Capital Allocation Methods—Policyholder vs. Shareholder Perspectives

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Abstract: A key component of actuarial pricing involves the allocation of the required risk load down to the individual policy level. This allocation generally depends on a corporate risk measure. However, an often unanswered or even unaddressed question involves the perspective of the risk measure; specifically, shareholders and policyholders naturally have very different inherent viewpoints of the risk distribution. This paper discusses the implications of these differing risk viewpoints on policy pricing. In addition, the paper describes the problem within the context of the theory of financial economics, and concludes with some recommendations and opinions on the current state of risk allocation in the actuarial profession.

INTRODUCTION

In order to price an insurance policy or book of business, most actuarial methods require some sort of an allocation of either the corporate surplus or the total corporate risk load. This allocation is generally accomplished by means of a risk measure. There is, however, a very fundamental – and often unaddressed – issue regarding this risk measure: should the risk measure reflect a policyholder or a shareholder viewpoint?

Policyholders and shareholders will be expected to possess a very different set of risk preferences. As Glenn Meyers points out, "from policyholder's standpoint, the only risk that matters is insurer insolvency." [1] Shareholders, on the other hand, may be more concerned about the total spectrum of adverse outcomes, including any outcome in which actual return on contributed surplus falls short of expected return. Moreover, policyholders distinguish between "degrees" of insolvency, whereas once the surplus is "wiped out" shareholders are unconcerned about just how "bad" any resulting policyholder shortfalls may be. From a company management or shareholder perspective, Kreps expresses this idea as follows: "once you are buried, it doesn't matter how much dirt is on top." [2] But for policyholders, the amount of "dirt on top" at the funeral (the so-called "policyholders deficit") is a critical consideration.[1]

In this paper, we will provide a simple pricing example, in order to illustrate and discuss some common actuarial allocation techniques from both a shareholder and policyholder perspective. From an actuarial viewpoint, we will discuss both the capital allocation and the Ruhm/Mango/Kreps (or "RMK") approaches to a solution. We will also provide a financial pricing

[1] It is important to note that the existence of guaranty funds can influence the policyholder's perspective of risk. For lines that are subject to guaranty fund protection, policyholders of insolvent insurance companies may be able to obtain reimbursement from the guaranty fund; however, the recovery may not be complete, and will generally involve significant delays and uncertainties.

solution. The paper will close with some general conclusions and recommendations.

Capital Allocation Methods

Let's start by framing the problem in statistical terms. Assume that a newly-formed insurance company will write *n* contracts or segments, with losses on each of the contracts payable at the end of one year. For each contract/segment, losses are represented by the random variable Xi, i = 1,2,…,n. Aggregate losses for the insurance company are denoted by the random variable Y, where Y = ∑Xi. We will ignore underwriting and loss adjustment expenses, as well as federal income taxes.

The actuarial allocation problem involves the determination of the premium, Pi, to be charged (at the beginning of the year) for each of these *n* policies. Most actuarial allocation methods assume – either explicitly or implicitly – that there is some overall *corporate* goal, such as a target return-on-equity (ROE). In many actuarial methods, this corporate goal applies *separately* to each individual policy or segment as well; in other words, the premium for *each* of these *n* policies is also required to satisfy this corporate goal.

This determination generally involves an allocation of the insurance company's total surplus to each individual contract. In order to allocate surplus, we require both a *total risk measure*, and an *allocation rule* for pushing that total risk measure down to the contract level. The total risk measure, or p(Y), is usually a function of the aggregate corporate loss random variable. The allocation rule, or r(Xi), is a function that applies separately to the loss random variable for each of the *n* policies. Generally we look for an allocation rule that sums up to the total risk measure – that is, ∑r(Xi)=p(Y).[2] Surplus is then allocated in proportion to the allocation of the risk measure.

A Simple Pricing Example

In order to clearly illustrate the ideas involved, let's focus on a very simple, illustrative pricing example. Assume that a start-up insurance company has been formed to write two lines of business, auto physical damage (APD) and catastrophe reinsurance (Cat). Aggregate losses are payable at the end of one year, but vary by state-of-the-world according to the following table:

State-of-World	State Probability	Total APD Loss	Total Cat Loss	Total Company Loss
Good	50.0%	$80	$10	$90
Bad	49.5%	$120	$10	$130
Ugly	0.5%	$120	$300	$420
Expected Value		$100	$11.45	$111.45

Following the notation introduced above, let Xapd be the random variable for APD losses; Xcat is the Cat loss random variable; and Y is the total company loss random variable, where Y = Xapd + Xcat.

[2] The notation here is borrowed from Venter, Major & Kreps [3].

Shareholders have contributed \$150 of up-front capital to fund this new company; we will assume that shareholders require a 10% per annum return on this capital investment. The risk-free rate is 5% per annum. Also, assume that the insurance company's asset portfolio will be invested at the risk-free rate of 5%. In order for shareholders to achieve an expected return of 10%, the *total* corporate premium must be equal to \$113.29.[3]

As a first attempt, let's utilize excess tail value at risk (XTVaR) as our total risk measure. The XTVaR risk measure is specified as follows: $p(Y) = E[Y - E(Y) \mid Y>b]$, where *b* is a *cutoff point* for the losses. For this risk measure, we also have a natural allocation rule given by $r(Xi) = E[Xi - E(Xi) \mid Y>b]$. This also happens to be an additive allocation rule; that is $\sum r(Xi)=p(Y)$.[4] For a cutoff point, we will use b=\$276.45, which is the amount of aggregate losses which will entirely "wipe out" the insurance company's surplus. In this sense, our risk measure is really focusing on the *risk of insolvency* to the insurance company.

For this measure, we can easily calculate both the total risk, and the allocation of that risk to component:

$p(Y) = E[Y - E(Y) \mid Y>\$276.45] = \$420 - \$111.45 = \$308.55$

$r(Xapd) = E[Xapd - E(Xapd) \mid Y>\$276.45] = \$120 - \$100 = \$20$

$r(Xcat) = E[Xcat - E(Xcat) \mid Y>\$276.45] = \$300 - \$11.45 = \$288.55$

Surplus is then allocated in proportion to the allocation of the risk measure, or 6.5% (\$20/\$308.55) to APD and 93.5% (\$288.55/\$308.55) to Cat. This results in the following allocation of the \$150 surplus: \$9.75 to APD, and \$140.25 to Cat. The higher allocation to the Cat line reflects that line's much greater relative contribution to the insolvency risk of the company.

Lastly, we need to determine the premiums that result in an expected ROE of 10% for each line. The resulting premiums are \$95.70 for APD and \$17.59 for Cat, as demonstrated in the following table:

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3 Assuming that the entirety of the premium is paid up-front, then assets at the beginning of the year are equal to the total premium of \$113.29 plus total surplus of \$150, which equals \$263.29. At the 5% risk-free rate, assets at the end of the year are equal to \$263.29 x 1.05 = \$276.45. With expected aggregate losses of \$111.45, the expected surplus at the end of the year equals \$276.45 - \$111.45 = \$165. Thus, the expected return on surplus is \$165 / \$150 – 1 = 10%.

4 See Venter, Major & Kreps [3].

	APD	Cat
(1) Premium	$95.70	$17.59
(2) Allocated Surplus	$9.75	$140.25
(3) Assets at Beginning of Year = (1) + (2)	$105.45	$157.84
(4) Assets at Year-End = (3) x 1.05	$110.72	$165.73
(5) Expected Loss at Year-End	$100	$11.45
(6) Expected Surplus at Year-End = (4) - (5)	$10.72	$154.28
(7) Expected Return on Surplus = (6) / (2) – 1.0	10%	10%

Policyholder Versus Shareholder Risk Measures

The resulting premiums in the example above are dependent on the surplus allocation, which depends on both the total risk measure and the allocation rule. The question, then, that naturally arises is "how do we know that we have selected the 'right' total risk measure?"

In the previous solution, we utilized a risk measure that focused on the risk of insolvency, or the total depletion of surplus. As discussed earlier, an insolvency-based risk measure is appropriate from the standpoint of the *policyholder*. In our example, policyholders are only concerned about the loss outcome in the "Ugly" scenario; in this scenario, year-end assets will be inadequate to cover year-end losses, leaving the company unable to fully meet its obligation to policyholders.[5]

On the other hand, *shareholders* may be concerned about more than just insolvency risk. Shareholders have invested the $150 of surplus in this company in the hopes of realizing an acceptable return on that investment. As such, shareholders may also be concerned about scenarios in which the total return on this investment falls short of their 10% expected/required return. That is, in terms of the loss outcomes, shareholders are potentially concerned about any scenario in which the actual corporate loss exceeds its expected value. In our example, this occurs under both the "Bad" and the "Ugly" scenario.

Alternatively, shareholders may be concerned about any outcome which involves a loss of capital, or so-called "capital consumption". Mango [4] uses the notion of an "experience account" from finite reinsurance to explain the concept of capital consumption. Specifically, any scenario in which total costs exceed total revenues – where revenues include both premiums and investment income on collected premiums – creates an operating deficit, or a "capital consumption". In our example, the total premium invested at the risk-free rate results in a total revenue flow of $113.29 x 1.05 = $118.95. Thus, any aggregate loss in excess of $118.95 results in a loss of capital, and this occurs under both the "Bad" and the "Ugly" scenario.

For the sake of comparison, let's re-do the pricing example using capital consumption as the risk measure. Specifically, we will maintain the XTVaR model, but we will now set the cutoff point *b*

[5] Many other policyholder risk measures are possible. For example, we could also use probability of ruin or expected policyholder deficit as the total risk measure.

equal to the capital consumption point of \$118.95. This results in the following risk allocation:

p(Y) = E[Y – E(Y) | Y>\$118.95] = (0.495/0.500) x (\$130 - \$111.45) + (0.005/0.500) x (\$420 - \$111.45) = \$21.45

r(Xapd) = E[Xapd – E(Xapd) | Y>\$118.95] = (0.495/0.500) x (\$120 - \$100) + (0.005/0.500) x (\$120 - \$100) = \$20

r(Xcat) = E[Xcat – E(Xcat) | Y>\$118.95] = (0.495/0.500) x (\$10 - \$11.45) + (0.005/0.500) x (\$300 - \$11.45) = \$1.45

The \$150 of capital is then allocated in proportion to the risk measure allocation, resulting in the following capital allocation: \$139.86 to APD, and \$10.14 to cat. Finally, we determine the premiums that result in an expected ROE of 10% for each line, as shown in the following table:

	APD	Cat
(1) Premium	\$101.90	\$11.39
(2) Allocated Surplus	\$139.86	\$10.14
(3) Assets at Beginning of Year = (1) + (2)	\$241.76	\$21.53
(4) Assets at Year-End = (3) x 1.05	\$253.85	\$22.61
(5) Expected Loss at Year-End	\$100.00	\$11.45
(6) Expected Surplus at Year-End = (4) - (5)	\$153.85	\$11.16
(7) Expected Return on Surplus = (6) / (2) – 1.0	10%	10%

Note the large impact of the selected cutoff point on the resulting premiums. In particular, the policyholder (or insolvency) based allocation rule assigned a *much* higher capital amount, and resulting premium, to the Cat line than the shareholder (or "capital consumption") based allocation rule. Of course, this is an over-simplified and carefully-selected example; moreover, the analysis focuses only on one risk measure. However, Vaughn [5] performed a similar analysis on a realistic multi-line insurance data set, with a large number of both policyholder and shareholder based allocation rules. In that analysis, the insolvency-based allocation rules consistently allocated a much higher percentage of risk (and premium) to the highly-skew, or cat-prone, lines than the shareholder allocation rules.

As demonstrated, the choice between a policyholder and a shareholder based risk measure can make a very significant difference in the actual line pricing. In the actuarial literature, there is currently very little guidance given regarding the selection between the two different viewpoints. Venter, Major and Kreps [3] do discuss the issue in the context of the XTVaR risk measure, and offer the following comments:

One possibility for establishing a cutoff probability for tail risk measures would be to use the probability of having any loss of capital at all. Then XTVaR would be the average loss of capital when there is a loss of capital. Another possible choice is the probability that capital is exhausted. The former is arguably more relevant to capital allocation, in that it charges for any use of capital rather than focusing on the shortfalls upon its depletion….

On the other hand, policyholders tend to be sensitive to impairment or default. Studies suggest that they demand premium reductions one or two orders of magnitude greater than the expected value of the default cost in order to accept less than certain recovery. This is in part due to undiversified purchases of insurance. Thus the value of default has meaningful pricing effects, and policyholder concerns become quite relevant to shareholders as well.

In other words, Venter/Major/Kreps contend that a valid case could be made for either an insolvency-based or a capital consumption cutoff point. Yet, given the large difference in resulting premiums, it would be desirable to have a firmer theoretical basis for this decision. This will be discussed more in later sections, in the context of current financial economic theory.

Variance-Based Risk Measures– Something In Between

Before we move on to pricing techniques that do not require an actual allocation of capital, let's consider the following risk measure for the capital allocation: p(Y)=Var(Y). A natural, and additive, allocation rule corresponding to this risk measure is the following: r(Xi)=Cov(Xi,Y). For our simple example, the resulting risk allocation is as follows:

P(Y) = Var(Y) = 0.500 x ($90 - $111.45)^2 + 0.495 x ($130 - $111.45)^2 + 0.005 x ($420 - $111.45)^2 = 876.4

r(Xapd) = Cov(Xapd,Y) = 0.500 x [($80 - $100) x ($90 - $111.45)] + 0.495 x [($120 - $100) x ($130 - $111.45)] + 0.005 x [($120 - $100) x ($420 - $111.45)] = 429

r(Xcat) = Cov(Xcat,Y) = 0.500 x [($10 - $11.45) x ($90 - $111.45)] + 0.495 x [($10 - $11.45) x ($130 - $111.45)] + 0.005 x [($300 - $11.45) x ($420 - $111.45)] = 447.4

This results in a surplus allocation of $73.43 to APD and $76.57 to Cat – which is actually very close to a fifty-fifty split. The resulting premiums are $98.74 for APD and $14.55 for Cat, as demonstrated in the following table.

	APD	Cat
(1) Premium	$98.74	$14.55
(2) Allocated Surplus	$73.43	$76.57
(3) Assets at Beginning of Year = (1) + (2)	$172.17	$91.12
(4) Assets at Year-End = (3) x 1.05	$180.78	$95.68
(5) Expected Loss at Year-End	$100	$11.45
(6) Expected Surplus at Year-End = (4) - (5)	$80.78	$84.23
(7) Expected Return on Surplus = (6) / (2) – 1.0	10%	10%

Note that the premiums in this example fall in between the two XTVaR solutions from the previous subsection. Also, note that this solution is sometimes referred to as the "CAPM solution", because of its similarity in *appearance* to the familiar CAPM of financial theory. In general, the variance risk measure should also be considered as a shareholder-based measure. Again, policyholders are only concerned about insolvency; outcomes which create variance below the "insolvency point" are not of concern to the policyholders. On the other hand, actuaries sometimes assume that shareholders are concerned about the variance of the return variable[6], which is the implicit perspective of this risk measure.

Allocation of Risk Loads

As opposed to methods which allocate capital to line or segment, other actuarial methods directly allocate the total corporate *risk load*, thereby eliminating the need for a capital allocation to line. The corporate risk load is defined as total corporate premium minus the discounted (at the risk-free rate) expected value of aggregate losses. This total corporate risk load can still be determined via a corporate "goal" such as target ROE. For example, it was demonstrated in the previous section that a total corporate premium of $113.29 corresponded to an expected corporate ROE of 10%. For each of the three examples, this total corporate premium was spread differently between the two lines (depending on the selected risk measure and the allocation of capital to line), but the total corporate premium remained unchanged.

Hence, in our simplified example from the previous section, the total corporate risk load that corresponds to a 10% ROE goal is calculated as follows:

Risk Load = Premium – Discounted (at risk-free rate) Expected Loss = $113.29 - $111.45 / 1.05 = $7.15.

Each of the three allocation methods discussed in the previous section can be used to directly allocate this *risk load*, instead of an allocation of *capital*. As an example, when we discussed XTVaR with an insolvency-based cutoff point (b=$276.45), the total risk measure p(Y) was allocated 6.5% to APD and 93.5% to Cat. Allocating the risk load (as opposed to the capital) in proportion to this risk measure results in a risk load of $7.15 x 6.5% = $0.46 for APD and $7.15 x 93.5% = $6.69 for Cat. The premiums are then determined by adding the risk load to the discounted expected loss amount for each line, as follows:

APD Premium = $100/1.05 + $0.46 = $95.70

Cat Premium = $11.45/1.05 + $6.69 = $17.59

As shown, the resulting premiums are identical to the surplus allocation example that relied on XTVaR with an insolvency-based cutoff point. This equivalency can also be verified for both the XTVaR with a capital consumption cutoff and the variance approach. Here, the difference is more in terminology than in substance.

The RMK Approach

A recent development in allocation pricing is the so-called RMK approach. As in the previous section, the RMK approach can be used to allocate overall corporate risk loads to line of business, without requiring a surplus allocation. However, the method still requires a "risk measure", which

[6] See the discussion of RMK methods below.

accomplishes a similar role as the p(Y) measure from our previous section. And, once again, we must first ask ourselves if this risk measure should be guided by the risk preferences of the policyholders or the shareholders, as these two constituencies can have a very different viewpoint toward risk.

In general, RMK literature appears to emphasize a shareholder interpretation of this risk measure. For instance, Clark [6] states that "from a stockholders perspective, the risk that matters most is the risk that losses will eat into the capital invested in the company (i.e. that capital will be 'consumed')." He then goes on to provide an example of the RMK approach with a "capital consumption" risk measure (see Exhibit 3a in the Clark paper). This would be comparable to the approach used in our XTVaR with a capital consumption cutoff in the section above.

Capital consumption, of course, isn't the only potential shareholder risk measure. Clark also notes that "stockholders may be interested, for example, in minimizing the variance of the company's results," and he provides a numeric illustration (see Exhibit 3b of that paper). This would be comparable to our variance allocation method in the earlier section.

However, while Clark doesn't explicitly consider it, the RMK approach could also be utilized with a policyholder approach to risk preferences. The important thing to note is that the RMK methods also require a certain interpretation of the insurer risk preferences, and these can be viewed from *either* a policyholder or a shareholder perspective.

The Financial Theory Solution

For both the capital allocation and the RMK approach, we need to specify a risk measure. This selected risk measure can have a big impact on the resulting premium, as demonstrated in the simple pricing example. So should we use a risk measure that is based on capital consumption, variance, insolvency risk, or some other quantity? In this section, we look to financial theory for some guidance.

As noted above, actuarial risk load methods generally utilize the following formula for the premium on a given policy:

Premium = Discounted (at risk-free rate) Expected Loss + Total Corporate Risk Load x Allocated Risk Percentage

Moreover, the "Allocated Risk Percentage" in this formula is often determined via a shareholder-based risk measure, such as XTVaR with an expected loss or "capital consumption" cutoff point. There are two real shortcomings with the actuarial literature here. First, the actuarial literature tends to focus very heavily on the mechanics for allocating various risk measures, while offering very little real guidance or theoretical support regarding the selection of the risk measure. Secondly, the actuarial methods are, in effect, combining *two* separate, and often distinct, perspectives on risk – i.e. the shareholder view and the policyholder view – into a *single* risk measure.

On the other hand, financial methods for insurance pricing recognize and attempt to overcome these weaknesses. Importantly, the financial method acknowledges and separately quantifies the two distinct viewpoints. The most common financial formula for the premium on a given policy is as follows[7]:

Premium = Discounted (at risk-adjusted rate) Expected Loss + Total Corporate Frictional Capital Costs x Allocated Capital

Importantly, this formula or method acknowledges and separately quantifies the two distinct viewpoints on risk: the policyholder (or "insolvency") perspective is reflected in the surplus allocation, whereas the shareholder perspective is reflected in the *risk-adjusted discount rate* for the expected loss. Furthermore, it is critical to note that the shareholder perspective is *different* from both the "capital consumption" and the variance viewpoints discussed in the previous section. These earlier viewpoints assumed that shareholders focus on the variability of the corporate return as a single entity, whereas financial models focus on the covariance of the corporate return in the context of a much broader financial market index. That is, in the financial model, the shareholder perspective on risk accommodates modern financial theories regarding shareholder portfolio diversification.

Strictly speaking, the expected losses for each line should be discounted at a risk-adjusted discount rate. This risk adjustment reflects shareholder risk and is usually based on some financial market model. Determining the proper risk adjustment for the discount rate by line of insurance is a difficult problem. In practice, empirical studies of "underwriting betas" have not demonstrated large differences in systematic risk by line [9]. Many authors following a financial approach also argue on intuitive grounds that no risk adjustment is required in the discount rate; Feldblum [12] explains the rationale as follows: "Underwriting risks are independent of capital market movements; these risks are diversifiable and do not warrant additional returns." For these reasons, in many financial papers on the subject the expected losses are discounted at the risk-free rate (reflecting a "zero-beta" for each line) and we will follow that approach in the financial solution in this paper.

In the financial formula above, the total "frictional costs of capital" play the role of the corporate risk load in the actuarial model. Since the primary purpose of this paper is to focus on the *allocation* issues in pricing insurance, let's calibrate this frictional cost percentage in order to match the corporate risk load (shown, in an earlier section, to be equal to $7.15) in our earlier example. The frictional cost percentage that accomplishes this calibration is determined by calculating the ratio of the corporate risk load to the total surplus: $7.15 / $150 = 4.77%.

The key point of this section is that in the economic/financial model, the *policyholder* or "insolvency" viewpoint determines the allocation of capital. Zanjani [10] summarizes as follows:

[7] For a detailed presentation of this formula, see Myers/Cohn [7] and Myers/Read [8].

"The important point is that, in general, the appropriate capital allocation rule is driven by *consumer* attitudes toward risk. In principle, the rule could be affected by any aspect of the distribution of *defaulted* claims..." Zanjani then provides several examples of policyholder-based capital allocation rules. For consistency with the earlier section, let's use XTVaR with an insolvency-based cutoff point for our capital allocation. As shown earlier, this results in the following allocation of capital by line: APD = $9.75, Cat = $140.25. The financial formula then results in the following premiums by line:

APD = $100 / 1.05 + 4.77% x $9.75 = $95.70

Cat = $11.45 / 1.05 + 4.77% x $140.25 = $17.59

These are identical to the premiums determined earlier using the actuarial methods with XTVaR and an insolvency-based cutoff point.

Conclusions and Opinions

Granted, this is an oversimplified, and somewhat exaggerated pricing example. However, the example serves to illustrate a common pricing tradeoff between highly skew, cat-prone lines of business and lines with ordinary volatility but no cat risk. The following comments represent the author's conclusions and opinions regarding the current state of allocation methods in actuarial science.

Actuarial methods – both capital allocation methods and RMK approaches – typically utilize a single risk measure (e.g. the p(Y) function of capital allocation or the L(x) function of RMK). This forces the actuary to *choose* between a policyholder-based risk measure (such as XTVaR with a high cutoff point) and a shareholder risk measure (such as capital consumption). On the other hand, the financial method offers an approach and framework that allows the actuary to incorporate both viewpoints – as opposed to forcing a choice between them.

For actuarial methods that utilize a shareholder risk measure, there is no good way to incorporate the impact of individual shareholder diversification, since the risk measure is a function of the aggregate loss variable, Y, alone.[8]

Actuarial methods typically focus much more on the mathematics underlying the allocation than the theory and rationale for it. In fact, many actuarial papers have abandoned theory altogether, and require a completely subjective input for "corporate risk preferences". But abandoning the search for a theoretically-sound solution that is based on the principles of shareholder value maximization leaves each company searching aimlessly after its own personal *ignis fatuus*. Actuaries can, and should, do better.

[8] In order to reflect systematic risk, the total risk measure would need to be a function of both Y and the systematic risk, or "beta" of Y. Some have suggested that a reasonable solution to this "systematic risk" problem is to define Y as net income – using the "market portfolio" as the assumed asset allocation for the company – instead of aggregate losses. However, there are many conceptual problems associated with this change – as discussed in [11].

In contrast, financial methods are grounded in theory, and reflect the important insights of economics and finance. Financial methods start from "first principles" of economics, under various assumptions about insurance, and then proceed to a pricing solution. It is important to note that many actuaries and others have criticized the specific assumptions underlying the financial methods. Even so, the main messages should not be ignored, which are as follows: (a) the expected losses should be discounted at a risk-adjusted discount rate which incorporates the central theme of individual investor diversification, and the covariance of the insurance losses with the broader stock index;[9] and (b) to the extent that insurance consumers are concerned about solvency risks, then any remaining frictional costs (or "risk loads", in actuarial terminology) should be allocated in accordance with a policyholder risk measure.

Actuarial capital allocation methods that use a policyholder-based risk measure will generally provide a good approximation to financial pricing methods, provided that the systematic risk component of the loss variables is close to zero.

Actuarial methods – either capital allocation or RMK – that utilize a capital consumption (or other 'shareholder based") approach will undercharge cat lines. Lines with ordinary volatility, but no significant skewness or insolvency exposure, will be overcharged.

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[9] As noted earlier, most financial models generally utilize a risk-free discount rate. Feldblum [12] explains as follows: "Underwriting risks are independent of capital markets movements; these risks are diversifiable and do not warrant additional returns."