Comprehensive Actuarial Risk Evaluation (CARE)

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This paper has been produced by the Enterprise and Financial Risk Committee of the IAA and has been approved by that committee.

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Background

The global financial crisis revealed some significant gaps in risk management. The underlying cause is in truth a variety of contributory factors. One of the contributory factors, often singled out as a root cause is the reliance the banking industry placed on sophisticated mathematical models. There are two elements to this issue, firstly the extent and use of the models to make informed decisions, and secondly the models themselves. Mathematical models are deductive by nature, and simplifications of real life. The problems with models can be the premise, the use or the validity/accuracy of the underlying thing it tries to represent. There is scope for fundamental misunderstandings between model creators (and their models) and management who make decisions based upon the outputs. The failure of management to understand the nature of the models and any associated overconfidence in their decision making ability can be addressed, at least in part, by having a Comprehensive Actuarial Risk Evaluation (CARE) performed by an actuary.

Using convenient mathematical models to quantify risk can be like looking for your lost keys under the nearest lamp post, as this is where the light is. Edmund Phelps (Economics 2006 Nobel Prize winner) is skeptical about "too much belief in mathematical models"; and the U.K. Turner[1] report also mentions "misplaced reliance on sophisticated maths" as a contributing factor to the crisis. This is not to say that models are not helpful, but that they need to be combined with experience, business acumen and judgment, and to be used properly. Similarly if a pilot crashes a plane because he does not know how it works or its limitations, then this is not the engineer's fault. The CARE would help to ensure that the board of a firm is fully aware of the context and capabilities of the risk management framework and models used in the organization.

Overview

The Comprehensive Actuarial Risk Evaluation paper will recommend a framework that describes a comprehensive evaluation of a risk. "Comprehensive" means that the analysis will quantify risk from numerous perspectives, such as market consistent vs. fundamental value, short term vs. long term, known risks vs. emerging risk elements, frequency risk (earnings volatility) vs. severity risk (solvency); viewed stand-alone and in the context of the full risk portfolio.

Some concepts, such as regulation, are industry specific. In these cases, the paper will be limited to Life Insurance, P&C Insurance, Banking, Pensions and Investments. This does not mean that the rest of the paper can not be used for trans-industry assessments.

There are various Enterprise Risk Management (ERM) frameworks in existence (including the Casualty Actuarial Society (CAS) and Committee of Sponsoring Organizations of the Treadway COmmission (COSO) frameworks), and all of these frameworks involve the evaluation of risks as a key step. There currently are however no global actuarial professional standards for risk evaluation performed by an actuary within the field of ERM.

[1] Financial Service Authority, *The Turner review: A regulatory response to the Global banking crisis,* March 2009. (See http://www.fsa.gov.uk/pubs/other/turner_review.pdf)

The primary goal of CARE is to provide a starting point for a comprehensive evaluation of risk to be performed by actuaries and to germinate the best actuarial practices within the risk evaluation sub-section of ERM.

The secondary goal is to equip the actuarial profession with a valuable toolkit that increasingly demands more exposure at the highest levels of the financial institutions and that can contribute to the elevation of the reputation of and the demand for the actuarial profession. A CARE report will provide a standard for a thorough review and will provide a systematic description of the comprehensive evaluation that actuaries can use in risk reports. It will allow an actuary to clearly cite what part of the comprehensive evaluation was or was not performed in a particular situation. This paper will provide a description of this risk evaluation and use numerous examples of how this may then be applied to specific risks that actuaries are commonly called to evaluate.

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1. Introduction – Why CARE?

In today's world, the risks facing large global financial firms become more and more complex and the severity of risk management failures forces the stakeholders to demand better risk transparency and a more robust risk-adjusted decision-making process from senior management. This demand has boosted the rapid development of ERM in recent years.

Historically, risks in financial service industries are measured and managed by different cohorts of people with distinct backgrounds and siloed views on risks. Those different views of risks are often fragmented and inconsistent with each other. Incomplete or inconsistent risk evaluation greatly hinders successful risk management. To enable a company-level view on overall risk exposure firms need to create the "big picture" of risks for senior management. This holistic view requires financial firms to adopt comprehensive and consistent risk assessment and measurement techniques to derive a broad panorama of the risks and give perspective on risk-adjusted returns of various business activities. CARE facilitates senior management involvement and enables an actuary to get a seat at the table by providing the management with an enterprise wide understanding of risks to support the executive agenda.

It is important to consider risk in the context of the core competences of the firm, what is highly risky for one firm, may be a core competence of another. The CARE can play a role in being objective and independent in the assessment of the risks for the firm given the context, history, culture and the strategic positioning. This includes opportunity costs – in some cases inaction may be the most risky course of action.

Why Comprehensive?

Barings Bank was brought down by a derivatives trader in Singapore and most people had no clues who this person was before the event happened. Lessons learned from failures over the years of many financial institutions tell us that troubles created from one relatively unnoticeable corner of an organisation or business spectrum can have a huge impact on the entire firm, no matter how robust other business are. It is not prudent to write insurance/coverage/CDS, etc., for an event that will never happen and put down less than adequate funding to survive the event. If the firm cannot survive the event, it is not actuarially sound practice to say that it is insured/covered etc., no matter how unlikely the event seems to be.

Financial firms need deep and comprehensive understanding of the risks they are taking due to the nature of their risk-taking business. No matter whether the risk management techniques are bottom-up or top-down, financial services firms need a holistic and comprehensive understanding of the risks. This means firms need to fully understand:

1. Individual risks
2. Risk correlations
3. Risks on the corporate balance sheet
4. Risks that are off the corporate balance sheet
5. Economic risk position (as opposed to only the accounting view)
6. Risks both at the holding company level as well as the subsidiary level
7. Implications of risk position for the company activities and strategy
8. Risk controls and risk mitigation

Different sized companies have different levels of sophistication with regard to risk management. A comprehensive evaluation of risks could provide options such that insurers could select their best fit.

Comprehensive also refers to conducting comparison and assessment of different risk measurement approaches. Insurers need to know the advantages and limitations of each risk measurement approach and develop methods for managing the limitations. The goal of CARE is to gain deeper understanding of risks from various viewpoints, including risk measurement approaches. It has also been suggested that a concentration on a single risk measure puts a firm at risk of unknowingly accumulating dangerous amounts of risk that can only be discerned with a different risk measure.[2]

A comprehensive view on risk exposure allows the Board and senior management to set the appropriate risk appetite for the firm, which can then be cascaded down to the business units and by risk type and used to guide strategic and tactical business decisions. The Board needs the perspective allowed by the CARE because they are often called upon to balance the interests of multiple constituencies. For example, firms are often funded by both equity and debt financing (as well as a range of quasi-debt/equity instruments). The interests of various investors differ significantly, especially in the extreme adverse situations that are the focus of most risk measures.[3] Broadly, it can be said that bondholders and long-term policyholders have an interest in residual value which is represented by an Expected Shortfall (or CTE) measure while equity investors are likely to have a higher interest in the likelihood of the continuation of the firm and the resulting Franchise Value.[4]

Investors are also looking at their own risk profile and would have an interest in the wide range of risk information that is available from the CARE report that would allow them to determine the degree to which an investment in a firm adds to their portfolio diversification or further concentrates their risks.[3]

Why Actuarial?

Actuaries have a recognized skill in the mathematics of finance and risk management. This skill has additional authority because of professional bodies that have established a code of professional conduct, set minimum standards of competency for members and standards for work undertaken. This means that actuarial advice is rigorous, designed to understand risk, recognizes long term business complexities and uncertainties and is in the public interest. Being part of a profession implies high ethical standards and consistency of advice. Professionalism also includes actuarial training, which focuses on prudently taking and managing risks as well as a deep respect for the risk of the unknowns.

Actuaries are recognized as risk business experts by which is meant that they have practical hands on skills not just ivory tower solutions, and are adept at solving real world problems with practical and implementable solutions. Actuaries are well positioned to evaluate the risks in financial services business due to their strong analytical capabilities and technical expertise.

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[2] Ingram, Risk and Light, http://www.ermsymposium.org/2009/pdf/2009-ingram-risk-light.pdf
[3] Hitchcox, Klumpes, McGaughey, Smith, and Taverner, ERM for Insurance Companies – Adding the Investor's Point of View, March 2006, http://www.actuaries.org.uk/__data/assets/pdf_file/0007/164149/sm20100125.pdf
[4] Panning, Managing the Invisible: Measuring Risk, Managing Capital, Maximizing Value, http://papers.ssrn.com/sol3/papers.cfm?abstract_id=913682

Actuaries have a healthy respect for the limitations of models. Models do not predict the future and do not replace judgment. They merely help gain better insights and understandings as to what can go wrong given the inputs used. As the designers and owners of many risk models, actuaries are well positioned to understand precisely how much reliance should be placed on models and where additional judgment is needed.

2. Description of a CARE Report

The users of a CARE are able to place a high degree of reliance on the information's relevance, transparency of assumptions, completeness and comprehensibility, including the communication of any uncertainty inherent in the information.

The CARE report will contain the following elements:

1. Purpose of the report.
2. Qualifications of the actuary preparing the report – education, experience and credentials.
3. Expected users and usage of the report as well as limitations of the report, including the ways the report cannot be used.
4. Statement of adherence to other specific actuarial standards.
5. Discussion of data used for the analysis:
    - The reasonableness of any prior data, studies, analyses, or methods; key assumptions and rationale behind them;
    - Any forward-looking assumptions and rationale behind them;
    - A statement that no unaccounted material events have occurred prior to the valuation date that could potentially impact the asset adequacy analysis on which the actuary's analysis is based.
6. Description of methods and assumptions used for the analysis:
    - Discussion of reasons for choosing these methods and assumptions, including description of other possible methods and assumptions that were not used and the rational for de-prioritizing them
    - Discussion of the validation of models used and peer review performed.
7. Presentation of analysis results:
    - Risk types
    - Discussions of risk dimensions (e.g., accounting vs. economic, stand-alone or portfolio view, etc.)
    - Ranking of various risks by risk measures:
        - Comparisons of different risk measures could explain the situations where the ranking of risks changes significantly if different measures are used. For example, different ranking of risks might result when looking at standard deviation (or volatility) vs. a Value-at-Risk (VaR) or other tail risk measure. The report will also explain why these differences arise, and whether one particular risk measure and the

resulting ranking are more indicative of the nature of a particular risk than another.

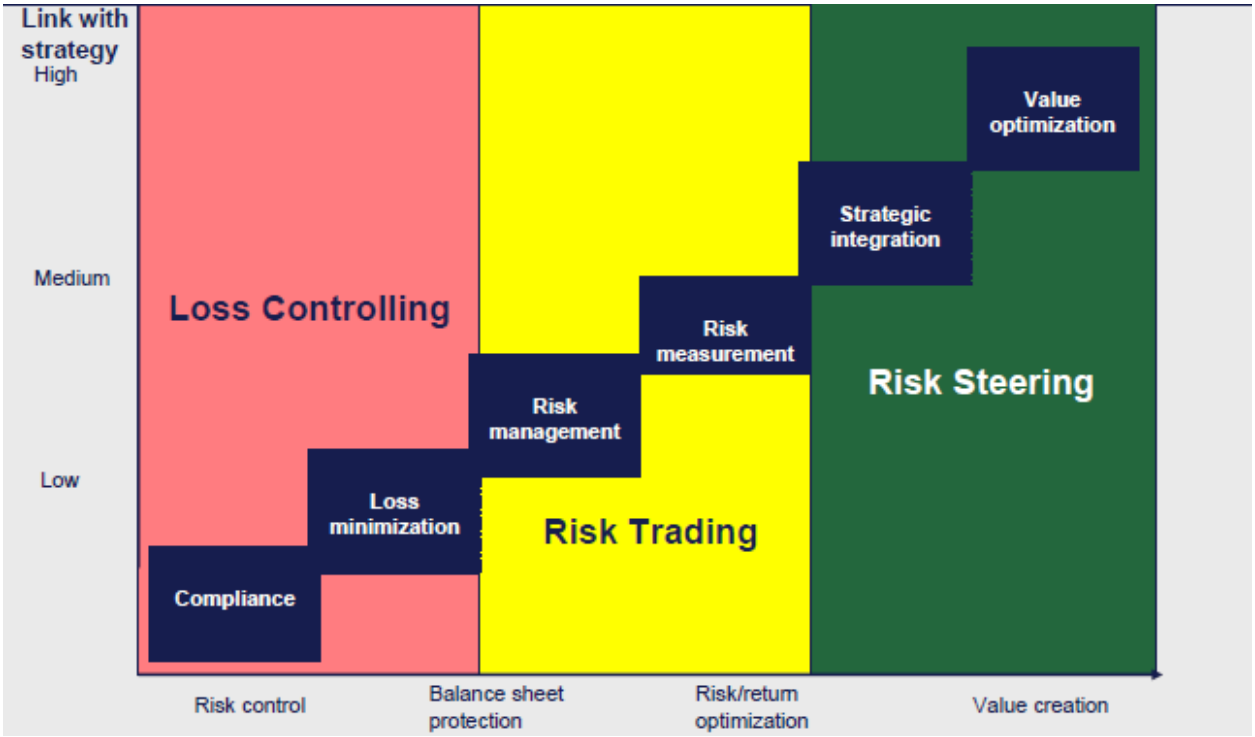
8. The actuary may also indicate reasonable steps taken to ensure the documentation is retained for a reasonable period of time, and no less than the length of time necessary to comply with any statutory, regulatory, or other requirements. This can be achieved by, for example, copying a company legal secretary on the report. The actuary need not retain the documentation personally; it is sufficient to be retained by the actuary's employer.
9. Conclusions and recommendations (optional). Since a CARE Report is primarily an expository report, it does not necessarily need to come to any conclusions from the findings. However, it may be very valuable to the users of the report and beneficial for the elevating the CARE discussion that the actuary gives his or her expert perspective on the potential implications of the risk exposures to the company and provides recommendations on the tactical actions that senior management might need to take to mitigate the risk (e.g., explore hedging, reallocate capital, diversify asset holdings, investigate reinsurance, etc.).
10. Comparisons and key changes since previous report (may include the key drivers of the key changes).

3. Uses of Risk Assessments

The CARE is primarily used to support risk management activities. While the CARE might be part of a process for determining accounting values or solvency values for risk, it is primarily intended to support the work of making decisions to treat or not treat risks. There are three broad categories of risk management uses for risk assessments:

- Loss controlling
- Risk trading
- Risk steering

Once the treatment has been selected, then monitoring and review is required, to ensure that the organizations risks are developing as expected. This is similar to the actuarial control cycle (specify a problem, develop a solution, monitor the consequences and repeat the process) which is at the heart of actuarial work. A key role is played by the risk management culture of an organization. This is particularly true for large organizations where the risks can emerge from many parts of the organization and many sub-cultures can exist, making some risks hard to identify.



3.1 Loss Controlling

Risk controlling is a fundamental activity that seeks to restrict exposure to potential losses or risks. Almost all business activities include some amount of risk control activity. In insurance companies, the major risk controlling activities include authority limits and exposure limits for underwriting of insurance and credit risks. It also includes internal audit and other functions for controlling operational risks. Eventually, some firms added in controls around other risks such as interest rate and equity risks using Asset Liability Management (ALM) and hedging as a risk control processes. In banks, the same sorts of credit and operational risk controlling activities exist. In non-financial firms, there is often a large added physical component to loss controlling. Safety and industrial engineering programs work on physical risks. In addition, many non-financial firms have large exposure to physical property risks that are insurable. So management of an insurance program is a major risk control process. In addition, there are supply chain and raw materials risks. These are managed by a variety of techniques, including but not limited to hedging. And in all firms, managing foreign exchange and liquidity risks are practiced to varying degrees.

Most commonly, these risks are managed in isolation by specialists in each particular risk element. This is the traditional picture of risk management. The advancement to risk controlling that ERM brings is the possibility of bringing all of these risks to the same table, looking at them on some comparable basis and determining the degree to which a firm wants to retain or reduce exposure to risks on a consistent basis from a top down point of view. Consistent risk assessment is the method for achieving this comparable view of risk for aggregate risk controlling.

Risk controlling often starts with a “Statement of Risk Appetite / tolerance”[5] that could include a quantitative limit on the cost of a risk. This limit could be stated in terms of some activity metric, for example, amount of assets for investment limits or premiums for insurance limits. For this method to be effective, however, the risks need to be broken into small classes with fairly homogenous levels of risk.

An example showing why limits should be applied to homogeneous classes follows. Suppose that "bonds" are limited to $100 million. It does not make sense to apply the same $100 million limit to U.S. treasuries or to CCC corporate bonds. If the limit is stated as $100 million of bonds with no more than 10% below investment grade, then the $10 million could be in BB or CCC bonds. There are very different levels of risk for BB versus CCC holdings.

To make risk controlling adhere to a more constrained range of risks, the limit can be stated in terms of a risk assessment value. One common risk assessment value that is often used is Value at Risk.

3.2 Risk Trading

Risk trading is the second major type of ERM activity. Modern ERM can be traced to the trading businesses of banks. Hard lessons from uncontrolled risk trading led to the development of processes and standards for controlling the traded risks. A major element in these systems is the function of valuing, or in other words, pricing of risks. For this discussion, all activities that include the deliberate acquisition of risks for the purpose of making a profit by management of a pool of risks are considered to be risk trading. With that definition, insurance and reinsurance companies can be seen to be pure risk trading firms. Actuaries are at the heart of this activity as major players in the pricing and valuation of insurance risks. With this method of organizing risk management activities, it is clear that most actuarial activity is and has always been risk management.

Risk assessment for pricing purposes involves the assessment of expected losses as well as the range of potential losses. The pricing process uses this information as well as the risk preference function of the risk trader to form a target price for a risk. This target price is compared to the market price. The risk trader will make decisions to buy or sell a risk depending on the relationship between the target price and the market price.

Some risk trading is not based on risk assessment but only on analysis of the market prices. This type of trading is only viable if there is a liquid market.

ERM changes risk pricing by introducing a consistent view of valuing risk margins across all risks. For actuaries and insurance products this has taken the form of economic capital and cost of capital pricing. Risk assessments are done that provide consistent information for all risks. Most commonly, the risk margins are then assessed relative to standard deviation or particular percentile of losses in terms of Value at Risk or Expected Shortfall.

[5] The writers view risk appetite as a top-down qualitative statement while risk tolerances as the quantitative translation of the limit on risk-taking. See Section 5.3 "Risk Appetite" for further discussions.

3.3 Risk Steering

At a fundamental level, actuarial practice has been organized along the basic insurance principle of diversification. The cost of risk to the insurer with a diversified pool of risks is much lower than the cost of risk for an individual customer with their one specific risk.

Management has always looked to choose strategies that enhance firm value. ERM and CARE provide a new and more quantitative approach to this high level activity.

At the macro level, management will leverage the risk and reward information that comes from the ERM systems to optimize the risk reward mix of the entire portfolio of insurance and investment risks that they hold. Proposals to grow or shrink parts of the business and choices to offset or transfer different major portions of the total risk positions can be viewed in terms of risk adjusted return. This can be done as part of a capital budgeting / strategic resource allocation exercise and can be incorporated into regular decision making. Some firms bring this approach into consideration only for major ad hoc decisions on acquisitions or divestitures and some use it all of the time.

There are several common activities that may support the macro level risk exploitation:

- **Economic Capital:** Realistic risk capital for the actual risks of the company is calculated for all risks and adjustments are made for diversification between the risks. Identification of the highest concentration of risk as well as the risks with lower correlation to those higher concentration risks is information that can be exploited. Insurers will find that they have a competitive advantage in adding risks to those areas with lower correlation to their largest risks. Insurers charge somewhat above their “average” risk margin for risks that are highly correlated to their largest risks. In fact, at the macro level as with the micro level, much of the exploitation results from moving away from averages to specific values for sub classes.
- **Risk Adjusted Value:** Activities are compared by either a "return for risk" ratio or a risk adjusted value calculation. In the risk adjusted return on capital (RAROC) approach, earnings are divided by risk capital. Alternately, embedded value is calculated in various forms that include an adjustment for risk often including the cost of embedded options and cost of risk capital. Franchise value can also be calculated that reflects risk directly through a survivorship approach. In the RAROC and embedded value calculations it is important to include risk adjusted terminal values for any assets or liabilities that are not fully settled during the period being measured. Franchise value, though calculated over a longer time period, faces the same issue at whatever future point the calculation is cut-off.
- **Risk Adjusted Product Pricing:** Product pricing reflects the cost of capital associated with the economic capital of the product as well as volatility of expected income. Product profit projections show the pure profit as well as the return for risk of the product. Risk adjusted value added is another way of approaching this that has the advantage that it does not favour shrinkage of the business as a rate driven risk adjusted rate of return does.
- **Capital Budgeting:** The capital needed to fulfill proposed business plans is projected based on the economic capital associated with the plans. Acceptance of strategic plans includes consideration of these capital needs and the returns

associated with the capital that will be used. Risk exploitation as described above is one of the ways to optimize the use of capital over the planning period.

- **Risk Adjusted Compensation:** An incentive system that is tied to the risk exploitation principles is usually needed to focus attention away from other non-risk adjusted performance targets such as sales or profits. In some cases, the strategic choice with the best risk adjusted value might have lower expected profits with lower volatility. That will be opposed strongly by managers with purely profit related incentives. Those with purely sales based incentives might find that it is much easier to sell the products with the worst risk adjusted returns. A risk adjusted compensation situation creates the incentives to sell the products with the best risk adjusted returns.

Risk steering can be seen as a process for finding and choosing the businesses with the better risk adjusted returns to emphasize in firm strategic plans. Competitors will find that their path of least resistance will be the businesses with lower returns or higher risks.

3.4 Other Uses for CARE

Accounting values for risks might be subject to constraints that conform to valuation rules that are developed with a CARE. For example, an accounting value could be based upon a market value but be subject to testing with one of the other bases for risk evaluation.

Solvency values are sometimes stated in terms of one particular metric – such as a one year VaR at 99.5%. But it is subject to testing comparing to another metric, such as 95% CTE on a run-off basis. This approach is broadly consistent with CARE and a CARE will provide the information for such a comparison.

Some firms might develop their aggregate capital target based upon one metric but base their capital allocation scheme upon a different metric. The CARE is able to support that type of usage.

4. Limitations of Risk Assessments

4.1 Understanding the Limitations

> *The essential problem is that our models, ..., as complex as they have become, are still too simple to capture the full array of governing variables that drive global economic reality. A model, of necessity, is an abstraction from the full detail of the real world.*[6]

[6] Allan Greenspan, "We will never have a perfect model of risk", Financial Times, March 2008.
See http://www.ft.com/cms/s/0/edbdbcf6-f360-11dc-b6bc-0000779fd2ac.html?nclick_check=1

Any model is a simplified representation of reality. It is a tool and should only be used as such. Any model balances accuracy with practicality and usability (e.g., technology, ease of use, time constraints, ease of understanding and communicating).

As George E P Box said "All models are wrong, but some are useful"[7]. For example Newton's laws are relatively simple and provide an excellent explanation of mechanics in the vast majority of situations. It is critical however to understand the limitations of any model and make sure these are understood by any users of the model. In the case of Newton's laws it would be disastrous to use them in calculations involving very high speeds and / or strong gravitational fields.

The users of the models need to be clear on not only what they know and what their models quantify, but also need to know the limits of their knowledge and their models. Key to understanding the limitations of any model are a thorough understanding of the assumptions underlying the model and how well they hold in the particular circumstance the model is being used for.

The robustness of models – particularly when there is uncertainty surrounding the inputs is crucial to understand. One fundamental method for understanding the robustness of a model is to use stress tests where one parameter / model element is changed at a time to assess its impact. Stress tests can help to identify the key parameters and how sensitive the outputs are to these parameters.

It is important to use judgment when considering the outputs of any model. Scenario testing, often using expert judgment is a common method to create alternative answers for comparison testing. Another test is to determine which model parameters reproduce market pricing.

Deviation of outputs from these tests from the model outputs does not necessarily suggest the model is flawed, but it does raise some interesting questions – both of the model and the judgment used to construct the scenarios.

4.2 The Causes and Dangers of Over-reliance

Lack of understanding of the limitations of a model and lack of questioning and skepticism can lead to false reliance on the results. Why would we be over-reliant on a model, even when we are aware of its limitations?

4.2.1 Overconfidence

People tend to overestimate their ability to predict outcomes and their control over risk and uncertainty.

[7] Box, George E. P.; Norman R. Draper (1987). Empirical Model-Building and Response Surfaces, p. 424, Wiley.

4.2.2 Hindsight bias

Most models are grounded in historical experience. However historical experience occurred in a world that is different from today. Technology, social changes, and environmental changes constantly change the state of the world. Additionally the standard stochastic technique is to project numerous scenarios based on a given mean and standard deviation. If thousands of possible scenarios are possible in the future then thousands of potential scenarios were possible in the past. The actual historical path is one of thousands of possibilities that could have happened and may not necessarily be the mean. A healthy dose of skepticism is a necessary component in the determination of parameters for a risk model.

4.2.3 Survivorship bias

Many have seen the proof that when looking at the historical performance stocks have outperformed bonds. However in looking at the data in hindsight analysis typically starts by looking at existing companies. This type of analysis tends to ignore companies that are no longer around or even for equity markets that may no longer exist. Exclusion of failures as well as survivors in determining the parameters for a risk assessment can significantly understate risk.

4.2.4 Abandonment of judgment

This could be due to a variety of reasons. Lack of understanding could lead to an analyst resorting to a standard technique which is not in reality appropriate rather than really justifying how relevant the technique is to the situation?

4.2.5 Extrapolation to tails

A risk when using models is when they are used outside of their comfort zone. If a model is used to understand events which lie outside of the experience used to parameterize them, then the level of confidence in the outputs is (or at least should be) severely reduced. A simple example can point out the flaws in this approach. A model that fits a linear reduction in mortality due to mortality improvement will eventually reach a point where not only humans are immortal but where mortality is negative (people return from the dead).

The level of understanding of an issue can be thought of as falling into one of four categories:

- Known knowns (answers)
- Known unknowns (questions)
- Unknown unknowns
- Wrongly believed to be known

Known knowns present no risk (if they are truly known). Models address known unknowns. We have a question and we can attempt to answer it. We know what our risk models are trying to assess.

Unknown unknowns present the second biggest problem. We cannot answer a question if we do not know the question. All we can do is guess at the question and hope our answer covers it. In the case of risk assessments we can make subjective allowances for this category of risk but cannot accurately analyze it. Risk assessors are able to minimize the size of this group of risks by asking as many questions as possible and researching the answers and by monitoring emerging trends and sources of risk. Also an assessment of the order of magnitude of potential unknown unknowns can be provided.

The most dangerous category is the issues wrongly believed to be known. These can lead us to a false sense of security and overconfidence in our models. The category of "wrongly believed to be known" actually becomes a more severe issue.

4.3 Communicating the Limitations

Communication is a crucial step in any risk modeling exercise. Following hurricanes Katrina, Rita and Wilma in 2005 there were many criticisms of catastrophe models, in particular that they failed to predict the disastrous consequences of the levees failing. The model vendors responded that the models were not intended to cover the flooding due to the prolonged pressure on the levees rather than from overtopping storm surge. Whether the flaws in the estimates of insured loss were due to model deficiencies or user error one thing that clearly failed somewhere along the line was communication of the limitations of the models.

A CARE report includes statements about the degree to which the above limitations would apply to the particular risk evaluation. The report might include statements that compare the limitations of the risk evaluation to other common risks. For example, if the CARE report includes an evaluation of the risk in a portfolio of venture fund investments, the limitations might be compared to another investment portfolio such as an index in the major stock exchange of the same market.

The CARE report will also identify the situations and scenarios in which the model results would be unreliable. The situations considered include:

1. The data is found to be insufficiently representative of the underlying situation.
2. There is a disconnection between the market price of risk and the model price. This is either due to a profit opportunity or a model defect.
3. The implicit assumptions of the model that drive the formation of the formulas that make up the model are no longer valid.
4. The explicit assumptions are no longer valid because the environment is not sufficiently similar to the situation when the assumptions were formed. (This is something that most risk model procedures challenge every time the model is updated. The usual procedure of most models is to refresh many and possibly all of the assumptions on every major update and some of the assumptions on minor updates.)
5. The behaviour or make up of customers regarding their payment of premiums or their take-up of benefits is sufficiently different from the prior assumption.

It is important that these points of unreliability be identified in advance so that if the changes in the world are drifting towards such a point, there is some additional credibility to making important changes to the model. Without this step, it is possible that incremental changes will not be recognized as fully detrimental to the risk assessment validity.

Key issues when communicating uncertainty include:

- Materiality
- Clarity (avoiding confusion)
- Circumstances in which model / risk assessment will or will not be appropriate
- Potential Impact

5. Defining Risk

Risk is defined in the Oxford English Dictionary as:

1. A situation involving exposure to danger.
2. The possibility that something unpleasant will happen.
3. A person or thing causing a risk or regarded in relation to risk (e.g., a fire risk).

Within this paper the definition of risk used is the potential for an outcome with negative consequences. A negative consequence can be the failure to meet objectives, fulfill realistic expectations or take advantage of a positive (profitable) opportunity.

5.1 Perspective

The actuary assessing risk can look at it from specific perspectives. The perspectives are defined by reference to the following:

- **The frame of reference:** What entity is assuming or relinquishing the risk? Answers could be: an individual, a company, a government, a group of companies, etc.
- **The base-line:** This could be absolute such as the risk of insolvency or could be relative to a projected ROE[8] or competitors' ROE.
- **The nature of the consequences:** What is the worst impact of the risk? Negative consequences might be losses or they might be gains that are lower than the realistic expectations. The actuary can consider the potential variability of the outcome and how bad (or good) can the outcome be. It is also important to consider how the consequences are measured.

From these perspectives, the management of risk is not to predict the future. Instead it is about preparing what negative consequences are possible. As addressed later, by projecting key financial figures, actuaries tend to model different types of risks and translate them into financial

[8] Projected ROE: return on equity for future years being projected from risk models.

terms. However, this projection is certainly not a prediction of the future, but an assessment or measurement of the future with the best available information and business judgment.

While it is not possible to model every risk, we can translate each risk into something fungible based on the best obtainable information about the future to make it possible to compare one risk to the other or to aggregate risks. Percentage of shareholders' equity, market value of assets, net revenue and net profits are common measures of risk. Translating lost opportunity, lost time, or lost reputation into monetary terms will either take defining the specific scenario or estimation of a range of likely results.

5.2 Taxonomy of Risk

There are many ways to classify risk. We list here some important classifications.

5.2.1 Systemic vs. Non-Systemic

Systemic risk refers to the interrelations of various entities or their exposures. An entity is exposed to systemic risk if due to contracts or other relations between entities that the impairment of a non-affiliated entity would potentially cause the failure of further non-affiliated entities.

5.2.2 Internal vs. External

Internal risk is within the control of the organization or entity. Internal risks deal with management, investment policy, models used by the company, underwriting, etc. External risks are outside the control of the company. These include changes in the economic environment such as recessions, changes in the social environment such as attitudes toward entitlement, health, and birth rates, changes in the legislative environment such as changes in laws such as tariffs, taxes, mandated accounting systems, regulatory departments and regulations. Political risks can be mild, such as are related to the election of a new party in power, and political risks can be severe, such as the risk of nationalization of private enterprise. External risks also include the risk that human beings tend to make mistakes en-mass. This "herding" behaviour includes the thinking that “if other people can do X (and make money, get away with it, etc.), then I can too.”

5.2.3 Model Risks

Modeling is useful and indispensible in the world of risk management. Nevertheless, part of what caused the global financial crisis was thinking that models included all major risks. A risk can be classified as to whether it is included in the model or not. Furthermore, risks associated with the model can be examined.

- **Process risk** – the risk relating to the random nature of the outcome/process that creates the losses/events. This risk is unavoidable, but can be mitigated over time by use of large samples and considering the importance of the order of the process

- **Model specification risk** – While this risk is extremely difficult to quantify, if many institutions use the same model, this could also be a source of systemic risk. This is the risk that the structure of model itself is incorrect. An example of this risk might be the erroneous use of the lognormal distribution when a Pareto distribution would have been a better representation of the underlying process.
- **Parameter selection risk** – the risk that the parameters selected for the model are incorrect. Any model will include parameters. These parameters will be calibrated using either data or judgment (preferably both). Any data will always be limited in both volume and relevance. The selection of parameters will always be subject to parameter risk. Parameter risk can also be a source of systemic risk if many institutions use similar parameters.

  For example default rate is a parameter. If all insurers/creditors use a credit default rate that is too low, then when one institution fails, they may all fail. Prior to 2007, mortgage insurers and mortgage lenders used historical default rates to estimate maximum probable loss. These default rates were incorrect due to the fact that historical default rates were incurred in the era prior to interest-only loans sub-prime mortgages, and a large number of variable rate mortgages.

5.2.4 Level of Understanding

Risks fall across a spectrum, where at one extreme are the fully known loss distributions of closed games to the risks that have followed similar loss patterns for significant periods of time. Emerging risks and low frequency risks have varying past experience that may or may not be sufficient to form a reliable prediction of future loss distribution. At the extreme end of the range are risks that are known to exist but that have almost totally uncertain loss distributions, and finally are those risks that are not currently known to exist, some of which may be “black swans” events[9]. These unknown risks cannot be reliably modeled with current model tools. This is because some types of risks do not have clear statistical or mathematical relationship while current modeling tools focus seeking mathematical solutions to measure risks. Readers may recall some discussions with regard to the distinction of tractable risk and Knightian uncertainty[10]. Due to historical reasons or practical limitations, the immeasurable risk or Knightian uncertainty is often overlooked by risk management practitioners, which possibly could be a reason of many risk failures. See Section 6.5 "Known Risk and Emerging Risks" and Section 6.9 "Risk Types" for further discussion of this matter.

5.2.5 Time Horizon

“Time” refers to the time between initiation of the event and conclusion of the event. This is not to be confused with high frequency versus low frequency risks. Global climate change, for example, is a long term risk experienced over decades. A hurricane is a low-frequency, high severity, and short-term risk. It is short term in the sense that the effects of the hurricane are incurred within the span of several days.

[9] Black Swans refer to high-impact, hard-to-predict, and rare events beyond the realm of normal expectations. The term was described by Nassim Nicholas Taleb in his 2007 book "The Black Swan".
[10] Named after economist Frank Knight and refers to risk that is immeasurable, not possible to calculate.

5.3 Risk Appetite

The economic climate and recent market events have sharpened the focus on risk. Tolerance and capacity constraints (e.g., capital funding) generate a need for rigor and consistency in risk-taking decisions to help ensure optimization of risk / reward trade-offs. The first and foremost is to establish a risk appetite.

Risk appetite is an expression of the willingness and/or capacity of an organization to tolerate exposure to risk to achieve its strategic objectives. As well as defining what is meant by "risk", management has also to decide on how much risk they want to expose themselves to, both in terms of target risk exposure and maximum limits on how much risk they are willing to take on.

To define a risk appetite requires risk to be defined in an explicit way including: frequency, magnitude and time horizon. Setting risk appetite is a subjective process which balances the expected returns that can be generated by taking risks and the corresponding potential for loss. Risk appetite frameworks provide management with a holistic perspective of balancing risks and rewards. Defining a pragmatic and quantitative risk appetite framework is the focus of significant investment for financial services firms.

Risk appetite is part of strategic scope of Enterprise Risk Management, which by definition should be developed centrally. Risk appetite is typically set by the Board, but it also reflects investors' aspirations and regulatory requirements. Setting the risk appetite is predominantly a top-down process starting from senior management and filtering down the company's structure. However, the addition of more bottom-up input could make it easier to articulate the risk appetite for individual operating units, provide a more informed balance of quantitative and qualitative measures and enable frontline teams to respond more dynamically to evolving market environments.

Measurements of risk appetites naturally link to strategic goals and they may include:

- Optimally manage the company's capital
- Eliminate risks that threaten solvency/viability
- Manage earning volatility
- Establish public reputation

As part of a robust risk management culture within an enterprise, the risk appetite establishment and enforcement generally considers following:

- Effective limit structure that reflects overall risk appetite and current business structure
- Stringent set of well documented and understood risk-taking policies
- Clearly differentiated but effective monitoring of risk taking and risk appetite
- Enforcement of consistent risk measurement approaches and effective, decision-oriented reporting processes
- Alignment of incentive systems with corporate objectives for risk-adjusted return

Note that risk tolerance and risk appetite are often interchangeable in many literatures. However, as mentioned earlier, writers of this report recognize a subtle distinction between these two: risk appetite a top-down qualitative statement and risk tolerances as the quantitative translation of risk taking.

6. Multi-dimensionality of Risk

Certainly a full and big picture of risk is multi-dimensional. Different users of risk reports look at different aspects of the risks. However, we admit that risks are objective (i.e., they exist regardless how you observe and measure them) and that risks are changing dynamically driven by both internal and external risk factors.

There are many ways to classify risks. While it is impossible to evaluate every dimension, the key dimensions to consider include:

- Market consistent value vs. fundamental value
- Accounting basis vs. economic basis
- Regulatory measure of risks
- Short term vs. long term risks
- Known risks vs. emerging risks
- Frequency risk (earnings volatility) vs. severity risk (solvency)
- Viewed stand-alone vs. full risk portfolio
- Risk types
- Liquidity risk

6.1 Market Consistent Value vs. Fundamental Value

One of the most consequential decisions about how risk is measured is how to incorporate market data in the measurement of the risk. To quote Warren Buffett, "In the short run, the market is a voting machine. In the long run, it's a weighing machine." The purpose of the risk evaluation will be a key driver of the relative importance of market consistency of analysis performed. If the risk could lead to irreparable damage to the enterprise or its stakeholders in the short term then market consistency is of key importance. If it is possible to trade out of the impact of the risk then management will be interested in longer term assumptions based on best estimates rather than the whims of the market. In all cases, both approaches provide useful information. If the two approaches give widely different outputs then the reasons for these differences and their implications need to be clearly understood.

Assuming that the risk under consideration will be ultimately realized (if at all) as one or more cash flows whose amount and/or timing is uncertain, it is desirable to express information about that risk as a single value which is comparable to other amounts.

One common way to express a risk as a single value is the cost of hedging or removing the risk; this can be called the "price" of the risk. For risks directly associated with readily marketable securities the quantification of the risk as an amount of cash held today is simply the current market value of the basket of securities required to hedge this risk since the risk can be completely neutralized by exchanging it for that amount of cash.

There are many risks which cannot be priced so directly. Fortunately, there is a framework for dealing with contingent claims, that is, claims that are contingent on the value of some other directly measurable amount. The Fundamental Theorem of Asset Pricing asserts that a market is arbitrage-free if and only if there exists a martingale measure equivalent to the real world measure. This has been proven for a wide variety of processes. Arbitrage opportunities do not

appear to be readily available in real markets (except when liquidity dries up), which is fortunate because arbitrage opportunities would be pathological to any reasonably simple model. Therefore, we assume no arbitrage, assume some underlying real world stochastic process, and find the equivalent martingale measure where we can price any cash flow by expectation under the martingale measure. Furthermore, if the market is assumed to be complete, then the martingale measure is unique, implying a single price for any instrument.

Market Consistent

Of course, there are problems, such as what model to assume for a real world process (e.g., include jumps? How many factors are in a multi-factor model?), but the problems are not insurmountable. These models usually give values for the risks which have several advantages over other methodologies. For example, they have both some theory and clearly observable data to support them, appear to be objective, and generally give reasonable values. Because of these positive characteristics, many market participants use these models in their decision-making process, which, combined with the fact that sometimes the assumptions hold well enough to accurately reflect the actual market process, tends to keep the actual market price around the levels indicated by the pricing models.

The major drawback of these models, like all models, is that they are simply a reflection of reality, and while they are often useful, there are differences between the assumptions of the models and the real world and one can not confuse the map with the territory. For example, there are many markets which are not complete, and therefore do not support unique prices, or during times of stress, where firms cannot obtain the funding necessary to arbitrage away even real arbitrage opportunities persist. And unfortunately for risk managers, it is generally in those scenarios where we are concerned about risk the most. Nevertheless, the fundamental theorem of asset pricing and the assumption of no arbitrage provide a powerful tool that is useful for projecting the price of a risk under many scenarios.

Fundamental Analysis

The major alternative to pricing under a martingale measure is to use a fundamental analysis. A fundamental analysis is an attempt to arrive at the "true" value of a risk for the purpose of determining whether the market values the risk too dearly or too cheaply. It may use historical or even current price information but what distinguishes a fundamental analysis from a market analysis is the substitution of the judgment of the person doing the analysis for the value as seen in the market or as calculated based on market values and the Fundamental Theorem of Asset Pricing. Under a market-based approach, using the same methodology and the same data, two different practitioners will arrive at the same results (again, assuming a complete market so that prices are unique). However, two different fundamental analysts can use the same methodology and the same data and arrive at very different conclusions because of the selection of assumptions and reliance on judgment that are the key to this method.

If the problem with the expectation under a martingale measure is that while the amount of cash required to buy or sell a risk is usually close to the calculated value, but can sometimes be very different, the problem with the fundamental approach is that the amount of cash required to buy or sell a risk is usually very different from the calculated value, but can sometimes be close.

Some people consider fundamental value to be more "real" than market-based approaches, and believe that in the long run, the market price will converge to a well-done fundamental analysis.

Good fundamental analysis is essential for the long term success of an enterprise. Following the simple maxim of "Buy low, sell high," a successful firm will shed risk when the market prices it too cheaply and bear risk when the market prices it too dearly. However, deciding which is which will generally not be the responsibility of the risk manager, whose principal role is to provide independence and transparency to senior decision makers. The risk takers in the business unit or trading function are responsible for the fundamental analysis required to decide whether a particular risk or set of risks is worth the price, and the ultimate success of the firm will depend on the quality of those analyses.

And so from a risk management standpoint, the issue about a fundamental analysis becomes determining whether it is done well or not. Looking at the qualifications of the person or group doing the fundamental analysis is a good place to start; it is also the reason why fundamental analyses done within a risk management department are suspect – if a risk manager could perform an analysis to determine whether a market price is good or not, they would probably be better suited to a business unit analysis role than risk management. For example, an actuary might be qualified to perform such an analysis for evaluating mortality risk versus a traded mortality derivative (where the actuary would be expected to be an excellent analyst), but unless they have had experience as a portfolio manager it would not be appropriate to perform such an analysis on the level of interest rates or value of U.S. equities.

In the case of a fundamental analysis done on a risk in which the firm has a core competency in analyzing and retaining that type of risk, there is good reason to believe that the firm's opinion of the value of a risk is more likely to be realized than the market's "opinion." However, a risk manager still needs to understand the analyses which are being used to make decisions about taking risk. Decision makers tend to look at measures of central tendency to make decisions; the question becomes whether this is this a good transaction "on average" or "most of the time." However, the risk manager needs to provide transparency into the whole array of possibilities, the "distribution," so to speak. A risk manager could make use of the fundamental analysis, potentially stressing key assumptions to try to look at this distribution or modifying the methodologies as a test for model error. A risk manager might also coordinate with the control function to ensure the integrity of the data being used in the analyses.

But where a fundamental analysis is believed to be done poorly, or the case of a risk retained where no fundamental analysis was ever done, it is tempting to try to fill in the blanks and perform a more thorough fundamental analysis within the risk management department. But without the appropriate expertise to do this properly, assigning a number to the risk might create a false sense of understanding of a risk which is not really well understood. A market-based approach to measuring this risk has the advantage of expressing the risk at a price that it actually can be disposed at. If the risk cannot be hedged or disposed of or if management decides to retain the risk regardless of the quality of the analysis done in making the original decision to obtain the risk, the risk manager can work to ensure that the firm develop the expertise necessary to making proper decisions regarding that risk and others like it.

In areas where the risk manager defers to the analysis done by the business units and performs oversight and analysis of model error of the fundamental models developed by subject matter experts, risk managers can develop their own market-based approach to looking at risk. Such an analysis highlights to senior decision makers those areas where a business unit's opinion of a risk and the market's opinion of the risk diverge most significantly, providing a useful second

opinion on the level of risk that the firm is bearing. Further, when reporting risk measures to third parties, the relative subjectivity of fundamental based approaches as well as the greater likelihood for external parties to dispose of the risk at market prices makes it less appropriate when market-based alternatives are available.

6.2 Accounting Basis vs. Economic Basis

6.2.1 Accounting Basis[11]

Traditionally market observers and insurance companies use various accounting measures to measure the business growth (such as premium or asset growth CAGR – Compound Annual Growth Rate) or profitability (such as ROE – Return on Equity and ROA – Return on Assets). Some people also started to use accounting information to measure the risk-taking. For example, some use the asset-to-equity or debt-to-equity to measure the financial leverage. The ratio of cash or equivalents over total investment could measure the liquidity. The duration or average maturities of fixed-income assets relative to liabilities could be used to measure the interest rate risks. The ratio of equity investments over total investments could be used to measure the equity risk. In the simplest (and possibly the most useful) way, the P&L (profit and loss) itself is indicator of risk. For example, one recent New York Times article[12] has reported that, the reason why Goldman Sachs was able to escape from 2007 sub-prime wave, according to the interview with Goldman Sachs's CFO was that this investment bank closely "looked at the P&L of our business every day". The CFO also said, according to the same article, that

> We have lots of models here that are important, but none are more important than the P&L, and we check every day to make sure our P&L is consistent with where our risk models say it should be. In December our mortgage business lost money for ten days in a row. It was not a lot of money, but by the tenth day we thought that we should sit down and talk about it.

The story above is at least one example that accounting information is important in the risk management process. Basic accounting measurements do give helpful information for risk managers but there are a range of accounting bases a P&L could use including mark to market and book value and each base gives distinct answers. Fair value accounting is widely seen as the most useful base to gauge the activities on both asset side and liability side of company's balance sheet.

There are, however, several limitations of current or traditional accounting systems in measuring risk:

1. Current accounting systems (including U.S. GAAP) do not warn investors when financial institutions take risk charges as profits. Increased profits resulting from high leverage are not risk-adjusted in current accounting systems and therefore the increased risk is hidden. Traditional accounting measurements fail to provide investors warning messages when institutions' profits or growth are primarily driven by increased risk. As a result, increased risks are hidden and could accumulate

[11] See Appendix 6 for more references or background reading of accounting basis
[12] Joe Nocera, "Risk Mismanagement", The New York Times, January 2, 2009. (See http://www.nytimes.com/2009/01/04/magazine/04risk-t.html?_r=1&pagewanted=1)

across a hypothetical "red line" without early warning and thus trigger a crash of investor confidence when the hidden risks explode.

2. Current accounting systems are not economic based, meaning that the earnings are neither risk-adjusted nor do they reflect changes in the market. Definitional differences of contracts can have a large impact on the accounting. Two contracts that are very similar from a cash flow perspective can show a very different incidence of revenue and profit recognition. This is because the current accounting system is created to match revenues with expenses rather than to reflect risk-taking or value creation. In addition the equity reported under the current accounting framework is not economic. If an investor is only looking at ROEs, he or she could incorrectly presume that a company with lower ROE is "worse" than an aggressive company with higher ROEs. Another example is that, in the U.S., the GAAP requires life actuaries to use the assumptions at policy acquisition to value their liabilities for certain types of business. This will soon change, however, as the methods for calculating life reserves in the United States are undergoing a fundamental change and will soon become “risk based” under the so-called "principle-based approach".
3. Current accounting rules for insurance do not disclose to the investors all the risks that enterprise is taking. For example, although the asset-to-equity ratio can be used to measure the leverage, this is only one of many sources of risk. Practitioners may keep in mind that different types of business have different risks, thus have different capital requirements. The leverage ratio for a company that is writing auto insurance and investing on government bonds may not be appropriate for a company whose balance sheet is loaded with variable annuities with guaranteed living benefits and investing in non-investment grade corporate bonds.
4. Current accounting rules (and maybe any accounting rules) are a product of compromise of interests of different counterparties and also incorporate a balance between theoretical correctness and practicality. Thus no single accounting statement may truly represent the specifics of an individual company.

For all accounting systems, the actuary needs to be aware that accounting rules, however well intended or favourably described, may in some cases represent a different timing, amount or even direction of result than a "pure economic" or "real market" approach to risk. It is therefore always relevant for the actuary to test whether the accounted results are different from the risk models that might be based more on "market value" or "pure economic" values.

Accurate business judgment according to traditional accounting ratios are only possible for people who are intimately familiar the accounting rules as well as the limitations of accounting rules. Some accounting information is obscure and not easily understood by investors. For example, in the middle of the 2008 financial crisis, many market observers worried about the recoverability of the Deferred Acquisition Cost (DAC) asset held by insurers. The reason is that the DAC is big, intangible, and not easily understood by investors. In a situation of financial distress, this obscurity had the effect of increasing skepticism. But even armed with knowledge of the limitations of accounting rules, there might not be enough information in the accounts to make good economic judgments.

An example of this situation happened with the early stages of the sub-prime crisis. Some collateralized debt obligations (CDO) contracts were marked down severely based upon accounting rules that were seeking to replicate market prices when there was no market and no cash losses from the CDOs. But the accounting losses triggered real events that led to severe

consequences for many of the firms holding those contracts well in advance of any true market value or economic losses. That is not to say that in that case those marks were wrong. But it is a very clear example where accounting, rather than economics was the risk. Indeed the practitioner should recognize that an adverse accounting result is a significant risk in itself and can be recognized in the CARE whether or not there is a "market value" or "true economic". This is particularly the case for risk assessments which look at the potential for insolvency since insolvency will be defined on a specified basis.

6.2.2 Economic Basis

Current financial reporting systems are not closely linked with risk management or value creation within the insurance industry. However, insurance company financial reporting has been going through a significant transformation in recent years. Insurers are beginning to look at their business based on what many refer to as the "economic value framework," which focuses on tracing the timing and "volume" of values that created in various activities such as sales, servicing, investment and risk management. According to "Quantitative Risk management 2005", economic capital represents the emerging best practice for measuring and reporting all kinds of risk across a financial organization. Under this framework, insurance companies determine the economic value of the capital invested in their business and the economic value of earnings to derive a risk-adjusted return on capital. Standard setters, primarily European insurance regulators through Solvency II and the International Accounting Standards Board through IFRS Phase II, propose adopting many of these concepts for solvency and performance reporting.

There are two major aspects of the "next generation" economic valuation:

1. The economic view of value creation (i.e., how, when and how much value is created)
2. Market consistency (i.e., how timely, transparent, reliable and comparable are the financial figures that investors rely on).

The economic view of the insurance business tracks how and when values are created for owners. In its simplest form, the economic value of earnings is equal to cash flow plus the change in the economic value of the assets minus the change in the economic value of liabilities. Economic liabilities are the present value of expected cash flows plus an additional amount that would provide investors a return for placing their economic capital at risk (the "risk margin"). Typically, economic earnings equal the risk margin, and economic earnings divided by economic capital represents the return on capital. This return on capital can be used to measure the value creation from insurance underwriting activities.

Management creates economic value if return on economic capital equals or exceeds the cost of capital. One of the core components of the economic view of insurance business is the nature of being "risk adjusted." This means the values insurers create for their investors are adequate compensation for the risks the investors take. In order to accurately measure risk-taking activities such as underwriting and investment, from an economic perspective, an insurance company has to construct an economic balance sheet and an economic income statement.

The market consistency is another key aspect of economic valuation. The fair value accounting (or mark-to-market accounting) is one of the major steps moving towards market consistency. The FAS 157 accounting rule under U.S. GAAP is one of the important developments of this

change although this accounting has been criticized during the 2008 financial crisis. Although FAS 157 currently has many problems to be corrected, it represents one key movement of more transparent and comparable financial reporting. It is by far the most reliable accounting to gauge the market expectations and deliver the "nearest to reality" information to investors. In our view, as part of the movement to economic valuation, the trend of using fair value reporting could not be reversed as investors do not want to go back to dark again.

One important development in the area of economic valuation is the growing popularity of market-consistent embedded value (MCEV). MCEV reporting, popular in Europe and Canada, tries to capture the value of an insurance business by discounting the future projected cash flows under the most realistic scenarios. The options and guarantees are valued consistently with the approaches in modern financial economics. The investment assumptions are market consistent so that investors could compare company to company of their insurance underwriting performance as well as compare insurance operations to non-insurance financial institutions. Many large insurance firms already started to disclose their MCEV to in conjunction with their regular financial reporting such as GAAP or IFRS. However, the MCEV is still neither truly economic, nor fair value. This is because:

- The non-market assumptions (most actuarial assumptions) are still entity-specific, not market consistent.
- MCEV does not explicitly refer to risk margins, although it does include a cost of capital provision, which is implicitly a risk margin. Thus it is not fully risk-adjusted reporting.
- MCEV uses internal models to determine capital level as well as the cost of capital. Under MCEV, the compensation to the investor for assuming risk is typically calculated using a capital rate applied to the appropriate level of capital. This compensation is a cost no different than any other expense. In determining the appropriate level of capital, many companies rely on external rating agency models targeting a desired credit rating or regulatory capital requirement rather than internal economic capital estimates. While these capital models are grounded in assessing the underlying risk of the products, they generally employ "average" factors that do not vary by product and may not reflect the unique risks of the business being valued. Additionally, the cost of capital rate is typically based on company-specific targets and a company's own capital structure. The degree of consistency with external investor expectations varies. Instead of using an economic capital rate that is the market's view of the specific risk, MCEV typically employs the insurer's view of risk based on average factors.
- Under MCEV, the investment returns and discount rates are both risk free yields (e.g., swap rates). The MCEV framework essentially encourages taking full credits of the performance risk on asset side, but does not allow liability to reflect performance risk charges. This actually will penalize companies whose underlying earning source (or value creation) relying on investment income.

Insurers generally face challenges on how to quantify the risk-taking and returns between two separate business activities: insurance underwriting and investment. One view could see insurance underwriting as a vehicle to raise funds via collecting premiums or fees. Insurance companies would then take this fund to generate profits through their strategic and tactical investment activities. Underwriting creates value by raising funds at a cost lower than the entity's risk adjusted cost of capital, including the case where this cost is negative (i.e., underwriting profit is generated). The key risks embedded in underwriting activities are both the

systematic and catastrophic fluctuations in the claims paying process and also in companies' operations that support underwriting. Investment creates value by beating the benchmark return. The key risks in fund management are mainly credit risk, ALM risk, liquidity risk, operations (including compliance) risk, and equity market volatility. Measuring value-added relative to risk of those two different functions would significantly enhance management's decision making and increase the company's transparency. This is actually the "heart and soul" of economic valuation.

Economic Balance Sheet

An insurance company's balance sheet essentially shows the company's value creation status under today's environment. Insurers entered contracts with policyholders by giving "promises" when future loss events occur in exchange of compensation – premiums or fees. From this perspective, insurers are funding their balance sheet by "borrowing" money from policyholders except their future re-payments are contingent on certain events. Another source of funding is the capital raised from shareholders

Economic view of assets

The economic view of assets represents the market value of the funds insurers raised from different sources: policyholders and shareholders. This economic view does not include any intangible assets such as goodwill under U.S. GAAP or IFRS. Asset managers add value by beating the benchmarks being created by constructing the replicating portfolio that replicating the liability cash flows or key characteristics (see Appendix 6 for more background on replicating portfolio).

Economic view of liabilities

The economic view of liabilities represents the market value of insurance obligations. For business without material embedded options; this economic view values liabilities under deterministic scenarios. For business with material embedded options, the economic view is consistent with option valuation methods in the financial market. Although market valuation methods may have to use entity-specific assumptions, it should use market inputs as far as possible.

Economic capital

Insurers' capital level is determined by the risks they are exposed to. There are many risk based capital concepts in the insurance industry. In the past, risk based capital was determined by regulatory requirements or rating agency models using a target rating. There are some rule of thumb linkages of both regulatory and rating agency capital. For example, a Risk Based Capital (RBC) ratio of 350% in the U.S. is approximately an AA rating from Standard & Poor's (S&P) for some life products. In recent years, the industry has actively discussed and implemented the economic capital concept – quantifying a company's capital level according to entity specific risks. The most popular way to quantify economic capital is with a bottom-up approach:

1. Some types of risks (such as credit, equity, insurance and /or operational risks) are modeled on a business unit level by shocking several key risk factors such as equity performance, interest rate, mortality or policyholder behaviour assumptions. Stochastic economic scenarios will generally be provided to do stress testing.
2. Diversification effects will be considered on a corporate level after aggregating risks together. When determining the level of economic capital, the most popular definition is the level of capital that an insurance company has to be able to absorb all losses within twelve months with a 99.5% probability. This Value at Risk measure is used in the upcoming Solvency II regime in the European Union, the current U.K. regime and in Australia.

No matter how the economic capital is approached, the current practices of economic capital modeling represent management's view of risks. In a broader context, there are two basic philosophies how insurers could look at their balance sheet and capitalization:

1. The economic capital is to mature the future obligations to keep the company adequately capitalized even under severe economic or underwriting shocks. This is called the "liability runoff" view of economic capital. This view of economic capital measures an insurance company's ability to meet its future obligations under alternative scenarios and is the approach generally preferred by U.S. regulators.
2. The economic capital is to compensate the market participants with the risks embedded in the business. This is so-called "exit value" view of economic capital, which measures (on a risk adjusted basis) the funds that are available to investors, or in simple words, how much capital the company need for investors willing to purchase their business without paying additional costs.

Funding of economic capital

It is challenging task of discussing how to fund the capital in an insurance company's balance sheet. There are two major sources of capital for a typical public company:

1. Fund capital with shareholders' equity
2. Fund capital by issuing debts to creditors.

It is obviously more expensive if a company chooses to fund their capital with equity. However, this is also safer than borrowing. The purpose of setting up economic capital is to ensure adequate capitalization level of the company. Funding capital with borrowing inevitably increases the leverage of the company, and thus the risk of the company. On the other hand, for capital intensive businesses like insurance, funding capital with equity leads to lower performance, especially when equity capital is scarce or expensive. Some writers have commented that economic capital is the definition of how much equity should be in the business and that debt should be used to fund capital needs, such as the difference between economic and regulatory capital, which is above economic[13].

Capital can also be funded with "soft capital" sources such as surplus notes, subordinated debts, credit facilities, or other forms of contingent capital. Compared with equity, those are generally "cheaper" capital sources. However, depending on the risk profiles and contract

[13] See Rubin, Lockerman, Shi, and Tills, "Economic Measurement of Insurance Liabilities: The Risk and Capital Perspective", Actuarial Practice Forum, Society of Actuaries, 2009.

features, these sources of capital might create additional risks particularly if economic capital is not at the right level.

Economic Income Statement

The economic view of income statement captures the underlying economics of insurance. In theory, it should correctly reflect the changes of the economic balance sheet and clearly identify the sources of income (via various activities that either add or destroy values).

The key to the economic view of income statement is to identify the real sources of income. The possible sources of income for insurance business may include (but are not limited to):

- Gain at issue through acquisition of new policies
- Economic rent capturing policyholder inefficiency
- Value creation via proprietary distributions
- Cost of acquisition (of new policies) lower than cost of capital
    - Experience variance (e.g., mortality, morbidity, spread, expenses, taxes, etc.)
    - Release / increase of risk margins
    - Assumption changes and model changes
- Reduction of frictional costs (via activities such as risk management, capital planning or transactions)
- Proprietary investment and trading activities by outperforming a benchmark (after risk adjustments). The investment spread could be attributed into:
    - True trading outperformance via asset allocation and security selection
    - Profits from increased leverage
    - Intentional ALM mismatch and /or hedging ineffectiveness
    - Value changes of shareholders' put options (i.e., value can be created by putting creditors at risk. For example, the contingent capital insurers entered with counterparties will be more in the money under pre-defined situations).

6.3 Regulatory Measure of Risk

6.3.1 Introduction

A Comprehensive Actuarial Risk Evaluation will include consideration of the applicable prudential regulatory standards. In many jurisdictions, the prudential standards have been migrating to be very well considered risk based values for both technical provisions (reserves) and for capital requirements. But consideration of the prudential standards is necessary whether those standards are based on a good risk evaluation or not. The CARE can include a statement comparing the regulatory standards for the risk or company being evaluated to the company's internal capital assessment. Situations where the regulatory standards are higher than the company's internal capital assessment will be clearly identified as well as risks where the standards are significantly lower than the company's assessment. The CARE report will include appropriate cautions about each of those situations as they arise.

Firms that take risks whose associated regulatory standard is significantly higher than their own assessment, may choose to ignore the regulatory standards in their decision making whereas firms that take risks where the regulatory standards are significantly lower than their other evaluations are often tempted to base their decisions on the "official" standard. The first type of firm may ultimately hold a level of capital that regulators deem inadequate as returns do not reflect the cost of the excess regulatory capital. The second type of firms will have their rude awakening eventually. This epiphany could occur when large random losses occur which are improbable over any short-term horizon (low frequency), but inevitable in the long term (high impact), when the external environment changes unexpectedly, or even when the regulatory standards are suddenly revised upwards to a more reasonable level that they had not prepared for.

Another important element to be considered in a CARE report is the manner in which the regulatory standard applies AFTER a major loss. In some situations, the regulator standards have acted to acerbate an adverse scenario, requiring larger amounts of capital after a major loss in order to replenish capital up to the pre-loss standards. This "day after" analysis can also be a part of a CARE report.

It is also necessary to realize that the existence of regulation itself poses risks. This section is devoted to regulatory risk *measures*. The fact that regulation itself can create uncertainty and competitive advantages (disadvantages) is a separate issue and some of the risks created by regulation are enumerated in Appendix 3.

6.3.2 Summary of Solvency Capital Frameworks

This section describes the major world-wide regulatory standards. These are RBC, MCCSR, Basel II, Solvency II, the international rating agencies (private, but nevertheless a de-facto regulatory standard), international Accounting Standards, GAAP and SAP. Risk Based Capital is used in the United States to monitor insurance company capital adequacy. The MCCSR (Minimum Continuing Capital and Surplus Requirements) is used in Canada to regulate insurance company solvency and is similar to RBC. Basel II is used in the EU and for large banks in the United States and appears to be ready to become the world-wide standard for bank regulation over the next several years. Solvency II is the solvency standard for insurance companies in the European Union. The rating agencies such as AM Best, Fitch, Moody's and Standard and Poor's are used world-wide to assess the stability of financial institutions and even governments throughout the world. These private companies are not affiliated with any country or regulatory body, but nevertheless, financial firms invest a great deal of time and money making sure that their ratings by these companies are at the level targeted by the directors and demanded by stockholders.

Regulatory capital requirements are unfortunately specific to various countries or groups of countries. We have included requirements that have emerged as international standards such as Basel II, and Solvency II. It is possible that future versions of this paper will include unique regulations for additional countries, such as India, Australia, China, etc.

A summary of the solvency regulation standards overviewed in this paper is presented in the following table.

Regulatory Standard	Life	Health	Property & Casualty	Pension	Banks	Investment Firms	Countries
RBC (Risk Based Capital)	x	x	x				U.S. Only
MCCSR	x	x	x				Canada Only
Solvency II	x	x	x				EU
Basel II					x	x	EU, U.S. Core Banks[14] & more[15]
Rating Agencies[16]	x	x	x	x	x	x	World-wide

6.3.3 Solvency Standards

The following discussion enumerates the solvency and credit worthiness standards for a select set of regulatory environments and a select set of financial areas. The main focus for regulators is solvency. Other areas of significant regulation are consumer affordability and market conduct. However, issues other than solvency have been excluded at this time, due to the fact that the risk of insolvency/default is the one area in which regulators have created risk measures.

Although insolvency is generally defined by the fact that liabilities exceed assets, another possible measure for a stock company is attainment of less than investment grade status. A phenomenon called the death spiral occurs when a company is classified by a rating organization as “less than investment grade.” Generally lower creditworthiness leads to higher costs of raising funds from capital market and increased difficulties selling policies (or higher costs raising funds from policyholders). These may in turn result in further financial rating downgrades. Appendix 4 details solvency standards in the following frameworks:

- United States Risk Based Capital for insurance
- Canada Minimum Continuing Capital and Solvency Requirements for Insurance
- European Union Solvency II Standards for Insurance (not effective yet)
- European Union Basel II Solvency Standards for Banks
- Rating Agency Systems
- Other systems

6.4 Short Term vs. Long Term Risks

Risk manifestation can happen in different time frames. While in some cases, the manifestation is perceived as a sudden event, in other cases it can take an extended period before a risk that has become manifest is actually perceived as such. In the first case, the negative event is triggered by a sudden change of the external conditions in a short time; therefore these risks can be called short term risks. In the second case, a gradual change of the external conditions lead to the negative consequences we refer to as risk manifestations; therefore these risks can be called long term risks.

[14] Core banks in the United States are those with consolidated total assets (excluding assets held by an insurance underwriting subsidiary of a bank holding company) of $250 billion or more or with consolidated total on-balance-sheet foreign exposure of $10 billion or more.
[15] According to a publication by the IMF over 100 countries have committed to implementing Basel II. The implementations, however, will be at various times and various levels of uniformity.
[16] Rating Agencies include Standard and Poor’s, Fitch, Moody's and Best's. It is unclear to what extent the rating agencies are applicable to private investment funds.

Examples for short term risks include:

- Weather phenomena (storms, hail)
- Natural catastrophes (flood, earthquake)
- Accidents
- Man-made catastrophes
- Pandemics with short incubation periods (e.g., influenza)

Examples for long term risks include:

- Climate change
- Longevity risk (in pensions)
- Pandemics with long incubation periods (e.g., AIDS, CJD)
- Environmental contamination

When a short term risk becomes manifest, the fact that a loss has been incurred is known quickly, even if the amount will evolve during the settlement phase. Example: if a factory has burned, the reconstruction price and the cost of the business interruption can be quantified.

With long term risks, the manifestation happens gradually; therefore it could be years, decades or even centuries before the entire impact can be stated with certainty. Example: Due to innovations in the medical field, people live longer. This increases pension payouts. When will we know the true distribution, and when will life span increases cease?

For many purposes, a standard has arisen of determining a value for all risks based upon the same time horizon. This is a very helpful approach, since the combination of risk assessment values that were evaluated over their full exposure period was problematic. The standard period that is most popular is one year. This is used for Solvency II in Europe and has been adopted by many firms in other areas.

To do a one-year evaluation of risks with longer exposure periods, the definition of the ending value for the risks becomes very important. The CRO Forum (Chief Risk Officer Forum) in Europe has recommended that the ending value be a market value or a market consistent value. In this way, the future exposure to the risk beyond the end of the year is reflected.

While this approach has several advantages, it also presents several problems. First, since it does not capture the full emergence of the risk, it is possible that this measure will understate the risk of longer term exposures. By understating the risk, it might encourage insurers to shift more and more to offering products with long deferred emergence of problems. Second, the process as described in (citation) does not clearly even take into account likely swings of market values for market traded risks and does not consistently treat non-traded risks. It is possible that this process mishandles the two components of market price for risk. One component is the market view of the level of the risk and the other is a supply demand based fluctuation. The stated process for the market traded risks does not necessarily require a full provision for the supply demand portion of the margin. Additionally, there is no supply-demand based fluctuation provision in the determination of the non-traded risks. Because of this, non-traded risks will have more stable risk evaluations than market traded risks. This may increase the preference for non-traded risks. In summary, the danger with the one year protocol is that it will encourage firms to emphasize longer term non-traded risks over shorter term traded risks.

6.5 Known Risk and Emerging Risks

Frank Knight famously delineated risks with known loss distributions from uncertainty with unknown loss distribution in his 1921 book *Risk Uncertainty and Profit*. Today's risk managers would see a different breakdown as being most significant.

First of all, the only risks with fully known loss distributions are closed games of chance. All other situations have varying degrees of Knightian Uncertainty. Consequently, instead of seeing certainty vs. uncertainty as a black-and-white issue, it makes sense to view risks as falling across a spectrum of color from certainty to uncertainty. At the extreme end of certainty are the fully known loss distributions of closed games. Next come the risks that have followed similar loss patterns for significant periods of time, then risks where there is less or varying past experience that may or may not be sufficient to form a reliable prediction of future loss distribution. Next to the extreme end of uncertainty are risks that are known to exist but that have almost totally uncertain loss distributions. And finally at the most extreme end are those risks that are not currently known to exist. So in terms of a risk assessment, the actuary needs to determine and document an opinion of where along the spectrum of uncertainty each risk sits as well as the information and reasoning that leads to that conclusion.

Emerging risks are those risks that have either unknown severity or (more commonly) unknown frequency. Reasons for uncertainty in frequency and severity include: 1) the event has never happened; 2) the frequency of the event is so low that there are no credible statistics to gather to form a frequency distribution or; 3) because the event has emerged due to changes in the social and economic framework of the world (the last item is frequently referred to as paradigm shifts). In reality items 2 and 3 often overlap where some past events may have occurred but changes in the environment reduce the pool of experience due to decreased relevance of past data.

"Black Swan risks," as coined by Nassim Taleb in his 2007 book, *The Black Swan*, are similar to but not the same as emerging risks. Black Swan risks are massively adverse events that are totally unexpected in advance. Something like a major influenza pandemic could not be classified as a Black Swan because it is anticipated but has unknown frequency. The pandemic would be correctly classified as an "Emerging Risk".

There are a number of techniques for assessing emerging risks. These methods include scenario analysis, the Delphi Technique, and Monte-Carlo modeling.

- **Scenario Analysis**: With a scenario analysis, a particular set of circumstances are declared to have happened and the consequences of those circumstances are developed. In the absence of historical data expert opinion is typically used in designing the scope of the scenario and its impact. The scenarios show the range of potential outcomes for the risk. As a further development a probability may be attached to the scenario. If a wide enough range of scenarios are produced with corresponding frequency and severity assessments this would allow Monte Carlo modeling to be performed.
- **Delphi Techniques**: The Delphi technique is a method for extracting expert opinion based on the assumption that group judgments are more valid than individual judgments. A group of independent experts or managers is requested to make estimates of the likelihood and impact of events. The experts answer questionnaires in several rounds. After each round a facilitator provides a summary of the experts'

forecasts from the previous round as well as the reasoning they provided for their judgments. Experts are encouraged to consider the replies from other members of the group from previous rounds, both quantitative and qualitative. The aim is that during this process the group will converge towards a consensus, and that consensus is a close match for the true underlying answer.

- **Monte Carlo Modeling**: If the frequency and severity are unknown, but ranges of these values can be estimated, then it is possible to assign distributions to frequency and severity, and run simulations to gain insight into the ranges of possible losses. Actuaries prefer certainty, but sometimes it is necessary to gain insight into events about which little is known, and modeling can be used to gain this insight. Monte Carlo modeling produces a series of simulations which can be examined to assess the range of losses and their expected return periods.

  A further input for a Monte Carlo model are the dependencies between variables (not selecting these is equivalent of implicitly selecting the variables to be independent). This is the area where the risk evaluator is most likely to be at the “emerging” end of the scale and assumptions are most likely to be judgment based.

  As an example from general insurance, this technique could be used to assess the ability of a large entity with multiple locations to survive an event of unknown frequency and severity such as terrorism. In the case of modeling terrorism, loss severity may be modeled to included worker's compensation, bodily injury and property damage. The assigned frequency distribution, for example, may be different for each location and inversely related to the distance to the nearest suspected terrorism target.

  A further example is quantitative operational risk modeling in banks. For shorter return periods internal and external loss data should be available (i.e., we are at the more “known” end of the spectrum). For the longer return periods data is likely to be either unavailable or of low relevance (so we are toward the “emerging” end of the spectrum). For the longer return periods scenario analysis, producing both frequency and severity, is used. The two are combined to perform Monte Carlo modeling so that various points along the aggregated distribution can be examined.

  It is critically important to communicate the extreme uncertainty of probabilities developed using simulations with unknown frequency and severity distributions. This is particularly the case when looking at emerging events where the impact of extrapolation may amplify any error in modelling assumptions.

  However, management and risk managers also need to assess the possibility of increased model risk with Monte Carlo – the risk of the model turning into a black box that no one except the designers understand. This is especially important when sometimes the tool is purchased from a third commercial vendor which the users are totally kept out of the inner model algorisms.

6.6 Frequency Risk (earnings volatility) vs. Severity Risk (solvency)

6.6.1 Overview

Insurers tend to group insurance products and insurable events into high-frequency low-severity versus low frequency high severity. The law of large numbers works very well for high-frequency low severity events so that the expected value of pooled losses becomes very predictable. The law of large numbers still applies to low frequency high severity event, however it may take decades or even centuries for the "large number" of events needed to occur. Combining a constantly evolving business environment and management time horizons this means that the law of large numbers is of much less relevance to these extreme events. Often for low frequency high severity events the insurer is not able to determine the statistical distribution of the event making modeling problematic and exposing the insurer to what many today call "Black Swan Risk".

It is possible to make the economic value of an event more predictable (less risky) by various risk mitigation techniques, for example though the purchase of (re)insurance. This converts the unpredictable loss event from an insurance risk to a credit risk. Conversely, the (re)insurance company that takes on the portion of the loss excess of a certain value is assuming a great deal of unpredictability/risk. By taking on a diverse portfolio of these risks the reinsurer seeks to manage their risk through diversification on the assumption that very few low frequency high severity risks will occur within the same underwriting period.

What about “low-frequency-low-severity risks” and “high-frequency-high-severity-risks”? Low frequency low severity risks are low risk and consequently of less interest. Typically it is more economical for these types of events to be self-insured. The one exception to this is major medical coverage (e.g., Health Management Organization[17] coverage in the U.S.) where the insurance carrier finds it more efficient to encourage low cost preventative and early detection procedures in order to protect against the more infrequent high cost claims. However, highly correlated low severity, low frequency events may in fact more closely resemble a low frequency, high severity risk.

High frequency high severity risks are uncommon and for these risks other forms of risk mitigation are likely to be more suitable than insurance. An example is hurricane risk in Florida or flood risk for houses built in a flood plain. Without government intervention insurers will naturally avoid any situation where large losses occur frequently, i.e., where the product of frequency and severity exceeds the ability of the entity to fund the loss at the premium an insured is willing to pay.

Examples of high frequency low severity events include:

1. Private passenger automobile physical damage insurance and
2. Homeowners property insurance (in non-coastal / non-earthquake/ non-cat areas)
3. Fee for Service (FFS)[18]

[17] "Health Management Organization (HMO) is a type of group health care practice that provides basic and supplemental health maintenance and treatment services to voluntary enrolees who prepay a fixed periodic fee that is set without regard to the amount or kind of services received. In addition to diagnostic and treatment services, including hospitalization and surgery, an HMO often offers supplemental services, such as dental, mental, and eye care, and prescription drugs. Federal financial support for the establishment of HMOs was provided under Title XIII of the 1973 U.S. Public Health Service Act", – Definition from Mosby's Medical Dictionary, 8th edition.

[18] Fee for Service occurs when doctors and other health care providers receive a fee for each service such as an office visit, test, procedure, or other health care service.

Examples of low frequency high severity events include:

1. Hurricane or earthquake damage
2. Life Insurance policies to the non-elderly population with very high sums insured.
3. Directors and officers insurance claims
4. Terrorism

Examples listed above are primarily non-life insurance examples with maximal potential losses ranging from several million to billions of dollars. Life insurance products with several million dollar limits would also be included in the high severity low frequency list.

Auto insurance that covers physical damage is one of the most commonly used examples of a high frequency low severity risk. In fact, due to the law of large numbers, it is so predictable that companies with many automobiles often choose to self insure rather than purchase insurance.

We sometimes hear terms like frequency risk vs. severity risk. Frequency risk can refer to the uncertainty arising from regular and relatively lower impact events. Severity risk is generally the high impact events such as natural catastrophe that may result in solvency issues for companies. Frequency risk and severity risk can both drive the company to failure. However, a lot of currently popular risk management practices focus on frequency risks. The reason is not because severity risk has less importance, but it is just because severity risk is extremely challenging to measure and mitigate. However it is typically the low frequency high severity risks that lead to potential solvency issues. Competition can result in competitors holding inadequate capital against severity risk given the difficulties in measuring it. A CARE report needs to cover both aspects.

High severity, low frequency events are riskier in many senses:

- Higher coefficient of variation
- More risk to insolvency
- More difficult for management to understand
- A few years, or even possibly a couple of decades of experience may not be sufficient for accurately quantifying the risk
- More difficult for the general public to understand (and consequently possibly subject to political pressure)
- May be dismissed by management as being overly conservative.

One way to quantify the risk associated with a high severity, low frequency event is to model it. However, the CARE report can make it clear that the model is a representation of what might happen and does not replace judgment. An alternative approach is to use futurism methods (such as the Delphi technique) which involved senior managers imagining what can go wrong, why, what the financial impact can be and sharing this information with other senior managers who using the complete list try to prioritize which risks need more attention.

See Appendix 2 for more backgrounds of frequency and severity.

6.6.2 What Belongs in a Care Report

A first step in quantifying a risk is to assign to the risk a frequency and a severity when applicable. This can be done empirically using historical data, or it can be done judgmentally.

The starting point should normally be empirical analysis based on available data but expert judgment should always be used in tandem. The CARE report can recognize that the statistics used in the empirical analysis were developed in the world of yesterday which may not be the world of tomorrow. Furthermore a range of frequencies and a range of severities should be assigned. It is generally not the expected severity that causes an entity to fail, it is a one-in-fifty or a one-in-one hundred event that causes turmoil. Another scenario that can lead to a crisis is a higher than expected frequency accompanied by a higher than expected severity. An example of this is two back-to-back hurricanes.

It is natural to provide frequency in terms of number of occurrences per year or per month, but this type of data will be misleading as the entity grows, shrinks, or otherwise changes. It is best to provide frequency in terms of an "exposure base" such as number of automobiles, square feet, number of employees, revenue, profit, units sold, etc.

A loss that occurs once every 20 years is called a 95th percentile loss. A loss that occurs once every 100 years is referred to as a 99th percentile loss. Many business practitioners feel that looking at losses at the 95th and 99th percentiles is at best very difficult, at worst excessive and unreasonable. This is understandable given the premise that successful businessmen, especially entrepreneurs, tend to be optimists. However, a business that intends to survive over a span of several decades has to consider *at a minimum* losses at the 95th percentile and 99th percentile. There are many reasons for this:

- An entity is exposed to more than one risk. Every one of these risks has a range of severities. The more risks an entity is exposed to, the higher the probability that at least one of them will experience a 95th or 99th percentile loss. It is not possible to predict ahead of time which risk will hit the large severity. Suppose an entity has exposure to 5 different independent risks, the probability that at least one of them will experience a 95th percentile loss in the next 20 years is 99.6%. Furthermore the probability that at least one of them will experience a 99th percentile loss in that 20 year period is 63%.
- Experts' judgment used to determine the return period of events is not perfect. Consequently, what the experts label as a 1-in-100 event, might in reality be a 1-in-25 event. One reason for this is that there is very limited data for determining frequencies and severities at return times of one every 100 or one every 20 years, so there is a large degree of uncertainty in any estimate. A second reason is that sometimes there is political pressure from diverse entities to lower the expected losses provided by modelers. Last but not least there may be structural change to the frequency and severity distributions over time (paradigm shift) which may be hard to recognize with limited data. Thus it is critical for financial institutions to develop "killer scenarios" and consequently to build capability to perform a thorough stress testing, even though risk managers might not be able to assign a probability to loss events.

6.7 Viewed Stand-alone vs. Full Risk Portfolio

The Comprehensive Actuarial Risk Evaluation reflects each risk that is evaluated both on a stand-alone basis and as it stands within the entire portfolio of risks for the entity. This is because the entity risk managers need to know both pieces of information for risk controlling, for risk pricing, risk based performance measurement and for risk steering. The difference between

the values of these two bases is referred to as the diversification benefit. The diversification benefit is described in detail below. Knowing the two numbers also tells the risk manager the degree to which the aggregate risk level and the degree of capital adequacy depends upon the level of interdependency of lines of business. This is important because interdependency assumptions are formed with the most limited amount of data supporting them and may change as market conditions change.

From strategic risk management perspective, stand-alone and portfolio views of risks represent two distinctive philosophies in managing risks. Stand-alone view is a typical bottom up view of risks, where risk managers diagnose individual risk factors starting from individual risk "cells". Then they need to aggregate those risks and take diversification effects to derive a bigger picture on companies' risk exposures. Portfolio view of risk, on the other hand, represents a top-down view of risks. The final goal for portfolio view of risks is to clearly understand the risks embedded in the enterprise's overall balance sheet. Under portfolio view of risks, though individual risk factors interact each other, company's overall risk profile can demonstrate certain observable reactivity with macro-economic or other external environment. Driven by those two different views, risk managers are required to understand three distinctive risk management activities:

- Risk controlling
- Risk pricing
- Risk steering

For risk controlling, it is usually more practical to set a limit for each risk on a stand-alone basis. However, the level of the limit might be set reflecting the impact that the risk has on the risk level of the entire portfolio.

For risk pricing, the risk manager needs to know the stand alone risk levels, as they are often indicative of market prices. In some cases market participants will take on risks at rates lower than the stand alone value because of the amount of diversification benefit that they have determined in their risk portfolio. If a risk manager sees pricing that indicates this situation based upon the stand alone risk values, then they will make that known in their CARE report as this may indicate shareholder value being allocated incorrectly as described below.

The same type of analysis will be applied when the actuary is reviewing the reserve risk. The CARE report will identify the level of reserve risk on a stand-alone and on a fully diversified basis.

Risk steering is primarily concerned with the most effective utilization of the diversification benefit. A very useful piece of information for the risk steering process is the diversification benefit as a percentage of the stand alone risk.

Risk steering is also concerned with who owns the diversification benefit. To the extent diversification reduces the amount of required capital and this reduction is allocated to the stand-alone lines, the required returns for the stand-alone lines are reduced. Yet shareholders invest in diversified financial institutions in the expectations that they will benefit from diversification. Otherwise there is no reason for a shareholder not to invest in a portfolio of single risk companies and gain the diversification through their portfolio. If we take this as a given we might conclude that shareholders invest in a diversified financial institution in the anticipation of getting the same level of returns as a portfolio of stand-alones with a lower

amount of capital invested. The gains from diversification belong to the shareholder and the capital allocated to stand-alone lines should not be reduced in performance measurement.

Diversification Benefit

Diversification has been long used by financial institutions for effective risk management. Each risk type has different correlation to other risk types. Aggregating risk exposures to incorporate the diversification benefit gives a better and more accurate risk evaluation of the whole portfolio.

From the perspective of the insurance industry, diversification has enabled policyholders to buy protection at a reasonable price by pooling the risks of individual insured. Insurance companies use reinsurance, hedging strategies, product diversification, and geographic diversification for risk management.

Generally speaking, we can measure diversification benefit at three levels:

1. Between different risk factors (market risk, credit risk, insurance risk, operation risk, etc.)
2. Between different products (endowments, variable annuity, etc.)
3. Between different geographic regions (developed market, emerging market, etc.)

Aggregation Method

Quantification of the diversification benefit is important for effective risk management. Some methods for quantification of the "diversification benefit" are listed below

1. **Statistical approach**: use statistical methods to aggregate the values from different risk factors
    - Correlation matrix – correlation indicates the direction of a linear relationship between two individual risk factors. Correlation matrix, which contains correlation of a series factors, can be used to calculate the aggregated risks by aggregating the individually quantified risks to multiply with correlation matrix across individual risk types.
    - Copula – a copula is used as a general way of formulating a multivariate distribution in such a way that various general types of dependence can be represented[19]. Copula is to formulate a multivariate distribution via a simple transformation being made of each marginal variable in such that each transformed marginal variable has a uniform distribution. Dependence modeling with copula functions is widely used in applications of financial risk assessment and actuarial analysis – for example in the pricing of collateralized debt obligations and credit default swaps (CDS) [20].
2. **Structural approach**: risk factors are aggregated at a scenario level (i.e., economic scenario) with correlation between scenarios built in. The aggregate value distributions are then generated based on these general scenarios.

[19] Roger B. Nelsen, *An Introduction to Copulas*, 1999, ISBN 0-387-98623-5.
[20] Meneguzzo, David; Walter Vecchiato (Nov 2003). "Copula sensitivity in collateralized debt obligations and basket default swaps". Journal of Futures Markets 24 (1): 37–70.

6.8 Liquidity Risk

Liquidity risk may be defined as an organization's ability to meet unexpected demands for cash or short term funding through ongoing cash flow or the sale of assets at fair market prices. For the insurance industry, several historical events raised awareness of liquidity exposures. In the 1990s, some issuers of Guaranteed Investment Contracts (GICs) had liquidity problems when their GIC outflows were not decreased and market interest rates fell. Striking examples of these exposures included Executive Life, Equitable Life, and General American. In the 2008 financial crisis, the liquidity crisis of AIG was one of the notable events of the "financial earthquake". In this case, the downgrade of AIG resulted in an increase in payments, per a contractual requirement associated with its credit derivatives portfolio.

Available liquidity is fundamentally a degree of access to cash or cash-like instruments when needed, in particular in stressed situations. Managing the funding sources available is typically a key part of the treasury operations of a company. For complex financial institutions, such as life insurance companies, who typically write long-term liabilities, a good understanding of the liquidity profile of their balance sheet's components is crucial. Liquidity events are generally the secondary degree effects of other primary risk events. Liquidity issues can be triggered by events such as:

- Asset/liability maturity mismatch
- Rating downgrade of a company's creditworthiness or financial strength
- Negative media exposure or general rumours that cause public concern and greater potential for a "run on the bank"
- Requirements to post additional collateral on derivative contracts or additional margin on leveraged positions, e.g., in response to market price changes
- Economy or industry deterioration

Liquidity risk often emerges as either sudden change in state or deterioration of positions over time. Therefore trying to capture liquidity risks via the valuation of assets (usually a haircut is applied to non-traded assets such as partnership participation) or the valuation of liabilities (where liquidity premiums may need to be incorporated into the valuation) may prove to be insufficient. A separate and distinct liquidity analysis is usually performed. A liquidity analysis will compare the amount of liquidity available versus known and potential demands for liquidity within a given time horizon. Typically, an immediate stress-test scenario over some short time horizon (e.g., for one day, one week, one month, three months) and a longer-term "bleeding" scenario (e.g., over one year) are modelled and examined. Within the context of a global financial conglomerate, each sector, each business, and each country-specific liquidity exposures and restrictions should be comprehensively considered. For example, while it may be possible to upstream dividends from a non-regulated non-insurance subsidiary in Bermuda within a one week time frame, it may take up to one year to obtain regulatory approval to upstream dividends from a regulated insurance subsidiary in Australia. Or, in another situation, it could take more than one year to sell an asset, such as a subsidiary or a large real estate holding.

Development of the necessary data, dynamics, and integrated systems to be able to perform such liquidity analysis is not a trivial exercise. However, it is a critical part of the development of a company's risk management.

Practical Implementation

A potential approach to performing such a liquidity analysis is to consider sources of available liquidity, and compare this with potential demands for liquidity, under a variety of stress-test scenarios.

Typical sources of available liquidity are:

On-Balance Sheet

- Cash
- Liquid market instruments
- Short-term performing receivables and loan assets
- Raising of debt and/or equity financing
- Other assets that can be liquidated in required time frames

Off-Balance Sheet

- Letters of credit held that may be drawn
- Funding facilities provided by creditors, such as banks and business partners

Typical *demands* for liquidity are:

On-Balance Sheet

- Short term payables
- Short term loan liabilities
- Company expenses not capitalized
- Embedded options in liabilities such as surrender payments
- Collateral payments and margin calls

Measuring Liquidity Risk Sources and Needs

The sources of and needs for liquidity can be compared simply considering all time dimensions that are relevant from business and legal perspective. For example, insurance liabilities could be split up into how much – on a best-estimate basis – is expected to be paid to customers within one month, three months or one year. This would incorporate, for example, claims practices that legally mandate a company to pay within one month of claim approval. If such legal stipulations do not exist, then past-payment norms can be assumed.

The next step should be to consider the sources and needs under various scenarios. Here, various legal rights built into the contract need to be considered. For example, all deposits in current accounts at a bank can be withdrawn legally within one day, while fixed deposit accounts have their respective drawdown restrictions. A worst-case scenario analysis considers the most stressed liquidity situation that can occur given the contracts written and the promises made to clients and policyholders. For the insurance contracts, these would include surrender rights under extreme stressed conditions, such as a "run on the bank". Again, the scenario would then be assessed for meaningful, multiple time horizons. Here, in assessing a worst case, a probabilistic link is usually made to the company's expressed risk tolerance to maintain the same consistent approach to setting capital for various risk types (e.g., 95% confidence of loss no more than X over one-yr horizon).

Stress scenarios used for such liquidity analyses vary based on the business and contractual requirements.

Liquidity Stress Scenarios

Liquidity affects financial institutions in a number of forms:

1. The ***run-on-the-bank*** scenario is one where liquidity demands from obligors are suddenly made at much higher volumes than anticipated and exceed the firm's ability to fulfil those demands over a required time horizon.
2. The ***bleeding*** scenario is a situation where the liquidity position of a financial institution deteriorates over time due to some endogenous and/or exogenous events, such as slow deterioration of risk assessment of customers, changes in market buying preferences, or loss of reputational status of a company leading to a slow loss of profitable accounts
3. The run-on-the-bank and bleeding scenarios can be exacerbated by a credit squeeze and/or asset market freeze:
    a. The ***credit squeeze*** scenario is one where financing is no longer available when the company needs it. This is called funding liquidity in banking.
    b. The ***asset market freeze*** is a scenario where the market for one or several classes of assets does not operate as effectively in the buying and selling of assets. Effectively, assets that had been marketable suddenly become illiquid. This is called market liquidity in banking. Before a total freeze happens, asset markets might go through periods when there is liquidity, but at valuations that are discontinuous with the previously liquid market prices

1. Run on the bank scenario

The “run-on-the-bank” risk was apparent to insurance regulators and rating agencies after the failures of Mutual Benefit, Executive Life and General American in the U.S. in the 1990s, and the Equitable in the U.K. (2000). Literature from banking often does not include mention of this aspect of liquidity directly, since the advent of central bank as a liquidity backstop was thought to have eliminated this risk from the banking sector. The experience of Northern Rock in the United Kingdom, which was the first retail level, “lines around the block”, bank run in over 100 years in the U.K. has exploded that theory. AIG was brought under government supervision in 2008 as a result of an liquidity issue related to increased collateral required by derivative contracts upon the downgrade of AIG.

The AIG situation is an example of contingent liquidity needs. The collateral calls were contingent on the ratings change of AIG. Care should be taken to identify all contingent cash requirements and care should be taken to disclose any contingencies that are triggered in the test. Sometimes, these contingent liquidity needs are not well documented, especially if at the time of entering into the transaction that creates the contingent liquidity needs, the event triggering the liquidity need is thought to be extremely remote. There are very few historical examples of run-on-the-bank liquidity situations and each was a very unique situation. Therefore, there are few hard and fast rules that can be determined for setting assumptions.

As mentioned previously, to create an internally consistent economic risk measure, a probabilistic link is usually made to the company's expressed risk tolerance to maintain the same consistent approach to setting economic capital (e.g., 95% confidence of loss no more than X over one-yr horizon). The paper “Actuarial Response to FSA liquidity standards” gives a step by step example of how an actuary would assess both the liabilities and the assets to form the assumptions. Specific run-on-the-bank scenarios might include a doubling of the rate of voluntary withdrawals of funds, a total withdrawal of all funds with discretionary withdrawal options and something between those two extremes. Another factor to consider can be the speed of withdrawals; different assumptions might be made for institutional vs. individual customer funds.

2. Bleeding scenario

The bleeding scenario risk is more difficult yet just as critical to capture because its effects often arise from negative changes to internal – strategic or operational – practices or positions of the company as well and external and market shifts over time. Approaching the modelling of the bleeding scenario, a combination of historical experience and "what if" analysis can be performed to set the parameters. For example, a company can incorporate the liquidity impact of past challenges it experienced in setting adequate underwriting requirements for a certain customer group that resulted in underestimation of their withdrawal behaviour over time, or a slow loss of assets as a result of a deteriorated strategic position that after some time led to the best most profitable customers being acquired by a competitor firm.

a. Credit Squeeze

Funding liquidity problems occur when a firm regularly mismatches the maturities of its liabilities with its available cash, sales, or financing ability. The expectation may have been that there would be sufficient free cash flow to make interest payments and refinancing of the debt would be readily available. For an insurer, this might occur if funds from short term liabilities are invested in longer term assets with the presumption that there will be a roll-over of the liability funds upon their maturity.

Funding liquidity issues might arise due to specific firm related issues or from a broad shift in the market. In the 2007-2008 financial crisis, there are several markets that froze. Funding liquidity risk should also be incorporated into stress and scenario tests. Usually these tests are somewhat more limited than the run-on-the-bank test. Funding liquidity risk assessment might just assess the risk from the specific sets of funding sources along with the cash expected to be produced by the uses of those specific funds.

This piecewise assessment of funding liquidity may be very important or even necessary if there are legal entity barriers between various parts of the firm that might prevent timely movement of cash from one part of the firm to another in the event of a problem.

A specific credit risk scenario to test would be a failure to refinance (or roll over) any short term borrowing for a period of 30 days, 60 days or 90 days. In addition, the length of time of failure to refinance that would result in an inability to meet obligations could be determined.

b. Asset Market Freeze

In October 1987, the deepest and most liquid market in the world, the U.S. stock market, went into free fall because of a temporary, but very large mismatch between buyers and

sellers. Stories of the events of those days tell us that for hours at a time, there was some doubt about whether that market could function. All markets can experience short term or intermediate term problems. Under all current risk based capital regimes, there is also a pro-cyclical effect that can help to throw markets into this situation where deteriorating markets can feed shrinking valuations and increasing estimates of risk which feeds asset sales that further depress markets, until there is a situation where the markets cease to function.

Markets that are less liquid are at least in theory more susceptible to market liquidity risk. One way of assessing the market liquidity risk would be to identify the degree to which the securities of the firm are traded in markets of high, medium or low liquidity. In addition, changes and potential changes to the liquidity of the markets could be identified as a part of the assessment process. The market for CDO's related to U.S. mortgage securities was frozen for several months in 2007. But in fact, that market was never particularly liquid. An elaborate system for creating prices for valuation also fell apart during this period. The failure of the pricing system actually had larger repercussions than the trading freeze. The uncertainty about valuation of the CDOs created the uncertainty about the solvency of the banks which resulted in the liquidity freeze of the global banking system.

Scenarios of asset market seizures for each separate market can be tested. Various lengths of time should be tested as well. Each market should be tested separately to determine if a freeze of any length of time could independently cause a problem for the firm in meeting funding needs. Freezes for combinations of markets could be tested as well.

Combination Scenario Tests

Although running separate tests is valuable in discerning the firm's exposure to broad categories of liquidity risk, the most important scenarios for risk management purposes will combine elements from all liquidity exposures. A good rule of thumb regarding market crises is that, for many reasons that are not always readily apparent beforehand, correlations go to one. Therefore it is prudent to assume that assume that demands on liquidity come from several different sources, while at the same time, sources of liquidity are diminished as well.

Liquidity scenarios are notable because of the lack of good historical data with which to build a good quantitative model, so a great deal of judgment and creativity in designing the scenarios is called for. And because there is little historical precedent, it is easy for critics to claim that the test is too stressful and unrealistic. However, these obstacles should not hold back the risk manager from designing scenarios that reflect all potential liquidity risks. No matter how remote the events might seem, it is important to highlight for senior management the types of scenarios where illiquidity can cause the abrupt failure of the firm.

Monitoring Liquidity Risk

The most widely used metric for measuring liquidity risk for financial firms is the TED spread. It is calculated as the difference between 3-month Treasury bills versus 3-month LIBOR. It is

typically around 50 bps, but during the 2008 financial crisis it peaked at over 4% for a brief time. ECB uses spread of EURIBOR over EONIA for a similar purpose.[*]

The Bank of England monitors and publishes an index of overall market liquidity as part of its twice yearly Financial Stability Report. This is based on three factors – see Bank of England (2007a) for details:

- Tightness – based on bid/offer spreads for gilts, FX and FTSE 100 equities.
- Depth – based on a measure of the volume of trades possible without impacting market prices, and the speed at which price fluctuations resulting from trades are dissipated, again based on gilts, FX and FTSE 100 equities.
- Premium – a measure of the prospective premium in the corporate bond market as a compensation for liquidity risk.

Information about those three criteria could be tracked for markets where the firm is exposed and changes to these indicators could be a part of the liquidity risk assessment.

Rating Agency Liquidity Tests

The rating agencies all have similar liquidity tests. For example, in 2004, Standard & Poor's instituted a pair of liquidity ratios that were patterned after the liquidity tests from traditional credit analysis. These liquidity tests define a calculation of liquid assets and liquid liabilities under two time frames or scenarios: immediate and ongoing. Specific risk factors are stated for many different types of life insurance liabilities. These factors are meant to indicate the degree to which each type of liabilities would be likely to demand cash in each of the two scenarios. These factors are multiplied by additional factors that S&P calls “surrenderability”, which is meant to be an indication of the actual or perceived liquidity of the liability. Some liabilities are contractually illiquid, while others have a large enough penalty, that they are perceived to be illiquid by the holders of those liabilities. The same process is repeated for invested assets. Some assets are felt to be 100% liquid in all scenarios (U.S. Government Debt), while others are thought to be totally illiquid in stress situations (low rated bonds and private placement bonds). Most assets are given various levels of haircuts in each of the two stress scenarios. For example, common stocks are thought to be worth 70 percent of market value at the time of the test.

From these rules, it appears that the S&P test includes elements of the asset market freeze scenario and the run-on-the-bank scenario. Perhaps S&P assumed that a likely cause of a run-on-the-bank situation might often be caused by the run-up to the asset market freeze.

While the factors that S&P uses may not be appropriate for some or even most firms, the process is broadly the same process that firms can use to assess their liquidity risk. That would be a stress/scenario testing process that looks at both acute and chronic liquidity squeeze scenarios over short, medium and long time periods. The person performing the test will need to assess each asset and liability under each scenario and form a judgment regarding the call for cash and the availability as a source of cash. For liabilities, it will often be necessary to form assumptions about the degree to which different classes of policyholders will exercise their

[*] TED (the yield spread between U.S. Treasuries and Eurodollar), LIBOR (London Interbank Offered Rate), ECB (European Central Bank), EURIBOR (Euro Interbank Offered Rate), EONIA (Euro OverNight Index Average).

surrender or withdrawal options in a stressed situation. Often, it is assumed that institutional clients will fully exercise their options at the earliest and potentially most inconvenient time. Retail customers tend to be somewhat less efficient; but as the Northern Rock situation showed, retail customers can exercise their options to withdraw with enough efficiency to cause very serious problems as well. The financial markets may react to the company specific run-on-the-bank as well. Bid-asked spreads for transactions with wounded firms will often rise to reflect both the additional credit risk as well as a vulture mentality that will seek to squeeze more profit out of transactions where the damaged firm is seen as having few alternatives. In addition, there are other situations where there will need to be special consideration of the liquidity, such as very large positions. Very large positions can take on the illiquidity characteristics of wholly owned subsidiaries or real assets. While these holdings might be carried at a market price that reflects actual transactions at a recent time, the market might have little or no appetite for amounts of that asset. Lines of credit are usually difficult to access in extreme stress scenarios. There have been instances where banks have failed to honour lines of credit for firms in extreme duress.

From these rules, it appears that the S&P test includes elements of asset market freeze in with the run on the bank scenario, perhaps assuming that a likely cause of a run-on-the-bank situation might often be caused by the run-up to the asset market freeze.

6.9 Risk Types

There are many types of different risks depending how people define them. As a brand new perspective, the risks could be viewed in two broad categories:

1. **Statistical risks** – risks generally can be measured or modelled with mathematical or statistical approaches such as stochastic modelling. These risks include:
    - Market risk
    - Credit risk
    - Insurance risk
    - ALM mismatch risk
    - Liquidity risk
2. **Non-statistical risks** – risks that are impossible or extremely difficult to model with existing knowledge of them. These risks include:
    - Black swan
    - Paradigm shift
    - Reputational risk
    - Opportunity risk
    - Strategic risk

Statistical risks are the focus of risk management techniques (such as economic capital modelling), and economic performance measurements (such as market consistent embedded value and market consistent fair value reporting). However, it is increasingly accepted that non-statistical risks are often the driver of failures. In the following sections, instead of describing modelling techniques, we give examples of each type of risks for readers to gain familiarity of risk types.

Market Risk

Market risk is a collective term for risks that are related to the changes and fluctuations of the financial markets. Such risks involve fluctuations in the equity market, interest rate curve level and shape, and currency exchange rates, for example. Market risk can lead to unexpected changes to company's capital position and create higher volatilities in company's earnings. Market risk is generally one of the key focus areas for financial services players in their risk management or economic capital management activities.

Credit Risk

Credit risk can be split into the risk of fluctuations in the credit quality of a financial obligation (e.g., credit spread risk) and the risk of a failure to pay cash-flows owed (counterparty risk).

Counterparty Credit risk is the risk that other parties cannot or will not honour their obligations fully or that there will be a material delay in the payment. Because there are many types of counterparties – from individuals to suppliers/vendors, to sovereign governments – and many different types of obligations – from auto loans to derivatives transactions – counterparty credit risk takes many forms and institutions manage it in different ways. One way is to limit the counterparty exposure of the institution to third parties. However this could be difficult if there are a limited number of reinsurance or banking counterparties available to trade with. The sub-prime mortgage meltdown starting from late 2006 is deeply rooted in counterparty credit risk mismanagement.

Credit quality risk is the risk of fluctuations in the value of a financial obligation due to a change in credit quality. This could manifest as a change in value due to a change in credit spread. Alternatively it could manifest itself as a change in the credit rating of an institution. Credit quality risk can also be considered as a form of market risk.

Insurance Risk

Insurance risk is also commonly referred to as hazard risk or underwriting risk. It is a risk of loss resulting when the pricing or underwriting of a product established is not commensurate with the true risk a product brings on. An example of insurance risk is asbestos-related liabilities for Lloyd's. Asbestos was widely used as a fireproofing and insulation material until the 1970s when it was found to be linked to cancer and other diseases. Lloyd's, the London based underwriter, had massive exposure to asbestos related liabilities, whose symptoms only surfaced in the 1980s and 1990s. However, the latency and the massive amount of the liability almost brought the underwriter to the brink of extinction. Another example of insurance risk was the massive under-pricing of equity guarantees by life insurers in mid-1990s.

Asset Liability Risk

Asset liability risk is a risk of mismatch between the values of asset and liability due to, for example, interest rate fluctuations. The problem is not that the value of assets might fall or that the value of liabilities might rise, but that the capital might be depleted by narrowing of the difference between assets and liabilities – that the values of assets and liabilities might fail to

move in tandem. Asset-liability risk is a leveraged form of risk. The capital of most financial institutions is small relative to the firm's assets or liabilities, so small percentage changes in assets or liabilities can translate into large percentage changes in capital.

The term ALM risk was originally used interchangeable with interest rate risk. But developments in Asset Liability Management have largely expanded this concept. Asset Liability Risk today can mean any risks that will cause asset / liability mismatch. Asset-liability management is a series of techniques to manage the elements of the two sides of the economic balance sheet such that asset and liability value movements match each other.

One example is a U.S. mutual life insurance company – the Equitable. During the early 1980s, the USD yield curve was inverted, with short-term interest rates spiking into the high teens. The Equitable sold a number of long-term Guaranteed Interest Contracts (GICs) guaranteeing rates of around 16% for periods up to ten years. During this period, GICs were routinely sold for principal amounts of USD 100 million or more, a significant figure on the balance sheet. Equitable invested the assets short-term to earn the high interest rates guaranteed on the contracts. Short-term interest rates soon came down. When the Equitable had to reinvest, it could not achieve the interest rates it was paying on the GICs. The firm was crippled. Eventually, it had to demutualize and was acquired by the AXA Group in early 1990s.

Liquidity Risk

Liquidity risk is the financial risk associated with uncertain access to cash require to fulfil obligations when they are due. An institution might have a sudden need for cash if its credit rating falls, if it experiences sudden unexpected cash outflows, or if some other event causes counterparties to avoid trading with or lending to the institution. A firm is also exposed to liquidity risk if markets on which it depends to access cash are subject to loss of liquidity.

There are numerous examples of financial institutions that were technically solvent (assets exceeded liabilities) but failed due to inadequate liquidity. These include General American, Mutual Benefit Life, Bear Stearns, Lehman Brothers, Baldwin United, etc.

The story of Baldwin United (BU) is an example of liquidity risk. BU was a holding company whose main holdings were in life insurance, property and casualty insurance, and mortgage insurance. In addition, BU owned a few other companies, such as a piano manufacturing company and a trading stamps company. BU's life companies sold billions of dollars worth of accumulation annuities with high credited interest rates. These high rates were essentially guaranteed by a bailout provision, which waived the surrender charge if the company credited an interest rate lower than a very high bailout rate. BU borrowed a substantial amount of money to purchase a mortgage insurance company and stated quickly that it would repay the debt over a short period. The company was implementing a tax strategy of shifting the gains and losses from its life companies to its property and casualty companies, and for the strategy to work, the mortgage company needed to make money. When the U.S. economy experienced a downturn in the early 1980s, mortgage default rates increased. Soon the mortgage insurance company was not making enough money for the strategy to work. BU said it would need more time to repay the loan for the mortgage insurance company, and this, in combination with some other negative reporting, caused large scale surrenders, which is the life insurance equivalent of a “run on a bank” (i.e., policyholders who had lent money to the insurer (as depositors lend to a bank) demanded their money back quickly because of a lack of confidence). Because the investment in the mortgage insurance company was such a huge part of the portfolio

(approximately 20%), the total amount of cash that could be generated by selling a large volume of mortgages in a short period of time was less then the market value of assets, and was not sufficient meet the obligations on BU's liabilities. Ironically, this happened in spite of the significant value of the mortgage insurance company: It went public for a few years later, with a market value of $1 billion. Policy owners eventually recovered their money with interest, although credited interest rates were substantially less than the high credited rates initially promised.

Black Swan Events

The Black Swan theory refers to a large-impact, hard-to-predict, and rare event beyond the realm of normal expectations and it refers only to events of large consequence and their dominant role in history. Black Swan events are a special category of what are called outliers.

The beginning of the 21st century was marked with a black swan event – such as the 9/11 terrorist attack, which has caused almost all terrorism coverage to be removed from Property & Casualty private insurers. The federal government eventually had to step in to create TRIA (Terrorism Risk Insurance Act) to ensure availability of terrorism insurance. This is because large construction projects were put suspended due to the inability of contractors to obtain terrorism insurance. Hurricane Katrina is another event that caused catastrophic losses to P/C insurers, especially in the homeowner insurance market. While many insurers had considered the possibility of a hurricane of the magnitude of Katrina was possible, they did not include the possibility of the levees in New Orleans failing. The industry has had to revisit exclusions on flood damage, and the effectiveness of NFIP (National Flood Insurance Program[21]) to maintain soundness of this type of insurance protection.

Paradigm Shift

Paradigm shift refers to a change in the state of the world from what had been nearly universally accepted. For example, a change in consumer buying habits from buying airline tickets through travel agents to buying them over the Internet would be a paradigm shift.

Paradigm shifts are prominent in the media industry. Flat-screen high definition TV has replaced almost all traditional televisions. Digital Video Recording is also replacing traditional video-recording. DVD and CD have almost entirely replaced video cassettes while I-pod and MP-3 players have replaced walkman and portable CD players. Movie-on-demand or online movie rental is challenging traditional “brick-and-mortar” movie rental business. These paradigm shifts show that businesses have to try hard to keep up with the progress of technology in order not to be left behind.

A paradigm shift also happened in the healthcare insurance industry. In the 1970s physicians were considered low risk for disability coverage. With the introduction and popularity of Health Management Organization (HMO) in the U.S., physicians are facing increasing administrative burden (such as filling mounting paperwork) coupled with decreasing reimbursement. The result is many physicians concluded that it would be better to retire on disability rather than working

[21] Williams, O., “Federal Emergency Management Agency, Ongoing Challenges Facing the National Flood Insurance Program,” Testimony Before the Committee on Banking, Housing and Urban Affairs, U.S. Senate, October 2, 2007.

through patients' chronic health issues. HMO thus caused a paradigm shift that completely changed physicians' attitudes towards continuing to work.

Reputational Risk

Reputation risk is the risk that negative publicity regarding an institution's business practices will lead to a loss of revenue or litigation. For retail payment-related systems, reputation risk is linked with customer expectations regarding the delivery of retail payment services, and whether the institution is meeting its regulatory and consumer protection obligations relating to those services. An institution's reputation, particularly the trust afforded it by customers and counter-parties can be irrevocably tarnished due to perceived or real breaches in its ability to conduct business securely and responsibly. In addition, financial institutions are responsible for risks associated with the activities of third-party service providers with which they contract. For example, deficiencies in security and privacy policies that result in the release of customer information by a service provider may result in reputation damage.

The Korean car maker, Hyundai, first made a name for itself in the United States in the late 1980s. The car was popular at first, but soon earned a reputation for developing rust and other quality problems. The company was "haunted" by its reputation in the 1990s when it was trying to launch newer products. However, beginning in 2001, to help overcome its reputation for poor quality, the company announced a 10-year, 100,000-mile warranty, which was far more comforting than the industry's standard three-year, 30,000-mile warranty, and essentially guaranteed the car for its entire expected working life.

Meanwhile, the Hyundai Sonata was selected to be the official taxicab during the Beijing Olympics. In January 2008, Hyundai grabbed further attention in the U.S. by offering to take back a car that is financed or leased by a worker who subsequently loses a job, as consumers were reeling from the collapse in housing and stock market prices and growing fears of unemployment. When the program was introduced, the Hyundai Assurance program was seen as more than just a marketing campaign, but also as psychological affirmation that the economy was not going to collapse entirely. The program paid off well – analysts proclaimed the program a success when Hyundai reported U.S. sales were up 14% in January compared to the same month a year earlier, while the entire U.S. auto market fell 37%.

Operational Risk

An operational risk is a risk arising from execution of a company's business functions. As such, it is a very broad concept including e.g., fraud risks, legal risks, physical or environmental risks, etc.

The best example of operational risk in the insurance industry is the market conduct around issuing illustrations with vanishing premiums in the early 1980s. Due to high interest rates at the time companies were able to illustrate that if an insured paid only a small number of premiums the investment income paid on reserves as part of the dividend would be sufficient to pay all future premiums. As interest rates fell many of these vanishing premiums reappeared resulting in class action law suits against carriers.

Another example illustrating operational risk is Enron, the Houston, Texas company originally involved in transmitting and distributing electricity and natural gas throughout the United States.

The company developed, built, and operated power plants and pipelines while dealing with rules of law and other infrastructures worldwide. In 1998, Enron moved into the water sector, creating the Azurix Corporation, which it part-floated on the New York Stock Exchange in June 1999. Azurix failed to break into the water utility market, and one of its major concessions, in Buenos Aires, was a large-scale money-loser. After the move to Houston, many analysts criticized the Enron management as swimming in debt. The Enron management pursued aggressive retribution against its critics setting the pattern for dealing with accountants, lawyers and the financial media.

Enron grew wealthy due largely to marketing, promoting power and the fraudulently inflated stock price. Enron was hailed by many, including labour and the workforce, as an overall great company, praised for its large long-term pensions, benefits for its workers and extremely effective management until its exposure in corporate fraud. As was later discovered, many of Enron's recorded assets and profits were inflated, or even wholly fraudulent and nonexistent. Debts and losses were put into entities formed "offshore" that were not included in the firm's financial statement, and other sophisticated and arcane financial transactions between Enron and related companies were used to take unprofitable entities off the company's books.

Opportunity Risk

The risk that a better opportunity may present itself after an irreversible decision has been made. Such risks are prominent when there is a technology shift in the market. For example, it can happen when a product will lose its patent protection or that a manufacturing process becomes outdated. It can also happen when a new technology enters marketplace.

The opportunity risk is perfectly illustrated by the competition in the cellular phone market. Motorola's failure to pursue both analogue and digital cellular-phone technology allowed Nokia to become the industry leader. Later, Nokia's decision to concentrate on high-end smart phones and spending 80% of its research and development budget toward this market, led them to not double bet on moderately priced phones. This allowed rival Samsung to capitalize on and become dominant in the midrange phones market, increasing the overall risk level of Nokia's market position.

Strategic Risk

There is no commonly accepted standard definition of strategic risk. It is identified as a potentially significant risk in Pillar II of the Basel II framework, but no definition is provided. In its Pillar II guidelines, the Committee of European Banking Supervisors (CEBS) suggests the following: Strategic risk is "the current or prospective risk to earnings and capital arising from changes in the business environment and from adverse business decisions, improper implementation of decisions or lack of responsiveness to changes in the business environment".

The failure of a large retail store, Kmart, is a classic example of strategic risk. Kmart was an innovator of new concepts in mass-merchandizing industry by developing low-price merchandizing concept with operations started in 1937, 30 years before Walmart and Target even entered the market. However, through time, it loses its niches on three fronts: the prices it offers, the segment of customers it targets at, and the shopping experience it brings to its customers. The loss on these three fronts made Kmart indistinguishable from and eventually losing to its major competitors, which subsequently drove the company into bankruptcy.

7. Conclusion

> *I will never sacrifice reality for elegance without explaining why I have done so. Nor will I give the people who use my model false comfort about its accuracy. Instead, I will make explicit its assumptions and oversights.* [22]

Models have a useful part to play. Clear communication of the parts of the risk that are and are not modelled is crucial information in order to be able to use the models as a useful input to making strategic decisions. But too much belief in the specific numbers could be dangerous, and give false security. Models have to be connected to the real world and used and validated by a firm's management for them to become a useful tool. A CARE is able to serve as an important independent view on the risks undertaken by the firm and the methods used to manage and quantify them.

The communication and blend of skills of the actuarial profession have never been more needed. The CARE would be an important step in ensuring that management and boards are aware of the risks in their own risk management.

[22] *The Financial Modelers' Manifesto (2008),* by Emanuel Derman and Paul Wilmott.

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Appendix 2 – The Mathematics of Frequency and Severity

The Law of Large Numbers and Variance of a Sample

The law of large numbers and the variance of a sample are the reasons why an event that is very risky, and would bring disaster to an individual, becomes manageable and less risky when an insurance company, or self-insuring entity pools the risk with other similar risks.

The law of large numbers: Suppose that L is a random variable denoting the loss that could be experienced by event. L has an unknown distribution with mean and variance E(L) and VAR(L). If a random sample of N such losses are pooled together. Let L-bar denote the average of those losses. Then E(L-bar) = E(L) and VAR(L-bar) = Var(L)/N. Thus, if risk is measured by variance, then the risk becomes smaller and smaller as more and more risks are pooled.

The Variance of a sum of Random Variables

For many risks, there is uncertainty associated with both the frequency (number of occurrences) and the size of the occurrences. The following mathematics shows how the variance of a total annual loss is affected by uncertainty in the number of occurrences and the size of each of those occurrences.

Let N and X be mutually independent random variables.

N takes on a value of zero or one. N is frequency.

X denotes the severity of each event.

Denote $S = X_1 + X_2 + X_3 + ... + X_N$, where N is a random variable.

Then

(1) E(S) = E(N)*E(X)

(2) VAR(S) = E(N)VAR(X) + VAR(N)*[E(x)]^2

Note that the distribution N*X, which is the product of the two distributions is called a "compound distribution" and is a significantly different distribution.

Mitigating Frequency and Severity Risk with Reinsurance

Suppose that management chooses its risk appetite for underwriting exposure to be:

- Maximum loss from a single event at a return period of one-in-250
- Over a time horizon of one future underwriting year
- An acceptable magnitude of $20m

The modeled gross loss from a particular event may be as follows:

Percentile	Incidence Occurs	Loss in Millions
25.0%	3 out of 4 years	$ 0.2
33.0%	2 out of 3 years	$ 0.5
50.0%	One out of 2 years	$ 0.7
67.0%	One out of 3 years	$ 2.2
75.0%	One out of 4 years	$ 3.4
80.0%	One out of 5 years	$ 4.2
90.0%	One out of 10 years	$ 8.1
95.0%	One out of 20 years	$ 20.7
99.0%	one out of 100 years	$ 91.7
99.6%	One out of every 250 years	$ 203.9

Then the risk in its entirety is unacceptable; the firm can only absorb 10% of the risk below prudently.

One option would be to accept 10% of the risk. This might involve ceding 90% of the risk on a proportional basis. Another option would be to only insure losses below $20 million by purchasing insurance for the $190 M XS $20 M layer, thus gaining protection from an event slightly larger than the projected 250 year event.

Appendix 3 – Risk Created by Regulation

1. **Restrictive regulation**
    a. Restrictions either prevent the entity from meeting their goals or create a significant monetary burden.
    b. Concrete Examples:
        i. Restrictions on profit margins,
        ii. Restrictions on pricing differentials between classes,
        iii. Requirements for capital adequacy,
        iv. Requirements for reinsurance deposits,
        v. Requirements for documentation/data reporting, etc.
    c. Countermeasures:
        i. Avoid jurisdictions with burdensome regulations
        ii. Be more efficient than the competition at adhering to regulation

2. **Unexpected changes in regulation**
    a. Regulations change in a way that requires the company to change the way it does business, creating significant expense and/or revenue loss for the company.
    b. Concrete examples include:
        i. New restrictions on pricing differentials between classes
        ii. Elimination of a classification or underwriting criteria (gender, pregnancy, age, zip-code, pre-existing conditions)
        iii. Additional documentation required
        iv. New taxes
    c. Countermeasures:
        i. Keep abreast of legislation
        ii. If there are quasi-governmental committees that have industry members, think about nominating one of your employees for the committee.

3. **Inept or dishonest regulation**
    a. Regulators in a particular jurisdiction create burdens by not reacting to requests, written correspondence, phone calls, meetings, etc., in expected ways.
    b. Concrete examples include:
        i. Losing paperwork
        ii. Expecting bribes or other favours
        iii. Not returning calls
        iv. Civil servants not understanding their jurisdictions regulations
        v. Excessive turnover in personnel such that a request for some approval must be reinitiated.
    c. Countermeasures:
        i. Experience
        ii. Consultants with experience
        iii. A relationship with a civil servant within the jurisdiction.

4. **Too little regulation**
    a. Competitors are able to engage in “unwise” practices that allow them to gain market share. These practices will eventually put the competitors out of business, but not until they have caused you pain. When the companies do go out of business you may be required to bail out the insured via an assessment or guarantee fund.

5. **Catastrophe pools**
    a. Some jurisdictions require that all insurers participate in the losses for weather catastrophes. Sometimes complicated rules for participation percentages depend on how much voluntary business the company writes.
    b. Concrete examples
        i. Texas Wind Pool
        ii. Mississippi Wind Pool.
    c. Countermeasure: Use cat modelling and understand the jurisdiction rules to determine the extent of the risk for your company and how to mitigate it.

6. **Last but most important, inefficient competition**
    a. The risk that your company’s method of dealing with the regulations creates a competitive disadvantage for your company.
    b. Concrete examples
        i. Company is not as efficient at completing documentation as competition.
        ii. Company incurs fines due to lack of understanding of regulation.
        iii. Company interprets regulation as more restrictive than it is.

Appendix 4 – Solvency Standards

Note: The following represents the authors' understanding of some of the global regulatory standards as of the time of drafting. These standards are changing rapidly and this static report will not be up to date with current practice.

1. United States RBC (Risk Based Capital) Solvency for Insurance

One of the authors has seen an example, in practice, where a well run company had an RBC below the action level. In this case, however, the result was misleading because the company in question was a subsidiary of a large holding company with plenty of combined capital. This example shows that it may not be meaningful to look at the risks and/or capital requirements of one member of a group in isolation.

This is the abstract from the above paper being published by NAIC[23]:

> *The risk-based capital requirements adopted by the NAIC in 1994 are a major advance in the solvency regulation of property/casualty insurance companies. The components of the risk-based capital formula are grounded in actuarial and financial analyses of the risks faced by insurance companies and of the capital needed to guard against those risks. The intricacy of the risk-based capital formula"... "make the new capital requirements difficult to follow. This paper leads the reader through the formula"... "The paper first takes the reader through the components of the risk-based capital formula, as well as the "covariance adjustment" connecting them. The emphasis is on the development and justification of the charges, not simply on the accounting entries needed. Casualty actuaries were instrumental in developing several components of the risk-based capital formula: the covariance adjustment, the offset for claims-made business, the offset for loss-sensitive contracts, the treatment of workers compensation tabular loss reserve discounts, and the additional charges for rapidly growing companies. In discussing the actuarial considerations in these five issues, the paper demonstrates how actuarial science has major practical implications for insurance regulation. To be effective, the risk-based capital formula must be combined with statutory enactments empowering regulatory officials to take action against financially distressed companies. The paper explains the "action levels" in the NAIC Risk-Based Capital Model Act, as well as the various potential uses of the risk-based capital results.*

[23] "NAIC Property/Casualty Insurance Company Risk-Based Capital Requirements", by Sholom Feldblum (www.casact.org/pubs/proceed/proceed96/96297.pdf)

Summary of United States RBC Calculation for insurers[24]

Within the United States in 2008, the main tool for regulators to assess the capital adequacy for Insurance companies is RBC. This is a complicated sophisticated tool introduced in 1994 by the NAIC that calculates the required capital of an insurance company based on various risk factors such as underwriting risk, credit risk, and market risk. From a regulator's standpoint, the main fault, if there is one, is that it does not give regulators the authority to act soon enough.

Note: Insurers in the United States are required to annually fill out a large book called the "Annual Statement." A copy of this book is sent to each of the states in which the company does business. The process of filling out the annual statement includes such things as completing ten-year loss triangles by line of business[25]. Usually, an insurer purchases software that helps complete the annual statement and also runs error checks on the data. In the process of filling out the annual statement, the software calculates an RBC for each insurer, so the insurer does not have to understand the intimate details of the formula, although they generally do understand that poor loss development and low surplus levels will hurt (lower) their RBC ratio.

The capital charges that go into calculating the U.S. LIFE RBC are:

- Asset risk (C0 and C1) asset default , fluctuation in fair value of assets
- Insurance risk (C2) inadequate pricing, underestimation of claims reserves
- Interest rate risk (C3) losses due to changes in interest rate, mismatch of asset and liability cash flows
- Business risk (C4)

Risk Categories: The capital charges that go into calculating the U.S. P&C RBC are:

- R0: Assets with affiliates and guarantees for affiliates
  - Investments in insurance affiliates, non-controlled assets, guarantees for affiliates, contingent liabilities
- R1: Cash, Bonds and short term investments
  - Fixed income securities: cash, bonds, bond size adjustment factor, mortgage loans
  - Short term investments
  - Collateral loans
  - Asset concentration adjustment for fixed income securities
- R2: Equity investments
  - Common stocks, preferred stocks, real estate, other invested assets, aggregate write-ins for invested assets, asset concentration adjustment for equity investments
- R3: Credit risk
  - Reinsurance recoverable, other receivables
- R4: Reserving risk
  - Basic reserving risk charge
  - Offset for loss-sensitive business

[24] Source: NAIC Property/Casualty Insurance Company Risk-Based Capital Requirements by Sholom Feldblum
[25] The fact that the state regulatory system was able to mandate the release of company-by-company loss triangle information is a huge accomplishment and a tribute to both Richard Roth and the state based regulatory system in the U.S.

- Adjustment for claims-made business, loss concentration factor
- Growth charge for reserving risk

- R5: Written premium risk
  - Basic premium risk charge
  - Offset for loss-sensitive business
  - Adjustment for claims-made business
  - Premium concentration factor
  - Growth charge for premium risk

Minimum Capital Charge = R0 + square root of ([$R1^2$ + $R2^2$ + $(.5R3)^2$ + $(.5R3+R4)^2$ + $R5^2$])

The RBC Ratio = Total Adjusted Capital/ (2* Minimum Capital Charge)

The following table describes the regulatory responses required as a result of RBC levels.

Regulatory responses required as a result of RBC levels.

Less Insolvency
More Insolvency

Regulatory level	Insolvency Exposure	Total adjusted capital / Authorized Control Level Capital	Action required
Safety Level		> 200%	• No actions required
Company action level		150% - 200%	• Company submits RBC plan to commissioner. Commissioner determines if satisfactory.
Regulatory action level		100% - 150%	• Company submits RBC plan to commissioner. Commissioner determines what corrective action must be taken.
Authorized control level		70% - 100%	• Commissioner can take whatever regulatory action is necessary to protect interests of policyholders and creditors
Mandatory control level		< 70%	• Commissioner can place company under regulatory control (i.e. rehabilitation or liquidation)

Source:NAIC

2. Canada MCCSR (Minimum Continuing Capital and Solvency Requirements) Solvency for Insurance

MCCSR is very similar to RBC, although there are significant differences. The table below comes from a paper written by Sun Life Insurance Company of Canada, and compares RBC to MCCSR for annuities. The factors in the table below might have updated, but the idea is to demonstrate a comparison of two solvency systems.

	Capital Requirement under	
Tvoe of Risk	MCCSR	RBC
Asset Default (C-1):		
Government backed bonds	0.00% of assets	0.00% of assets
AAA rated	.25%	.30%
AA	.50%	.30%
A	1.00%	1.00%
BBB	2.00%	1.00%
BB	4.00%	4.00%
Mortgages	4.00%	3.00%
Pricing (C-2):		
Annuity mortality	1.00% of reserves	None
Asset/Liability Mismatch (C-3):		
Length of guarantee period		
< 1 year	1.00% of reserves	.50% of reserves
> 1 year, < 10 years	1.00%	None
> 10 years	2.00%	None
Business Risk (C-4):		
Annuities subject to		
Guarantee Fund assessment	None	2.00% of reserves

3. European Union – Solvency II – Solvency Standards for Insurance

European financial services regulations are broadly separated into three distinct areas and legislation is designed specifically for each area. These areas are:

- Banking (Basel I and Basel II)
- Insurance and Pension Funds (Solvency I and Solvency II)
- Investment Services

The EU is in the process of implementing Solvency II. The legislation is close to being adopted at the first stage after the council of ministers agreed a draft wording. A vote of the European Parliament is expected in Q1 2009 and it is expected that the legislation will be passed.

Solvency II has been described as a Basel III for Insurance because it tries to take a holistic and risk sensitive view of regulatory capital. Diversification between risks is allowed for in Solvency II contrary to Basel II.

The key features of Solvency II are as follows:

- Best-Estimate Valuation of Liabilities (including Market Consistent Valuation and Risk Margins)
    - The principle behind this is that all prudent margins are removed from the valuation of liabilities and placed in an explicit capital requirement in excess of the value of the liabilities.
- Market Consistent Valuation
    - Assets and Liabilities will need to be calculated on a market consistent basis. This means that P&C cash flows will need to be discounted and life insurance will need to take account of the time value of any options or guarantees in the products.
- Risk Margins
    - Where liabilities are not traded in a deep and liquid market a pseudo market price needs to be inferred. Solvency II looks likely to adopt the Swiss Cost of Capital approach to calculating the pseudo market price of non-traded liabilities.
- Multi-Level Regulatory Capital Regime with progressive regulatory intervention
    - The first level of regulatory intervention comes when an insurer breaches Solvency Capital Requirement (SCR). There is a more severe point of regulatory intervention when an insurer breaches the Minimum Capital Requirement (MCR).
- Risk Sensitive Model for Regulatory Capital covering (Market, Credit, Insurance, Operational)
    - It is likely that the regulatory capital model will be very similar to that used in a series of Quantitative Impact Studies that have taken place over recent years. This model involves the market consistent balance sheet behind recalculated under a series of adverse stresses (for example equity markets down 32%). After each stress the extra capital required is noted. The individual additional capital requirements are then aggregated via a hierarchy of correlation matrices to arrive at the Solvency Capital Requirement.
    - It looks likely that the Minimum Capital Requirement will be based on a fraction of the SCR with a cap and floor.
- Internal Models for Regulatory Capital
    - Insurers will be able to apply to use their own internal models for the calculation of regulatory capital. To qualify the insurance company management must prove that they have a good model and that the model is embedded into the decision making process of the company (the Use Test). Regulators must approve internal models before they can be accepted for the calculation of regulatory capital. Application processes for internal models are starting in 2009.
- Three Pillars
    - As with Basel II there will be three pillars to the regulation. The above points relate to Pillar 1. The highlight of Pillar 2 is the Own Risk and Solvency Assessment in which the company has to make an assessment of the capital it requires considering all risks to which it is exposed – not just those covered by Pillar 1. In Pillar 3 covers disclosure of the risks and capital required.

Until recently there was also a mechanism for group support which has been deferred in the final draft.

While Solvency II is not due for implementation until 2012 several European countries already have similar regulatory frameworks that could be labeled Solvency 1.5. They share many of the features of Solvency II and indeed much of the design of Solvency II has drawn on the experiences of these countries. Countries who have adopted Solvency 1.5 regimes include U.K., Switzerland, Sweden, Denmark and The Netherlands.

While Solvency II has been designed by the European Union, it will likely be adopted by affiliate countries to the European Union. It will also be important for any companies with a European parent who will need to report on Solvency II.

Helpful references on Solvency II:

FSAs Path to Solvency II:
http://www.fsa.gov.uk/pubs/discussion/dp08_04.pdf

CEIOPS Solvency II consultation Paper:
http://www.ceiops.eu/media/docman/public_files/consultations/IssuesPaperORSA.pdf

CEA (Organization of European Insurance Organizations) Response to CEIOPS Issues Paper:
http://www.ceiops.eu/media/docman/public_files/consultations/consultationpapers/Comments%20CEA.pdf

Groupe Consultatif (European Actuaries) Response to CEIOPS Issues Paper:
http://www.ceiops.eu/media/docman/public_files/consultations/consultationpapers/Comments%20Groupe%20Consultatif.pdf

Comparison of U.S. and European solvency systems:
http://www.naic.org/documents/committees_e_isawg_081103_solvency2.pdf

4. European Union Basel II Solvency Standards for Banks

As was stated before, European financial services regulations is broadly separated into three distinct areas and legislation is designed specifically for each area. These areas are:

- Banking (Basel I and Basel II)
- Insurance and Pension Funds (Solvency I and Solvency II)
- Investment Services

The Basel II accord was implemented in 2006 in the European Union as the Capital Requirements Directive and came into full effect in 2008. Some modifications have been proposed.

The Capital Requirement Directive can be found here:
http://eur-lex.europa.eu/LexUriServ/site/en/oj/2006/l_177/l_17720060630en00010200.pdf

The Basel II Accord can be found here: http://www.bis.org/publ/bcbs107.htm

The banking regulation page at the EU can be found here:
http://ec.europa.eu/internal_market/bank/regcapital/index_en.htm#consultation

The following extract from the U.K. Regulator website summarizes Basel II / CRD:

> The new Basel Accord has been implemented in the European Union via the Capital Requirements Directive (CRD). It affects banks and building societies and certain types of investment firms. The new framework consists of three 'pillars'. Pillar 1 of the new standards sets out the minimum capital requirements firms will be required to meet for credit, market and operational risk. Under Pillar 2, firms and supervisors have to take a view on whether a firm should hold additional capital against risks not covered in Pillar 1 and must take action accordingly. The aim of Pillar 3 is to improve market discipline by requiring firms to publish certain details of their risks, capital and risk management.[26]

5. Rating Agency Systems

All of the agencies below issue both long term and short term ratings based on the ability of an entity to meet debt obligations over a short time horizon and then over a long term horizon. Each agency uses its own proprietary methodology and rating system, but the results are usually similar.

Standard & Poor's
Standard and Poor's methodology is similar in theory to RBC, however the factors and formulas used by S&P are proprietary. Standard and Poor's ratings are based on a capital adequacy model. S&P's credit ratings for long term obligations in order of best to worst are AAA, AA, A, BBB, BB, B, CCC, CC, C and D. If a company is not rated it is indicated using the letters NR.

Fitch
According to Fitch's website, the Fitch rating for banks is based on 1) The economic and operating environment, 2) Ownership and Support 3) Management Strategy and Franchise 4) Risk Management 5) Financial Strength and 6) Corporate Governance. Ratings are decided upon in a committee setting. The economic and operating environment includes accounting practices, regulatory framework, and competition. Financial strength includes profitability, funding, capital, and liquidity. Fitch's bank ratings range from A to F, where A is a very strong bank, B is a strong bank, C is an adequate bank with some issues, E is a bank with serious problems, F is a bank which has defaulted or would have defaulted without external support.

To rate insurance companies, Fitch uses a proprietary model called "prism" which 1) uses country specific data to model liabilities 2) assesses the effect of interest rate changes, evaluates the benefits of diversification, and includes historical loss default percentages. Fitch ratings in order from best to worst are AAA, AA, A, BBB, BB,B, CCC,CC,C,RD and D. These are long term ratings based on a company's perceived ability to pay financial obligations.

[26] Source: http://www.fsa.gov.uk/Pages/About/What/International/basel/index.shtml

AM Best
AM Best's Capital Model is similar in design to the NAIC RBC model. The types of risks are similar. The formula itself is also similar. Both take the square root of the squared numbers after adding half of the credit risk to the reserving risk. Of the four rating agencies, AM Best is the one with the most experience in rating insurance companies.

Moody's
Moody's issues bank scores that measure a bank's probability of needing assistance. Moody's bank ratings from best to worst are the following. A,B,C,D,E where a bank rated "E" is most likely to need assistance to meet obligations.

Moody's insurance ratings from best to worst are the following: Aaa, Aa1, Aa2, Aa3, A1, A2, A3, Baa1, Baa2, Baa3, Ba1,Ba2,Ba3, B1,B2,B3,Caa1,Caa2,Caa3,Ca and C. Ratings Baa3 and above are considered investment grade. An insurance company with a rating of C is likely in default. Moody's also has three special rating WR – Withdrawn Rating, P – Provisional and NR – Not Rated.

6. Other

Pension Schemes
Pension Schemes are currently outside the scope of Solvency II although there has been much debate of whether or not they should be included. For the time being most pension schemes will not be covered by Solvency II.

Much of the pensions risk management currently taking place in the European Union is a result of realization at board level of the substantial market and longevity risk that many corporations find themselves exposed to now that accounting standards are forcing disclosure of pension liabilities.

As in the U.S., the U.K. has created a pension insurance agency called the Pension Protection Fund in order to insure against pension fund deficits.

Asset Management
In the European Union the Investment Management sector is largely regulated by the Markets in Financial Instruments Directive (MiFiD[27]).

Other Countries[28]
These are countries outside of the European Union and North America who have some sort of RBC style system.

- Australia
  - Similar to Solvency II. Liability valuation, risk categories, a factor based prescribed method and internal models.
- Canada
  - A factor based system. Risk categories, minimum capital test, dynamic capital adequacy testing, minimum continuing capital and surplus requirement on ratings.

[27] See http://ec.europa.eu/internal_market/securities/isd/index_en.htm
[28] Source: "Solvency" by Arne Sandström

- Singapore
    - Valuation of assets and liabilities, risk categories, and a risk based capital system.
- Switzerland
    - Valuation of assets and liabilities, risk categories, standard model, scenario testing to determine the target capital and internal models.

Appendix 5 – Relevant insurance accounting standards

The world appears to be moving toward one more-or-less uniform accounting basis. The change in the accounting basis does little to change the risks. However, it changes the format in which risks are reported and/or calculated.

International Accounting Standard Board (IASB)

IFRS 4 (Current) – Insurance Accounting
http://www.iasb.org/NR/rdonlyres/7A2F4D0E-F097-4DB6-9EDE-9B861219E8EC/0/IFRS4.pdf

IFRS 4 Phase II – Insurance Accounting Discussion Paper
http://www.iasb.org/NR/rdonlyres/08C8BB09-61B7-4BE8-AA39-A1F71F665135/0/InsurancePart1.pdf

IFRS 7 – Disclosure of Financial Instruments
http://www.iasb.org/NR/rdonlyres/751CAE70-F5AB-4D13-AC36-D8A052AEB8FC/0/IFRS7.pdf

IAS 19 – Pension Scheme Accounting
http://www.iasb.org/NR/rdonlyres/143A8F89-C7E7-4DFB-8603-065D5F73043E/0/IAS19.pdf

United States

Currently within U.S., insurance companies are required to balance their books in two different accounting systems.

- **U.S. Statutory**: For most P&C lines of business, losses are not discounted, consequently there is an implicit risk margin included in their reserves. For life and annuity products, the losses are discounted at prescribed valuation interest rates. U.S. Statutory reporting, however, is going through a significant reform currently and it is marked by the movement to so-called "principle based approach". As of 2009, most U.S. states have implemented the "first generation" principle based regulation covering certain variable annuities business on the reserving (called actuarial guidelines 43) and required capital quantifications (called C3 phase 2).
- **U.S. GAAP**: Losses are discounted and there is no implicit or explicit risk margin (except for certain traditional life products). For certain traditional life products such as whole life and term life, they are valued under the GAAP standard FAS 60, where a provision of adverse deviation is required for prudence. This provision could be considered as a margin for future uncertainties. However, it is not a true risk margin.

Appendix 6 – Some Concepts on Economic Valuations

Concept of Replicating Portfolio

The concept of a replicating portfolio attracts more and more attention in recent years, especially in Europe. The replicating portfolio is constructed to mimic the liability cash flow payoff by using simple types of asset classes such as bonds, equities or options. For example, in the case of a simple form of term insurance, the replicating portfolio could be constructed with risk free government bonds. The market value of this replicating portfolio could be viewed as the market value of the underlying insurance liabilities.

The value of the replicating portfolio reflects the present value of their insurance cash flows arising from underwriting activities (without taking any financial risks) discounted at the risk free rate plus a margin that reflects the risks or costs in pure underwriting activities. Then the replicating portfolio is "lent" to asset managers as their "liability." The replicating portfolio also becomes the benchmark for the asset management performance measurement. To the extent that asset managers purely invest in the replicating portfolio, there is no economic value added, as the same effect will be felt on both the liability and asset side. To the extent that asset managers can beat the benchmark at a risk-adjusted basis, they are adding value to this company.

Replicating portfolio can be constructed by optimizing the asset allocations via minimizing the cash flow differences from asset and liabilities under various economic scenarios. Mean-Variance techniques can be leveraged with computing program to determine the optimized asset class allocations (such as zero coupon bonds, equities, interest rate swaps, swaptions, etc). Generally the optimizations have constraints such as regulatory requirements on investment limits and risk capital requirements.

Two Distinctive Views on Economic Capital

There are two distinctive views on defining economic capital:

- **The liability run-off view of economic capital**
  This is perhaps the most familiar view to life insurance actuaries, assumes insurance companies keep and maintain the insurance contracts they have entered into with their policyholders until contract termination due to maturity, death, surrenders, annuitization or replacement. With general insurance this is to the extinction of liabilities. Under this view, both regulators and policyholders are afforded security (with a certain level of confidence) that insurance companies are able to cover their future obligations over the lifetime of the pooled contracts.
- **The exit value view of economic capital**
  This treats the insurance contracts as pooled risks that could be transferred to other market participants. In order for another market participant to accept (purchase) the contractual rights and obligations of the pooled insurance policies at a reasonable price, an insurance company has to set up and incorporate a certain level of risk allowance. These risk allowances compensate the other market participant for taking over the risks associated with the transferred business. For life insurance business,

these risks include not only the volatilities in earnings and the risk that the expected value of future obligations is incorrect, but also guarantees and options provided to policyholders as well as any frictional costs, illiquidity, operational risks, paradigm shifts and "black swan events." Under this view a regulator can transfer the liabilities of an insolvent insurer to one that is solvent.

Appendix 7 – Specific Risk Metrics

Note – This section only listed various risk metrics without further expanding the definitions and applications.

Management Risk Appetite Style Risk Metrics

- Value (or Earnings) at Risk (VaR)
- Expected Shortfall (or Value or Earnings) (CTE) [29]

Typical Regulatory / Rating Agency Risk Metrics

- Value at Risk
  - UK ICAS (Pillar 2) Regime
  - Proposed Solvency II Standard
  - South Africa (new PGN-110)
- Expected Shortfall (CTE)
  - U.S. C3 phase II and Actuarial Guidance 43
  - South Africa (old PGN-110)

Solvency Capital adequacy

- RBC ratio (United States)
- Capital adequacy ratio (Europe)

Hedging Style Risk Metrics

- Modified duration
- Effective duration
- Key rate duration
- Convexity
- Greeks
  - Delta
  - Gamma
    - Cross-Gammas
  - Vega
  - Theta
  - Rho

Investment Management Style Risk Metrics

- Alpha
- Beta
- Sharpe ratio

Pure Statistical Risk Metrics (Distribution Moments)

- First
  - Mean

[29] See http://sbo.nn.k12.va.us/cte/documents/CTEnewsletter.pdf

- Second
  - Standard Deviation
  - Covariance
  - Semi-Deviation
- Third
  - Skew
- Fourth
  - Kurtosis

Extra Material

Useful Reference:

1. "An Introduction to Risk Measures for Actuarial Applications", by Mary Hardy[30]
2. "Risk Management Metrics to support Key Business Decisions", by Fred Tavan[31]

[30] See http://www.casact.org/library/studynotes/hardy4.pdf
[31] See http://rmtf.soa.org/rmtf_rmm.html