Specialty Guide on Economic Capital

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I. Foreword

This Specialty Guide on Economic Capital is a work in progress. It was made available in June of 2003 by members of the Economic Capital (EC) Subgroup of the Society of Actuaries Risk Management Task Force (RMTF) as an indication of the Subgroup's progress since its formation in the Spring of 2002, and to stimulate wider discussion of the issues raised in the report.

Acknowledgments go to the following members of the EC subgroup for their active contributions in completing this report:

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This update reflects a few corrections discovered since the original release of the Guide. We would like to point out that this document will continue to be updated periodically, as new experience emerges. Please direct any comments to Hubert.Mueller@towersperrin.com. We welcome your feedback.

Finally, special thanks go to Valentina Isakina (SOA Liaison) and Julie Young (SOA Support) for their assistance in coordinating the efforts of our subgroup.

Hubert Mueller

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II. Introduction and Overview

This Specialty Guide is designed to be a source of information for practitioners interested in:

- Learning more about the subject of *Economic Capital (EC),*
- Finding out about current market practices in this area, and
- Getting acquainted with available literature on this topic.

The Specialty Guide has been put together by members of the Economic Capital subgroup of the Risk Management Task Force, using the results of a 2002 Survey on Economic Capital conducted by the subgroup, and their experiences with Economic Capital. We would like to point out that this Specialty Guide is not intended to represent only Best Practices in the marketplace, but rather to outline current practices commonly in use. Best Practices will be described in a subsequent paper on this topic (yet to be developed).

The Specialty Guide addresses the following topics:

- Definition of Economic Capital,
- Uses of Economic Capital in the current marketplace,
- Tie-in of Economic Capital to Regulatory / Rating Agency Capital,
- Current approaches to calculating Economic Capital, and
- Current approaches to allocating Economic Capital.

A summary of the answers obtained from the industry survey, as well as a review and discussion of available literature is provided in two separate Appendices.

We would like to point out that the EC subgroup maintains an updated version of this Specialty Guide on its website, which is available by going to the RMTF page on the SOA's website (http://www.soa.org/sections/rmtf/rmtf.html), or by going to the Economic Capital Calculation and Allocation (ECCA) subgroup webpage at http://www.soa.org/sections/rmtf/rmtf_ecca.html. Please refer to this website for any recent developments by this subgroup.

III. Executive Summary

Economic Capital ("EC") has become a topic discussed at various industry conferences, received attention by regulators and rating agencies, and has shown up over the years in various other disciplines, in particular in the banking industry. While the topic is becoming more mainstream, a standard definition of EC is not readily available, as shown by the wide variety of responses to our Economic Capital Survey. While specific definitions vary, some common threads tie the various descriptions together:

- Sufficient surplus to cover adverse outcomes,
- A given level of risk tolerance, and
- A specified time horizon.

An assortment of risks and various tolerance levels utilized by companies are listed in this document, based on the survey results. Although virtually all types of risks are mentioned, development work to date has been more focused on financial risks, and therefore the document primarily explores these in more detail.

While Regulatory and Rating Agency Capital have fairly well defined uses (i.e., determining solvency and creditworthiness of an organization), Economic Capital impacts many company business management and decision-making processes. EC can also have quite a few macro applications within a company. For example, a company can be "sliced-and-diced" into its various product lines, and then risk attributes and contributions can be determined. Once this has taken place, the next step some companies take is to allocate capital using an "optimal" mix in a capital budgeting process to determine the business lines in which to invest more (or less). In evaluating a company in an M&A situation, one supplemental method would be to look at the EC in the context of the new organization. EC can also be used to actively manage and measure risk across an organization (i.e. in an ERM or ALM context). Lastly, some companies may use EC on a more passive basis in their financial and management reporting.

From a micro perspective, product pricing using EC can be a useful way of comparing different business lines to each other while controlling risks by using it to set risk tolerances and

constraints. Additionally, depending on the specific goals of a company, incentive compensation and performance measurement can be based on EC.

The possible approaches for calculating EC are probably as numerous as the various definitions. Many of the methods described in this document would be familiar to most actuaries. Scenario-based methods would include running full economic scenarios, certain stress test scenarios or using a random scenario generator/stochastic model. In addition, Regulatory Capital for variable annuity products with guarantees will be defined using stochastic scenarios (RBC C-3 Phase II). Other methods would include factor-based tables, mean-variance-covariance models and option pricing theory. Some practical examples are explored and a theoretical method is supplied in the appendices.

When more than one motivation or method exists for capital calculations, companies will invariably find themselves with different required capital figures that need to be allocated within the company. While EC differs from Regulatory or Rating Agency Capital due to different drivers, that is not to say that they are not related (due to the external requirement to at least hold the Regulatory and Rating Agency Capital). If Regulatory and Rating Agency Capital is higher than Economic Capital, the extra amount (or "face capital") has to be allocated somewhere within the company, while actively optimizing this difference. There are several methods available, ranging from top-down approaches that either keep the face capital in the corporate line or allocate it based on a pro-rata calculation, to bottom-up approaches that treat each line of business as a separate entity and allocate on a marginal basis. In bottom-up methods, a further decision has to be made for the allocation of diversification benefits.

As discussions on EC evolve, progress, and converge, best practices will inevitably begin to be developed. For example, the banking industry has been focused on this topic for a longer period of time, so it may be beneficial to leverage their experience in developing best practices for the insurance industry, while at the same time recognizing key differences that will need to be addressed. We note that the International Association of Insurance Supervisors (IAIS) is currently discussing the issue of determining the "right" amount of capital, given a company's risks. Actuaries should take the lead in gathering information and addressing the differences from the banking industry so that such best practices can be shared and improved upon.

We will continue to explore these issues going forward.

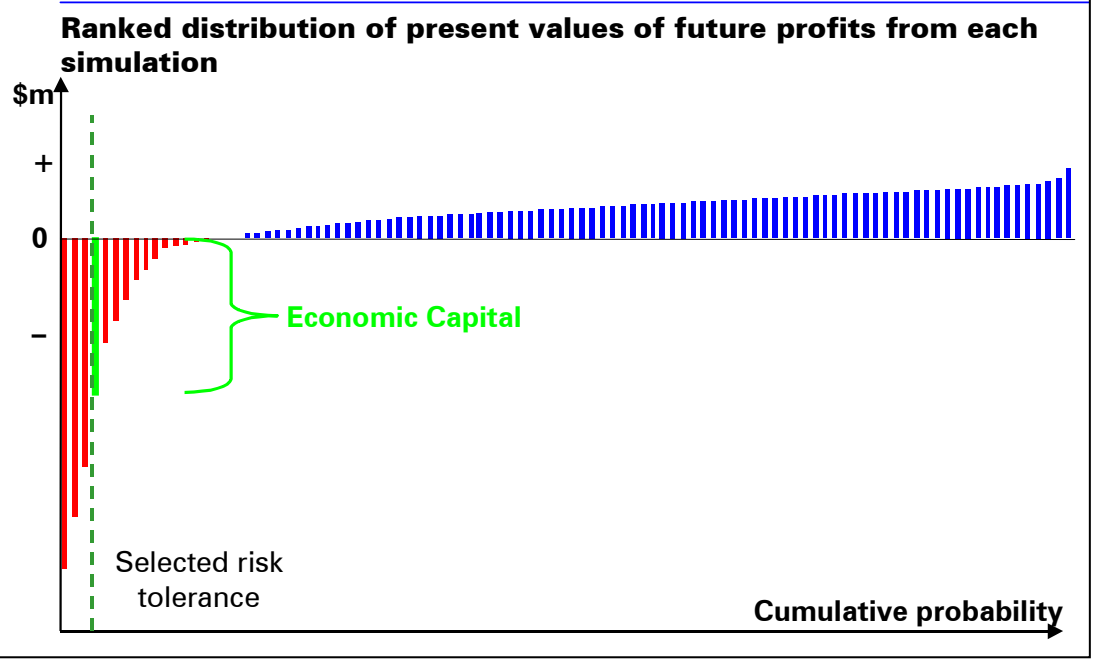
IV. How Do We Define Economic Capital?

(a) Overview

At its most basic level, Economic Capital can be defined as sufficient surplus to cover potential losses, at a given risk tolerance level, over a specified time horizon. This is the working definition we will use throughout this Specialty Guide, adding details as needed for specific applications. We will also acquaint the reader with alternative definitions currently in use in the marketplace, based on the survey conducted last fall.

Graphically, Economic Capital can be illustrated as follows:

FIGURE 1: Determining Economic Capital for selected risk tolerance level



We would like to distinguish Economic Capital from Regulatory or Rating Agency Capital. Economic Capital is based on calculations that are specific to the company's risks, while Regulatory or Rating Agency Capital formulas are based on industry averages which may or may not be suitable to any particular company. In this document, we have avoided use of the

terms “Risk-Based Capital” and “RBC”, which are often used to imply “Regulatory Capital.” In our opinion, a company’s particular risks are more properly reflected in Economic Capital rather than in Regulatory Capital. This is discussed further in Section VI.

We found that there is no one consistent definition of Economic Capital in use in the marketplace. Definitions in use are numerous, but the following three main definitions, developed from the many responses to our survey, demonstrate the main themes of the various practical alternatives currently in use.

TABLE 4.1

Alternative Definitions of Economic Capital *

Definition #1	Economic Capital is defined as sufficient surplus to meet potential negative cash flows and reductions in value of assets or increases in value of liabilities at a given level of risk tolerance, over a specified time horizon.
Definition #2	Economic Capital is defined as the excess of the market value of the assets over the fair value of liabilities required to ensure that obligations can be satisfied at a given level of risk tolerance, over a specified time horizon.
Definition #3	Economic Capital is defined as sufficient surplus to maintain solvency at a given level of risk tolerance, over a specified time horizon.

* Based on 77 responses to the EC Survey (2002)

While Definitions #1 and #3 refer to “sufficient surplus”, Definition #2 instead focuses on the characteristics of the assets (market value) and the liabilities (fair value) that define this surplus.

Each definition presents a different expression for the adverse outcome that the Economic Capital is intended to protect against. Definition #1 refers to “potential cash flows and reductions in value of assets or increases in value of liabilities.” Definition #2 is concerned only that “obligations can be satisfied.” The goal of Definition #3 is to “maintain solvency.” These broad definitions seem to imply that all risks are to be taken into account. Types of risks covered are discussed in section (c) below.

We are aware of some companies (particularly those which are owned by banks) using earnings-oriented approaches for calculating Economic Capital.

All definitions above refer to “a given level of risk tolerance.” Methods of setting the risk tolerance levels are introduced in section (b) below.

All definitions above refer to a "specified time horizon." Specific choices of time horizons are discussed in the section entitled "Current Approaches to Calculating Economic Capital."

(b) Risk Tolerance Levels

Several methods are commonly used to set the risk tolerance levels, including:

- A specified percentile (e.g., 98th percentile), often related to the financial strength rating of the company, and
- Conditional Tail Expectation (CTE). CTE(n) represents the average of the (100-n) worst scenarios. For example, CTE(90) is the average of the worst 10% of scenarios.

The first approach is the one commonly used by the rating agencies, while the latter is being used in Canada, and will likely be used for setting regulatory capital requirements for variable products with guarantees ("RBC C-3 Phase II"), starting in 2004. This is further explained in Section VI.

A discussion of specific alternative risk tolerance levels is included in Section VII. That section also discusses misestimation and deterioration of the mean, as well as the assumption that the liabilities on the balance sheet "cover" the mean.

(c) Risks Covered

Our survey respondents seemed to support the idea that all risks faced by the enterprise should be considered in this calculation. One respondent referred to "all risks that can reasonably be measured"; and another, to "all risks that require money."

The following main risk categories were identified as relevant for calculating Economic Capital by the survey respondents (parentheses below shows the % of respondents that listed this risk as relevant to the calculation of Economic Capital):

- Interest Rate Risk (96%),
- Pricing Risk (93%),
- Credit Risk (92%),
- Equity Market Risk (91%),
- Liquidity Risk (86%), and

- Operational (Business) Risk (79%).

In determining the appropriate level of EC, the interaction among these risks should be considered. This could be accomplished by the use of either multivariate distributions or correlation factors.

Several respondents mentioned other liability risks that would need to be considered, including:

- Separate account risk, i.e., the risk of adverse market performance, which can lead to lower negative profit margins on equity-based products, as well as payouts under the death and living guarantees typically offered with such products, and
- Transfer risk, i.e. the risk of policyholders exercising their transfer rights under equity-based products to the detriment of the insurance company.

Also, several respondents mentioned that Economic Capital would need to account for "Capital on Capital,"[1] related to the assets backing Economic Capital.

One respondent specified that all operational risks should be included, and others referred to subsets of this category, as follows:

- All business risks (regulatory, political, tax, legislative, economic, overall market security),
- Strategic, marketing, diversification (or lack of), growth limit, product risk (obsolescence),
- Mismanagement, expense management, sales risk,
- Governance, audit risk, and
- Reputation risk.

The following asset risks were identified as relevant by one or more survey respondents: currency, financing, real estate and other asset values, asset/liability mismatch, liquidity, and reinvestment (prepayment) risk.

Several underwriting risks were listed as well: model risk, fluctuations under pricing risk, spread, mortality and other contingencies, concentration and unique sector risks.

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[1] While used by some companies, some of the members of this subgroup felt strongly that "Capital on Capital" is not needed.

There was considerable focus on the type of risk variously known as catastrophic, event, unidentified, chaos, or random risk.

We would like to point out that while the calculation of Economic Capital does not necessarily exclude any of these risks, this Specialty Guide focuses primarily on financial risks. The reader is encouraged to consult the work of the Enterprise Risk Management subgroup for further details on non-financial risks.

V. Uses of Economic Capital

(a) Overview

In practice, there are several important types of capital requirements, including Regulatory, Rating Agency, and Economic Capital.

- Regulatory Capital requirements are minimums established explicitly by the regulatory agencies that hold jurisdiction where the company has major operations,
- Rating Agency Capital requirements are those using prescribed formulas which, in large part, determine the company financial strength ratings assigned by such organizations as A.M. Best, Moody's and Standard & Poor's, and
- Economic Capital requirements are those derived from explicitly stated financial objectives or constraints which are proprietary to the company's risks, such as those defined in Section IV.

These various capital requirements are not completely independent. More importantly, all capital requirements can be converted to an Economic Capital equivalent by imputing their probability-of-ruin implications, for example. The utility and relevance of this conversion is discussed in the following two sections.

Companies that favor using Economic Capital cite several reasons, including:

1. Economic Capital reflects the underlying economics of the business as opposed to political and rating agency conservatism,
2. Regulatory and Rating Agency Capital may actually not allow for some of the risks a company faces, such as interest rate guarantees, guaranteed surrender values and a whole range of operational risks,
3. Since Regulatory Capital varies by political jurisdiction, if a large institution working across many jurisdictions were to make decisions based on Regulatory Capital requirements, it may have different strategies for each region. This would amount to running a number of smaller independent institutions and result in a forfeiture of gains from economies of scale,

4. There are opportunities to hedge the difference between Regulatory and Economic Capital. This is accomplished through "rule arbitrage," i.e., by shifting risks into different jurisdictions with different capital requirements through the use of reinsurance, captives, etc., and

5. Economic Capital can more directly be compared across lines of business, e.g., banking products versus insurance products.

(b) Survey Feedback

Three questions on the recent industry survey addressed the use of EC by today's actuaries. The most basic question--whether you have "been using the concept of EC at your company or in your consulting work"--saw a nearly even split between Yes and No, with slightly less than half of the 500 respondents reporting that they are currently using EC. Among those who used EC, their main reasons for using EC included "To provide management with the knowledge that risks were being adequately managed and sufficient surplus was available" (45%) and "better measurement of the performance of different business units" (33%). Less than 15 percent of the respondents said that they were using EC primarily for due diligence analysis, or to discuss excess capital with regulators and rating agencies. EC thus seems to be used more as an internal management tool than as a tool to communicate with external audiences.

Comparing answers to whether the respondents currently use EC and what the plans are in the future reveals a definite increasing trend in the use of EC, as shown in Table 5.1 below.

TABLE 5.1

Current and Planned Uses of EC

35%	Using now; anticipate same or greater significance in the future
29%	Not using now; anticipate it will have greater significance in the future
25%	Uncertain about future role
9%	Not using now; not anticipating to use in the future
1%	Using now; anticipate less significance in future

The heaviest users of EC are in diversified financial institutions, followed by life and annuity writers. EC seems to have greater acceptance and application in the non-insurance financial world and is still establishing a foothold with pure insurers. Consultants indicate they use EC concepts in their work comparatively less than the insurance employees; they are also less likely to indicate anticipation of greater use in the future.

Stock and mutual organizational structures elicited surprisingly similar response patterns. Nearly identical percentages of each (45% stock, 44% mutual) indicated they currently use EC concepts in their work, and approximately 65% anticipate greater use in the future. However, the primary use of EC does differ markedly. The majority of stock companies use EC primarily to give comfort to management that risks have been adequately managed. The majority of mutual companies use it primarily for identifying excess capital to regulators and rating agencies. Both mutual and stock companies listed performance of business units as a secondary reason.

The national scope of a company (Canadian, US, both, or multinational) seems to have little bearing on the prevalence of EC. However, larger companies by asset size tend to be more likely to use EC. This gap seems likely to widen in the future, since 70% of the largest companies indicate they anticipate greater significance of EC in the future while only 50% of the smallest company size do.

(c) Applications

Given this overview of how prevalent the general use of Economic Capital is, we now examine its specific uses and applications. The following list is not intended to be exhaustive, but it does capture the major uses of Economic Capital in today's insurance industry environment:

1. Determination of the Company or Product Risk Profile

A full risk profile for a company or product will include information about the short and long term exposure to large losses and to unacceptably high fluctuations in earnings as well as the impact of specific stress and/or liquidity tests. Economic Capital is one part of that risk profile, addressing the need to look at large amount, low probability losses over either a short or long term time horizon. Results for each activity, product, and/or business and in total can then be compared to assess the reduction in Economic Capital resulting from diversification among activities, products, and/or businesses. The amounts of Economic Capital are then displayed on

a chart that also shows the amount of reduction in capital due to the lack of correlation among activities. In Table 5.2 an illustrative set of values is shown for a company with three major products, “A”, “B”, and “C.”

TABLE 5.2

Example of Economic Capital (EC) by Product

Division	Market (Equity)	Market (Interest)	Credit	Insurance	Oper-ational	Gross Capital	Correlation Adjustment	Net Capital
Prod A	1	5	0	1	1	8	(1)	7
Prod B	0	12	13	0	5	30	(4)	26
Prod C	0	2	1	8	3	14	(3)	11
Total Product EC	1	19	14	9	9	52	(8)	44
Surplus Capital	1	2	3	0	1	7	N/A	N/A
Total EC	2	21	17	9	10	59	(14)	45

Each of those products has different levels and concentrations of Economic Capital. For each product reading across the row, the table shows the Economic Capital from each risk category, where the value is determined as if that risk were the only risk exposure of the entire company. Those values sum directly to the “Gross Capital” column. Then the column labeled “Correlation Adjustment” indicates the degree to which Economic Capital is reduced because of imperfect correlation of the different risks influencing the specific product. The “Net Capital” column then represents the Economic Capital that would be required if that product in its entirety were the only risk of the company. In addition, the Economic Capital for the investments backing the surplus of the company is shown. Depending on the company preference in presentation of Economic Capital, this can be all surplus or the surplus that is in excess of the surplus allocated to the product lines. When all product and surplus risks are taken into account, the table shows the total company Economic Capital by risk category and on a gross basis as well as the degree of reduction due to imperfect correlation of all risks.

This type of information can be used in other EC analyses, such as the capital budgeting process, determining appropriate risk limits, and especially in formulating strategies for investing the surplus of the company--which can be a major lever in the management of the company’s risk profile.

2. Capital Budgeting

Some companies have a capital budgeting and long range planning process that recognizes Economic Capital as a scarce resource requiring a systematic budgeting process. Under such a process each business unit submits a long range financial forecast that includes the level of projected profits as well as the net amount of capital that either is needed from the company to fund its plans or that can be released from the business to fund other company plans.

Sales of most insurance company products result in an increase in the amount of capital needed by the business due to low or negative initial profits and the need to support the new business with Economic Capital. After the year of issue, most insurance company products will show annual releases of capital both due to the earnings of the product as well as the release of supporting capital that is no longer needed due to lapses. The net capital needs of a business arise when growth (new sales less terminations) is high and/or profits are low and capital is released when growth is low and/or profits are high.

The definition of the capital needs for a product is the same as the definition of distributable earnings for an entire business: projected earnings less the increase in Economic Capital. The capital budgeting process will then focus on obtaining the right mix of short and long term returns for the capital that is needed for each set of business plans.

Both new and existing products can be subjected to this capital budgeting discipline. A forecast of capital usage by a new product can be developed and used as a factor in deciding which of several new products to develop. In considering new and existing products, capital budgeting may involve examining historic and projected financial returns.

3. Evaluation of Required Capital in M&A Situations

Many companies recognize the same type of cost of capital that is included in product pricing when they are evaluating potential M&A situations. The acquisition event triggers a need to establish the Economic Capital for the business acquired and is therefore included as a part of the initial cost of the transaction. Acquirers will look carefully as to whether they can afford to establish the full Economic Capital of the acquired business in addition to maintaining their own Economic Capital.

In a situation where multiple companies are evaluating a potential acquisition the company having the lowest correlation of risks with the acquired business will have the lowest marginal

cost of capital. For example, a company with a high degree of asset-based credit or market risk might have low marginal capital requirements in acquiring a business with high insurance risks that are not correlated to the financial markets or to credit cycles.

In the due diligence phase of an acquisition, the Economic Capital calculation process comes under intense scrutiny and is seen as one way to uncover the real risks of the potential acquisition.

4. Insurance Product Pricing

Many companies use allocated capital as a component in their pricing process. The difference between the after-tax returns on the assets backing allocated capital and the pricing hurdle rate is recognized as a cost in pricing under many companies' pricing processes either directly or indirectly.

In the indirect approach, the product pricing model recognizes the establishment and later release of Economic Capital as one of the annual product flows that make up the distributable earnings for the product. Annual distributable earnings are defined as the reported profits of the product model less the increase in the Economic Capital for each year. Once the Economic Capital is established, it is considered a part of the invested assets for the product and investment income is earned on those assets. However, this investment income is fully taxable. When the annual distributable earnings are discounted at a "cost of capital" or hurdle rate, the cost of capital indirectly depresses the results. Additions to the level of Economic Capital will decrease the present value of distributable earnings (or the Return on Investment which is the internal rate of return on the distributable earnings).

Under the direct approach, the difference between the after tax earnings rate on the assets backing Economic Capital and the hurdle rate is determined directly and calculated either as an annual charge or as a percentage of a present value of whatever factor(s) are used to approximate Economic Capital. For example, if the hurdle rate is 15% and the asset earnings rate is 10% and the tax rate is 35%, then the net annual cost of Economic Capital is {15% - 10% x (1 -35%)} = 8.5% of Economic Capital. If capital is approximated as 5% of reserves plus 10% of net amount at risk for a life insurance product, then the annual cost of capital will be 0.425% of reserves plus 0.85% of net amount at risk.

This is less common in short-term health insurance products where traditionally pricing centers on a loss ratio approach. Economic Capital and cost of capital cannot be easily incorporated into the loss ratio models. Health actuaries in companies where the Economic Capital approach is required will sometimes do their pricing on a loss ratio model and then develop the distributable earnings model as an alternate display of product pricing. However, the direct approach described above can be used when Economic Capital is approximated by a direct percentage of premiums or claims.

5. Risk Tolerances and Constraints

Some companies monitor Economic Capital with the idea of imposing tolerances and constraints on risks. This is an especially useful way to limit risk when the Economic Capital calculation process is responsive to actual variations in risk levels, rather than just to business volumes. For example, if management of a fixed annuity product line decides to change its investment strategy to a lower quality level its risk has increased. An Economic Capital calculation process that immediately reflects that increase in risk can be used to limit risk. That business can have an Economic Capital budget which allows writing a larger amount of lower risk business or a smaller amount of higher risk business.

This process of limiting risk will sometimes apply only to specific lines of business or within lines of business. Situations are chosen for these limits because they are seen as the most capital intensive activities.

6. Asset/Liability Management

Economic Capital is used by a few companies as a measurement of the effectiveness of Asset Liability Management (ALM) strategies. One of the objectives of the re-balancing process may be to maintain or re-establish the Economic Capital for a block of business at a target level, usually as a percentage of liabilities. Since the recent C-3 Phase I capital requirements are stated in terms of a calculation that is very much like an Economic Capital calculation, a rational goal for a company's ALM process might be to obtain the highest projected profits for a block where the Economic Capital is maintained at the lowest regulatory capital level allowed. In this situation the minimum EC is bound by the minimum regulatory capital. Also, ALM efficient frontier analysis could be used to determine if the capital at the minimum is sufficient, based on a company’s risk tolerance and constraints. Therefore, the “best” optimization situation is to

maximize profits when the internal estimate of EC is equal to the minimum National Association of Insurance Commissioners (NAIC) RBC level.

7. Calculating RAROC

Many companies use allocated Economic Capital in the determination of Risk Adjusted Capital, which leads to calculations of RAROC (Risk-Adjusted Return on Capital). These then are the primary measures of short term financial performance. Such RAROC measures are integral for comparing different product lines as well as comparing insurance and non-insurance-risk products, such as a subsidiary TPA.

Developing RAROC measures is a multi-step process. First, the overall required capital position of the company must be determined. Second, capital must be allocated to the various product lines and business units. Finally, a method of reconciling the total company capital with the allocated division amounts must be employed. Depending on the calculation method and the means of handling risks associated with surplus, the sum of the individual product risk adjusted capital amounts may be less than or greater than the company-level capital.

Typically a corporate area will calculate the RAROC figures. Communicating these results to the operating areas is integral to be sure they understand the target returns to which management expects products to perform. Additionally, including capital costs and target returns with product pricing requires that those involved in the pricing agree with the capital calculations being performed for RAROC.

8. Performance Measurement

A growing number of North American life insurers are implementing embedded value (EV) reporting techniques to gain a better understanding of their company's value creation over time. When calculating EVs, companies incorporate the cost of required capital into the values shown for the in-force and new business. [Note: a separate subgroup of the RMTF has recently been formed, with a goal of conducting further research on EV.]

When defining required capital, companies have traditionally used Regulatory or Rating Agency Capital formulas. Increasingly, companies are employing Economic Capital approaches in determining the appropriate level of required capital when calculating EVs, as these are deemed to be more representative of the company's actual cost of capital.

Some companies, particularly multinationals, have gone beyond traditional embedded value approaches and incorporate more enhanced stochastic analysis to better measure the cost of options and guarantees provided in the company's products. Actuarial literature has referenced this type of enhanced EV as "Economic Value", and the value generation as "Economic Value Added".

The philosophy underlying the calculation of Economic Capital is consistent with the methodology used to calculate Economic Values. Economic Capital thus supports the demand for greater internal and external financial transparency in the current marketplace.

9. Incentive Compensation

Very few companies were found to reflect their Economic Capital levels in their incentive compensation. In those cases, the incentive compensation is determined primarily from other measures and has an adjustment based on a range of acceptable ratios of actual capital to Economic Capital at the end of the year. In theory, actual product Risk-Adjusted Return on Capital (RAROC) compared to target levels would make a more meaningful basis than the more common target dollar amounts of gain for both incentive compensation and performance review purposes. Perhaps the relative newness of Economic Capital as well as its complexity and reliance on model projections prevent it from being widespread. A measure whose underlying calculations are understood by few and whose measurement methodology is based on assumptions about future events may not be an appropriate basis for salaries and bonuses.

10. Rating Agency and Regulatory Discussions

All companies monitor their actual capital in comparison to their Regulatory Capital. Most companies carefully monitor and frequently discuss their Regulatory Capital position in comparison to their Rating Agency Capital with rating agencies. The monitoring and projection process of both Regulatory and Rating Agency Capital amounts can serve as the basis for a better understanding of how Economic Capital can be measured. This in turn may lead to changes in the formulas used for a company’s own internal Economic Capital calculation.

Individual companies may disagree with the required capital derived from the regulatory and rating agency processes. However, regardless of differences between internal Economic Capital and external ones, companies may have their management decisions guided somewhat by the external measures. For example, a given merger may seem appropriate from an internal

perspective based on the M&A evaluation but the external measures may calculate the added business in a different manner that results in an undesirable required capital. Reconciling the differences between external and internal Economic Capital measures can be cumbersome but is necessary for management's full understanding of how to evaluate a company and its products.

No companies were found to have discussed their internal Economic Capital position with regulators.

A recent trend has been for external measures of Economic Capital to adopt more complex (and hopefully more meaningful / realistic) methods. For example, the NAIC RBC calculation is in a two-phase process of enhancing its "C-3" (interest rate) risk measurement. Also, A. M. Best is moving towards an "Enterprise Risk Model" (ERM) to supplement its Capital Adequacy Ratio. Such enhancements of external measures may not bring them more in line with internal calculations but this does not preclude there being improvements.

Standard & Poor's has created a dynamic model called "Financial Product Capital (FPC)" to measure the required Economic Capital. This dynamic model has been applied to non-insurance "books" (e.g. GIC, MTN programs, credit derivatives), quantification of financial and credit market risk mitigation strategies (e.g. OTC and exchange traded market and credit derivatives), certain "one off" structured capital market transactions, and financial product company subsidiaries or credit enhanced vehicles. The capital adequacy determined by the FPC Model is intended to replace the capital adequacy requirement historically derived using the Standard & Poor's capital adequacy model for the specified "book." Standard & Poor's wants to provide the flexibility to model the required capital based on economic exposures instead of industry-based factors for companies that demonstrate to have sophisticated risk management practices.

The main rationale for these new models and methodologies are:

1. Increased sophistication of risk management practices at insurance companies,
2. Failure of factor-based approaches to properly deal with the risks inherent in current products and investment strategies,
3. Inquiries from companies seeking quantitative recognition of risk management practices including quality of their product structures, and
4. Pressure on companies to optimize their capital base.

Although the rating agencies use various tools such as risk-based capital model to calculate the required capital position, it is only a starting point to the capital adequacy. Qualitative and other quantitative factors are used to derive a more complete picture of an insurer's capital position and its comparability to similar peers in the industry.

This is further discussed in Section VI.

VI. Tie-in of Economic Capital to Regulatory/Rating Agency Capital

This section deals with the inevitable fact that the Economic Capital calculated using an internal model would differ from the capital required by the regulator and the rating agencies. These differences arise not only because the methods for calculating them differ, but also because the motives behind the calculations differ. We will also discuss recent developments concerning Regulatory Capital.

(a) Motivation for Regulatory/Rating Agency Capital

Regulatory and Rating Agency Capital requirements are motivated fundamentally by solvency concerns. Rating agencies are also concerned with the level of financial strength and general creditworthiness of an organization. These ratings provide a prospective evaluation of an insurer's financial security to its policyholders and debt holders. Capital requirements are generally targeted using simplified methods (eg. factor approaches) at levels appropriate for the aggregate industry and cannot reflect the nature of the company's risks to the degree to which can be achieved through a customized internal model[2].

The motives behind calculating Economic Capital concern "appropriate" allocation of capital to the risks undertaken by the company. The level should be sufficient for a going-concern entity and reflect the degree of contribution of risk to the company. Holding too little EC threatens the ability of the company to meet its obligations; holding too much Economic Capital will unnecessarily reduce return on equity, and potentially distort rational economically-based decision making.

However, capital levels required by the regulator and rating agencies create an overall constraint as to the amount of capital held by the firm. Section VIII describes several methods a company may consider in recognizing these differences between Economic and Regulatory/Rating Agency Capital requirements, and allocate them to various lines of business or the corporate line.

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[2] There are some emerging trends in regulatory capital to be based on methods linked to internal models. These will closer align regulatory and economic capital levels.

(b) Recent Developments at the Regulatory Level[3]

There have been a number of articles recently detailing large losses and accelerated deferred acquisition cost (DAC) amortization related to equity-driven products. This has confirmed that better methods are required, both to value these product lines and to set capital requirements. There is a group developing such methods, and regulators are listening to their ideas. Sponsored by the American Academy of Actuaries (AAA) and chaired by Bob Brown, the Life Capital Adequacy Subcommittee's C-3 Work Group has recommended an approach for setting Regulatory Capital requirements for variable products with guarantees. It excludes index guarantees and has been dubbed "RBC C-3 Phase II".

Actuaries that work with annuity products may recall Phase I of this project. It uses interest rate scenarios to stress fixed annuities, using a company's actual mix of assets and liabilities. In both Phases of this project, an attempt is made to overcome the factor approach to risk-based capital. No company's block of business is "average." Using a company's actual mix of business, and running a broad range of scenarios, will develop a company-specific distribution of risk exposures. While the primary purpose of this project is to develop capital requirements, the methodologies are appropriate for pricing and risk management of many product lines. It is expected that the new capital requirements will be effective for year-end 2004. However, at least one rating agency has stated that they are looking to use the new guidelines when assessing capital requirements at year-end 2003.

The approach that has been recommended to the Life Risk-Based Capital Working Group (LRBCWG) of the NAIC uses the modified conditional tail expectation (CTE) measure. Actuarial certification of results will be required. Modeling hedges is allowed if the insurer is following a clearly defined hedging strategy. It is expected that a conservative factor approach will be allowed for minimum guaranteed death benefit (MGDB) blocks. An overview of the methodology is provided in the literature review (Appendix 3), page 2.

[3] A summary of a relevant article from Max Rudolph on the topic is included in Appendix 3, Review of Literature, page 2.

VII. Current approaches to calculating Economic Capital

This section of the Specialty Guide on EC is focused on describing various methods to calculate Economic Capital. The first sub-section gives a high level overview of possible alternatives to calculating EC, including a description of adjustments for correlation. Also, theoretical considerations involved in calculating EC are included in Appendix 1 of this Guide. The second part of this section contains several examples of EC calculations. The examples demonstrate the approaches that have actually been used by some companies in formulating their EC.

(a) Overview of EC Calculation Methods

There are a number of different approaches to calculating Economic Capital (EC). The different approaches have similar theoretical underpinnings and may be viewed as different paths to accomplish the same goal. Some approaches are more efficient in some situations than others. Moreover, one may find some methods more complicated than others. It is not uncommon to see companies using different approaches for different lines of businesses and/or product types. The decision is typically based on availability of data and resources as well as the materiality of the block of business to which a particular approach is applied. We have identified the following practical approaches to calculating EC[4]:

1. Full Economic Scenarios

This approach is useful in situations where the primary goal is to determine EC for all the risks combined. This method does not result in any explicit amount of EC that may be attributable to any particular risk.

Under this method, EC is calculated using the following steps:

- Corporate provides a set of economic scenarios to all business units. Scenario assumptions include interest, equity returns, inflation, defaults, and actual versus expected claims for various products. The correlations for the different factors are reflected in the manner that scenarios are constructed,

[4] We would like to point out that these methods are not meant to be mutually exclusive.

- Each business unit (BU) calculates their operating income and their surplus for each future scenario, for each future year, and
- Corporate aggregates the results of all BUs, ranks them and determines the desired percentile Value-at-Risk (VAR) or CTE.

Companies using this method may calculate the EC for operational risk at the enterprise level and allocate it to various BUs using any reasonable approach.

Another application of the Full Economic Scenario approach is to calculate EC by analyzing the change in the present value of future profits (PVFP) under different scenarios. The first step is to calculate the PVFP under a specified set of actuarial and investment assumptions. Let us call it the base scenario. Another set of assumptions is used to recalculate the PVFP. EC is then calculated using the difference between the PVFPs under different scenarios.

2. Stress Test Method

This is among the more straightforward methodologies and is related to the previous approach. Judgment usually plays a key role in applying this method. Generally, a highly adverse scenario is set as the basis for determining the EC. This method can be used for a single aspect of economic risk, such as mortality catastrophe risk or interest rate risk (like the New York 7 scenarios), or for a combination of economic risks.

3. Factor Tables

The mechanics of this method are similar to the US and Canadian regulatory capital bases. This method works as follows:

Models are used to develop factors for the various risks to which the company is exposed. The factors represent the Economic Capital for a particular type of risk (credit, market, insurance, operational) for a unit of a segment of company activity with homogenous risk characteristics. (for example, a factor of $0.50 per thousand of net amount at risk for all individual life insurance policies where the remaining term is less than one year),

- Company activity is summarized into these homogeneous segments and the number of units of each activity is determined,
- Units and factors are multiplied and summed to get the gross Economic Capital, and

- Adjustments are usually made for correlations to determine the net Economic Capital. Sometimes, a company may believe that they have not been able to determine the factors for all the risks and therefore, the calculated EC should not be reduced further.

The factor table is determined based on industry-wide or company-specific models of the Economic Capital needs per unit of activity. Using industry experience to determine the factors will likely result in EC close to Regulatory Capital levels.

4. Stochastic Models

Stochastic models are generally classified into one of two categories:

- Univariate Stochastic Model, or
- Multivariate Stochastic Model.

As the names imply, univariate models have only one variable and multivariate models have more than one. Multivariate models implicitly allow for covariance among the different variables being analyzed. On the other hand, a covariance adjustment has to be made outside the univariate models, to allow for the effect of diversification.

In this method, a scenario generator is used to create random scenarios and the actual capital needed under each scenario is calculated using an actuarial projection model. The resulting capital needs are ranked and Economic Capital is determined according to the chosen risk tolerance level, i.e. 95th percentile, 90% CTE, etc.

Example: Let us assume that a company wants to calculate EC for mortality and lapse risks using stochastic simulations. There are two alternates:

- *Develop two univariate models – one for mortality and one for lapse. This may be a reasonable approach in instances in which the company has a diverse range of products and multiple mortality and lapse tables have to be used. The stochastic model generates scenarios assuming that the various mortality and lapse tables represent means of the various assumptions. The simulations would result in probability distributions of the mortality and surrender benefit costs. The results will be adjusted outside the models to account for the covariance, or*

- *Develop a bivariate model – e.g., a model that reflects mortality and lapse risk simultaneously. Generally speaking, this approach is more feasible when the underlying mortality and lapse tables are few and straightforward. This approach has the benefit of calculating the covariance adjustment implicitly, so, there is no need to approximate covariance adjustment outside the model.*

5. Scenario Generator

In this method, a major economic risk is assumed to be a random variable or a function of a random variable. A random number generator is used to populate a time series for the target variable. The function and parameters of the function are chosen to fulfill a series of criteria - often called stylized facts. One such stylized fact relates to the relationship between the results and prices in the market.

The choices for scenario generators include "risk neutral" and "real world."

- Risk neutral means that the average present value of cashflows of some set of securities averaged over all of the scenarios is equal to the market price of those securities at time zero, and

- Real world means that the scenarios satisfy criteria that reflect the expectations of the modeler. Usually those expectations are one of three things: (a) scenarios reflect the historical average over some predefined period; (b) the average scenario reproduces the initial conditions, or (c) scenarios reflect some expected trend for the future.

6. Statistical Methods: Mean-Variance-Covariance Model

Under this method, the mean, variance and covariance of the distribution of gains and losses is developed using a stochastic model or other method. A normal distribution is assumed and Economic Capital is determined from normal distribution tables.

Example: Approximation for Mortality & Lapse Risk EC: The following approach may be used to approximate the amount of EC required to cover mortality and lapse risk.

- *Calculate the mean and variance of death and surrender benefits costs for each policy, eg:*

$$\text{Expected Death Benefit Cost } E[D] = \sum_{n} (\text{Dth Ben} - \text{actuarial reserve})_t * {}_tp_x * q_{x+t} * v^t$$

$$E[D^2] = \sum_{n} [(\text{Dth Ben} - \text{actuarial reserve})_t * v^t]^2 * {}_tp_x * q_{x+t}$$

Variance of Death Benefit Cost $Var[D] = E[D^2] - (E[D])^2$

Where n is the outstanding term of the policy.

- *Assume that all policies represent independent risks. If one is not comfortable with this assumption, then he/she may want to calculate the means and variances by coverage.*
- *Use the Central Limit Theorem to determine the distribution of the sum of all policies (or coverages), and*
- *Determine the covariance adjustment using the square root method.*

7. Credit Risk Methods: Frequency & Severity/Recovery Models

Such models are usually based on historical studies for rating classes. Correlations can be handled on a sector-by-sector basis, where companies within a sector would all be assumed to have the same default/recovery probability in any one time period and there would be a table of correlation coefficients among the various sectors.

The other credit risk model is called the Merton Model and is based on equity prices and the idea that the value of a stock is equal to a call option on the value of the firm in excess of the value of the debt. The Merton Model can be used to determine the probability of default based on the stock price, the debt level and the volatility of the stock price. Other models will then have to be used to project the loss, given default occurs.

8. Operational Risk Methods: Frequency & Severity / Recovery Models

These models for losses are based on company and/or industry data. Since data is scarce, various techniques are used to incorporate "expert" opinions into the data to create quantitative results. Those techniques include Stochastic Differential Equations, Multiple Regression, Neural Networks, Systems Dynamic simulations, Bayesian Belief Networks and Fuzzy Logic.

9. Option Pricing Theory / Black Scholes Model

This approach can be extremely effective in some situations. These situations include products where the insured event can be assumed to occur at only a certain point in time. The loss situation that attracts EC is reframed as an option and the option pricing models are used to back into the EC amounts.

Example: Automotive residual value insurance where the insurer guarantees to pay the difference between the actual wholesale value of the vehicle after x years and the guaranteed residual value. In such products, the insured can return the vehicle to the insurer only during a window of a few days after x years. For calculating reserves and EC, it is not unusual to assume that the vehicle maybe returned only on a certain date. This assumption greatly simplifies the model.

Under this approach, experience is used to determine the parameters of a Black Scholes model. Once the parameters have been estimated, stochastic simulations can be performed very quickly to determine the loss distribution. EC would typically be set equal to a certain percentile less the amount of actuarial liabilities.

For example, if a company can develop a multivariate loss distribution, then EC could be set equal to:

EC = CTE(x) – Mean of the distribution + Provision for error in estimation of and deterioration of mean,

where:

x is generally at least 90, and depends on the time horizon covered by the distribution. The shorter the time horizon, the greater the value of x, and vice versa.

10. Adjustments for Correlation

The amount of EC held at the company level usually includes an adjustment for correlation among the various risks. The adjustment may be explicit or implicit. Depending on the situation, adjustments for correlation may be done at a micro level or at a macro level or at both levels. Micro adjustments involve determining covariances among and between each and every risk factor at each level of risk. To construct the massive covariance matrices involved requires a tremendous amount of data.

For macro correlation adjustments, economic capital is calculated for each risk type - credit, interest, equity, insurance, operational, exchange rates (fx), etc. Then broad correlation between the risk types is used as the basis for combining risks. Companies involved in different businesses also take credit for the diversification benefit.

Example: Let's assume that a bank owns an insurance company. The goal is to determine EC for the entire enterprise. In the first step, EC will be calculated for the two entities – the bank and the insurance company. Each entity's EC will take into account the correlation among the different risks to which it is exposed.

However, the amount of EC required for the enterprise would be less than the sum of the ECs for the bank and the insurance company. This is due to the diversified nature of business. As a result, there would be another covariance adjustment at this level. The magnitude of the adjustment will depend on a number of factors, including the nature of the products and the client profiles of the banking and insurance businesses.

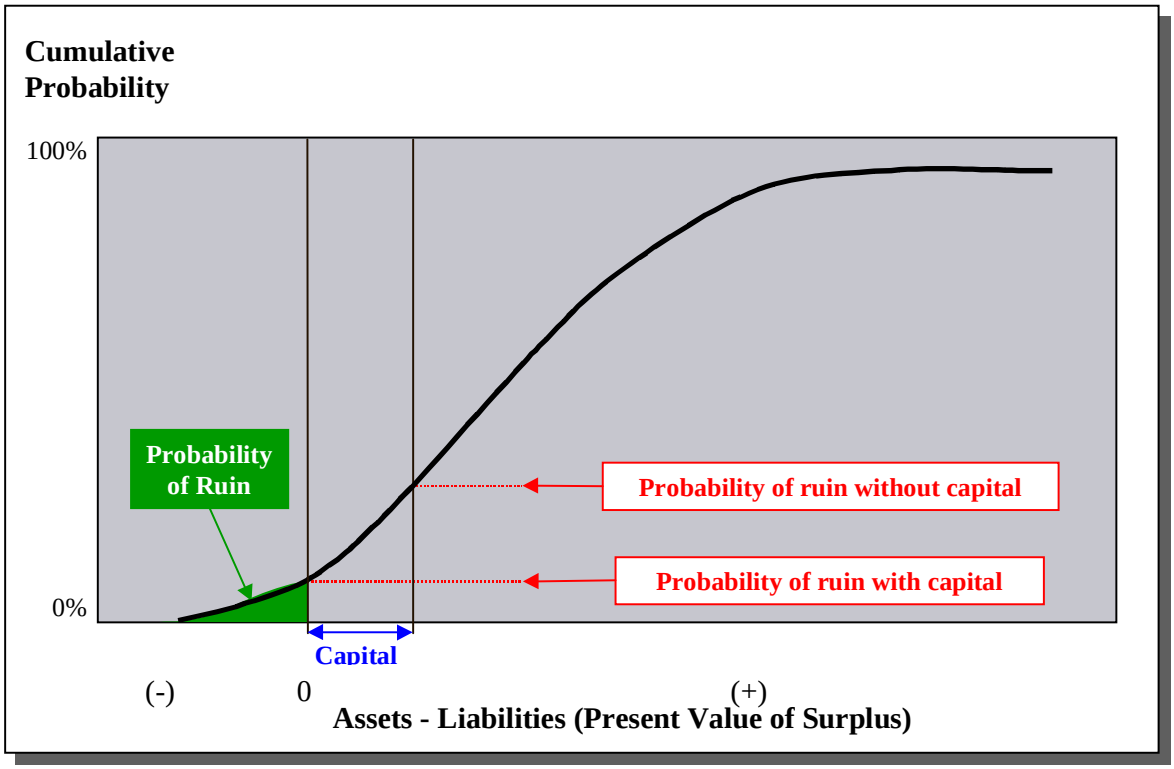
(b) Practical Methods to Calculate EC

There are several methods for determining Economic Capital. These are discussed below.

1. Example 1: Calculating EC from Probability of Ruin / Economic Cost of Ruin

In this section, we will discuss the probability of ruin and the economic cost of ruin methodologies. We will also compare them to value at risk (VAR). Probability of ruin is the probability that liabilities will exceed assets on a present value basis at a given future valuation date, resulting in technical insolvency. It can be calculated from the probability density function of the present value of future surplus by measuring the area under the curve corresponding to the section where liabilities exceed assets. This is shown in Figure 7.1 as the shaded area. Alternatively, it can be calculated from the cumulative distribution function by determining the probability point (on the y-axis) where liabilities equal assets (on the x-axis). These probability graphs are generated by running computer simulations of liabilities and assets using a stochastic financial model.

Figure 7.1: The Probability of Ruin can be calculated from the probability density function by measuring the area under the curve corresponding to the section where liabilities exceed assets on a present value basis



Economic Capital based on the probability of ruin is determined by calculating the amount of additional assets needed to reduce the probability of ruin to the probability target specified by management. Addition of capital shifts the curves in both figures to the right by the amount of additional assets, thereby reducing the shaded area in Figure 7.1. The target probability of ruin is set by management in consideration of several factors, primary among them the solvency concerns of policyholders — usually expressed in terms of the minimum financial strength rating that management desires from the rating agencies.

The probability-of-ruin approach is conceptually similar to the VAR approach used in banking for determining capital for market risk. Although there are technical computational differences between how insurers use probability of ruin and banks use VAR to determine capital, conceptually the two are linked. Both the probability-of-ruin and VAR methods have the advantage of being risk measures that are easy to understand and communicate. This no doubt is the reason that they are widely accepted in insurance and banking respectively. However, both risk measures fail to consider the severity of ruin events, i.e., the expected loss to policyholders.

Economic cost of ruin (or ECOR) is an enhancement to the ruin probability concept, though one that is more prevalent in the property/casualty arena. In the event of ruin, the policyholders expect to get some, but not all, of the benefits to which they are contractually entitled. The difference between what policyholders are promised and the expected value of their post-ruin benefits represents an expected shortfall to policyholders — this is called the economic cost of ruin. (It is sometimes called "expected policyholder deficit," but there may be insurance or prudential obligations in place to protect policyholders from this loss; we therefore prefer the term "economic cost of ruin.") ECOR thus considers not only the probability of ruin, but also the expected loss to policyholders in the event of ruin. In practice, ECOR is often expressed as a percentage of policyholder reserves.

ECOR has important advantages over probability of ruin and VAR. Two companies with the same ruin probability would typically have different, perhaps very different, ECORs. The company with the higher ECOR would have fewer funds remaining after liquidation to distribute to policyholders. Arguably, this policyholder payment capability captures the essence of the need for capital. For some companies, the conceptual advantages of ECOR are outweighed by practicalities, such as the fact that probability of ruin is computationally simpler. Advances in computational efficiency are overcoming these practical constraints.

The overall EC for the enterprise is determined for each combination or set of financial and operational strategies that were proposed in the prior step. Recent surveys of insurance companies indicate their strong desire to reflect major operational risks and strategies in determining the capital requirement. Since both financial and operational risks are incorporated in the financial model used to calculate cumulative earnings, operational risks would be automatically reflected in establishing the capital requirement.

2. Example 2: Calculating EC from Change in Statutory Profits

Another approach to calculating EC is to use a method based on the change in the present value of after-tax statutory profits (PVFP) as the amount of capital required for a given contingency. For this purpose, we will define PVFP to be the present value of profits under a specified set of actuarial and investment assumptions, ignoring any charges for holding capital. It is also one measure of the value of the business. Using different assumptions to calculate the PVFP, the amount of capital held by an insurer to protect against a given adverse contingency can be determined.

It should be noted that there are several different bases for dealing with profits in the definition (or calculation) of EC that are used in different situations: (a) retain profits in the fund (usually referred to as "profits retained"), (b) profits are paid as earned ("profits released"), and (c) profits are paid as expected to be earned.

(a) "Profits retained" EC is the amount of capital in addition to earned profits needed to assure that the company meets the EC criteria (economic, market value and financial reporting). This is the definition that is generally used for cash flow testing and for regulatory definitions. However, most companies do not expect to leave the profits to accumulate in a fund for each block of policies. This would suggest that a "profits released" version of the calculation might make sense.

(b) “Profits released” EC would be defined as the amount of capital needed after profits are paid to shareholders to meet the economic criteria. To generalize that method, you would have to define the accounting basis used to develop the amount of profits that would be withdrawn and then include those dividend cashflows in the model. This would be more realistic but is significantly more cumbersome, especially as accounting migrates to a higher dependence on stochastic calculations.

(c) “Paid as expected” EC is not particularly realistic, since it implies a level of payout that is not directly related to the earnings of each scenario, but it can be used as an approximation to the "profits released" EC since the "profits released" calculation is so much more involved than either the "profits retained" or the "paid as expected" method.

“Paid as expected" method is simply just the "profits retained" less the expected profits.

The following is an over-simplified approach that will demonstrate the methodology. Using best estimate assumptions for a given block of business, determine the PVFP. For one assumption set, e.g. mortality, recalculate the embedded value, this time using an adverse assumption set. The difference in the two embedded values would then be the amount of Economic Capital needed to provide for the adverse mortality for the block of business.

Because the example is an oversimplification, there are numerous issues (risk discount rate, projection period, etc.) that would need to be resolved in order for the measure to be meaningful. In addition, because the assumptions have been defined deterministically, the measure of the degree of confidence that this level of EC provides is not available. It should be

noted that PVFPs typically do not reflect embedded options and guarantees. A confidence level can be built into the amount of change in the assumption set, e.g., an adverse mortality assumption of two standard deviations. Finally, the example only deals with the change in one assumption and does not consider the change in other assumptions nor the correlation of the change in the mortality assumption to various other assumptions with each other.

A first step at making the above approach more meaningful would be to analyze the mortality distribution in detail. We'll call this the "Hybrid Approach". Rather than using an arbitrary adverse assumption, e.g. 110% of best estimate mortality, standard deviations of the mortality function can be developed from the data underlying the best estimate assumption. The adverse mortality assumption would then be defined based on the degree of confidence desired and the assumed probability distribution function to determine the assumption to be used in calculating the adverse assumption embedded value.

To extend the example, assume that standard deviations are available for the mortality assumption, the new money rate assumption, and the asset default assumption. For each of the assumptions, using the desired degree of confidence, the EC required for each adverse assumption change can be determined as if each assumption occurred in isolation. However, it is not the case that the EC required to protect against all three of the adverse events is the sum of the three separate Economic Capital calculations.

Define EC_m as the amount of capital required for mortality, EC_d as the amount of capital required for asset defaults, and EC_i as the amount of capital required for new money rate fluctuations. Using the simplifying assumption that there is 100% correlation between EC_d and EC_i, the total capital for these two events is additive. Further, assuming that these are uncorrelated to the mortality risk, the EC required would be $(EC_m^2 + (EC_d + EC_i)^2)^{1/2}$.

Extending the above Hybrid Approach to a theoretically correct Economic Capital calculation requires the development of means and standard deviations for all assumptions used, as well as correlations among the assumptions. PVFP can be developed stochastically under numerous simulations (1,000 or 10,000 trials, for example). The mean PVFP would correspond to the "best estimate" PVFP calculated in the earlier examples. The adverse assumption PVFP would be based on the degree of confidence desired. The difference would be the EC required with the desired degree of confidence.

The theoretically correct approach has a major obstacle as to its usefulness: the amount of time needed to generate the simulations is excessive today, both in terms of computer run-time and programming and implementation time. However, if the parameters are defined appropriately, and the obstacles to implementation are overcome, this method will produce a good measure of the true EC required to protect an insurance enterprise.

Finally, developing the various means, standard deviations and correlation parameters is a non-trivial exercise, and extremely important as the results of the Economic Capital calculation come directly from their derivation. The approach to the development of the statistical parameters is beyond the scope of this example.

3. Example 3: Calculating EC for a typical Life Insurance Company

This example illustrates the calculation of EC for a hypothetical life insurance company – ABC Life Co., using stochastic asset/liability modeling. To simplify the presentation and appreciation of the underlying concepts, the illustration does not cover all the risks to which a typical life insurer is exposed.

The company has defined EC as follows:

The amount of capital needed to cover misestimation of mean, deterioration of mean and statistical fluctuations.

In addition, the company has decided on the following parameters:

- Adjust the amount of capital to the extent balance sheet assets and liabilities have provisions to cover misestimation of the mean or any other EC item,
- EC calculations should cover the time period over which the company has made commitments/guarantees or have exposures. Since the company has a sizeable block of Term to 100 policies, 100 years time horizon has been selected for cash flow projections, and
- EC will be set at the 99^{th} percentile of the loss distribution of the various risks taken together. Since the company cannot determine the loss distribution of the combined risk factors, approximations will be used to achieve the desired objective.

The company develops a multi-variate Monte Carlo Simulation model to determine mortality and lapse risk for the entire portfolio. The outputs from the model include capital requirements for mortality and lapse risk independently as well as the required capital when the two risks are allowed to interact with each other.

Another model was developed to gauge interest rate risk. This approach was taken for the following reasons:

- Combining interest rate risk with mortality and lapse risks is a modeling challenge,
- The run-time increases significantly if the three risks are analyzed together, and

- Interest rate risk is by far the most significant risk for this company and they want to analyze this risk separately and more rigorously than other risks.

Table 7.1 below has an illustrative Economic Capital calculation utilizing the results of the various models. It uses a traditional approximation to determine the covariance adjustment. Please note that the amount of Economic Capital includes an adjustment for the amount that is capital in nature but is included under reserves in the company's balance sheet.

TABLE 7.1

Illustrative Economic Capital (EC) Calculation (US $ 000's)

Interest Rate Risk:	(a)	99th percentile	152,301
	(b)	Mean	119,701
	(c)	Actuarial liability on balance sheet	136,823
	(d)	Capital (a) - (b)	32,600
	(e)	Amount of capital included in balance sheet liability (c) - (b)	17,122
	(f)	**EC for Interest Rate Risk (d) - (e)**	**15,478**
Mortality Risk:	**(g)**	**EC = 99th percentile – Mean**	**1,105**
Lapse Risk:	**(h)**	**EC = 99th percentile – Mean**	**1,996**
Unadjusted EC before covariance = (i) = (d) + (g) + (h)			35,701
Unadjusted EC after covariance = (j) = $[(d)^2 + (g)^2 + (h)^2]^{1/2}$			32,679
Adjustment for the amount of capital included in balance sheet liability = (e)			17,122
EC = (j) - (e)			**15,557**

VIII. Current Approaches to Allocation of Economic Capital

As discussed in Section VI, a company will typically hold the largest of Economic Capital, Rating Agency Capital and Regulatory Capital. We will refer to the maximum of the latter two as "required capital" in the examples below. We will call the difference between the required and the calculated Economic Capital the "face capital". "Free capital" is any capital held over and above the larger of the economic and required capital.

Some companies also refer to these as:

- "Tier 1" capital (Economic Capital),
- "Tier 2" capital (Face Capital), and
- "Tier 3" capital (Free Capital).

This section illustrates several methods of allocating EC, starting at the enterprise level and then moving to the business segment level.

(a) Allocating EC at the Enterprise Level

Consider first the case of a mono-line insurer with an "A" financial strength rating. Suppose that the amount of capital necessary to maintain an "A" rating is $150 million and that the Economic Capital is calculated to be $125 million. The company currently holds $170 million in actual capital. Then the "face" capital is $25 million and the "free capital" is $20 million. If instead the Economic Capital were $165 million, then the face capital would be ($15 million), and free capital would be $5 million.

Consider now the case of a multi-line insurer wishing to allocate capital to its lines of business. Unless the risks are perfectly correlated, the total Economic Capital will be less than the sum of the Economic Capital calculated for each business unit independently. This is the diversification benefit. The insurer must then determine how to allocate this diversification benefit to the lines of business.

Similarly, the company must determine how to allocate the face capital (if any) across lines of business.

In the next part of this section, we will describe how the company may allocate Economic Capital among various business segments and the corporate line. Here, we will describe several approaches to allocating the face capital. In general, each approach starts with an allocation of the required capital and then taking the difference between the allocated required capital and the allocated Economic Capital.

Possible approaches for allocating face capital include:

1. Hold the face capital fully in the corporate line,
2. Allocate using a marginal approach[5]. That is, calculate the change in face capital that occurs if the business unit is removed from consideration. This change (the negative of it actually) is the face capital for the given unit. After performing this exercise for each business unit, any remainder is allocated to the corporate line,
3. Allocate on a pro-rata basis. This can be done weighted by Economic Capital or by reserves or by the sum of reserves and Economic Capital, and
4. Calculate the face capital by treating each business line as if it were a mono-line company, with any diversification benefit allocated to the corporate line.

To illustrate, consider ABC insurance company with three main lines of business, Annuities, Life and Group Health. The reserves for the three lines are $100 million, $200 million and $75 million respectively. The total company required capital is $50 million. The Economic Capital is $40 million and the company's actual capital is $65 million. Therefore, the face capital is $10 million and the free capital is $15 million.

The company's own method of allocating Economic Capital (whatever it may be) gives $5 million to the life insurance line, $25 million to the annuity and $15 million to the health line. There is a $5 million diversification benefit that is credited to the corporate line, so the total Economic Capital is $40 million.

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[5] A somewhat different marginal approach is presented by A. Zeppetella – see Appendix 3 for more details. (http://www.soa.org/research/required_capital.pdf)

Under method 1, each line would be allocated their Economic Capital. The face capital of the corporate line would be the same as for the entire company: $10 million.

Under method 2, it will be necessary to calculate the required capital of the company after each business unit is removed. When doing so, the company must decide whether to reduce the total assets held by the firm accordingly (since the assets themselves impact the required capital). Suppose that the values thus computed yield face capital levels of $0, $15 and $7 million respectively with the removal of each line. Then the face capital for those lines would be $10, ($5) and $3 million respectively. The corporate line would hold the remaining $2 million.

Under method 3, weighting by the reserves, we would have $2.7, $5.3 and $2.0 million face capital respectively to the product lines and zero to the corporate line.

Under method 4, the allocation might be $6, $1, and $4 million to the product lines and ($1) million to the corporate line. As in method 2, an allocation of assets would be required in order to do the calculation properly.

Methods 2 and 4 can be modified so that the corporate line never holds face capital. Additionally, some industry experts argue that the allocated face capital should never be negative.

The advantages and disadvantages of each method are summarized in Table 8.1 below.

TABLE 8.1

Comparison of Various Methods to Allocate EC

Method	*Advantages*	*Disadvantages*
Hold in Corporate Line	• Simple • Insulates product lines from vagaries of required capital formulas	• Could lead to over investment in lines of business that tie up excessive required capital
Marginal	• Attempts to allocate true cost of face capital for adding given line of business	• Complicated
Pro-rata	• Simple • Allocates face capital to business units	• May allocate large amount of face capital to LOB that generated none and vice-versa.
Treat each LOB as if monoline	• Somewhat easier to understand than marginal approach • Neither helps nor hurts a given LOB due to presence of other LOBs	• May allocate large amounts of capital to LOB that adds little required capital due to diversification

In practice, many companies who calculate EC in one of these ways typically charge the product lines for any face capital held at the corporate level, either implicitly based on the difference in hurdle rates vs. after-tax investment returns on capital, or explicitly, by imposing a capital rent charge which reflects the company's cost of holding this capital. The allocation of such costs to the lines typically follows the general methodology underlying the allocation of Economic Capital.

(b) Allocation of EC to Business Segments

Having determined the appropriate capital requirement at the enterprise level to satisfy policyholders' interests, it is necessary to fairly attribute capital to each segment in a way that reflects its contribution to the enterprise-wide capital requirement. This attribution allows the proper evaluation of the performance of each business segment.

There are several methods for attributing capital to each business unit. These methods differ primarily by the choice of risk measure used to estimate the capital requirement of each segment in relation to risk.

One such method is to attribute capital across business segments in proportion to the present value of expected customer payments. Under this method, each product is assumed to contribute to the risk of insolvency in proportion to the economic value of commitments to customers — and thus all products are assumed to involve the same degree of risk. Since this is not the case in most situations, less risky products provide a capital subsidy to the more risky products. The resulting unfairness may result in business decisions that destroy economic value.

To attribute capital fairly across segments, capital requirements must be determined in relation to the risk of each segment. Since, at the most intuitive level, policyholders, regulators and insurance executives can see that the level of risk is directly related to the probability of ruin of the company, it is often suggested that probability of ruin or VAR constraints be used to drive the capital attribution process. However, both probability of ruin and VAR have a drawback if they are used to attribute capital to business segments or to determine the capital of merged or combined operations: when two or more risky portfolios are combined, the capital based on these measures for the combined portfolio may turn out to be equal to or more than the sum of the capital for each portfolio determined separately. Combining risky portfolios should,

however, decrease total risk, and therefore capital, due to risk diversification. Under certain conditions then, these risk measures may suggest incorrectly that combining portfolios increases the level of risk.

This drawback of probability of ruin and VAR arises when loss distributions of business segments are asymmetric and not correlated uniformly across the range of outcomes. This is prevalent in insurance where, unlike banking, most risks exhibit "fat tailed" probability distributions that cannot be fully represented simply by their mean-variance characteristics.

Economic cost of ruin is an enhancement to the ruin probability concept, though one that is more prevalent in the property/casualty arena: in the event of ruin, the policyholders expect to get some, but not all, of the benefits to which they are contractually entitled. The difference between what policyholders are promised and the expected value of their post-ruin benefits represents an expected shortfall to policyholders is called the economic cost of ruin. Economic cost of ruin (or ECOR) thus considers not only the probability of ruin, but also the expected loss to policyholders in the event of ruin.

Hence, a refinement to the method of allocating capital would be to use the ECOR ratio (i.e., the ratio of ECOR to the present value of expected customer payments) to drive the attribution process. ECOR does not suffer from the drawback described above for probability of ruin and VAR. Determining capital using ECOR correctly produces this result: Combining risky portfolios reduces the capital requirement for the same level of risk tolerance, and produces sensible results when used to attribute capital to business segments.

In any case, the attribution process requires completion of two steps.

1. Calculation of stand-alone capital requirements:

   The objective of this step is to determine the minimum amount of capital that is needed by each individual segment to meet the corporate level risk constraint, expressed as a probability of default or ECOR ratio, for example. Note that adding up the stand-alone capital requirements calculated above will result in a capital requirement that is greater than the aggregate capital requirement of the enterprise. The difference between the two amounts represents the capital saving achieved by diversification. This benefit needs to be allocated to business segments.

2. Allocation of the diversification benefit to segments:

   The allocation of the diversification benefit to segments needs to reflect the contribution of each segment to aggregate enterprise risk. It involves calculation of the marginal capital requirement of each segment, i.e., the amount of capital needed by the enterprise to add the segment to the enterprise. The difference between this marginal capital requirement and the stand-alone capital requirement calculated in the preceding step represents the maximum amount of diversification credit associated with any segment. The actual amount of credit given to any segment will be less than this maximum. It will be derived by use of any one of several possible algorithms that are designed to make the resulting allocation fair across segments.

It is important to note that capital attribution results can be highly sensitive to the risk measure and risk constraints that are selected. In particular, as described in the prior section, there are situations in which using a probability-of-ruin constraint can lead to severely erroneous conclusions about capital requirements and to inappropriate attribution of capital across business segments (especially in property/casualty insurance companies). These difficulties can be avoided by using the CTE measure or (for property/casualty companies) the ECOR ratio as measures of risk, and selecting an appropriate target as a risk constraint.

One noteworthy feature of capital attribution is that, even if the enterprise-wide capital requirement is established on the basis of regulatory, rating agency or competitive capital considerations, it can be fairly attributed to business segment by first converting the enterprise-wide requirements into an implied risk constraint (e.g., CTE). The imputed financial constraint at the enterprise level can then be applied at the business unit level, and business unit capital requirements can be derived therefrom. After applying any necessary diversification benefits, this results in an economically fair capital attribution. Indeed, given the practical difficulties in assigning regulatory, rating agency or competitive capital at the business unit level, this may represent the most realistic and meaningful way to attribute such capital.

To summarize, it is important to attribute capital to business segments to determine which segments, and which financial and operational strategies within a segment, are creating or destroying value.

(c) Allocation of EC for Pricing Purposes

For pricing purposes, Economic Capital is allocated at the pricing model cell level. In theory, this could be done using the same methodology that is used to determine the capital level for the line of business.

In practice, that is rarely done. In a recent industry survey on pricing practices, two thirds of companies using EC in some form indicated that they are using simplified formulas for incorporating EC into pricing, rather than simulation models or tail probabilities.

A simple approximation is typically developed for pricing purposes. This approximation is usually a linear formula that depends on amounts that are readily available as the pricing calculations are being completed for each period of time.

Examples of such formulas would include:

(a) Life Products: a x NARt + b * tV_x, where NAR is the Net Amount at Risk and tV_x is the reserve
or c x NARt * tqx + b * tV_x

(b) Annuity Products: (d * tV) or (e * Account Value)

(c) Health Products: f * Premiums

The factors a through f are determined so that if they were applied to the in-force business, the total would equal the Economic Capital for the line of business. Factors a, c and f in the examples above will usually be determined from the insurance risk portion of Economic Capital, while factors b, d, and e are determined from the credit and market risk portions of total Economic Capital. Operational risk and the difference between the total Economic Capital and the sum of the Economic Capital for each risk type are commonly allocated to one of the other factors as a net gross-up.

In situations where significant changes in business volumes are expected from new product sales, the pricing factor development may be based on projected levels of business. Care should be taken to assure that the simplified factors will reproduce the product line Economic Capital for likely ranges of actual activity. These factors also need to be reviewed regularly to determine the amount of drift that has resulted from the approximations used.

Appendices

Appendix 1: A Theoretical Method of Calculating EC

Appendix 2: Industry Survey on EC

(Provided in a separate attachment)

Appendix 3: Review of Literature

(Provided in a separate attachment)

Appendix 1: A Theoretical Method of Calculating EC

First, we describe a theoretical procedure for estimating EC for a financial institution. For purposes of this example, EC is considered to be a theoretical concept. It is the amount of capital that would protect a financial institution from adverse movements in asset prices and liability values over a given period of time. The financial institution in question can be an insurance company, a commercial bank, or an investment bank. The EC concept is completely general and applies equally to any firm that carries substantial amount of financial assets and liabilities in its balance sheet.

It is safe to say that in the theoretical literature on EC, there is no consensus about the way EC should be defined and calculated. Some authors define EC as some multiple of revenue volatility, others define it as some multiple of earnings volatility. Still other authors use concepts like Value at Risk - VAR, or Daily Earnings at Risk – DEAR, or Conditional Tail Expectation (CTE) or TailVar to arrive at a definition of EC. The definition of EC that is given below is closely related to the volatility that surplus of the firm is expected to experience over time.

1. **Formal Statement of *the Economic Capital* Problem**

Consider a financial institution. At time zero – present time – the market/fair value of liabilities is denoted by L_0. We will assume that the value of L_0 is known with certainty[6]. We denote by L_1 the value of corresponding liabilities one period later[7]. As of time zero, the value of L_1 is unknown. L_1 is a random variable. We write:

$$L_1 = L_0 (1 + R_L), \qquad (3)$$

[6] This assumption is not always true. Consider, for example the liabilities of an insurance company. The *fair value* of most insurance products at any given time is subject to a host of assumptions. We are using the term *fair value* and not *market value,* because, apart from rare occasions when blocks of insurance business are bought and sold, liabilities of insurance companies are not traded. Therefore, we can only estimate fair value of insurance liabilities using a large number of actuarial assumptions.

[7] What should be the length of "one-period"? A good practical answer is "one year". A period shorter than one year is impractical, because of the difficulty of securing all the data. If we choose a period much longer than a year, then we have to worry about the assets and liabilities *during* the period as well as the end of the period.

where R_L is the rate of return (or growth) of liabilities over the period. R_L is a random variable, with given (known) expected value and standard deviation (variance). We write:

$$E(R_L) = \overline{R_L},$$

$$Var(R_L) = \sigma_{RL}^2.$$

It follows that the expected value and variance of L_1 will be:

$$E(L_1) = L_0(1 + \overline{R_L}),$$

$$Var(L_1) = \sigma_{L1}^2 = L_0^2\sigma_{RL}^2.$$

To support these liabilities and to ensure solvency, the company holds a portfolio of assets. At time zero, the market value of assets is denoted by A_0. We will assume that as of time zero, the value of A_0 is known with certainty. We denote by A_1 the value of corresponding assets one period later. As of time zero, the value of A_1 is unknown. A_1 is a random variable. We write:

$$A_1 = A_0(1 + R_A), \qquad (4)$$

where, R_A is the rate of return (or growth) of assets over the period. R_A is a random variable. Depending on the specific portfolio of assets that is chosen, it will have a given (known)

expected value, standard deviation (variance), and correlation coefficient with the company's portfolio of liabilities. We write:

$$E(R_A) = \overline{R_A},$$

$$Var(R_A) = \sigma_{RA}^2,$$

$$\rho_{R_A,R_L} = \frac{\sigma_{R_A,R_L}}{\sigma_{R_A}\sigma_{R_L}}.$$

It follows that expected value and variance of A_1, and $Cov(A_1, L_1)$ will be:

$$E(A_1) = A_0 * (1 + \overline{R_A}),$$

$$Var(A_1) = \sigma^2_{LA1} = A_0^2 \sigma^2_{RA},$$

$$Cov(A_1, L_1) = A_0 L_0 \sigma_{R_A, R_L} = A_0 L_0 \rho_{RA.RL}\, \sigma_{R_A}\, \sigma_{R_L}.$$

In what follows, we shall also assume that the random variables L_1, A_1 are normally distributed with the above means, variances and covariance/correlation coefficient.

EC as of time zero, and one, is denoted, respectively, by K_0 and K_1, and are defined as follows:

$$K_0 = A_0 - L_0,$$
$$K_1 = A_1 - L_1.$$

As of time zero, K_0 is known with certainty, and is non-random. As of time zero K_1, on the other hand, is a random variable.

For the company to be solvent as of time zero, it must be the case that K_0 is non-negative, so we will assume that:

$$K_0 \geq 0.$$

In other words, at any given time the company should have enough assets on its books to support the acquired liabilities[8]. But that is not enough. We would like K_0 to be significantly greater than zero, so that, as of time zero we can be sure, with a high degree of certainty, that K_1 will be positive as well.

Stated formally, Economic Capital at time zero, K_0, should be set at a level large enough to ensure:

$$\Pr(K_1 \geq k\, L_1) \geq 1 - \alpha, \qquad (5)$$

[8] Although, historically, one can find many instances financial institutions that continued to do business, even though by all objective estimates of their assets and liabilities they were insolvent.

α*, risk tolerance level*, is usually set at 1.00%[9]. We call *k the "comfort ratio."* If we choose *k* to be zero, then all we are asking is for the company to be *just* solvent as of time one. We might, however, want to set *k* at a level significantly greater than zero, say, at 1% or 5%[10]. Since $A_0 = L_0 + K_0$, we can restate the Economic Capital Problem as follows:

> *A financial institution with a given portfolio of liabilities - with market/fair value as of time zero of L_0, with expected value as of time 1 of $\overline{L}_1$, and with standard deviation of σ_{L1} - should have a portfolio of assets - with market value as of time zero of A_0, with expected value as of time 1 of $\overline{A}_1$, with standard deviation of σ_{A1}, and covariance with liability portfolio of $Cov(A_1, L_1) = A_0 L_0 \rho_{RA.RL} \sigma_{RA} \sigma_{RL}$, to ensure that:*

$$\Pr\{A_1 - (1+k)L_1 \geq 0_1\} = 1 - \alpha. \qquad (6)$$

2. **Estimation of *Economic Capital***

Formally, equation (6) above can be written as follows:

$$F(L_0, \overline{R}_L, \sigma_{RL}, A_0, \overline{R}_A, \sigma_{RA}, \rho_{RA,RL}, k, \alpha) = 0. \qquad (7)$$

Equation (7) above has nine variables. Given the value of any of the eight variables and their functional relationship, we can solve for the remaining variables. For example, if we know the value of the variables, $L_0, \overline{L}_1, \sigma_{L1}, \overline{A}_1, \sigma_{A1}, \rho_{RA,RL}, k, \alpha$, we can solve for A_0, and hence find the value of K_0:

$$A_0 = G(L_0, \overline{R}_1, \sigma_{RL}, \overline{R}_A, \sigma_{RA}, \rho_{RA,RL}, k, \alpha). \qquad (8)$$

Table A.1 gives some illustrative values of parameters and the resulting solutions[11].

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[9] Other values for α, might be 0.1%, 2%, or 5%. Note that a "AAA" rated company would have an α that is very small, say, 0.1%. On the other hand, a financial institution that is comfortable operating with a "B" rating from the rating agencies, might be satisfied with an α = 2%.

[10] In fact, as we shall see below, the objective function will be solved for K_0. If we denote the solution for K_0.by $K_0^{(opt)}$, then we might want to set k close to $K_0^{(opt)}/L_0$..

[11] It is not easy to solve equation (7) analytically. We have used the Solver software of Excel to derive the solutions.

As we see from the table, the optimum amount of Economic Capital that a financial institution should carry varies positively with the volatility – variance – of the asset portfolio chosen, and varies inversely with expected return of the asset portfolio. The amount of Economic Capital also varies inversely with the correlation coefficient between asset and liability portfolios: The higher the correlation coefficient, the lower the amount EC that a financial institution need have in order to prevent insolvency with a certain degree of risk tolerance.

TABLE A.1

Economic Capital Calculations

L_0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
$E(R_L)$	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%
$Sigma(R_L)$	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%
$E(R_A)$	**10.0%**	**15.0%**	**20.0%**	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%
$Sigma(R_A)$	15.0%	15.0%	15.0%	**10.0%**	**15.0%**	**20.0%**	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%	15.0%
$Rho(R_A, R_L)$	0.50	0.50	0.95	0.50	0.50	0.50	**-0.50**	**0.00**	**0.50**	**0.95**	0.50	0.50	0.50	0.50
K	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
Alfa	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	**0.1%**	**1.0%**	**2.0%**	**5.0%**
A_0	133.00	125.19	100.90	114.07	125.19	143.19	150.85	139.07	125.19	106.90	141.79	125.19	120.21	113.46
K_0	33.00	25.19	0.90	14.07	25.19	43.19	50.85	39.07	25.19	6.90	41.79	25.19	20.21	13.46
K_0/L_0	33%	25%	1%	14%	25%	43%	51%	39%	25%	7%	42%	25%	20%	13%

3. **Discussion of Theoretical Approach**

There are a number of shortcomings to the approach outlined above.

First, the Economic Capital calculation procedure as stated above does not take into account what happens to EC during the time period from time zero to one. In particular, it is possible for Economic Capital to become negative, say at time 0.25 – at the end of three months – and then turn positive at the end of the year.

Second, it is difficult to calculate EC, mainly due to the fact that it is usually very difficult, if not impossible, to come up with robust estimates of parameters such as the volatility of liability and asset portfolios, and the correlation coefficient between assets and liabilities. In the absence of reliable estimates of such parameters, other procedures, with an eye to practical implementation, have been proposed.