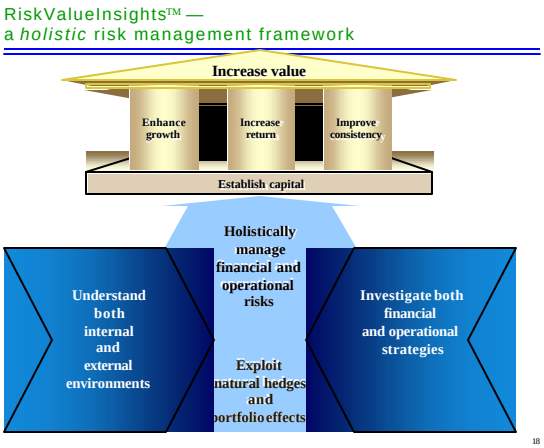
Appendix 3: Review of Literature

This section includes a review of the literature which we reviewed on EC. A bibliography will be provided.

Annotated Outline & Summary

Reference	Summary
Section 1. General Approach	
The section presents a general overview of approaches and techniques of risk management and the purpose of Economic Capital. It serves as a useful background for Economic Capital calculation.	
IAA Solvency Working Party. "Report of Solvency Working Party." February 2002 http://www.actuaries.org/members/en/committees/INSREG/documents/Solvency_Report_en.pdf	This paper summarizes the International Actuarial Association's (IAA) research regarding approaches to risk management and modeling results, which was prepared in response to the International Insurance Accounting Board's (IASB) work on international accounting standards. The objectives of the research were as follows: 1. Identify types of risk to which insurers are subject. 2. Identify approaches used to model each type of risk and results of modeling. 3. Identify approaches used to identify interaction/correlation between risks, and results of modeling. The Working Party reviewed existing risk classification schemes used by various regulatory bodies in different countries, and how they relate to capital requirements. They also suggested the following risk classification scheme (and included detailed descriptions of each type of risk): 1. Underwriting 2. Credit 3. Market 4. Operational 5. Liquidity 6. Event They researched and identified the following existing risk management tools, and provided an overview of each: 1. Collective Risk Models 2. Aggregate Risk Models 3. Diffusion Models and Other Stochastic Processes 4. Multi-State Models 5. Cash Flow Models They provided examples of specific risks faced by insurers, modeling approaches used to manage such risks, the results of modeling, and the impact on capital requirements. The overall findings of the Working Party were as follows: 1. Actuaries are in a unique position to provide perspective to insurers/regulators regarding the complex topics of risk management and financial condition. 2. There is currently no single internationally agreed-upon scheme for classifying insurer risks. The Working Party suggests convergence toward a single scheme, as

	suggested in the report. 3. To create comparability between banks and insurers, a common international structure for solvency assessment would be useful (though the differences in risk exposures and time horizons must be considered). 4. The report provides an overview of the risk assessment process used by actuaries to model and manage risk. 5. The report provides specific information and examples for some of the risks faced by insurers. 6. The Working Party believes that the actuarial profession can be of assistance to insurance regulators in developing common approaches to solvency assessments.
Rudolph, Max J., "Current AAA Recommendation for RBC C-3 Phase II". *Financial Reporter*. June 2003. Reprinted with permission by the author. http://www.soa.org/library/sectionnews/finrptng/FRN0306.pdf	What Products are Covered? ■ The focus for this project has been on variable annuity products. This is due primarily to the non-diversifiable nature of equity risk when combined with death benefit and living benefit features common to these products. An MGDB option might guarantee a death benefit that rolls up the initial premium by 5% per year. The AAA's goal is to better recognize that risk, and earlier. Equity indexed products are outside the scope of this recommendation. Industry comments to the LRBCWG expressed concerns on a number of topics that are being addressed. Scenarios ■ Companies are encouraged to use their own models, but must calibrate to historical returns. It is expected that a variety of fund types will be provided. Much of the work so far has used Regime Switching Log normal (RSLN) models. A version developed by Dr. Mary Hardy at the University of Waterloo is available for educational purposes on the SOA web site at www.soa.org/research/rsemw.html . These models assume that, most of the time, equities follow a distribution that can be described as stable, with moderate volatility. However, in order to describe the reality of a fat tail, an unstable, high volatility, distribution is needed. From period to period, the model jumps from one regime to the other using a Markov process. Two-regime versions of these models describe the major American and Canadian indices quite well. Required Capital ■ Regulatory capital is defined as the 90 CTE (modified) value, minus the reserve held. For each scenario, the greatest present value of the negative statutory surplus at all future calendar year-ends during the projection period is calculated for the entire book of covered business combined. Results for all scenarios are then sorted and used in the modified CTE methodology. The recommendation includes these results with the common stock component of the RBC covariance formula. Assumptions ■ Discussion continues regarding the use of prudent best estimate assumptions. The modified CTE methodology provides a basis for determining conservatism that is not available today in point estimate reserves. This will require a paradigm shift for many practitioners. Depending on the combination of policy features being valued and the degree of in-the-moneyness at the valuation date, a conservative assumption might be higher or lower than the best estimate. Best estimate assumptions should be used in the models. However, when the direction of conservatism is known and actual experience is not credible, the actuary should lean toward conservatism. Terminology ■ Several terms in the recommendation might be new to the practicing actuary. A glossary is included in the Academy paper, but here's a head start using examples

	to define the terms. ■ Gross wealth ratio – Using a 5-year horizon, if the gross wealth ratio is 1.10 that means that the fund has grown by 10% over the 5-year period, before expenses. Similarly, a .6 ratio means that the fund is now worth 60% of its original value. A ratio of 1.0 means the value at the end of 5 years is the same as it was at the beginning. It does not mean there have been no fluctuations along the way. ■ MGDB (minimum guaranteed death benefit) – If a product guarantees a death benefit that could be larger than the surrender value due to fund performance, then the contract features an MGDB. ■ VAGLB (variable annuity guaranteed living benefit) – This product feature guarantees a minimum surrender value, maturity value or income benefit at specified election dates while the policyholder is living. Other Sources of Information ■ www.actuary.org/pdf/life/rbc_16dec02.pdf
Tillinghast–Towers Perrin. "RiskValueInsights™ Creating Value through Enterprise Risk Management–A Practical Approach for the Insurance Industry". http://www.tillinghast.com/tillinghast/publications/reports/Creating_Value_through_Ent_Risk_Mgmt/2002051306.pdf	A detailed research document which describes the dynamics between risk and value, specifically for the insurance industry. It is based on Tillinghast – Towers Perrin's RiskValueInsight™ framework and process, which is focused on maximizing the economic value of an insurance enterprise, while minimizing the risks of large deviations from expected performance.  The monograph is intended to help insurance executives respond in a coherent way to strategic, financial and operational questions such as: ■ How to identify the key or emerging risks that deserve senior management attention (Chapter V) ■ How to measure and manage operational risks with the same level of sophistication as financial risks (Chapter V) ■ How to relate risk management activities to the business's bottom line (Chapter VI) ■ How much capital is needed and how to convince the rating agencies (Chapter VII) ■ How to evaluate business segment performance, given the differing levels of risk each segment contributes to the enterprise (Chapter VII) ■ How to maximize return on capital, given a company's risk appetite (Chapter VIII)

Section 2. Calculation of Economic Capital	
Before capital can be allocated to operating divisions a risk measure and calculation methodology must be chosen. Even at the broad, firm-level basis considerable complexity and judgment are involved. Depending on the perspective (internal management, external investors, regulators, rating agencies) different levels of required capital may be considered appropriate. At times the issue of Economic Capital calculation can get bogged down in rather technical and academic mathematical analyses. The more purely mathematical articles are *not* included in this recommended reading and outline. However, some articles with a more theoretical perspective are included due to their addressing issues important for the later development of practical techniques.	
Beder, Tanya Styblo. "VaR: Seductive but Dangerous." *Financial Analysts Journal*. Sep / Oct 1995. Internet link: none.	This paper discusses the reasons VaR fails as a sole measure of risk, noting that due to the sensitivity of the calculation to assumptions employed, VaR calculations on the same portfolio may differ significantly from user to user. Further, because of the existence and importance of non-quantitative sources of risk--political, liquidity, personnel, etc.--the paper concludes that VaR must be supplemented with stress testing and other prudent management practices.
Jorion, Philippe. "Risk2: Measuring the Risk in Value At Risk." *Financial Analysts Journal*. Nov / Dec 1996. Internet link: none.	The application of VaR has increased in popularity in the insurance industry. This paper is recommended as a presentation of a theoretical background to the understanding of this risk measurement.
NAIC. "Risk-Based Capital: General Overview." NAIC website, no date. http://www.naic.org/1financial_reporting/rbc/RBCoverview.doc Risk-Based Capital General Overview Gorski, Larry M. (moderator). "Follow-up To Risk-Based Capital C-3 Component Methodology Change. Session 57PD." RECORD, Volume 27, No. 2. Toronto Spring Meeting June 20–22, 2001. http://www.soa.org/library/record/2000-09/rsa01v27n257pd.pdf Longley-Cook, Alastair G (Moderator). "Phase 2 Of The C-3 Project Update. Session 75PD." RECORD, Volume 28, No 1. Colorado	NAIC RBC presents a regulatory opinion of capital requirements. Though this is likely different than a firm's own measurements of Economic Capital it can often be applied in similar manners. The articles specified address various components of RBC. The NAIC's own RBC General Overview is just that--a brief document highlighting the ideas of RBC. It steps through a definition of the major risk components (C-0, C-1, etc.) Note it was written before common stock was broken out as its own component from the other assets. Though very basic and high-level, this brief document highlights the general idea of categorizing risks and combining them, with a few paragraphs describing the covariance adjustment's impact on the final RBC. It could be useful as a general introduction to the idea of EC and how one body has chosen to evaluate required capital. The Longley-Cook and Gorski sessions from recent SOA meetings address topics related to the changes in C-3 methodology and the implementation of some stochastic testing. The presentations include discussion of both the rationale behind the revisions and some of the technical aspects of implementing them. Finally, the DI and LTC developments SOA session transcription is recommended hesitantly. The first speaker focuses on revisions to the DI premium factors. His comments regarding the results of sensitivity testing to various assumptions are potentially useful in terms of showing how recommended capital levels should be tested under a variety of scenarios and assumptions. Examination of the stop loss factor is also discussed. Though the modeling does not seem to have been in-depth, the point that stop loss includes 2 distinct coverages that must be considered in conjunction is useful in the context of EC requiring a holistic view of company business.

Springs Spring Meeting. May 30–31, 2002. http://www.soa.org/library/record/2000-09/rsa02v28n175pd.pdf Jay, Burton D. (moderator). "Current Risk-Based Capital Developments For Disability Income, Long-Term Care, And Stop Loss. Session 95PD." RECORD, Volume 27, No. 1. Dallas Spring Meeting May 30–June 1, 2001. http://www.soa.org/library/record/2000-09/rsa01v27n195pd.pdf	
S&P Capital Calculation Insurance Capital Optimization published by Standard & Poor's	Traditional Risk-Based Capital (RBC): Similar to NAIC RBC capital calculation in that standard factors are applied to either assets or liabilities to calculate adequate capital. Company specific risk profile is not considered in the capital calculation. New Financial Product Company (FPC) Model: S&P has developed a new FPC model that incorporates an insurer's management and tolerance of risk into the analysis of capital adequacy. This new model allows insurers to hold lower capital if the companies have integrated risk management techniques and practices in the area of interest rate, credit and operation risk associated with their assets and liabilities. S&P doesn't adopt a uniform model for this purpose; it allows companies to adopt company-specific risk management practices. However, companies need to demonstrate to S&P the application of this new approach. At this point, FPC only applies to non-traditional business (GIC); however, it will be applied to traditional business of companies in the future.
Brender, Allan. "The Use of Internal Models for Determining Liabilities and Capital Requirements." *NAAJ*, vol. 6, no. 2. April 2002.	This is a valuable source that will bring readers up to date on the status of the new approaches for determining capital adequacy. Dr. Brender reviews the history of financial accounting in the U.S, Canada and the G10 over the last 25 years to document the trend away from broad uniform industry rules and toward more company-specific approaches. These new approaches recognize that while factor-based approaches, for example RBC, represent conservative views of industry-wide exposure, the resulting capital requirements will not necessarily reflect an institution's true capital needs. This paper focuses on the regulatory and supervisory issues involved in the use of company-specific models from OSFI's point of view. To compensate for the loss of conservative margins, supervisory authorities must specify that certain conditions be met before they permit the use of internal models for these purposes. This non-technical paper gives careful consideration to the regulatory and supervisory issues involved in this move to company-specific models.
Embrechts, Paul. "Correlation and Dependence	Recommended as a seminal article for those seeking a theoretical basis or developing examples / seminars for application. This is intensely mathematical and focuses on

in Risk Management: Properties and Pitfalls." Working paper. http://www.math.ethz.ch/~strauman/preprints/pitfalls.pdf	conjectures, proofs, and corollaries related to linear correlation vs. copulas and rank coefficients as measures of dependence between distributions. The article mentions relevant topics such as correlations between claim distributions, the special considerations of skewed tail distributions, and running DFA simulations for companies with multiple lines of business. However, clear applications and examples are not provided. The article could be useful to someone developing more concrete techniques to share with practicing actuaries. But it does not seem directly useful in real life applications.
Wang, Shaun. "Set of New Methods and Tools for Enterprise Risk Capital Management and Portfolio Optimization." *CAS Forum.* Summer 2002. http://www.casact.org/pubs/forum/02sforum/02sf043.pdf	This paper makes the case for a uniform framework of commonly accepted measures, tools, and methodologies to manage the entire "risk portfolio" that is an insurance enterprise. Toward that end, the author indicates how a simple transform of claim distributions can be used to extend the well-known Sharpe Ratio from CAPM to the insurance market, providing a natural measure for optimization. In addition to transforms, the paper provides an accessible introduction to the use of copulas, showing how an "empirical copula" constructed from historical data or stress tests is well suited to properly account for the higher correlation of events observed at extreme tails. The author shows how the two tools can be combined to extend "TailVaR" measures to the skewed, heavy-tailed distributions encountered in insurance. Finally the paper argues the advantages of variance as opposed to volatility as a base for allocating risk capital. Overall this paper is recommended for its useful insights and suggestions on a variety of inter-related issues in risk management. Portions in the latter half are less concrete than the earlier portions and seem more appropriate for academic discussion rather than being ready for application.
Cox Samuel H. and Hogan, Arthur M.B. "Life Insurer Risk-Based Capital: An Option Pricing Approach." *Journal of Actuarial Practice*, vol. 3 no 1. 1995. Internet link: none.	This paper focuses on total target capital levels, not capital allocation. It compares capital adequacy levels calculated using an option-based model with the risk capital produced by the New York formula for a sample of 18 publicly traded insurers. It discusses the sources of input data for such a model and concludes the New York formula requires more capital than would be imposed by the model's 'put' values.
Section 3. Capital Allocation	
Companies need to know the profitability of their business sold. Therefore, once an overall firm-level capital amount has been determined, companies need to distribute capital to each product / division / operating unit in order to determine the profitability of each.	
Venter, Gary G. "Allocating Surplus – Not!." *CAS Actuarial Review*, February 2002. http://www.casact.org/pubs/actrev/feb02/random.htm	In this brief note the author cautions that given the difficult issues involved in deciding allocation questions, different practitioners will often produce differing answers. Given that the consequences of making the wrong decision could mistakenly penalize a profitable line or encourage a truly unprofitable one, the author argues that traditional methods of allocation may prove counter-productive. The author notes that more modern techniques overcome this problem by tying capital allocation to risk measures and market costs, and points the interested reader to several references on the topic.

Venter, Gary G and Instrat, Guy Carpenter. "Capital Allocation Survey with Commentary." *CAS 2003 Thomas P. Bowles Jr. Symposium.* http://www.casact.org/coneduc/specsem/sp2003/papers/	This paper provides an overview of alternative methods to address the questions that capital allocation addresses. Four approaches are reviewed: (1) Selecting a risk measure and an allocation method and using them to allocate capital. (2) Comparing actual versus model pricing by business unit. (3) Computing the cost of the marginal capital needed for or released by target strategies. (4) Evaluating profitability in comparison to a leveraged mutual fund. Appendices provide more detail on specific methods. **Approach 1 – Capital Allocation** Risk measures to choose from are listed, including Value at Risk (VaR), Expected Policyholder Deficit (EPD), Mean of Transformed Loss, and others. Additionally, allocation methods are described such as Proportional Spread, Marginal Analysis, Game Theory, and others. The paper defines some of these and outlines advantages and disadvantages. It also explains that capital allocation does not address the value of risk taken on by the line of business. **Approach 2 – Actual versus Model Pricing** This method requires an evaluation of the market value of the risk transfer provided (using CAPM or similar methods). The paper outlines the approach and issues worth considering. This methodology is not well established. **Approach 3 – Calculating Marginal Capital Costs** This approach involves looking at the last increment of business written to see whether the additional capital required is less than the profit it generates. Methods for performing this analysis are discussed briefly. An advantage of this method of approach 1 is that total capital need not be allocated--rather, one must only evaluate the change in capital due to increasing or decreasing the amount of business. **Approach 4 – Mutual Fund Comparison** An insurer can be viewed as a tax-disadvantaged leveraged mutual fund and compared to an actual mutual fund with comparable characteristics (capital, probability distribution of returns, borrowing rate, investment portfolio). If investors have to borrow at a very low rate to get an equivalent return as provided by the insurer, the insurer is producing a better result.
Zeppetella Tony. "Allocation of Required Capital by Line of Business." Unpublished. http://www.soa.org/research/required_capital.pdf	Mr. Zeppetella addresses an important issue most companies have to deal with: allocating limited capital. Based on the concept of homogeneous functions and marginal analysis of risk based capital, the method he suggests provides a sound theoretical foundation, yet is relatively simple in its application. Compared to two allocation methods commonly used in the market, Mr. Zeppetella's method allocates greater benefit of diversification inherent in the RBC formula to smaller business units. His formula implicitly recognizes the benefit of diversification that smaller business units bring to the total company. A specific example helps show the numbers being applied in the formulas. Readers who are not familiar with the marginal analysis of RBC should read the author's other paper, "Marginal Analysis of Risk Based Capital."

Mango, Donald F. and Mulvey, John M., Ph. D. "Capital Adequacy and Allocation Using Dynamic Financial Analysis." *Casualty Actuarial Society Forum.* Summer 2000. http://www.casact.org/pubs/forum/00sforum/00sf055.pdf	The authors briefly describe a DFA model used to examine total capital requirements for a company. They also explore the allocation of capital to each division, briefly describing the standard marginal allocation (compare the amount of required capital for the entire company against the calculation for the entire company less each division, removing one division at a time). Finding this measure of allocation unsatisfactory from a game theoretical standpoint they use the Shapley value applied to variance of net income for allocation purposes. The results from the allocation methods are neither provided nor compared, though. The remainder of the article focuses on various Board-presentation and follow-up issues. The 5 pages or so of sections 2 and 3 which explore the standard allocation and Shapley value are a good foundation of the methods. Though the remainder of the article is sound it does not seem directly applicable.
Meyers, Glenn. "Cost of Financing Insurance." *Spring 2001 CAS Forum.* http://www.casact.org/pubs/forum/01spforum/01spf221.pdf	This is a straightforward presentation of the main topics of Economic Capital Calculation and Allocation. It addresses firm-level needs, allocation to divisions, and what such results mean from pricing and evaluation of product performance perspectives. The paper addresses both theoretical topics such as TailVaR and coherent measures of risk, but does so in a relatively non-technical manner. It does skip over some very key topics, such as how to determine the claim distributions and correlation coefficients. However, Meyers addresses his stated topics well and presents numerical examples to assist the reader. The extended example compares TailVaR and standard deviation results throughout, and includes such relevant results as capital allocation to divisions, optimal reinsurance levels, and target combined ratios (loss ratio and expense ratio combined).
Kulik, John. "A Practical Application of Modern Portfolio Theory to Capital Allocation." *Casualty Actuarial Society Forum.* Spring 1999. http://www.casact.org/pubs/forum/99spforum/99spf137.pdf	This paper proposes a method for allocating capital for the Casualty industry that parallels the concepts of the Capital Asset Pricing Model. The paper notes that while casualty risks are generally independent of the financial markets as a whole, with proper interpretation of the variance and covariance relationships between segments, the concept of 'systematic risk' can be specialized to apply to the broad Casualty insurance market itself. The author goes on to show how this observation can be used to justify the use of 'efficient market' principles to determine pricing and capital allocation questions and discusses the various factors that affect covariance between segments. The concepts are explained well. The assumptions which underpin the development of the concepts are discussed at length. Practical considerations are also outlined.
Panjer, Harry. "Measurement Of Risk, Solvency Requirements and Allocation Of Capital Within Financial Conglomerates." *AFIR/ICA.* March 2002. http://www.stats.uwaterloo.ca/Stats_Dept/IIPR/2001-reports/IIPR-01-15.pdf	Dr. Panjer's paper serves as a good stand-alone introduction to the concept of "coherence" as applied to both risk measurement and capital allocation procedures. It provides an analysis, based on first principles, of TailVaR as a methodology that satisfies these "coherence" criteria for the case of multivariate Normal risks. The practitioner would find the section with the numerical example of allocation of risk capital in a Bancassurance company to be particularly useful as it precisely illustrates both the valuable insights the methodology provides and the difficulties involved in its implementation. However, the problem of developing the covariance matrix required for these analyses is not addressed and is a core question for the practical use of this study. In addition, the entire exposition depends highly on the applicability of the multivariate Normal assumption to the loss distributions, an assumption that is convenient though not always realistic.

Ruhm, David and Mango, Donald. "A Risk Charge Calculation Based on Conditional Probability." CAS 2003 Thomas P. Bowles Jr. Symposium. **http://www.casact.org/coneduc/specsem/sp2003/papers/**	Using a simple example, this very readable paper builds on the work of several researchers to illustrate an approach to calculating risk charges known as covariance loadings--the extent to which each risk contributes to the aggregate portfolio risk. The method allows individual companies to use their own data (experience or simulation) to develop risk charges at the individual cell level that sum without further adjustment to the required aggregate portfolio charge. Such an approach is exactly suited for RAROC work. Conversely, the authors show how any similar "complete, additive" risk pricing system can be represented by such a covariance loading formula. Through a concept of an "implicit state-price structure" analogous to that underlying the Arrow-Debreu securities of the financial world, the authors show how the methodology in effect extends the familiar CAPM framework to the non-homogeneous risk distributions and dependence structures of the insurance world. Although ultimately based on simulation, the resulting risk charges represent a theoretically sound system that the user should also find intuitively satisfying.
Dhaene, Jan; Goovaerts, Mark J. and Kaas, Rob. "Economic Capital Allocation Derived from Risk Measures." *North American Actuarial Journal*. vol. 7, no. 2. 2003. **http://www.soa.org/bookstore/naaj03_04.html#economic**	The authors discuss using risk measures as a basis for allocating total enterprise capital among a conglomerate's subsidiaries and lines of business. Various properties of best practice risk measures are suggested, including additivity, capturing multi-dimensional economic risk characteristics and central tendency. The authors point out that good risk measures should cope with dependencies as well as with tails, and that certain risk measures should be avoided. Taking initial capital into account is vital. The authors stress the importance of considering the residual risks remaining after Economic Capital has been allocated.
Section 4. Applications of Allocated Capital	
Applications can include evaluating performance in relation to targets as well as evaluating whether certain projects or risks should be included in a company's portfolio. Casualty literature offers a few analyses examining specific reinsurance contracts that include only a few individual risks, and these articles are *not* included as recommended for the life / health industry.	
Patrik, Gary; Bernegger, Stefan; and Ruegg, Marcel. "The Use of Risk Adjusted Capital to Support Business Decision-Making." *Casualty Actuarial Society Forum.* Spring 1999. http://www.casact.org/pubs/forum/99spforum/99spf243.pdf	This paper presents a careful consideration of criteria required for a Risk Adjusted Capital (RAC) measure for risk management and decision support, noting that because required capital is not a static concept, traditional factor-based approaches are generally inadequate for this purpose. The authors provide an exhaustive checklist of elements involved in implementing a corporate-wide RAC system – one capable of driving the RAC analysis down to the individual business segments and thus providing a rational basis for allocating overall corporate return. They show that RAC satisfies most of the generally accepted requirements for an allocation system. The appendices provide a valuable source of background material.

Saita, Francesco. "Allocation of Risk Capital in Financial Institutions." *Financial Management*, vol. 28, no 3. Autumn 1999. http://www.findarticles.com/cf_dls/m4130/3_28/58453203/p1/article.jhtml?term=Saita	This is a valuable source that provides a good picture of the risk capital allocation process and its applications to evaluate performance. The objective of this paper is to provide a methodology for risk allocation and therefore capital allocation. This is essential for measures such as Risk Adjusted Return on Capital (RAROC) and Earnings at Risk (EAR) to be successfully implemented. In particular, this paper deals with the process of capital allocation and its applications on risk-adjusted performance evaluation. Three approaches to capital allocation are discussed: highly centralized Top-Down Allocation, most decentralized Creation of an Internal Market, and Negotiation (most common approach). To define the risk-adjusted performance, Capital-at-Risk measurement choice is crucial: Utilized CaR, Allocated CaR, or an intermediate approach. Three approaches are explained to take into account the diversification effect resulting from less than perfect correlation of risks: 1. Split the benefit in proportion of the CaR to the total. 2. Marginal allocation. 3. Internal Beta. Examples are given in the paper and a straightforward conclusion is made: the choice of "best" CaR measures depends on the purpose for which it is intended. Two risk-adjusted returns (RAROC and Residual Income) are compared with their relative advantages.
Newsome, J. Paul; Albanese, Robin; Foley, Vincent W. "Risk-Adjusted Capital: An Emerging Positive Secular Trend." Lehman Brothers, Sep 6, 2000.	Newsome and others write a straightforward paper about how risk-adjusted return on capital (RAROC) should be used to make business decisions for individual operating units / product lines within an insurer. The focus and examples are on P&C insurers, but their addressing of the topic is broad enough to apply to any insurance company. The article is a bit of a product placement / advertisement for some consulting services. Nonetheless its focus on the end use of RAROC and their view of what a more broad analysis would mean for the underwriting cycle and industry in general is beneficial as a big-picture reminder of what the calculation gymnastics involved in economic calculation and allocation can lead to.
Meyers, Glenn. "The Economics of Capital Allocation." *CAS 2003 Thomas P. Bowles Jr. Symposium.* http://www.casact.org/coneduc/specsem/sp2003/papers/	This paper is well recommended to clarify the basic premises underlying risk capital measures and their use in risk management. The author briefly summarizes the leading candidates among the many possible measures of risk, all of which accept the general principle that capital requirements increase with risk exposure. Through a straightforward series of propositions (with accompanying underwriting strategies) the author explains why the return on marginal capital must drive profitable underwriting decisions under any risk-capital measure consistent with the above principle. Further, the arguments show that if there is a limit on available capital, a profit-maximizing firm will seek to adjust its exposures until the return on marginal capital among all lines is equal. Though much of the paper focuses on proofs of equations and use of Lagrange multipliers, the author also contends that such mathematical rigor is not required to usefully implement the marginal capital strategies. It follows that a company seeking to allocate capital and intending to use return on capital as a decision factor must allocate that amount in proportion to marginal risk capital. The author introduces the term *heterogeneity multiplier* to refer to the ratio of total capital to the sum of the marginal risk capital. He then shows that if the risk measure satisfies the *sub-additivity axiom* common to most accepted measures of risk ("for random losses X and Y, C(X + Y) <= C(X) + C(Y)") then that ratio must be less than or equal to 1. The author points out that the ratio is equal to 1 only in case the risk measure also satisfies the axiom of *positive homogeneity* ("for all constants k >= 0, C(k·X) = k·C(X)"). Note that both axioms are satisfied for standard deviation, VaR, and TailVaR risk measures and form as well two of the four axioms that define a coherent risk measure. A useful example is developed to illustrate these points with the method of Lagrange

	multipliers applied to determine the common return on marginal capital that maximizes profit. An example is also given to illustrate where care must be taken in applying the marginal analysis to decisions on a larger scale such as adding or dropping entire lines of business.
Drzik, John; Nakada, Peter; Schuermann, Til. "Risk capital measurement in financial institutions" in two parts.	Addresses the broad issues of what the goals are for risk capital measurement and applications of the resulting calculations for management and performance measurement. Gives a few general hints that are useful (e.g. avoid simply looking at past variability to determine future estimates but rather take a more fundamental approach). The authors do include brief but useful applications of three items: intrinsic value, annual value added, lifetime value added for both resource allocations and performance measurement. Though useful as a general overview the authors do not at all address the technical problems of estimating distributions, correlations, etc. This is more an article intended for management that would then enlist practitioners to do the calculations than an article intended for practitioners to enhance their skills.
Zeppetella Tony. "Marginal Analysis of Risk Based Capital." *The Financial Reporter*, April 2002. http://www.soa.org/library/sectionnews/finrptng/FRN0204.pdf	The purpose of this paper is to analyze the components of a company's risk profile according to the NAIC formula and provide insights into how the marginal effect given the current risk position can affect the required capital and hence possibly the investment strategies. The author starts with a high level introduction on the two major changes of NAIC RBC formula for year-end 2001: the separation of common stock equity risk from other C-1 asset risk and the adjustment of some factors for the effect of taxes. The author then focuses on the risks in the square root of the formula. By taking partial derivatives of RBC with respect to the various C's, the weights reflecting the ratio of each risk component to the total square root of the sum of the squares of all the risk component in the square root can be determined. It first looks like a technical paper but arguments are very organized and clear. An example is followed to demonstrate two effects of the new formula: a company which has a lower stock allocation would have an even lower marginal cost of equity investments and the total RBC under the new formula is reduced compared to the old RBC formula. Optimal allocation of risks is also addressed. This paper does a nice job providing insight into the marginal effects of the new RBC formula with solid mathematical instruction.

Not Recommended

These articles were reviewed due to having potential but are not recommended as meeting the needs of the Economic Capital Calculation and Allocation goals. However, users may find some of the articles worth reading.

Academy Joint Risk Based Capital Task Force. "Comparison of the NAIC Life, P&C and Health RBC Formulas." Feb 12, 2002.

Artzner, P. "Application of Coherent Risk Measures to Capital Requirements in Insurance."

Artzner, P., Delbaen, F., Eber, J.-M., and Heath, D. "Coherent Measures of Risk."

Bock, Jerome. "Efficient Allocation of Economic Capital & Strategic Role of Economic Capital."

Bingham, Russell E. "Surplus--Concepts, Measures of Return, and Determination." PCAS LXXX. Also related commentaries Bender, Robert K. "Discussion of Bingham" PCAS LXXXIV. Ruhm, David and Grose, Carleton. "Discussion of Bender." PCAS LXXXVI.

Butsic, R.P. "Capital Allocation for property-liability insurers: a catastrophe reinsurance application."

Denault M. "Coherent Allocation of Risk Capital, Working Paper."

Kreps, Rodney. "Reinsurer Risk Loads from Marginal Surplus Requirements."

Longley-Cook, Alastair G (Moderator). "Risk-Based Capital Update. Session 61PD." RECORD, Volume 28, No. 1. Colorado Springs Spring Meeting May 30–31, 2002.

Mango, Donald. "An Application of Game Theory."

Mulvey, John M.; Michael J. Belfatti, Chris K. Madsen. "Integrated Financial Risk Management: Capital Allocation Issues."

Myers, Stuart and James Read, Jr. "Capital Allocation for Insurance Companies."

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