting of the current book is the most critical place where you can influence the future.

Under the risk dynamics concept, rapid expansion is also the manifestation of some real risk drivers. For instance, fast growth may be a result of: (i) adverse selection (the book is growing because of accepting more bad risks relative to the price), (ii) lack of control (the business is growing because no one’s pressing the brake). Of course, there are also some problems that the rapid growth actually causes (e.g. surplus strain, operational challenges, etc.).

Reinsurance is the major means of hedging unexpected volatility and diverting catastrophe risk concentration. Reinsurance is also one of the largest “spending” items for a company. It is essential to analyze the cost-benefit of the reinsurance program in the context of the enterprise’s risk appetite and capital requirements.

Movement in Interest Rates

Although relatively few property-casualty insurance failures are attributed directly to investment losses, investment is still a significant force. For short-tailed lines, the liquidity is a major concern, as the company may need to pay out large sums of money in a short time period. For long-tailed liability insurance, changes in the level of interest rates can significantly impact the pricing and market competition.

The level and movement of interest rates by itself has its own dynamics; it is driven by the external economic environment and is beyond the control of any single company. For a company, the interest rate is a key driver of profitability: a rise in the interest rate can boost investment income and thus profitability; however, it may spur more aggressive price-cutting among insurers and thus increase the threat to profitability. In periods of rising interest rates, many insurance companies engage in cash-flow underwriting, cutting prices so as to increase sales and enlarge the “float” and produce more investment income (as in one of Warren Buffets’s letters to shareholders). In the academic literature, Doherty and Garven (1991) analyzed the interaction between interest rates, insurance capital structure and insurance pricing as a possible cause for pricing cycles.

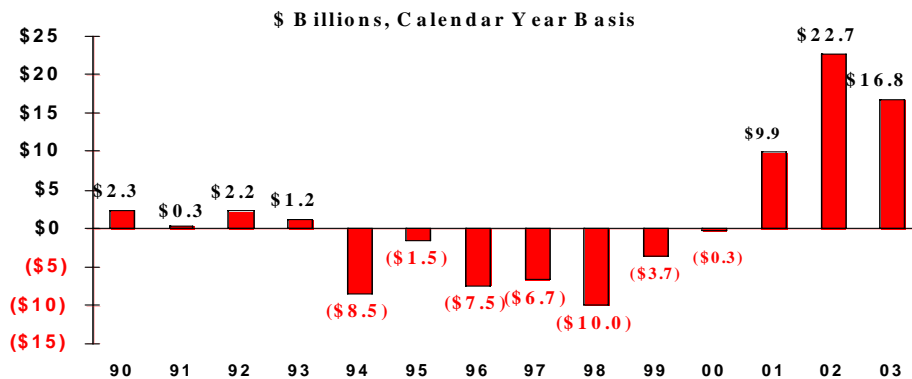
Risks in Data Interpretation and Data Modeling

There are inherent risks associated with the process of data analysis and modeling in property-casualty insurance. Firstly, the data is often incomplete due to the lagging of loss reporting, and data modeling is subject to projection errors in assumed loss trends and reporting patterns. Secondly, there are huge variations in how the data is being interpreted and utilized in the modeling process. Insurers have different views regarding what data is relevant to the calculations of expected losses or loss volatility,

and may have coded different variables. As a result, insurers come up with differing prices even if they are using the same data and employing the same actuarial method. For instance, given the same ten years of loss data, one company may assign equal weight to each of the ten years, and a second company may decide to use only the more-recent five years as they are believed to be more representative of current condition. Similarly, when the exposure and experience estimates differ, certain insurers may give more weight to exposure estimates while others may assign more weight to experience estimates.

Manifestation of the Property-Casualty Insurance Risk Dynamics

Figure 2.2 U.S. Property-Casualty Insurance Industry Prior Year Reserve Development (Data Source: A.M. Best)



The property-casualty industry exhibits periodic pricing/reserving cycles, with alternating periods of soft markets and hard markets. The period of soft markets is characterized by lower pricing, increased “switching” of insurance carriers by insurance buyers, relaxed underwriting standards, more generous coverage provisions, and in some cases reduced data and risk details being presented to the underwriter. The period of hard markets is characterized by increased prices, tightened underwriting standards, and narrowed coverage.

During the hard market, insurers are able to establish higher reserves while charging adequate prices. During the soft market, knowingly or unknowingly, insurers are pressured to under-reserve while they under-price policies. The coupling of the pricing and reserving cycle does not come as coincidence: at the turn when a soft market hardens, insurance rates go up, and companies can afford to revise /correct the reserves. The pricing and reserving cycles are more pronounced in the commercial liability lines, due to the complexity of the underlying risks and the time lag between the occurrence and reporting of claims.

Local Risk Dynamics: Underwriting Matters

Property-casualty insurance companies are characterized by their local risk dynamics associated with the risk selection process. In total, underwriting and pricing discipline is the most importance force affecting the system of risk dynamics. As documented in the Best Review (November 2005), “The Art of Underwriting”, for the same line of business, empirical studies show large discrepancies in loss ratios across companies in any given year. Insurance companies with good underwriting and risk management programs can enjoy very low loss ratios, while their peers are suffering very high loss ratios.

In order to understand the risk dynamics for property-casualty insurers, in the next section we will examine the psychological and behavioral aspects of the various players and their interactions.

Psychological/Behavioral Aspects of Decision-Making Processes

Now we turn to psychological/behavioral aspects – they are real forces impacting the day-to-day decision-making processes within insurance companies.

In his paper, “Fear is the Key: A Behavioral Guide to Underwriting Cycles”, Fitzpatrick (2004) described three important behavioral factors that influence insurance decisions:

“First and foremost is competition for revenue and market share, which as a practical matter drives the day-to-day behavior of underwriters to a far greater degree than concerns with ultimate profitability. Underwriters - like everyone else in business - are motivated by (i) the desire for financial reward and (ii) fear of losing employment or opportunities for advancement. And, during all but the absolute peaks of the underwriting cycle, underwriters are often evaluated according to the amount of premium they can generate, or the size of their existing book. The second factor is what can best be described as the ebb and flow of bureaucratic influence within an insurer that accompanies shifts in perceived profitability. The third factor is the influence of insurance agents and brokers on the pricing behavior of insurers, and the consequences of that influence.”

Below are some examples of individual psychological and behavioral factors at play:

Humans’ Optimism in the Face of Uncertainty: Pricing for (unknown) future costs allows for optimism on the part of underwriters, especially when performance and status are tied to their produced revenue. Even when the underwriters are presented with large historical losses, the force of optimism is often at work – “the big one (rare but conceivable event) does not happen on my watch”, or it was a “shock loss”. Asbestos offers a good example – people remove asbestos data because it won’t happen again, but they don’t load for the next unknown “asbestos” tort that will happen. When we remove evidence of the most unforeseen and/or latent losses, we understate the risks that we are taking and thus under-price risks.

Management's Tendency Toward Business Retention: Management has a tendency toward business retention at time of renewal. Renewal business tends to have a lower (better) loss ratio than new business. Insurers want to hold on to the good risks that they worked hard to attract. Furthermore, with fixed expenses dollars of running the business operations, a significant drop in premium volume (the denominator) would drive up expense ratios. As a result, in a soft market environment, even the more knowledgeable insurers are forced to cut prices to defend their market share. This exacerbates premium deficiency and the amplitude of the pricing cycle.

The tendency to hold business relates to the operational challenge of market entry and exit in insurance, since the operation requires (i) a fixed staff of underwriting expertise and data systems, and (ii) a good long-term relationship with brokers, produces and customers. This makes defending premium a natural response (even if it proves costly in the end).

Corporate Decision-Making Process: As a real life case, on one occasion during the bottom of the 1998-2000 soft market, the senior management of a large insurer attempted to cut back premium volume to avoid excess underwriting losses. However, the board voted against such a decision simply because of the fear of being sued by investors who would like to see revenue growth.

Part 3. Empirical Findings on Widely Used Risk Models

3.1 Diversification Benefit or Penalty?

Based on the law of large numbers as described in standard actuarial textbooks, one would predict that the loss ratio volatility decreases when there are more risks in the pool (or when the size of book increases). Many management consultants often tout the potential diversification benefits across product lines and geographic regions, which often encourages the desire for growth and expansion by insurance executives.

Like anything else, there are inherent costs and benefits associated with diversification. Determining the net benefit or penalty for diversification requires a detailed analysis of the firm's business model, including an assessment of the firm's ability to maximize the benefits while minimizing the costs associated with the diversification.

Potential benefits of diversification include:

- Scale of economy: sharing of fixed production costs across several business units within the firm, realization of intangible assets such as brand reputation, cross selling to existing customers
- Cross selling: firms with diversified product lines are able to achieve greater cost efficiencies by sharing inputs and efficiently allocating resources across product lines in response to changing industry conditions (see, Meador, Ryan and Schellhorn, 2000)
- Large internal capital market: diversification can generate larger internal capital and labor markets that can be more efficient than external capital and labor markets due to information asymmetry between the firm and the external markets
- Reduction of volatility: diversification reduces income volatility by combining revenue streams that are imperfectly correlated. For instance, geographic diversification is especially effective for managing catastrophic risk exposures.
- The more products that an insurer sells to a policyholder, the higher the rate of the policy retention (or the lower rate for switching insurers).

Potential costs of diversification include:

- Exacerbate agency costs. Agency costs are likely to rise when managerial monitoring and bonding becomes more difficult as firms become more complex.
- Leads to inefficient cross-subsidization of poorly performing business. By creating larger internal capital markets, diversification enables managers to avoid the market discipline that comes with external financing (Easterbrook, 1984). Absent the feedback for capital market discipline, under-performing units can continue to be subsidized by other units divisional performance may not be observable. This makes it more difficult to align managerial interests with those of owners.
- Diversification may hinder the acquiring of “extensive business expertise”, diminish our knowledge of the local risk dynamics, and thus may actually increase the level of risk.

To properly quantify the net effect (the costs and benefits) of diversification, we need to analyze both the volatility reduction among uncorrelated businesses and the downward forces associated with diversification (estimation error, increases in operational complexity and strains on resources).

Berger, Cummins, Weiss and Zi (2003) compare the relative cost and benefit of diversified and focused insurers over the period 1988-1992. They find that in commercial lines small specialized insurers outperform large diversified companies, thus there is a net diversification penalty. However, in personal lines, evidence support that there is net diversification benefit for large diversified insurers.

When it comes to diversification by “number of lines of business”, we refer to a more recent study by Liebenberg and Sommer (2006). They conducted extensive empirical studies that show that undiversified insurers outperform diversified insurers, earning at least a 1% higher return on asset or a 2% higher return on equity.

We performed our own empirical analysis on the effect of diversification in terms of the size of written premium (small regional versus large national). We studied a sample of 29 insurance companies which can be classified into three groups:

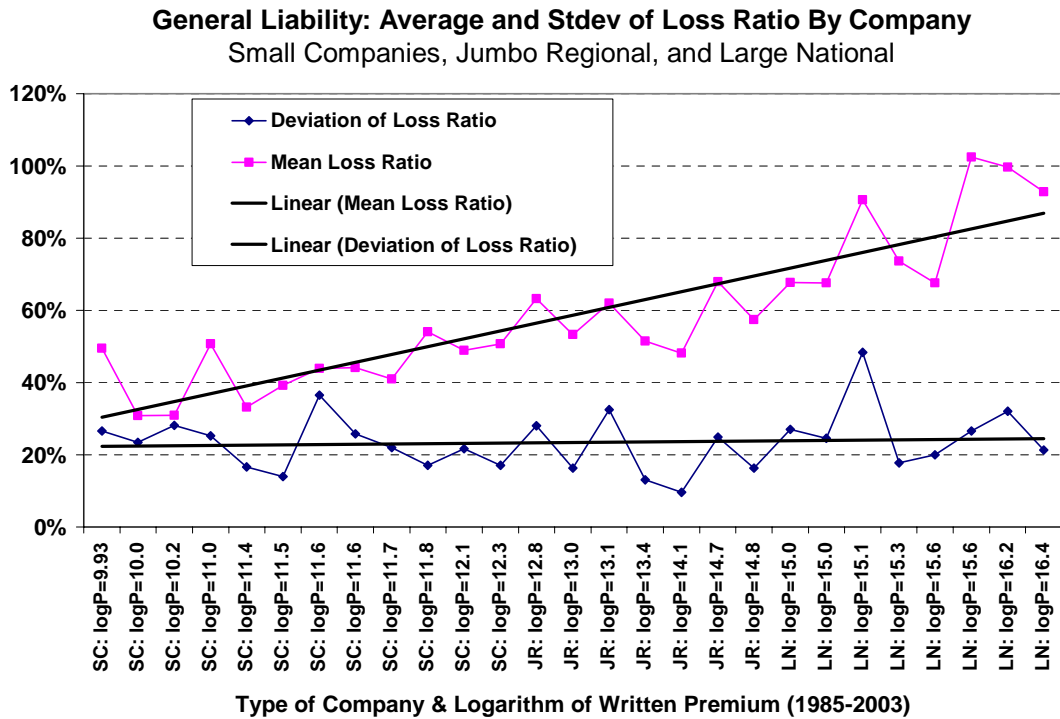
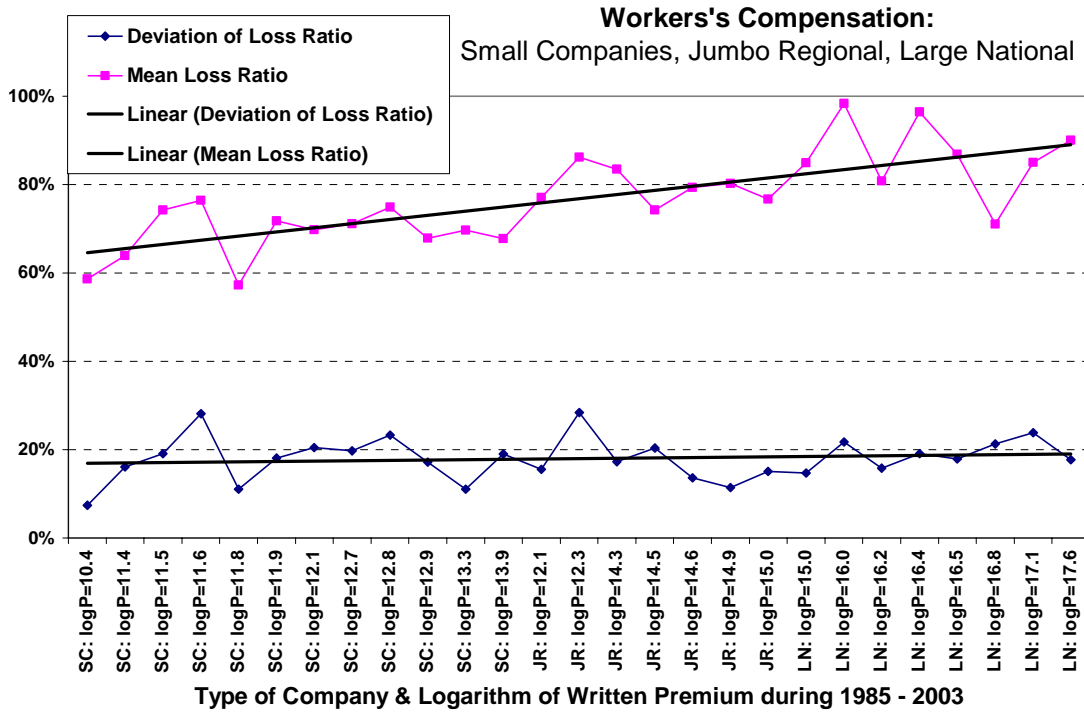
- 1) Small Companies (14 companies)
- 2) Jumbo Regional (7 companies)
- 3) Large National (8 companies)

- **We focused our analysis on the casualty lines, so as to remove the effect from the shocks by weather-related natural catastrophe losses. Specifically, our study focused on General Liability (excluding products) and Workers Compensation.**
- **We compared gross loss ratios without considering the effect of reinsurance.**

While the sample size appears limited, in both the Large National and Jumbo Regional, the number of companies represents a significant percentage of the total market. For the Small Companies, we strived to find multi-line writers with books of General Liability and Workers Compensation exceeding \$10,000,000.

Our empirical data analysis clearly indicates the large national companies have a higher mean and deviation in loss ratio than smaller companies. One might suggest a reason that larger companies write larger limits, but the results for Workers Compensation, a statutory line without limits distinctions, demonstrates the same results. One possible explanation is that large companies derive significant service fees (for instance, self-fronting programs may make direct loss ratios look inappropriately high; losses are passed back to the captive insurer.)

Figure 3.1 Mean and Deviation of Loss Ratio in relation to Size of Written Premium



A regression of the mean loss ratio against the logarithm of written premium during 1985-2003 yields the following relationship:

Mean Loss Ratio = 29.2% + 0.034 * Logarithm of WC Written Premiums during 1985-2003.

<i>Regression Statistics</i>	
Multiple R	0.69
R Square	0.48
Adjusted R Square	0.46
Standard Error	0.07
Observations	27

Note the coefficient for the X-variable (Logarithm of Written Premiums during 1985-2003) is positive. The p-Value for this coefficient being zero is 0.00006 and thus there is significance evidence for the positive correlation between company size and mean loss ratio.

We also ran a regression of the Deviation of Loss Ratio (as described in the appendix) against the logarithm of written premium during 1985-2003. We derived the following relationship:

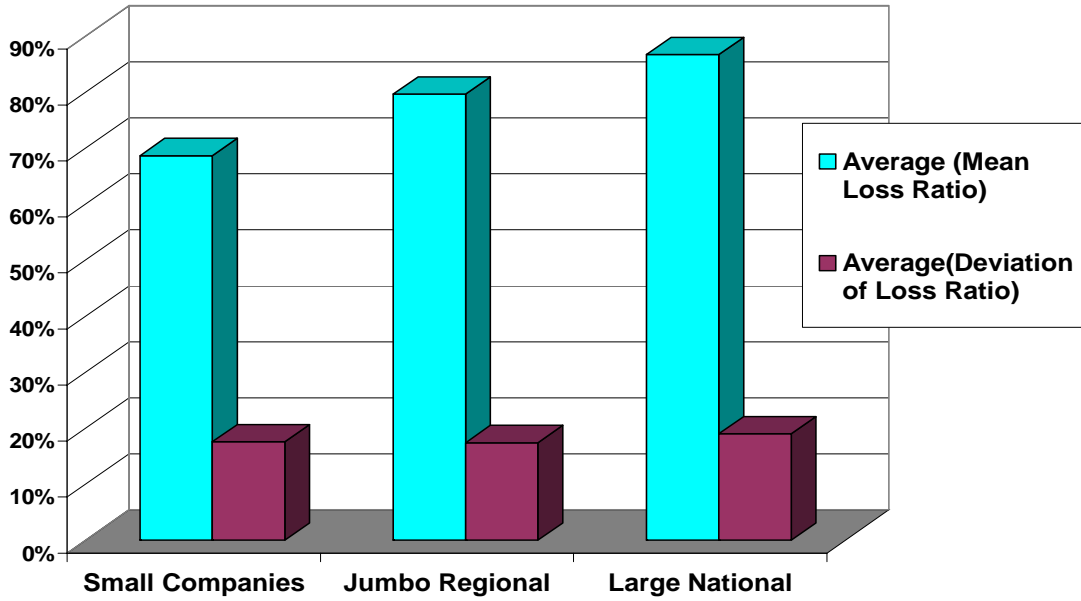
Deviation(Loss Ratio) = 14.2% + 0.00267* Logarithm of WC Written Premiums during 1985-2003.

<i>Regression Statistics</i>	
Multiple R	0.11
R Square	0.01
Adjusted R Square	(0.03)
Standard Error	0.05
Observations	27

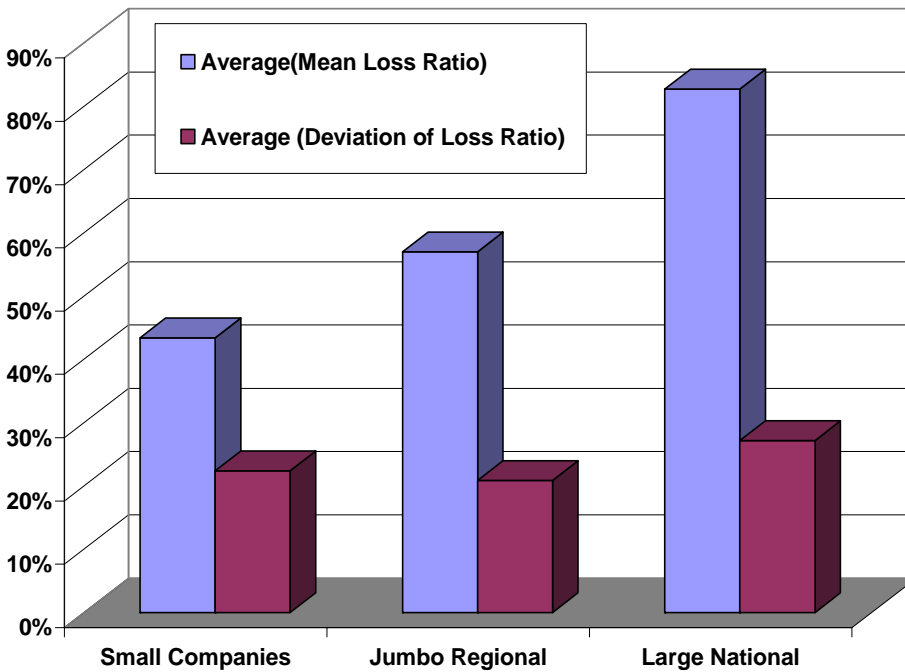
Note that the coefficient for the X-variable (Logarithm of Written Premiums during 1985-2003) is slightly positive. This is in contradiction to what we would have expected according to the law of large numbers.

Figure 3.2 Summary Results by Company Type

Workers Compensation: Loss Ratios By Company Type



General Liability: Loss Ratios By Company Type



We offer our explanations of the contrasting results for small versus large companies based on differences in their business models.

Based on informal interviews, we observed that the small companies have several aspects in common including:

- ✓ In smaller companies the rating options are more restricted, which helps to control the pricing and reduce the loss ratio volatility.
- ✓ Pricing is often based very heavily on an exposure basis, being per vehicle, per \$100 payroll, etc
- ✓ Given the markets in which they operate, they are able to rely heavily on exposure rating. Experience rating is a relatively minor modifier, not a base for pricing.
- ✓ Many smaller companies are located in smaller cities or rural areas, whereas the rate of underwriter turnover (to competitors) is lower. As a result, most underwriters get to see the loss developments on the book underwritten by them.
- ✓ Higher deductibles, self-insured retentions, composite rating, are generally not employed.

We suggest that the following issues create or exacerbate the problem for large companies:

- 1) Large companies tend to write more large commercial programs that have higher heterogeneity, which make it hard to compare based upon basic exposure units. Rate level changes are viewed against changing bases, not constant exposures bases, so rates become relative. Generally excess policies show greater loss ratio volatility.
- 2) Large insured clients are more sophisticated buyers, with more alternative options and bargaining power.
- 3) Pricing of risks has become more complex due to buying choices by the insureds such as deductibles, self-insured retentions and other plans.
- 4) Service fees may be more important than direct premiums.

- 5) Time pressures dictate that larger, complex risks must be underwritten and priced on an aggregate (fleet) basis, or composite basis, which usually implies experience rating.
- 6) Larger insurers write more heterogeneous and complex risks, where it is more difficult to estimate the required correct rate level. As a result, more leeway may be given to desk underwriters for rate variations.
- 7) In many larger companies, the underwriting knowledge is several levels removed from the decision-making. Further, in many cases, experiential knowledge is diminished by not seeing the same risks over multiple years and not having the underwriter and actuary see their own loss development. The premium-driven motivation of underwriters certainly makes things worse.

Remark: Steve Mildenhall (2006) has just written a paper with a rigorous treatment of the diversification issues, titled Actuarial Geometry. Mildenhall finds that the loss ratio volatility, instead of going to zero, converges to some constant as the size of company increases. His results on smaller companies show higher loss ratio volatility, which is different from ours. We have two explanations for this difference in results: 1) We used a smaller sample of companies over a 20 year history, while Mildenhall used more companies with 10 years of history. 2) We used premium-weighted average to calculate the mean loss ratio, and used a downside deviation measure as described in the appendix. Our metrics have the effect of smoothing out high loss ratios artificially generated by small premium denominators.

3.2. Model Risk or Lack of Information? -- Empirical Findings on Actuarial Reserving Methods

It is conventional wisdom that large companies can better predict their reserve development simply because they have a large body of data and actuarial staff. We shall perform empirical tests on two lines of business, “General Liability” and “Workers Compensation”. These two lines show different claim reporting patterns. While General Liability normally requires months (or years) to report the claims, Workers Compensation does have to report within days due to statute. Nevertheless, both WC and GL exhibit similarly long-tailed development in terms of loss dollars.

For a selected company in our sample and an accident year (say, 1997), we observe a sequence of booked loss ratios at the end of each year (e.g, 12/31/1997, 12/31/1998, ...) up to the most recent observation as of 12/31/2004. Thus we define

$$\text{Magnitude of Loss Development for Accident Year 1997} = \{ \text{Estimated Incurred Loss Ratio as of 12/31/2004} \} - \{ \text{Initial Booked Incurred Loss Ratio as of 12/31/1997} \}$$

Figures 3.3 & 3.4 compare the loss development among the three company groups. In order to facilitate cross company comparison, here we use incurred loss ratios (instead of incurred loss dollars).

As clearly indicated in Figures 3.3 & 3.4, on average, the large national companies experienced the worst upward reserve development for the accident years 1997-2000 (the period of the recent soft-market), for both the workers compensation and general liability. One possible explanation is that large insurers may write excess WC for large policyholders, and losses may be more volatile on excess policies.

Figure 3.3 Comparison of Company Loss Development: Workers' Compensation

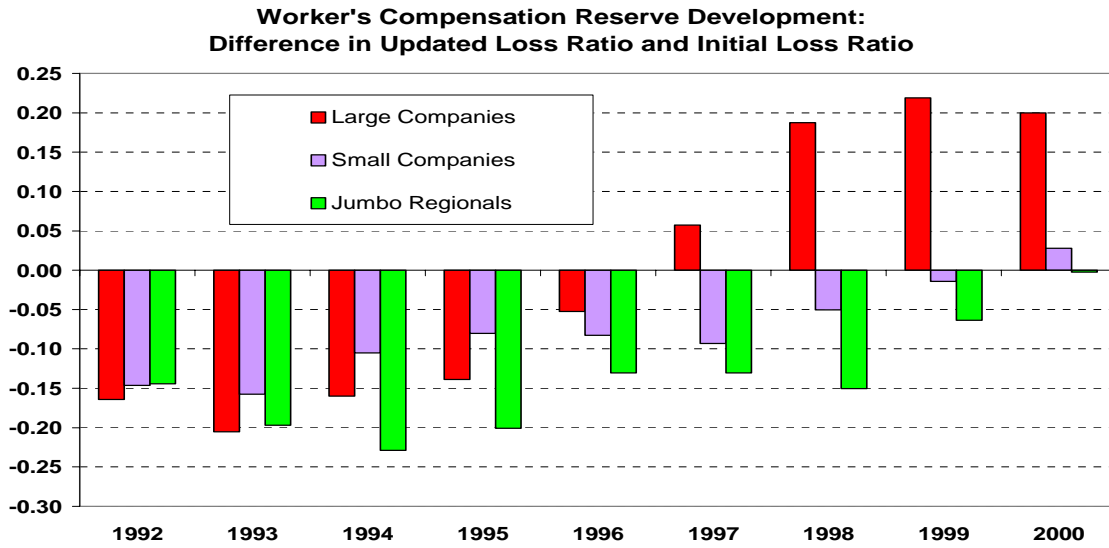
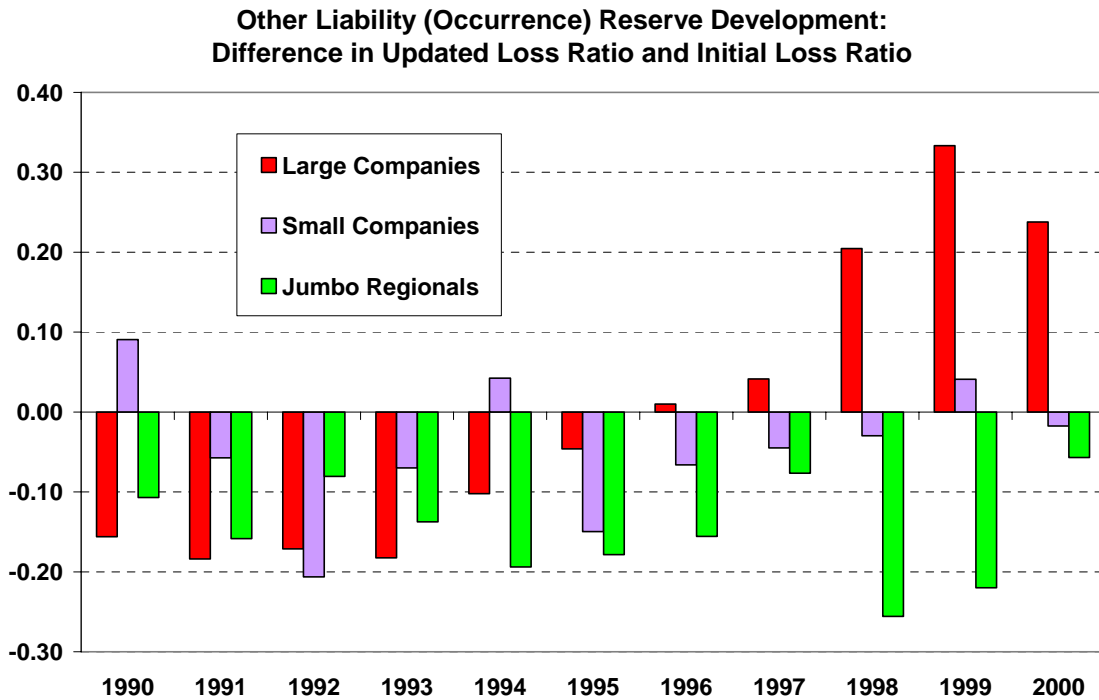


Figure 3.4. Comparison of Company Loss Development: General Liability



This empirical finding raises questions regarding the adequacy of actuarial reserving methods. The most popular actuarial reserving method is the Chain-Ladder method, which directly applies estimated historical age-to-age development factors to incurred (or paid) losses to project future loss developments.

We performed back-testing for the performance of the Chain-Ladder methods for our sample of companies.

- For each company and a given line of business (WC or GL), we use the loss development triangle data up to the end of calendar year 2000 as input data.
- We applied the Chain-Ladder method to project future loss developments to the end of calendar year 2004.
- We then compared the projected losses with the actual observed losses at the end of calendar year 2004.

As shown in Figures 3.5 to 3.8, the Chain-Ladder method performed reasonably well for small companies, but would have produced misleading indications for the large companies that we studied. Our analysis confirms a well-known fact that the Chain-Ladder method, if applied mechanically without adjusting for company pricing/reserving practice can be misleading (See Zehnwirth, 1990).

The Chain-Ladder method is especially susceptible to biased projections if the underlying market cycle is not identified or taken into account in a timely fashion. When the market is soft, some companies are pressured suppress reserves to put up a face of stable earning. The suppressed reserves have the effect of decreasing the age-to-age factors that “justifies” further reserve take-downs. When the insurance market hardens, many insurers revise upward their reserve estimates; the age-to-age factors are inflated, which in turn leads to further reserve increases and over-corrections.

Figure 3.5 Chain-Ladder Method Produces Significant Reserving Errors for Some Large National Companies – Workers' Compensation (WC) – Case Incurred Losses

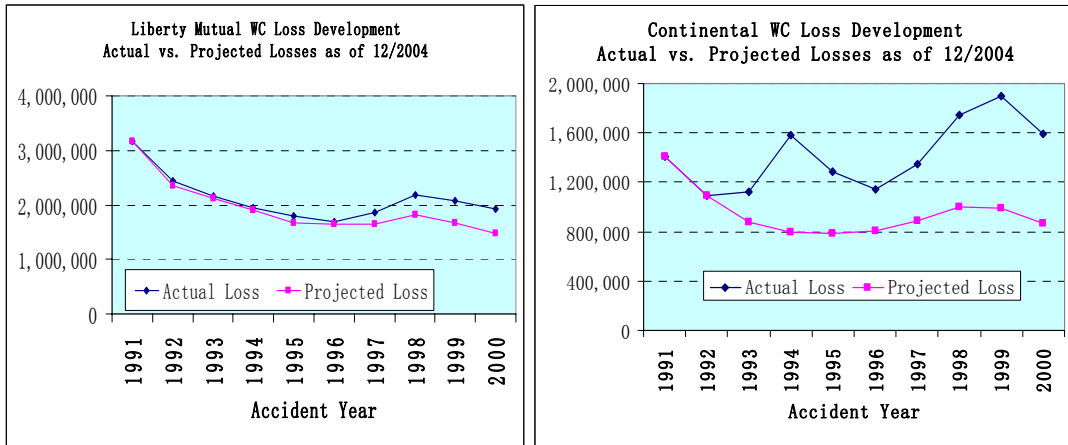


Figure 3.6 Chain-Ladder Method Works Reasonably Well for Some Small Companies – Workers' Compensation (WC) – Case Incurred Losses

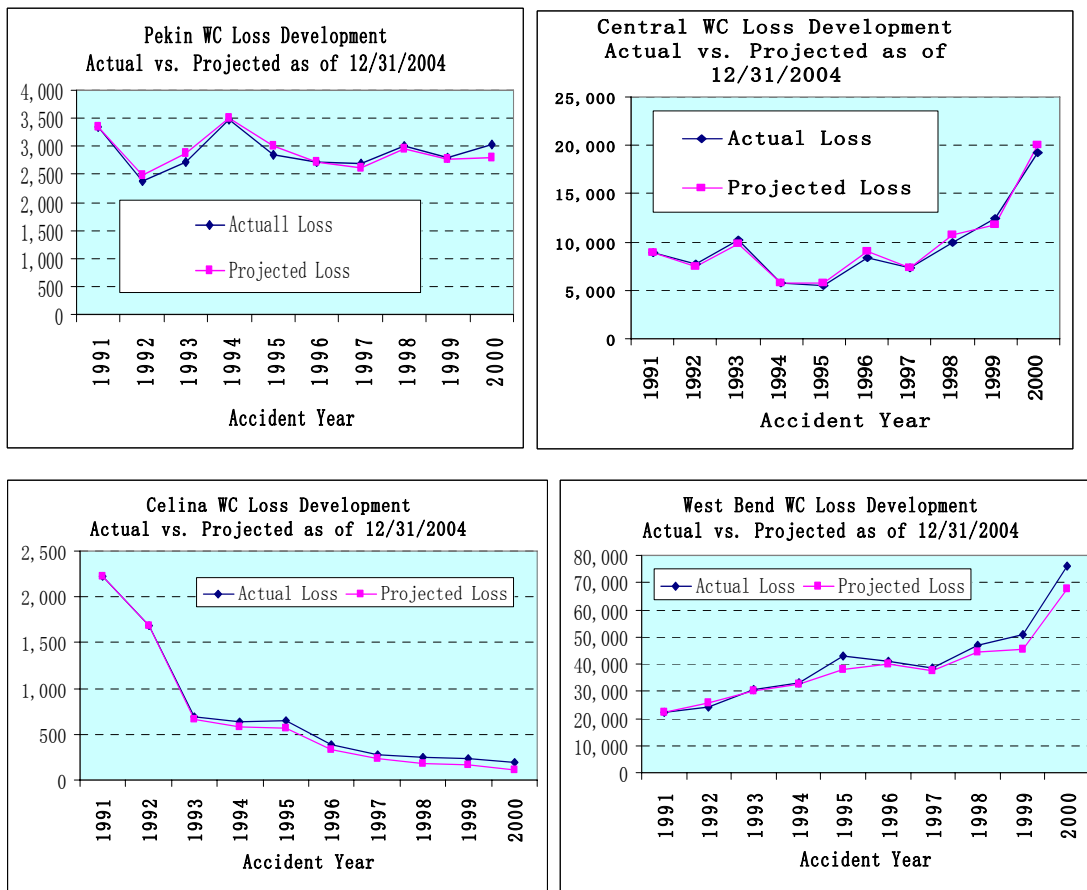


Figure 3.7 Chain-Ladder Method Produces Significant Reserving Errors for Some Larger National Companies – General Liability (GL) – Case Incurred Losses

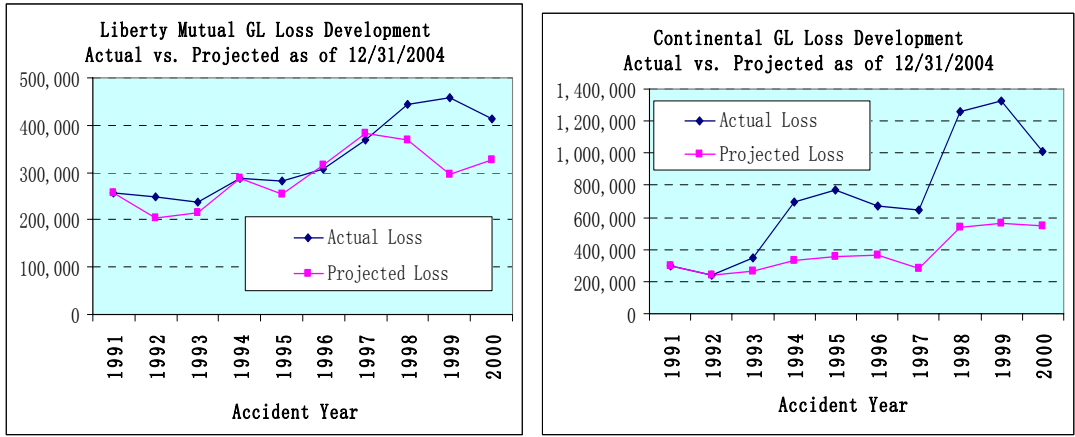
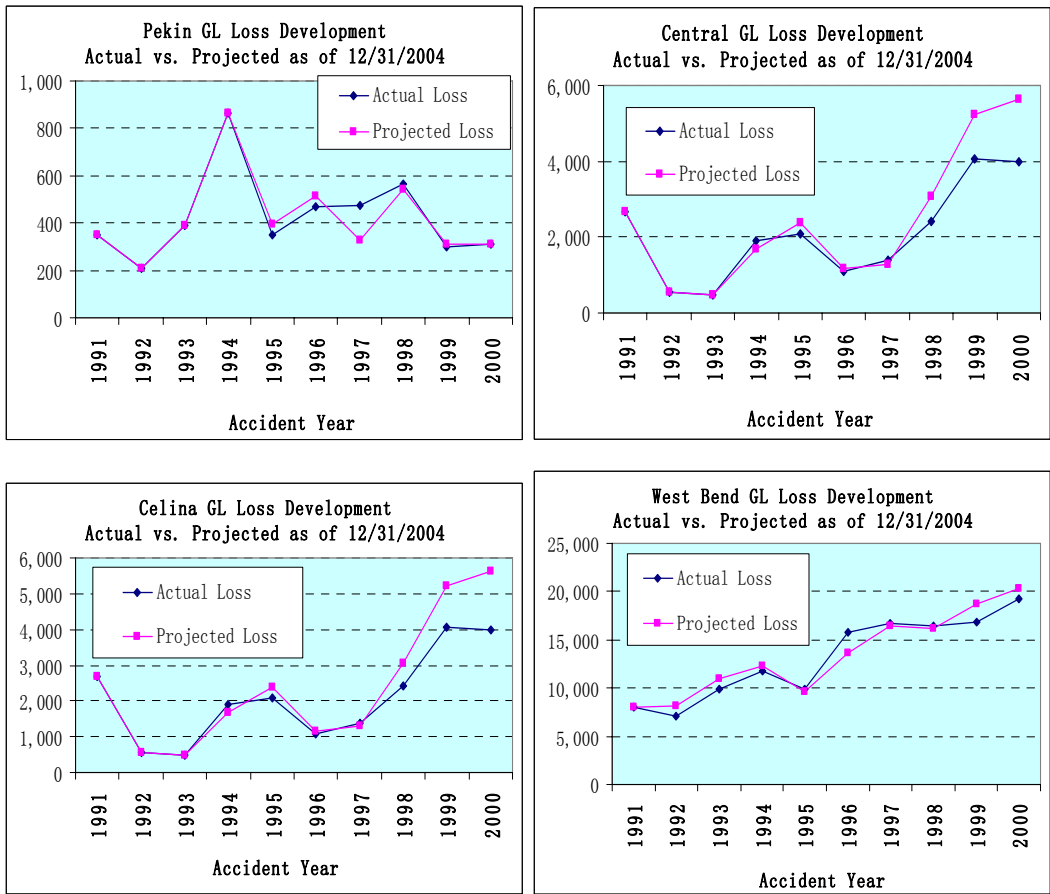


Figure 3.8 Chain-Ladder Method Works Reasonably Well for Some Small Companies – General Liability (GL) – Case Incurred Losses



Let us now look at the Bornhuetter-Ferguson reserving method: For long-tailed liability lines, when few claims have been reported in the early years of development, the basis for setting reserves is often the estimated loss ratio for that business. For the first 1-2 years, the posted incurred losses reflect mostly the rate level, not actual reported losses. In the Bornhuetter-Ferguson reserving method, an under-estimate of the level of required premium likely leads to under-reserving in the first few years. Thus, without another independent source of accurate estimate of the expected losses, we will face the same inherent problem associated with delayed reporting: *It is just like chasing our own tail if we use loss triangle methods to project expected losses and then use these expected losses in the B-F method for setting reserves.*

To break the cycle, we need an independent tracking of price levels that is not subject to the claim reporting delay. In the actuarial literature, Vaughn (2004) discusses various methods and issues related to tracking commercial line pricing levels.

Some may argue that using paid loss data (in addition to using incurred loss data) will help bring some objectivity to the reserving projection and might enable us to identify changes in estimated losses. There is partially truth and actuaries routinely use both incurred and paid loss reserve triangles. The problem with using paid loss triangle data is that the reporting delay is even longer! On balance, relying on paid data would not be able to overcome the inherent problem associated with delayed reporting.

Most of us have heard a common phrase “drive a car by looking out the rear window”, which is used as an analogy to applying statistical methods to project past losses to the future, which represents a significant model risk. This model risk can be especially severe for long-tailed lines and large insurers, as follows:

- 1) The model risk is higher for pricing and reserving long-tailed liability insurance. Due to the long reporting delay and settlement delay, actuarial projections of ultimate losses are based on incomplete data for policies written in the past 3-5 years. By the time the evaluation of reserves has reached confident levels, too

much time has passed to react to the underwriting and pricing for the line of business. In fact, we see a serial correlation in pricing error among policies written in several consecutive years: the same parameters (assumptions) are used to price several years' business with little actual data coming in.

- 2) Model risk is higher for large companies that rely heavily on experience rating (without keeping track of price level per unit of exposure). One could make the case that current pricing methodologies involving experience rating have the same limitations, that is, reacting too slowly to changing environments. Keeping track of price level per unit of exposure can alleviate this problem.

Different companies have varying reserving philosophies and practices.

We have seen some small companies that consistently booked adequate reserves over the years. In contrast, large publicly-held stock companies are more subject to earnings pressure, and the wide range of *reasonable* reserve levels makes these companies more subject to (knowing or unknowing) manipulation.

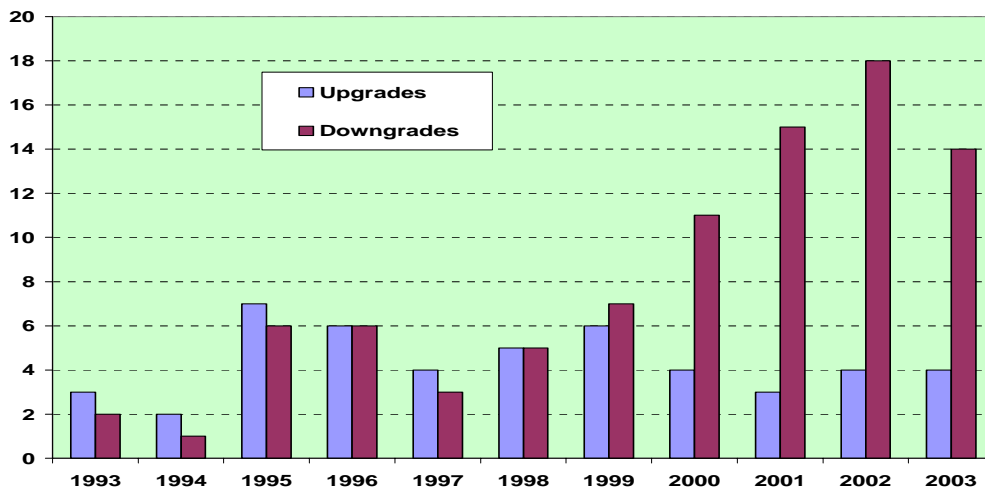
In the past 2-3 years, we have noticed considerable shifts in the reserving practice and heightened awareness for professional liability on the part of some actuarial firms. We have also observed a change in behavior on the part of the insurance executives after the introduction of Sarbanes-Oxley act. We expect that the Sarbanes-Oxley Act has created a large force to bring company reserves to a more adequate level. Mechanically applying past age-to-age factors to already strengthened reserve level may result in an over correction.

3.3. Could Rating Agency Actions Have Been More Timely?

Rating agencies (and regulators) can pretty much decide the operating room (and operating parameters) for insurance companies. When the capital position becomes weak relative to its risk exposures, that is, reaching some invisible boundary, an insurer may be dealt with a down-grade by rating agencies. A rating downgrade (to a below “A” level) may result in loss of customers and other financial distress costs.

Ideally, rating downgrades should happen when severe under-pricing and under-reserving is taking place during the soft market. However in recent history, most rating downgrades occur at the time of market hardening and emergence from a severe soft market (as shown in Figure 3.9); rating downgrades can prevent companies from achieving their desired growth in premiums, thus dashing the “dream” of some companies who were hoping to recoup losses when market hardens.

Figure 3.9 Number of Insurer Upgrades vs. Downgrades, 1993 to 2003 (Source: Standard & Poor’s)



Recognizing that the period of 1997-2000 was a soft market and the period of 2001-2003 was a hard market, Figure 3.9 shows that interventions by rating agencies have been belated. In several cases, the business being written that would ultimately create the

insolvency was being written in a time when the company's rating was in the "A" category.

The root cause of this belated action of rating agencies is attributed to the absence of forward-looking data and methodology to evaluate risk. In other words, the fundamental problem lies in the inability to accurately project long-tail exposures and/or to react in a "leading indicator" sense (before the trouble occurs). Rating agencies have been monitoring experience factors such as reserve development. Downgrades often occur on the performance of a book several years after it was written, not in the year of the underpricing. The authors cannot stress strongly enough that by the time underpricing has become obvious, the damage has already been done.

In order to help dampen the pricing and reserving cycles and thus moderate their potential disruptions to the general economy, rating agencies and regulators should encourage the wider use of forward-looking risk capital factors that reflect the specific risk dynamics and the current phase of the pricing and reserving cycle. As part of this forward-looking data, we should measure expected rate adequacy against the total exposure base; such measure, not the premium per se, should be used as an indicator of the underwriting risk.

Part 4. Examples of Effective Risk Models

The system of risk dynamics for an insurer inherently involves multiple forces, multiple players, and their interactions. To describe the risk dynamics, we need to develop different models for various forces and their interactions, from different perspectives, and using different sources of data/information.

4.1 Enterprise-Level: Market Competition

Here we demonstrate how we can quantify the competitive forces on pricing by utilizing data on the number of competitors and the inherent uncertainty in estimating the loss cost for the underlying business.

Here we show a simple mathematical model for the dynamics of market competition. Assume that there are “ k ” insurers bidding for the same business, these are the players of the market dynamic. There is inherent uncertainty associated with the estimates for the expected loss cost. We denote the estimated loss cost for insurer “ j ” by

$$\mu_j \sim \text{Normal}(\mu, \sigma_j),$$

which has a normal distribution around the true expected loss cost μ with a standard deviation σ_j . In this model, for illustration, we assume that each insurer estimates the known loss cost in such a way that there is variation but that variation is centered on the correct mean. In reality, we know that there are forces that can create systematic bias for all insurers (e.g., unexpected changes in inflation).

Suppose that insurer “ j ” adds a loading, RiskMargin $_j$, to its loss estimate μ_j . The quoted price by insurer “ j ” is:

$$\text{Quote}_j \sim \mu_j + \text{RiskMargin}_j$$

In a market bidding environment, the lowest price usually wins the business. The final transacted price will be the minimum among “ k ” quoted prices:

$$\text{Transacted Price} = \min\{\text{Quote}_1, \dots, \text{Quote}_k\}.$$

A mathematical simulation can demonstrate:

1. The risk of premium deficiency increases as σ_j increases, assuming that the risk margin remains constant (not-risk based.) For long-tailed liability insurance with significant reporting delay, there is much uncertainty in the estimated loss cost, which leads to higher σ_j , and in turn leads to higher chance of premium deficiency.
2. The premium deficiency risk increases when the product being sold isn't the same, which is true when bidders have different ratings, different reputations for claims handling, etc.
3. The risk of premium deficiency increases when there are more bidders (when k is large). In a soft market, more bidders drive competitiveness, and the competitiveness is translated into biased estimates. This model can help us better understand what happened during the 1997 soft reinsurance market, where there were many competitors bidding for the same business.
4. The risk of premium deficiency increases as the emergence lag increases, since emergence lag will directly impact the magnitude of the estimation error σ_j .
5. The risk of premium deficiency increases when some players act on excessive risk taking (the risk margin is very small or negative). This can illustrate what happened in the California Workers' Compensation market during 1998-2000, when the market leaders were aggressively cutting prices, fueled by the optimism in estimated benefits from statutory reform and the availability of cheap reinsurance.
6. An effective way of countering premium deficiency risk is to institute a mechanism that forces all insurers to charge a standard-deviation-based risk loading in their quoted prices:

$$\text{Quote}_j \sim \mu_j + \lambda_j \sigma_j, \quad \text{with a floor value for } \lambda_j.$$

This calls for companies to instill risk-based pricing that is proportional to the σ_j for the underlying risk. In a free market, players may not behave in

the way of standard-deviation based loading. Hopefully, rating agencies or regulators can encourage companies to instill this discipline.

Alkemper and Mango (2005) use a multiple-player simulation model to demonstrate how competition can lead to market cycles.

4.2 Enterprise-Level: Risk Capital

Insurers are required to hold capital to back up their insurance policies. The purpose of risk capital is to provide cushions against adverse results (including deficiencies in premium and the potential variability in loss ratio). For some lines of business or market segments, there is low variation in loss ratio, so the required risk capital is low. For other lines of business or market segments, there is large variation in the loss ratios, and the required risk capital is high. Long-tailed liability lines require risk capital commitments accumulated over the lifetime of reserve development.

Underwriting risk isn't defined by premium, but rather that premiums will be insufficient to cover losses and expenses. There is no inherent risk in premium, but in the adequacy or inadequacy it represents. For a given line of business, the underwriting risk is reduced if premiums per exposure unit are increased by 20%. On the other hand, if we keep the same aggregate premium by a rate decrease of 20% combined with a 25% increase in number of policies, the underwriting risk increases dramatically. Premium as a surrogate for exposure and risk, as it has been in the past, is totally inadequate.

Rating agency and regulatory risk-based capital models often apply fixed (static) factors to written premiums and reported loss reserves. Static risk capital factors (without adjusting for the premium and reserve adequacy) imply that the reported premium and reserves are surrogates for underwriting and reserve risk exposure. This is a widely recognized "flaw" in the risk-based capital framework. As an insurer increases reserves to a more adequate level, the more adequate level of reserve should have reduced the risk capital requirement; ironically, according to the static risk-based capital rules, the

company will be penalized by an increase in capital requirement, and possibly a rating downgrade.

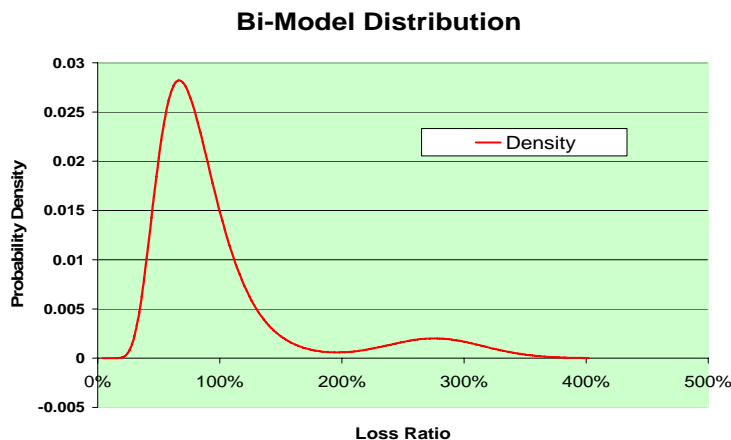
4.2.1 Measures of Downside Risk & Risk Capital Factors

Let X represent the potential outcomes of the ultimate loss ratio, or level of reserve. We will perform two-step calculations.

Step 1: Let η represent an independent assessment (or benchmark) of the target loss ratio or reserve level. We can evaluate $E[X] - \eta$ as the mean expected deficiency relative to the target level, η . When a company under prices or under reserves, we need to apply immediate *adjustment*, \$1 for \$1, *for the deficiency of premiums or reserves*; When a company over-prices or over-reserves, we should also use $E[X] - \eta$ to adjust downward for redundancies in the written premiums and reserves to the target level, η . This adjustment will directly impact the calculation of available surplus for the company. This step of adjustment is essential to overcome the drawbacks of applying static risk-based capital factors.

Step 2: The downside deviation from the mean, $\sigma[X]$. If the underlying distribution is skewed to the downside (e.g., Figure 4.1), some adjustments need to be made in the calculation of the downside deviation $\sigma[X]$.

Figure 4.1. A stylized loss ratio distribution for a commercial excess-of-loss business



We now apply a “fair pricing” approach to calculate the amount of required risk capital. We assume that the fair risk margin is a multiple, λ , of the downside deviation $\sigma[X]$. We also assume a *Target Extra Rate of Return* (TERR) on the required risk capital to compensate for risk-taking and other costs such as double taxation.

If the committed risk capital earns a risk-free interest rate, the TERR should come from the risk margin. Given the fair risk margin, we can infer that the required amount of risk capital commitment should be

$$\frac{\lambda \cdot \sigma[X]}{TERR}.$$

The values of λ and “TERR” will be globally set at the firm level or by external agencies.

4.2.2 Accumulated Capital Commitment for Long-tailed Lines of Business

A long-tailed liability insurance policy requires many years of risk capital commitment to support outstanding reserves. In order to quantify the total risk capital commitment over the life of the product, we need to break up the underwriting year loss volatility into a series of year-over-year loss development volatilities.

We denote the ultimate losses as X_{UW} , which will be revealed gradually over the next m years. Let X_j represent the revision in incurred losses over the course of $(j, j+1)$, for $j=0, 1, 2, \dots, m-1$. We have

$$X_{UW} = X_0 + X_1 + \dots + X_{m-1}.$$

Consider the loss development for \$1 expected loss at the time of underwriting. The remaining loss reserve at the beginning of year j is denoted by U_j . We use σ_j to represent the one-year revision volatility during year $(j, j+1)$, for per \$1 unpaid loss at the beginning of year $(j, j+1)$. Thus, the dollar amount reserve revision volatility during year $(j, j+1)$ can be estimated as

$$\text{Var}(X_j) = (U_j \cdot \sigma_j)^2, \text{ for } j=0, 1, 2, \dots, m-1.$$

If we assume that the year-over-year reserve incremental revisions resemble a random walk or Brownian motion, we have the following:

$$\text{Var}(X_{UW}) = \text{Var}(X_0) + \dots + \text{Var}(X_{m-1}), \text{ and}$$

$$\sigma_{UW} = \sqrt{\sum_{j=0}^{m-1} (U_j \cdot \sigma_j)^2}.$$

In the special case that all σ_j are the same for $j=0, 1, 2, \dots, m-1$, we have an annualized volatility factor:

$$\sigma_j = \frac{\sigma_{UW}}{\sqrt{\sum_{j=0}^{m-1} (U_j)^2}}. \quad (\text{eq-4.1})$$

Consider the development year $(j, j+1)$, $j=0, 1, 2, \dots, m-1$. For every \$1 outstanding loss, the volatility in the one-year loss development is σ_j . The fair-pricing risk margin is $\lambda\sigma_j$, which implies that the required risk capital at the beginning of year $(j, j+1)$ should be $\frac{\lambda \cdot \sigma_j}{TERR}$. Thus, we get the following *risk capital factor* to be applied to the target level of outstanding losses at the beginning of year $(j, j+1)$:

$$\text{RiskCapitalFactor}_j = \frac{\lambda \cdot \sigma_j}{TERR}. \quad (\text{eq-4.2})$$

During the course of loss development for \$1 expected loss, the present value (including risk-free discounting for the time value of money) of total risk capital commitments is

$$PV = \sum_{j=0}^{m-1} \left(\frac{U_j}{(1+i)^j} \right) \cdot \left(\frac{\lambda \cdot \sigma_j}{TERR} \right). \quad (\text{eq-4.3})$$

Remark: Equation (4.1) holds only when reserve revisions follow the pattern of random walk, and needs to be adjusted when σ_j are different from year to year. (As our studies show, year over year reserve revisions specifically and intentionally do not resemble geometric Brownian motion.) The specific path of reserving development matters, as it impacts the earning volatility and thus the likelihood of being

downgraded. Equation (4.1) needs to be further adjusted when reserving cycles are present. We defer these tasks to a follow-up study.

As starting point for performing risk assessment and valuation, we need to map out business segment by profit centers or by risk characteristics. For illustration, here we consider two lines of business: U.S. private passenger auto versus commercial auto, as examples of implementation of our risk valuation methodology.

4.3. Segment-Level: Risk Valuation

4.3.1 U.S. Private Passenger Auto Liability

Description of Risk Dynamics: The U.S. auto liability is characterized by predictable severity, low volatility of loss ratios and a small profit margin. Most PPA liability policy limits range from 30K to 300K. Filed rates are used in a non-discriminatory manner. There is rigid underwriting control and centralized pricing control. The pricing is done per individual vehicle. A proper time horizon of valuation can be 2-5 years, with early frequency indications being solid due to lower limits creating predictable severities. Expense differentials (e.g. direct writers versus independent agency companies) can affect the long-term competitiveness and survival of the company.

Factors to be considered for risk valuation:

- ✓ Miles driven, geographic location, driver record, age and sex, auto type, relatively low limits of liability
- ✓ Pace of medical inflation, and minimal impact of social inflation
- ✓ Past loss ratios and expenses structures
- ✓ Rate changes dominated by a handful of major market leaders
- ✓ Rates need to be filed and rigidly adhered to in a non-discriminatory manner
- ✓ Regulatory environment (in the U.S., rate regulation is state specific). Certain difficult regulatory states have led to unacceptable, but predictable loss ratios.

4.3.2 Commercial Auto Liability

Description of Risk Dynamics: Commercial Auto policies generally have higher policy limits (up to 2 million or 5 million) than PPA liability (mostly range from 30K to 300K). Heavy trucks tend to generate higher losses; loss costs also depend heavily on both the radius of use and the type of business. A proper time horizon of valuation is 3-7 years. Note that the reserve development for commercial auto is longer than personal auto due to higher limits written and that commercial auto coverage is more litigious.

Larger policies for commercial auto liability are priced on a fleet basis, as opposed to per vehicle. The fleet based pricing can create huge swings in the price level per vehicle or per mile driven. Additional rating mechanisms are available to the underwriter as competitive measures, such as self-insured retentions, large deductible and retrospective plans. These measures tend to reduce the predictability in the insured part, which in turn leads to wider pricing swings and higher loss ratio volatility. Regulation on pricing for fleets is virtually non-existent. Generally there is no clear market leader or benchmark of rate adequacy. There exist wide variations in risk characteristics as well as underwriting approaches. Data gathering for purposes of pricing is often inadequate given the rating schemes applied to fleet business. ISO data is often not utilized in the fleet underwriting process (the auto fleet can be heterogeneous, with different types of vehicles and uses)

Factors to be considered for risk valuation:

- ✓ Individual risk characteristics such as driver selection, training and compensation, routes and geographical areas driven, vehicles and cargos
- ✓ Pace of medical inflation, higher limits written create more exposure to social inflation
- ✓ Past loss ratios
- ✓ Basis of rating: fleet or non-fleet

Gathering of Relevant Data

From historical data we estimated underwriting year loss ratio volatilities as 4%, 6% and 18%, for PPA liability, commercial auto liability non-fleet, and commercial auto liability fleet, respectively. We also have estimated following loss-reporting pattern for PPA liability and commercial auto liability:

Period (year)	U_j for PPA Liability	U_j for Commercial Auto Liability
0	100.00%	100.00%
1	61.60%	75.52%
2	32.13%	52.26%
3	17.72%	33.88%
4	9.19%	19.67%
5	4.60%	10.77%
6	2.48%	6.12%
7	1.44%	3.81%
8	0.89%	2.47%
9	0.52%	1.57%
10	0.26%	0.92%
11	0.05%	0.40%
12	0.00%	0.00%

Analysis: As one of the outcomes of the risk valuation models, we can calculate the risk capital factors for these lines of business. We first apply equation (4.1) to convert underwriting year loss ratio volatility into annualized loss development volatility. By selecting values $\lambda=0.4$ and $TERR = 10\%$ for the baseline (before considering the effect

of soft or hard market), we get the following annual risk capital factors (to be applied to the target level of written premium and the target level of outstanding reserve):

Line of Business	U/W Year Loss Ratio Volatility	Annualized Volatility	Annual Risk Capital Factor
PPA Liability	4.0%	3.2%	0.10
Commercial Auto Non-Fleet	6.0%	4.2%	0.13
Commercial Auto Fleet	18.0%	12.7%	0.38

Results interpretation and recommendations:

It is noted that the risk capital factor is much higher for commercial auto fleet than non-fleet; this reflects the differences in risk characteristics and in historical loss ratio variations. By using a higher risk capital factor for commercial auto fleet, insurers have to charge higher risk margins in the pricing for this line of business; this will better reflect the economic capital reality. As demonstrated previously, this is an effective way of countering the premium deficiency risk.

Part 5. Summary & Conclusion

In this paper, we presented a theoretical ERM framework and applied it to property casualty insurers.

ERM is a journey and an ongoing learning process, and requires a humble attitude and disciplined approach. Nevertheless, after the first implementation of an ERM framework, the property-casualty insurer should have accomplished the following:

- Clearly-defined business model including business focus, competitive edge and risk tolerance level.
- Well articulated risk appetite and risk strategy, risk exposure accumulation;
- Well-integrated business processes for sales, marketing, underwriting, pricing, claims handling, reserving and investment functions and processes.
- Developed and tested robust risk valuation and risk model that are operational for day-to-day business management.

We now highlight our main findings of our analysis.

1) Be better prepared for the next underwriting and reserving cycle.

The property-casualty industry as a whole faces the inherent risk of estimation errors due to delayed emergence and recognition of unexpected loss trends. The industry also constantly faces emerging loss trends due to global warming and other factors. This would indicate that underwriting and reserving cycles aren't going to go away. However, a company can be better prepared for riding through the next cycle by more reliance on better management information (e.g., objective leading indicators) to guide pricing, underwriting, and reserve decisions.

2) Underwriting as first line of defense.

Although reserves appear to be the largest “uncertain” item on an insurer's balance-sheet, the under-pricing and poor underwriting were the root causes for reserve deficiencies. After all, underwriting and pricing of the current book is the first line of

defense in risk management, and it is the key area that the insurer can do something about the future.

3) There are clear geographical diversification benefits in managing catastrophic risk exposures. However, in commercial lines, we have found that small companies on average outperform large national companies. Our findings have implications for small to mid-sized companies. We were given the following comments from some of the industry veterans: “In the past, some rating agency gave much emphasis on diversification benefits, which encouraged a number of regional companies to diversify into multiple lines or multiple states, only to find out later that their underwriting results suffered severely from such initiatives.”

What is really needed by the insurance industry is a "new" portfolio theory that better reflects the risk dynamics in reality. The "new" portfolio theory should consider the firm's focus of expertise and competitive edge, synergy in operation, transaction costs associated with start-up and run-off the business, and the parameter uncertainty around risk estimates. Without such "new" portfolio theory, confusion will continue to plague the intellectuals. For one evidence, we can just note the differences between Basel II additive capital rule vs. the NAIC (& AM Best) square-root rule.

4) About 15 years ago, one researcher made a bold prediction that small companies could not survive in 10 year's time. To the contrary, small regional companies have traditionally outperformed large companies in gross loss ratio. The tremendous growth of captives and risk retention groups is essentially small insurance companies in a slightly different form, and similar to the growth of mutual companies over 100 years ago.

If one needs evidence of the weakness of some large multiple-line insurers, consider the following list of disappearing independent names: Aetna, INA, General Accident, Continental, Reliance, Commercial Union, Royal Globe, USF&G, Maryland Casualty, Transamerica, Kemper. Who will be the casualties to join the list above after the next soft market?

Future winners may be specialized companies with real understanding of the risk characteristics of business written, with data collection systems to support the risk selection, and with pricing that is able to create differentiation based on real loss drivers.

5) Trailing Indicators versus Leading Indicators

Experience-based trailing indicators are subject to estimation bias due to information lag and agency/incentive problems. What the insurance industry needs is leading indicators for guiding pricing decisions. Companies should gather and use forward-looking and empirical/objective data by closely monitoring emerging trends, potential impacts of new regulation or new technology, actions by key competitors and changes in competition due to influx and exit of players.

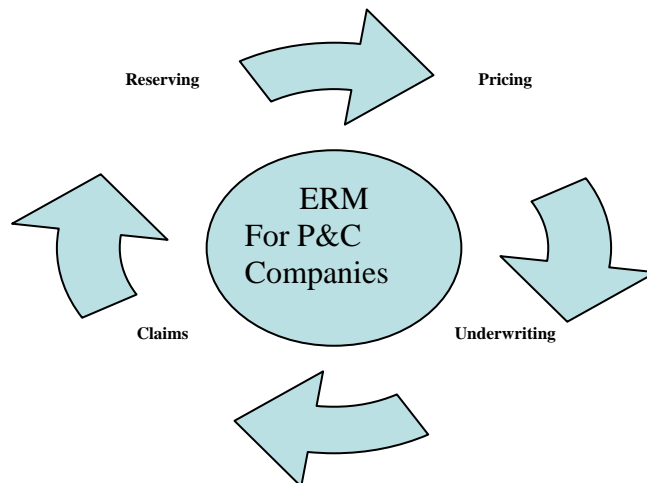
Companies need to diligently track rate level changes per unit of exposure (e.g., per power unit or mileage in trucking insurance, per \$100 of payroll in workers' compensation, etc). For those companies writing solely policies attaching at the ground level (or at low deductible levels), tracking the changes from standards such as ISO or AAIS loss costs should be helpful. Dealing with more complex risks and coverage not attaching at the ground level is much more complicated, and deserve a separate in-depth discussion.

While tracking changes in actual rate versus exposure basis has significant limitations, and the case can be made that very few complex risks have a clear exposure basis, the over-reliance on experience rating and comparable rating schemes puts an insurer clearly at risk of under-pricing. Establishing a fixed benchmark or benchmarks on risks as closely related to the true exposure as possible should enable companies to track rate level changes, and expected loss ratios, more accurately than loss experience changes on the risk.

It appears that the results of the smaller and jumbo regional companies are less subject to bias because of their adherence to exposure rating and the tracking against exposure

measurements rather than putting a heavy emphasis on experience rating. Experience of the risk becomes a modifier rather than a rating basis. The authors were not able to interview large national companies to the level of detail that they wished. Nevertheless, the authors pose the concept of rating and tracking rate levels on self-insured retention and high deductible policies intensively on a series of exposure bases from the ground, using experience more as a modifier than the rate generator. This would then enable tracking the excess pricing on a series of smaller exposure bases, rather than sales, or another macro measurement not closely correlated with the true exposure. Doing so would be a cumbersome process, and clearly be more expensive. However, in the realm of ERM the most significant danger posed to insurers has been the dramatic underpricing without recognition, and the subsequent under-reserving.

6) Companies need to put in place integrated internal business process. Companies need to incorporate the tracking of pricing data in the loss reserving process, and to use the reserving process as a feedback mechanism. Companies also need to link the loss reserve process with the claim department (changes in the case reserving method, speed of the settlement, and paying defense attorneys).



7) Most of the rating agencies' risk capital models have not yet promptly reflected changes in rate level. Instead, they tend to react to reserve increases that are the later manifestation of inadequate rates. Some of the current theoretical models show

misleading results especially in the overestimation of risk diversification benefit and in the underestimation of capital requirement for long-tail business.

What is needed is a truly risk-based (economic) capital framework that accurately reflects premium adequacy and risk characteristics. Risk-based capital framework should better reflect the underlying risk (various aspects including frequency, severity, correlation, pricing adequacy, the length of development tail). Such a risk-based capital framework should be understood by the practicing underwriters and actuaries. Risk-based capital framework belongs at the desk level, not just at the office of the CFOs and CROs.

Areas for Future Research

Further research is needed to develop a generalized portfolio theory that quantifies the net benefit or penalty of diversification by closely examining the business model.

A key part of ERM implementation is to develop risk valuation models as guide for day-to-day business decisions. In this paper we have discussed several risk dynamics and how we can effectively quantify such risk dynamics. However, full development and validation of such models shall require extensive field studies (which may require company visits, market survey, data gathering and analysis, and model testing). We envision and propose such efforts for the next phase of research.

References:

1. Alkemper, J. and D. Mango (2005) Risk Management Newsletter, Nov. 2005. pp. 13-17
2. A.M. Best Company (2004). Best's Aggregates & Averages: Property-Casualty, Oldwick, NJ.
3. Belfatti, M. (2006) Exposure Tracking – How well do you know your risks? Emphasis Magazine.
4. CAS ERM Committee, (2003). Overview of Enterprise Risk Management, available online from <http://www.casact.org/research/erm/overview.pdf>
5. COSO, (2004). The COSO ERM Framework. http://www.sox-online.com/coso_cobit_coso_framework.html
6. CEA, (2005) Solvency II – Update, <http://www.cea.assur.org/cea/v2.0/uk/accueil.php>
7. Cummins, J. D., M.A. Weiss, and H. Zi, (2003), Economies of Scope in Financial Services: A DEA Bootstrapping Analysis of the US Insurance Industry, working paper, Wharton Financial Institutions Center (Philadelphia, PA).
8. Easterbrook, F.H., (1984), Two Agency-Cost Explanations of Dividends, American Economic Review, Vol. 74, No. 4 (Sep., 1984) , pp. 650-659
9. Fitzpatrick, S.M. (2004) “Fear is the Key: A Behavioral Guide to Underwriting Cycles”, published in the Connecticut Insurance Law Journal, Vol. 10, No. 2, pp. 255-275.
10. IAA Solvency Working Party, (2003). Insurer Solvency Assessment Towards a global framework, http://www.actuaries.org/LIBRARY/Other/IAIS_Lisbon_Wason.pdf
11. Ingram, D. (2006) “Standard & Poor’s Enterprise Risk Management Evaluation of Insurers”, Risk Management Section Newsletter, March 2006, pages 14-17.
12. Liebenberg and Sommer (2006). Effects of Corporate Diversification: Evidence from the Property-Liability Insurance Industry, submitted for publication.

13. Klein, R.W. (2003). Underwriting Cycle, Encyclopedia of Actuarial Science, edited by Teugles, J.L. and B. Sundt, 1705-1714.
14. Meador, J.W., H.E. Ryan, Jr., and C.D. Schellhorn, (2000), Product Focus versus Diversification: Estimates of X-Efficiency for the US Life Insurance Industry, in Patrick T. Harker, and Stavros A. Zenios, eds.: Performance of financial institutions : efficiency, innovation, regulation (Cambridge University Press, New York).
15. Mildenhall, S. (2006). Actuarial Geometry, paper presented at the 2006 Risk Theory Society Seminar.
16. Standard & Poor's, (2005). Enterprise Risk Management And Risk Assessment, November 18, 2005, www.standardandpoors.com (search: erm)
17. U.S. House of Representatives, "Failed Promises: Insurance Company Insolvencies," a subcommittee on Oversight and Investigations of the Committee on Energy and Commerce, February 1990,
18. UK Working Party, (2003). "The Cycle Survival Kit", chaired by Nick line, available online from <http://www.actuaries.org.uk/files/pdf/proceedings/giro2003/Line.pdf>
19. Vaughn, T. R. (2004) [Commercial Lines Price Monitoring](http://www.casact.org/pubs/forum/04fforum/04ff497.pdf), CAS Forum Fall 2004, <http://www.casact.org/pubs/forum/04fforum/04ff497.pdf>
20. Zehnwirth, B. (1990). Chain Ladder Statistical Model, Claims Reserving Manual, Institute of Actuaries, London, Vol. II, Chapter 1.

Appendix: Our Metrics of Mean and Deviation of Loss Ratios

In this paper we used the following metrics for calculating Mean Loss Ratio and Deviation of Loss Ratio from historical data for a given company.

Consider the observed premiums and losses in the past n years, $j=1,2,\dots,n$. It was noted that

Year j	Premium in Year j	Loss in Year j
1	Premium_1	Loss_1
2	Premium_2	Loss_2
n	Premium_n	Loss_3

We calculate the Mean Loss Ratio as

$$\text{Mean Loss Ratio} = \frac{\sum_{j=1}^n \text{Loss}_j}{\sum_{j=1}^n \text{Premium}_j}.$$

This Mean Loss Ratio is a premium-weighted average. It is a more robust measure than the straight average loss ratio, and avoids the potential drawback of distortion by any single year where the premium base is small that might render the loss ratio for that year unstable.

We define a measure of downside deviation as

$$\text{Deviation}(\text{LossRatio}) = \frac{\sqrt{2\pi} \cdot \sum_{j=1}^n [\max(0, \text{Loss}_j - \text{Premium}_j * (\text{Mean Loss Ratio}))]}{\sum_{j=1}^n \text{Premium}_j}$$

The factor $\sqrt{2\pi} \approx 2.5$ is included so as to make our “Deviation” comparable to the standard deviation when the underlying distribution is normal.