Coherent Capital for Treaty ROE Calculations

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Abstract:

This paper explores how a coherent risk measure could be used to determine risk-sensitive capital requirements for reinsurance treaties. The need for a risk-sensitive capital calculation arises in the context of estimating the return on equity (ROE) for several treaties or different options on one treaty. Looking at the loss random variable alone is insufficient for a complete risk analysis since this would fail to incorporate the impact of adjustable premium and ceding commission provisions on the final net risk. The paper presents a framework for systematically reflecting treaty features by viewing capital as a function of the distribution of the final net underwriting loss. To avoid negative values for indicated capital, the concept of a risk quantity variable is introduced as a non-negative monotonically increasing function of the net underwriting loss variable. Two risk quantities are discussed: one obtained by capping the net underwriting loss from below at zero, and the other by taking the excess of the net underwriting loss above its expectation. A coherent risk measure is then applied to a risk quantity to obtain indicated capital. The approach is demonstrated in simple discrete distribution examples by applying a coherent measure, the Tail Value at Risk, to the two risk quantities. Sensitivity testing on the examples is presented showing how the different measures respond to changes in premium adequacy, swing rating, sliding scale commission plans, and layering. In summary, this paper is one attempt to bridge the gap between the theoretical results of coherence theory and the practical need for methods to set risk-sensitive capital in treaty ROE analysis.

Keywords: Coherence, Reinsurance, Capital Requirements, TVaR

1. INTRODUCTION

Current financial theory says the theoretically best way to measure risk is with a coherent risk measure. The theory views risk as uncertainty regarding the future net worth of an investment portfolio or company at a specified point in time ([1], [2]). The theory allows the net worth to possibly take on negative values. It measures risk as the additional amount of money needed to ensure the future net worth will fall within a predefined set of acceptable outcomes, called the acceptance set [2]. The measure could take on a negative value, indicating that risk-free assets, such as cash, could be withdrawn while still leaving the portfolio in the acceptable range. The measure and the acceptance set are directly related: the acceptance set is the set of all the net worth random variables on which the measure is less than or equal to zero. A coherent risk measure is one that satisfies several desirable properties. Some common measures of risk, such as variance, standard deviation, and the Value at Risk (VaR) fail to be coherent. On the other hand, other measures, including the Tail Value at Risk (TVaR) and the Proportional Hazard Transform (PHT), have been proved to be coherent. Several authors, including Artzner [2], Meyers [8], and Wirch and Hardy [14], have recommended using coherent risk measures to determine appropriate capital requirements. Our purpose in this paper is to explore how to apply coherent risk theory in order to obtain a coherent capital calculation for reinsurance treaty analysis.

While risk measures in insurance are often viewed as applying to loss random variables, that is insufficient for our purposes. The problem is that focusing solely on the loss random variables fails to capture the essential complexity of various adjustable features of reinsurance treaties. These features may alter the premium or change the ceding commission, so that these become functions of the loss outcome. Some of the features seem to reduce risk; others intuitively have no effect. Our goal is to arrive at a capital calculation that reflects the impact treaty features may have on the final net risk. In order to do this in a general and consistent fashion, we believe it is best to start with the final net underwriting loss random variable. Here the underwriting (technical) loss is defined as loss plus commission less premium.

But this raises a problem. The net underwriting loss random variable should often take on negative values, corresponding to underwriting gain scenarios. Yet, if we allow measures, even coherent measures, to operate on random variables that can become negative, we may well end up with a negative result. For an indicated capital algorithm to produce a negative answer is, in our view, flatly unacceptable. It is possible that our insistence on non-negative capital requirements is at odds with the basic conceptual structure of coherence theory in which it is well possible for the measure to be negative.

In any event, to handle the negative values problem in some generality, we introduce the concept of a risk quantity variable. We define a risk quantity variable as any non-negative random variable that is a monotonically increasing function of the net underwriting loss. Because the risk quantity is non-negative, we can never end up with a negative capital indication. To summarize, our general notion is to compute capital by applying a coherent measure such as TVaR or PHT to a risk quantity variable. We will call this a "coherent capital calculation" though our approach may differ in places with some of the basic structure of coherent risk measures.

We have found two plausible risk quantity variables. Both are based on the net underwriting loss random variable after application of all treaty provisions. The first is obtained by capping the underwriting loss from below at zero. Since underwriting gains correspond to negative underwriting losses, this capping collapses all underwriting gain scenarios to zero. The second approach uses a risk quantity variable obtained by taking the amount of underwriting loss in excess of its expected value.

To illustrate these methods, we will apply a coherent risk measure, TVaR, the Tail Value at Risk, to our risk quantity variables and thus obtain two different coherent capital formulas. We will show these coherent capital formulas have different behavior when viewed as functions of the loss, expense, and premium.

To show how these formulas work we will apply them to a hypothetical treaty with losses that follow a discrete loss distribution. We will then conduct sensitivity testing to see how indicated capital responds to changes in treaty pricing, treaty features, reinsurer share, and layering. For comparison purposes, we will also compute indicated capital based on a fixed leverage ratio against provisional premium and a fixed leverage ratio against initial expected layer loss. We will also run comparisons against the standard deviation of underwriting loss and the variance of underwriting loss. As previously stated, these are non-coherent risk measures.

In the end, we believe we will have shown with concrete examples that fixed leverage ratio methods are deficient and that net underwriting loss should be the basis for risk-sensitive capital calculations. Our work also casts doubt on the variance of underwriting loss and, to a lesser extent, on the standard deviation of underwriting loss. We will have demonstrated two different ways of implementing a coherent capital methodology, without concluding which one is best, but shown that they have quite different behavior.

In this paper our focus is on process risk and how to reflect changes in process risk induced by changes in treaty features. Because parameter risk, correlation, and portfolio effects have not been considered, our treatment is incomplete. Further, our approach to implementing coherent capital concepts may not be the only one. But nonetheless our larger conclusion is that at this point the introduction of coherent risk measures has not definitively settled the question of how to set capital. Though progress has been made, implementation of coherence concepts remains a topic open to further research in the future.

2. CAPITAL FOR TREATY ROE CALCULATIONS

Our interest in determining capital arises when computing the prospective ROE (return on equity) for a treaty. Typically we are asked to determine the ROE for a treaty at several premium rates. In our calculation, we must reflect any contingent commission, reinstatement, aggregate loss cap, swing rating, or other such provisions of the treaty. The amount of capital is a critical determinant of our results and so questions about how to set the capital become important. Because various treaty features that impact premiums and expenses can change the overall risk of the deal, a risk measure based on loss only is inadequate for our purpose. Our approach to capital requirements is, in this regard, similar to Feldblum's view that risk loads should not be based solely on the loss distribution [6].

When actually pricing a treaty, we would first model possible loss scenarios and use actuarial techniques to estimate the probability of each scenario. Depending on the terms and provisions of the treaty, each scenario leads to its own ultimate combined ratio, cash flows, and ROE. For each of these scenarios, we would hold the same amount of capital in our pricing model, because, a priori, we have no way of knowing which scenario will actually occur. We end up with a distribution of ROE values, not just a single point estimate. Also, the capital held in our models would not be a simple fixed block amount posted for one year, but would also include amounts varying over time to cover uncertainty in the reserves. In this paper, however, we will only consider the distribution of ultimate outcomes and will leave for others the question of how capital should be held over time to cover potential reserve inadequacy. Also we will assume in this paper that all values are at present value. This simplification will allow us to ignore the time value of money. In any real application, one should of course reflect the time value of money, payout pattern uncertainty, asset risk, and other related concerns.

We should also realize at the outset that use of any theoretically based measure to set capital may lead to an implicit leverage ratio on a treaty or block of treaties that is either higher or lower than industry rating agency or regulatory norms. While particular blocks of business may be more or less risky than presumed in deriving industry standards, there is a great deal of uncertainty and some subjectivity in selecting parameters for any model. Given that uncertainty, we are not suggesting that our estimates of required capital ought to lead to any revision of accepted industry capital benchmarks. Also, we are setting a theoretically appropriate level of capital by treaty that when aggregated over all treaties may differ from the actual amount of capital held by a company. In separating actually held capital from the capital used in pricing models, we are recognizing that no pricing penalties or subsidies should ensue from pre-existing under-capitalization or over-capitalization. Though in principle we should compute a benchmark amount of capital for our whole portfolio and then allocate this coherently [5] to individual treaties, our work here is focused on the simpler problem of computing benchmark capital for each treaty on a stand-alone basis. Our goal is to see if coherent capital approaches can be used to appropriately model the impact of treaty features on the capital requirement. Thus we leave as a topic for future research the consideration of portfolio effects, parameter risk, and correlation. To summarize, our purpose is to study procedures that should guarantee a logical ordering of the capital requirements for alternative treaty structures, and not to resolve questions about overall calibration or allocation.

3. COHERENT RISK MEASURES

The theory of risk measures took a major step forward with the introduction of the concept of coherence by Artzner, Delbaen, Eber and Heath in 1999 [1] and their presentation of results on the representation of coherent risk measures. Their work successfully implemented a general program of listing desirable properties for a risk measure and then characterizing the types of measures that satisfy those properties. Before and since, others such as Wang [11] and Venter [10], have made critical contributions to the theory and understanding of arbitrage-free pricing, power transforms, distortion measures, stochastic dominance properties, and other related concepts. Wirch and Hardy [14] explained the relation between concave distortion measures and coherent risk measures. Meyers [8], [9] did a great service to the actuarial community by writing an intuitive and accessible introduction to the concept.

In applying the concept to insurance, what is sometimes unclear in the literature is whether the risk measure is being viewed as a premium calculation, risk load calculation, or required capital formula. We will defer consideration of this issue till later after we have defined coherence in a general setting.

To begin the mathematical development of risk measures for insurance capital, we define a **risk measure**, ρ, as a function that maps a non-negative random variable, B, to a non-negative number, $\rho(B)$. The reason we insist on having non-negative variables is to avoid negative values for the risk measure and the resulting capital requirement. For an example of how this could occur, consider an underwriting loss distribution that takes on the value, –70 with 90% probability, -50 with 9% probability, and +400 with 1% probability. As we will later learn when we consider TVaR in more detail, the TVaR measure associated with the 90th percentile would be –5. But we would certainly not want that as a capital requirement. Assuming our restriction to non-negative random variables, we define coherence of the risk measure as follows:

Coherence Properties for Risk Measures (3.1)

A risk measure, ρ, is said to be coherent if it satisfies:

1. Zero has No Risk: If $B \equiv 0$, then $\rho(B)=0$
2. Monotonicity: If $B_1 \leq B_2$, then $\rho(B_1) \leq \rho(B_2)$
3. Scaling: If $\lambda>0$, then $\rho(\lambda B) = \lambda \rho(B)$
4. Subadditivity: $\rho(B_1+ B_2) \leq \rho(B_1) + \rho(B_2)$
5. Translation Additivity: If $\alpha >0$, $\rho(B+ \alpha) = \rho(B) + \alpha$
6. Bounded from Below: $E[B] \leq \rho(B)$
7. Bounded from Above: If $\max(B)<\infty$, then $\rho(B) \leq \max(B)$

This list was drawn from the lists of coherence properties that are contained in the papers by Meyers [8] and Wirch and Hardy [14]. We believe the translation additivity property and the bounds describe a coherent premium calculation operating on the loss distribution.

4. COHERENT CAPITAL

Our overall goal is to set capital, C, as a function of the loss, expense and premium. To apply the coherence properties in setting capital, we first define underwriting loss, U, as the sum of loss, L, plus expense, X, less the premium, P.

For our first method, we follow the suggestion of Wirch and Hardy [14] and define our risk quantity variable as the bounded underwriting loss, B, obtained by capping the underwriting loss from below at zero. Thus, in our notation, we have:

$$B = \max(0, U) = \max(0, L+X-P) \tag{4.1}$$

We may sometimes write B(U), B(U(L,X,P)), or B(L,X,P): whatever is most convenient. Note, B is a non-negative random variable and that all underwriting gain scenarios collapse to the "zero" mass point of B. We will define capital as Level Sensitive Coherent if it can be expressed by applying a coherent risk measure to the bounded underwriting loss.

Level Sensitive Capital Coherence (LSCC) Definition (4.2)

A capital function C is called *level sensitive coherent* if there exists a coherent risk measure, ρ, such that $C(L,X,P) = \rho(B(L,X,P))$ where $B=\max(0, L+X-P)$.

In basing our definition on bounded underwriting loss, we are implicitly saying that all contracts with the same distribution of bounded underwriting losses will get the same capital, even if different premiums, expenses, and losses are involved. This is a key strength of the approach. Underwriters and brokers can sometimes fashion two alternatives, say one with a swing premium and the other with a larger provisional premium and a profit commission that yield the same underwriting loss for any given loss scenario. Neglecting some cash flow and security issues, it is hard to argue why theoretically one alternative should have a different capital requirement and a different ROE than the other.

We will now derive LSCC properties with respect to loss, expense, and premium. These will be based on the properties of the coherent risk measure and on the behavior of the bounded underwriting loss function.

Our first coherence property for a risk measure was that the measure is zero on the random variable identically equal to zero. For Level Sensitive Coherent Capital, this implies no capital is needed if there are no possible underwriting losses. This is potentially controversial, because it disconnects our risk measure from whatever volatility may exist in underwriting gain scenarios.

Using $\max(0,L+X-P) \leq \max(0,L+\alpha+X-P) = \max(0,L+X-(P+\alpha)) \leq \max(0,L+X-P) + \alpha$ and the monotonicity and translation additivity properties for a coherent risk measure, we can show:

$$\rho(B(L+\alpha, X, P)) \leq \rho(B(L, X, P)) + \alpha. \tag{4.3}$$

and

$$\rho(B(L, X, P)) - \alpha \leq \rho(B(L, X, P+\alpha)) \tag{4.4}$$

Note that despite translation additivity of our risk measure, the LSCC amount might go up by less than \$1 after all losses are increased by \$1. As well for premium, increasing the premium by \$1 will decrease the required capital, but by an amount that could be, but does not have to be, less than \$1. This sensitivity of required capital to fixed increments in premium or loss is why we call LSCC, "level sensitive". Note that LSCC still depends on the volatility of the underwriting losses as long as there is some possibility of an actual net underwriting loss.

Scaling carries over in the obvious way: if all losses, expenses, and premiums are scaled by a common factor, then the LSCC coherent capital scales up the same way.

With subadditivity of the max operator we can show:

$$B(L_1+L_2, X_1+X_2, P_1+P_2) = \max(0, L_1+X_1-P_1+L_2+X_2-P_2) \leq$$

$$\max(0, L_1+X_1-P_1) + \max(0, L_2+X_2-P_2)$$

This, along with monotonicity and subadditivity of a coherent risk measure, implies

$$\rho(B(L_1+L_2, X_1+X_2, P_1+P_2)) \leq \rho(B(L_1,X_1,P_1)) + \rho(B(L_2,X_2,P_2)) \tag{4.5}$$

In other words, the LSCC needed for two treaties combined is less than or equal to the sum of the LSCC required for each treaty. Note the inequality is not strict. According to Wang [13], the case for strict inequality is only compelling when the separate underwriting losses are not comonotonic. Comonotonic means each of the random variables can be expressed as an increasing function of a third random variable. Under Wang's power transforms, the risk loads for separate layers sum up to the risk load of the combined layers. This suggests required capital ought to be similarly decomposable by layer. This is a question we will study later in our examples.

The following summarizes the properties of Level Sensitive Coherent Capital:

LSCC-Coherent Capital Properties with Respect to L, X, and P (4.6)

Let B = max(0, L+X-P) and assume ρ is a Coherent Risk Measure. Let C=ρ(B). Then:

1. No Capital Needed if No Risk of Underwriting Loss: If P-L-X >0, then C(L,X,P)=0.
2. Monotonicity: If $L_1+X_1-P_1 \leq L_2+X_2-P_2$, then $C(L_1, X_1, P_1) \leq C(L_2, X_2, P_2)$
3. Scaling: If $\lambda>0$, then $C(\lambda L, \lambda X, \lambda P)) = \lambda\, C(L,X,P)$
4. Subadditivity:

   $C(L_1+ L_2 , X_1+ X_2, P_1 + P_2) \leq C(L_1,X_1,P_1) + C(L_2,X_2,P_2)$
5. Translation Additivity Inequalities:

   i) $C(L+\alpha, X, P) \leq C(L, X, P) +\alpha$

   ii) $C(L, X+\alpha, P) \leq C(L, X, P) +\alpha$

   iii) $C(L, X, P) - \alpha \leq C(L, X, P+\alpha)$

Next we define our second notion of coherent capital, Deviation Sensitive Coherent Capital (DSCC). First we define the underwriting loss in excess of expectation, B*, via

$$B^* = \max(0, U-E[U]) \text{ where } U = L+X-P \tag{4.7}$$

Note that B* is unaffected by adding a fixed amount to the loss or to the premium. Also observe that B* can be strictly positive for scenarios where there are underwriting gains if those underwriting gains fall short of expectation. In defining B*, we are following a logic similar to that suggested by Bault [3] in which he discussed generalizing ruin theory for risk load calculations so that any adverse deviation from a target might be counted as contributing to the probability of ruin.

We will define capital as Deviation Sensitive Coherent if it can be expressed by applying a coherent risk measure to the bounded underwriting loss in excess of expectation.

Deviation Sensitive Capital Coherence (DSCC) Definition (4.8)

A capital function C is called deviation sensitive coherent if there exists a coherent risk measure, ρ, such that $C(L,X,P) = \rho(B^*(L,X,P))$ where $B^*(L,X,P) = \max(0, L+X-P-E[L+X-P])$.

Using modified versions of the arguments employed in analyzing LSCC properties, we obtain the following properties for DSCC with respect to loss, expense, and premium.

DSCC-Coherent Capital Properties with Respect to L, X, and P (4.8)

Let $B^*=\max(0, U-E[U])$ where $U = L+X-P$ and assume ρ is a Coherent Risk Measure. Let $C=\rho B^*$. Then:

1. No Risk if No Variability in Underwriting Loss: If $P-L-X \equiv \alpha$, then $C(L,X,P)=0$.
2. Monotonicity: If $L_1+X_1-P_1 \leq L_2+X_2-P_2$,

   then $E[U_1] + C(L_1, X_1, P_1) \leq E[U_2] + C(L_2, X_2, P_2)$
3. Scaling: If $\lambda>0$, then $C(\lambda L, \lambda X, \lambda P)) = \lambda C(L,X,P)$
4. Subadditivity: $C(L_1+ L_2 , X_1+ X_2, P_1 + P_2) \leq C(L_1,X_1,P_1)) + C(L_2,X_2,P_2)$
5. Translation Invariance:

   i) $C(L+\alpha, X, P) = C(L, X, P)$

   ii) $C(L, X+\alpha, P) = C(L, X, P)$

   iii) $C(L, X, P) = C(L, X, P+\alpha)$

The first major point to be made in comparing the DSCC and LSCC concepts of coherence is that they do actually differ: they are not merely different ways of saying the same thing. The difference shows up perhaps most strongly with respect to translation properties. As we saw previously, for LSCC adding $1 of premium decreases capital by an amount less than or equal to $1; but for DSCC this does not change capital at all.

Another point of interest is that DSCC and LSCC are equal when the expected underwriting loss is zero. It follows that LSCC will be less than DSCC when there is a negative expected underwriting loss; in other words when there is an expected underwriting gain. Since reinsurers write a treaty expecting to make money, this will typically be true.

Now that we have defined two concepts of coherent capital and derived their properties, we will next demonstrate the concepts using the coherent risk measure, TVaR.

5. VAR AND TVAR

A common approach to setting capital is to set it at the 90^{th}, 95^{th}, 99^{th} or other chosen percentile. Borrowing from financial terminology, the percentile is usually called the Value at Risk (VaR). Also, in managing catastrophe books, a similar idea is to control writings so as to keep the 100, 250, or 500-year event within acceptable bounds.

Given ε, we define VaR_ε as follows:

$$\text{VaR}_\varepsilon = \inf \{x \mid F(x) \geq \varepsilon\} \tag{5.1}$$

Here "inf" stands for infimum and the definition means that VaR is the lower bound of the set of all x such that the cumulative distribution at x is greater than or equal to ε.

While VaR has a great deal of appeal as a measure of risk, it is unfortunately not a coherent metric. This is shown by example in Exhibit 1: VaR vs. TVaR. This exhibit shows ten different loss scenarios for two different portfolios. The example is composed in such a way that the two different portfolios have the same loss distribution even though they suffer different amounts of loss for any particular event. In our example, VaR at the 80^{th} percentile level for each portfolio is 50, but VaR for the combined portfolio is 110. So, VaR at the 80^{th} percentile would indicate it is riskier to combine the two portfolios than it would be to double the losses for either portfolio. This fails to make intuitive sense and is in violation of the subadditivity property of coherence, 3.1.

The Tail Value at Risk is defined as the conditional expected value for points strictly above the Value at Risk.

$$\text{TVaR}_\varepsilon = E[X \mid X > \text{VaR}_\varepsilon] \tag{5.2}$$

TVaR is known to be coherent [9]. Thus, there is no example we can construct that will result in the sum of the TVaR for the individual portfolios being less than the TVaR for the combined portfolio. Continuing on with our specific numerical example, we see from Exhibit 1 that the sum of the TVaR for the individual portfolios exceeds TVaR for the combined portfolio (90+90>135). So, according to the TVaR measure, there is a risk benefit in combining the portfolios. If, on the other hand, the two portfolios in our example were 100% correlated, the sum of the TVaR would equal 180 or the sum of the two individual portfolios. This still satisfies the subadditivity property of coherence because the inequality in the definition is not strict.

Now that we have an understanding of TVaR, we will use it for demonstration purposes as the coherent measure in the definition of our two coherent capital formulas. We do not wish to suggest that TVaR is the only coherent measure appropriate for treaty pricing applications. One of the Proportional Hazards Transforms defined by Wang [12] would also be an excellent choice.

6. CAPITAL SENSITIVITY COMPARISONS

We will now study how our coherent capital formulas compare against each other and against other methods. The full list of methods we will examine is:

Fixed Leverage Ratio Against Provisional Premium

Fixed Leverage Ration Against Expected Loss

Standard Deviation of Underwriting Loss

Variance of Underwriting Loss

TVaR of Bound Underwriting Loss (LSCC)

TVaR of Underwriting Loss Excess of Expectation (DSCC)

First we will consider how the methods respond to a change in premium adequacy. This has practical importance for example in evaluating how much of a rate change is needed in order to achieve a target ROE. Using a fixed leverage ratio against premium effectively assigns more capital in response to an increase in rate. Why more capital is needed is unclear from a risk perspective. The effect is to make the ROE less sensitive to a rate change than it would otherwise be. In contrast, the amount of capital does not change with the rate when using either a fixed leverage ratio against expected loss, the standard deviation of underwriting loss, the variance of underwriting loss, or the DSCC method. While the amount of capital does not change, the resulting premium-to-capital leverage ratio will rise with a rate increase. With the LSCC method, the amount of indicated capital declines due to a rate increase. The ROE with LSCC is thus more sensitive to a rate change than the other methods as both the numerator and the denominator are affected. Table 1 summarizes the premium adequacy results shown in Exhibit 2.

Table 1	**Sensitivity of Capital to Premium Adequacy**			
Method		**Premium - 10%**	**Base Case**	**Premium +10%**
Fixed Premium Leverage	Capital	61	68	74
	Premium Leverage	1.48	1.48	1.48
Fixed Loss Leverage	Capital	68	68	68
	Premium Leverage	1.33	1.48	1.63
Standard Deviation	Capital	68	68	68
	Premium Leverage	1.33	1.48	1.63
Variance	Capital	68	68	68
	Premium Leverage	1.33	1.48	1.63
LSCC	Capital	70	63	55
	Premium Leverage	1.29	1.60	2.00
DSCC	Capital	68	68	68
	Premium Leverage	1.33	1.48	1.63

Note that we have set our base case so that all the methods yield the same answer except for the Level Sensitive Coherent Capital calculation. This was done because our base case has an expected net underwriting profit. As previously observed, in such a situation we will always have LSCC less than DSCC. Thus we cannot set all the methods equal. We are free to pick constants for the Standard Deviation and Variance methods, but once selected these constants are fixed and not allowed to change from scenario to scenario.

Next we look at scenarios involving a treaty that is priced by first agreeing on a net rate and then arriving at the final rate by grossing up for ceding commission. This "net rating" is not uncommon on excess of loss treaties. We consider how the methods respond if the ceding commission rate changes from a base case of 25% to either 20% or 30%. Table 2 summarizes the results from Exhibit 3.

Table 2		**Sensitivity to Changes in Cede on Net Rated Treaty**		
Method		**Cede = 20%**	**Cede = 25%**	**Cede = 30%**
Fixed Premium Leverage	Capital	63	68	72
	Premium Leverage	1.48	1.48	1.48
Fixed Loss Leverage	Capital	68	68	68
	Premium Leverage	1.39	1.48	1.59
Standard Deviation	Capital	68	68	68
	Premium Leverage	1.39	1.48	1.59
Variance	Capital	68	68	68
	Premium Leverage	1.39	1.48	1.59
LSCC	Capital	63	63	63
	Premium Leverage	1.50	1.60	1.71
DSCC	Capital	68	68	68
	Premium Leverage	1.39	1.48	1.59

The results are the same as for a change in premium adequacy except for the LSCC method. Because changing the ceding commission percentage on a net rated deal does not change the net underwriting loss, the LSCC method now agrees with the DSCC and the other underwriting loss based methods in indicating capital should not change between the scenarios.

Next we examine how the methods respond to a sliding scale commission plan. Results are shown in Table 3 for several different slides. The "Balanced" slide leads to no change in expected commission, the "Avg Inc" slide generates a net increase in expected commission, and the "Avg Dec" slide produces an average net decrease. The fixed premium and fixed loss leverage methods are of course totally unresponsive to changes in risk induced by any adjustable commission plan. LSCC and DSCC are responsive to the introduction of the slide, but then seem oblivious to the different slide options. The reason is that the minimum commission and corresponding loss ratio were picked to be the same for all the options. So all the slides yield the same net underwriting loss and risk quantity in the adverse scenarios that determine LSCC and DSCC. This underscores a positive feature of both our coherent capital methods: changing the distribution of favorable outcomes does not change the required capital.

Table 3	Sensitivity of Capital to Sliding Scale Commission				
Method		**No Slide**	**Balanced**	**Avg Inc Cede**	**Avg Dec Cede**
Fixed Premium Leverage	Capital	68	68	68	68
	Premium Leverage	1.48	1.48	1.48	1.48
Fixed Loss Leverage	Capital	68	68	68	68
	Premium Leverage	1.48	1.48	1.48	1.48
Standard Deviation	Capital	68	64	63	63
	Premium Leverage	1.48	1.56	1.59	1.59
Variance	Capital	68	61	59	58
	Premium Leverage	1.48	1.64	1.70	1.71
LSCC	Capital	63	58	58	58
	Premium Leverage	1.60	1.74	1.74	1.74
DSCC	Capital	68	63	63	63
	Premium Leverage	1.48	1.60	1.60	1.60

Now, we examine sensitivity under a Swing Rated Premium plan. In one scenario, the Max and Min are set so the average premium in the plan is balanced back to the premium in the Base Case without Swing Rating. In another, we reduce the Max and, in the other, we raise the Max. The swings we have in our example are more modest than those typically found in practice. Note we set capital under the Fixed Premium Leverage method relative to the Provisional Premium and not the expected Swing Premium. The swing in all scenarios shortens the tail of the underwriting loss distribution relative to the fixed premium Base Case. It does not change the shape of the tail as much as pull it towards the mean. However one would characterize it, the swing reduces volatility and as a result, all the methods, both coherent and non-coherent, that are based on the underwriting loss distribution indicate that less capital is needed. This is true even in the Balanced Case where there is no change in the expected underwriting loss. Table 4 summarizes the results found in Exhibit 5.

Table 4	Sensitivity of Capital to Swing Rated Premium				
Method		**No Swing**	**Balanced**	**Lower Max**	**Raise Max**
Fixed Premium Leverage	Capital	68	68	68	68
	Premium Leverage	1.48	1.48	1.48	1.48
Fixed Loss Leverage	Capital	68	68	68	68
	Premium Leverage	1.48	1.48	1.48	1.48
Standard Deviation	Capital	68	61	64	59
	Premium Leverage	1.48	1.65	1.56	1.70
Variance	Capital	68	55	61	51
	Premium Leverage	1.48	1.83	1.65	1.95
LSCC	Capital	63	52	59	48
	Premium Leverage	1.60	1.92	1.70	2.07
DSCC	Capital	68	57	64	53
	Premium Leverage	1.48	1.75	1.57	1.88

Next we examine how the methods respond to changing the share a reinsurer has in a deal. We know that both DSCC and LSCC have the scaling property and so their capital requirements scale up and down with the share and their indicated leverage ratios do not change. The Standard Deviation of Underwriting Loss scales as well, yet the Variance of Underwriting Loss does not. Results are shown in Table 5.

Table 5	Sensitivity of Capital to Changes in Share			
Method		**Base Share**	**2X Share**	**(1/2) X Share**
Fixed Premium Leverage	Capital	68	135	34
	Premium Leverage	1.48	1.48	1.48
Fixed Loss Leverage	Capital	68	135	34
	Premium Leverage	1.48	1.48	1.48
Standard Deviation	Capital	68	135	34
	Premium Leverage	1.48	1.48	1.48
Variance	Capital	68	270	17
	Premium Leverage	1.48	0.74	2.96
DSCC	Capital	63	125	31
	Premium Leverage	1.60	1.60	1.60
LSCC	Capital	68	135	34
	Premium Leverage	1.48	1.48	1.48

Finally, we consider different layering scenarios. In one, the reinsurer can take a lower per occurrence layer, in another a layer just above it, and in the last scenario it can take both layers together. We examine how the capital on the combined scenario compares with sum of the capital on the separate layer scenarios. Results are shown in Table 6.

Table 6	**Capital by Layer**				
Method		**Layer 1**	**Layer 2**	**Sum of Capital**	**Combined**
Fixed Premium Leverage	Capital	47	21	68	68
	Premium Leverage	1.48	1.48	1.48	1.48
Fixed Loss Leverage	Capital	47	21	68	68
	Premium Leverage	1.48	1.48	1.48	1.48
Standard Deviation	Capital	19	50	70	68
	Premium Leverage	3.58	0.62	1.44	1.48
Variance	Capital	5	38	43	68
	Premium Leverage	12.54	0.83	2.32	1.48
DSCC	Capital	16	47	63	63
	Premium Leverage	4.36	0.67	1.60	1.60
LSCC	Capital	19	48	68	68
	Premium Leverage	1.60	1.60	1.60	1.48

The sum of the variance-based capital requirements for the layers is less than the variance based capital for the combined layer, whereas the opposite is true for the standard deviation based capital requirement. Coherence would say combining the layers should not increase the capital. For our coherent capital measures, it so happened in our example that the sum of capital for the layers equaled the capital for the combined layer. Whether this is true in general, or is an artifact of the way our example was constructed is an issue that awaits further study. In reinsurance circles, many believe "ventilation" is an effective risk reduction strategy. Using a ventilation approach, the reinsurer takes shares of disconnected layers. It would be useful to see what coherence can tell us about such a strategy.

7. CONCLUSION

We have seen that basing a capital calculation on the net underwriting loss handles many of the problems that arise in setting capital for reinsurance treaty pricing applications. We have also found that implementation of coherent capital concepts does handle some of the problems that remain. Yet we have no theoretical reason to prefer one of our two coherent capital approaches above the other. So we present the results we have as interim steps taken to advance understanding of how to apply coherence concepts to tackle practical problems. We believe these initial results on how to implement coherent capital are useful in their own right and will provide a solid foundation and some direction for future research on the topic.

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Biographies of the Authors[1]

Ira Robbin

After receiving a BS in Mathematics from Michigan State University and a PhD in Mathematics from Rutgers University, the author took an actuarial research position with the Insurance Company of North America. Over his career, the author has directed pricing for casualty cash flow business, provided actuarial support for large risk property business, developed ROE and capital calculation models for pricing, and done other work where the latest theory often runs into difficulty when faced with the problems of practical application. The author has written papers on risk load, credibility estimation of IBNR, pricing ROE models, excess of aggregate insurance charges, loss development models, and other diverse topics. He has made presentations at CAS Meetings and Seminars, taught CAS examination courses, wrote a study note on profit provisions and served on several industry committees, including the ISO Increased Limits Committee and the NCCI Individual Risk Rating Plan Subcommittee. Currently, the author is a Senior Pricing Actuary with PartnerRe in Greenwich, where he has been pricing treaties and helping to develop improved pricing models.

Jesse De Couto

The author developed a strong interest in research and problem-solving while obtaining his BS in Biomedical Engineering at the University of Miami. There he designed and validated an active Laplacian bipolar concentric ring ECG sensor. The author then continued on to graduate from the College of Insurance with an MBA in Financial Risk Management. He took an actuarial position with PartnerRe in Greenwich and worked on pricing Regional and Specialty Lines treaties and on developing treaty ROE software. The author is now an Assistant Underwriter and Actuary for the Catastrophe Business Unit of PartnerRe in Bermuda.

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[1] The opinions expressed in this paper are those of the authors. No representation of the corporate position of PartnerRe should be inferred.

Exhibit 1

TVaR versus VaR

Scenario	Probability	Portfolio 1 Losses	Portfolio 2 Losses	Combined Portfolio Losses
1	10%	100	10	110
2	10%	80	20	100
3	10%	50	80	130
4	10%	40	100	140
5	10%	30	40	70
6	10%	20	30	50
7	10%	10	50	60
8	10%	20	30	50
9	10%	30	5	35
10	10%	5	20	25
VaR at 80th Percentile		**50**	**50**	**110**
TVaR at 80th Percentile Level		**90**	**90**	**135**

Sensitivity of Capital to Changes in Premium Adequacy

Exhibit 2
Sheet 1

Scenario 1

Base Case	
Prov Premium	100.0
Prov Ceding %	25.0%

Results by Method	Fixed Prem Leverage	Fixed Loss Leverage	Stnd Dev UW Loss	Variance UW Loss	LSCC	DSCC
Capital	67.5	67.5	67.5	67.5	62.5	67.5
Prem Leverage	1.481	1.481	1.481	1.481	1.600	1.481
Loss Leverage		1.037				
Scale constant			122%	1.48%		

Probability	Cumulative Probability	Loss	Provisional Premium	Provisional Commission	Premium Adjustment	Commission Adjustment	Final Premium	Final Commission	UW Loss	Capped UW Loss	UW Loss Excess of Expectation
10%	10%	25.0	100.0	25.0	0.0	0.0	100	25.0	-50.0	0.0	0.0
20%	30%	45.0	100.0	25.0	0.0	0.0	100	25.0	-30.0	0.0	0.0
25%	55%	55.0	100.0	25.0	0.0	0.0	100	25.0	-20.0	0.0	0.0
15%	70%	65.0	100.0	25.0	0.0	0.0	100	25.0	-10.0	0.0	0.0
10%	80%	75.0	100.0	25.0	0.0	0.0	100	25.0	0.0	0.0	5.0
5%	85%	90.0	100.0	25.0	0.0	0.0	100	25.0	15.0	15.0	20.0
5%	90%	110.0	100.0	25.0	0.0	0.0	100	25.0	35.0	35.0	40.0
5%	95%	150.0	100.0	25.0	0.0	0.0	100	25.0	75.0	75.0	80.0
5%	100%	200.0	100.0	25.0	0.0	0.0	100	25.0	125.0	125.0	130.0
	Expected Values:	**70.0**	**100.0**	**25.0**	**0.0**	**0.0**	**100.0**	**25.0**	**-5.0**	**12.5**	**14.0**

Sensitivity of Capital to Changes in Premium Adequacy

Exhibit 2
Sheet 2

Scenario 2

Rate Change	10.0%
Prov Premium	110.0
Prov Ceding %	25.0%

Results by Method	Fixed Prem Leverage	Fixed Loss Leverage	Stnd Dev UW Loss	Variance UW Loss	LSCC	DSCC
Capital	74.3	67.5	67.5	67.5	55.0	67.5
Prem Leverage	1.481	1.630	1.630	1.630	2.000	1.630
Loss Leverage	0.943	1.037				
Scale constant			122%	1.48%		

Probability	Cumulative Probability	Loss	Provisional Premium	Provisional Commission	Premium Adjustment	Commission Adjustment	Final Premium	Final Commission	UW Loss	Capped UW Loss	Capped UW Loss Xs of Expectation
10%	10%	25.0	110.0	27.5	0.0	0.0	110	27.5	-57.5	0.0	0.0
20%	30%	45.0	110.0	27.5	0.0	0.0	110	27.5	-37.5	0.0	0.0
25%	55%	55.0	110.0	27.5	0.0	0.0	110	27.5	-27.5	0.0	0.0
15%	70%	65.0	110.0	27.5	0.0	0.0	110	27.5	-17.5	0.0	0.0
10%	80%	75.0	110.0	27.5	0.0	0.0	110	27.5	-7.5	0.0	5.0
5%	85%	90.0	110.0	27.5	0.0	0.0	110	27.5	7.5	7.5	20.0
5%	90%	110.0	110.0	27.5	0.0	0.0	110	27.5	27.5	27.5	40.0
5%	95%	150.0	110.0	27.5	0.0	0.0	110	27.5	67.5	67.5	80.0
5%	100%	200.0	110.0	27.5	0.0	0.0	110	27.5	117.5	117.5	130.0
	Expected Values:	**70.0**	**110.0**	**27.5**	**0.0**	**0.0**	**110.0**	**27.5**	**-12.5**	**11.0**	**14.0**

Sensitivity of Capital to Changes in Premium Adequacy

Exhibit 2
Sheet 3

Scenario 3

Rate Change	-10.0%
Prov Premium	90.0
Prov Ceding %	25.0%

Results by Method						
	Fixed Prem Leverage	Fixed Loss Leverage	Stnd Dev UW Loss	Variance UW Loss	LSCC	DSCC
Capital	60.8	67.5	67.5	67.5	70.0	67.5
Prem Leverage	1.481	1.333	1.333	1.333	1.286	1.333
Loss Leverage	1.152	1.037				
Scale Constant			122%	1.48%		

Probability	Cumulative Probability	Loss	Provisional Premium	Provisional Commission	Premium Adjustment	Commission Adjustment	Final Premium	Final Commission	UW Loss	Capped UW Loss	Capped UW Loss Xs of Expectation
10%	10%	25.0	90.0	22.5	0.0	0.0	90	22.5	-42.5	0.0	0.0
20%	30%	45.0	90.0	22.5	0.0	0.0	90	22.5	-22.5	0.0	0.0
25%	55%	55.0	90.0	22.5	0.0	0.0	90	22.5	-12.5	0.0	0.0
15%	70%	65.0	90.0	22.5	0.0	0.0	90	22.5	-2.5	0.0	0.0
10%	80%	75.0	90.0	22.5	0.0	0.0	90	22.5	7.5	7.5	5.0
5%	85%	90.0	90.0	22.5	0.0	0.0	90	22.5	22.5	22.5	20.0
5%	90%	110.0	90.0	22.5	0.0	0.0	90	22.5	42.5	42.5	40.0
5%	95%	150.0	90.0	22.5	0.0	0.0	90	22.5	82.5	82.5	80.0
5%	100%	200.0	90.0	22.5	0.0	0.0	90	22.5	132.5	132.5	130.0
	Expected Values:	**70.0**	**90.0**	**22.5**	**0.0**	**0.0**	**90.0**	**22.5**	**2.5**	**14.8**	**14.0**

Sensitivity of Capital to Changes in Ceding Comm Rate on Net Rated Treaty

Exhibit 3
Sheet 1

Scenario 1

Base Case	
Prov Premium	100.0
Prov Ceding %	25.0%

Results by Method	Fixed Prem Leverage	Fixed Loss Leverage	Stnd Dev UW Loss	Variance UW Loss	LSCC	DSCC
Capital	67.5	67.5	67.5	67.5	62.5	67.5
Prem Leverage	1.481	1.481	1.481	1.481	1.600	1.481
Loss Leverage		1.037				
Scale constant			122%	1.48%		

Probability	Cumulative Probability	Loss	Provisional Premium	Provisional Commission	Premium Adjustment	Commission Adjustment	Final Premium	Final Commission	UW Loss	Capped UW Loss	UW Loss Excess of Expectation
10%	10%	25.0	100.0	25.0	0.0	0.0	100	25.0	-50.0	0.0	0.0
20%	30%	45.0	100.0	25.0	0.0	0.0	100	25.0	-30.0	0.0	0.0
25%	55%	55.0	100.0	25.0	0.0	0.0	100	25.0	-20.0	0.0	0.0
15%	70%	65.0	100.0	25.0	0.0	0.0	100	25.0	-10.0	0.0	0.0
10%	80%	75.0	100.0	25.0	0.0	0.0	100	25.0	0.0	0.0	5.0
5%	85%	90.0	100.0	25.0	0.0	0.0	100	25.0	15.0	15.0	20.0
5%	90%	110.0	100.0	25.0	0.0	0.0	100	25.0	35.0	35.0	40.0
5%	95%	150.0	100.0	25.0	0.0	0.0	100	25.0	75.0	75.0	80.0
5%	100%	200.0	100.0	25.0	0.0	0.0	100	25.0	125.0	125.0	130.0
	Expected Values:	**70.0**	**100.0**	**25.0**	**0.0**	**0.0**	**100.0**	**25.0**	**-5.0**	**12.5**	**14.0**

Sensitivity of Capital to Changes in Ceding Comm Rate on Net Rated Treaty

Exhibit 3
Sheet 2

Scenario 2

Comm Change	5.0%
Prov Premium	107.1
Prov Ceding %	30.0%

Results by Method						
	Fixed Prem Leverage	Fixed Loss Leverage	Stnd Dev UW Loss	Variance UW Loss	LSCC	DSCC
Capital	72.3	67.5	67.5	67.5	62.5	67.5
Prem Leverage	1.481	1.587	1.587	1.587	1.714	1.587
Loss Leverage	0.968	1.037				
Scale constant			122%	1.48%		

Probability	Cumulative Probability	Loss	Provisional Premium	Provisional Commission	Premium Adjustment	Commission Adjustment	Final Premium	Final Commission	UW Loss	Capped UW Loss	Capped UW Loss Xs of Expectation
10%	10%	25.0	107.1	32.1	0.0	0.0	107.1	32.1	-50.0	0.0	0.0
20%	30%	45.0	107.1	32.1	0.0	0.0	107.1	32.1	-30.0	0.0	0.0
25%	55%	55.0	107.1	32.1	0.0	0.0	107.1	32.1	-20.0	0.0	0.0
15%	70%	65.0	107.1	32.1	0.0	0.0	107.1	32.1	-10.0	0.0	0.0
10%	80%	75.0	107.1	32.1	0.0	0.0	107.1	32.1	0.0	0.0	5.0
5%	85%	90.0	107.1	32.1	0.0	0.0	107.1	32.1	15.0	15.0	20.0
5%	90%	110.0	107.1	32.1	0.0	0.0	107.1	32.1	35.0	35.0	40.0
5%	95%	150.0	107.1	32.1	0.0	0.0	107.1	32.1	75.0	75.0	80.0
5%	100%	200.0	107.1	32.1	0.0	0.0	107.1	32.1	125.0	125.0	130.0
	Expected Values:	**70.0**	**107.1**	**32.1**	**0.0**	**0.0**	**107.1**	**32.1**	**-5.0**	**12.5**	**14.0**

Sensitivity of Capital to Changes in Ceding Comm Rate on Net Rated Treaty

Exhibit 3
Sheet 3

Scenario 3

Comm Change	-5.0%
Prov Premium	93.8
Prov Ceding %	20.0%

Results by Method

	Fixed Prem Leverage	Fixed Loss Leverage	Stnd Dev UW Loss	Variance UW Loss	LSCC	DSCC
Capital	63.3	67.5	67.5	67.5	62.5	67.5
Prem Leverage	1.481	1.389	1.389	1.389	1.500	1.389
Loss Leverage	1.106	1.037				
Scale Constant			122%	1.48%		

Probability	Cumulative Probability	Loss	Provisional Premium	Provisional Commission	Premium Adjustment	Commission Adjustment	Final Premium	Final Commission	UW Loss	Capped UW Loss	Capped UW Loss Xs of Expectation
10%	10%	25.0	93.8	18.8	0.0	0.0	94	18.8	-50.0	0.0	0.0
20%	30%	45.0	93.8	18.8	0.0	0.0	94	18.8	-30.0	0.0	0.0
25%	55%	55.0	93.8	18.8	0.0	0.0	94	18.8	-20.0	0.0	0.0
15%	70%	65.0	93.8	18.8	0.0	0.0	94	18.8	-10.0	0.0	0.0
10%	80%	75.0	93.8	18.8	0.0	0.0	94	18.8	0.0	0.0	5.0
5%	85%	90.0	93.8	18.8	0.0	0.0	94	18.8	15.0	15.0	20.0
5%	90%	110.0	93.8	18.8	0.0	0.0	94	18.8	35.0	35.0	40.0
5%	95%	150.0	93.8	18.8	0.0	0.0	94	18.8	75.0	75.0	80.0
5%	100%	200.0	93.8	18.8	0.0	0.0	94	18.8	125.0	125.0	130.0
	Expected Values:	70.0	93.8	18.8	0.0	0.0	93.8	18.8	-5.0	12.5	14.0

Sensitivity of Capital to Sliding Scale Commission Plan

Exhibit 4
Sheet 1

Scenario 1

Slide	No Slide
Prov Premium	100.0
Prov Ceding %	25.0%

No Slide	Commission	LR
Min	25%	45%
Provision	25%	60%
Max	25%	80%

Results by Method						
	Fixed Prem Leverage	Fixed Loss Leverage	Stnd Dev UW Loss	Variance UW Loss	LSCC	DSCC
Capital	67.5	67.5	67.5	67.5	62.5	67.5
Prem Leverage	1.481	1.481	1.481	1.481	1.600	1.481
Loss Leverage		1.037				
Scale constant			122%	1.48%		

Probability	Cumulative Probability	Loss	Provisional Premium	Provisional Commission	Premium Adjustment	Commission Adjustment	Final Premium	Final Commission	UW Loss	Capped UW Loss	UW Loss Excess of Expectation
10%	10%	25.0	100.0	25.0	0.0	0.0	100	25.0	-50.0	0.0	0.0
20%	30%	45.0	100.0	25.0	0.0	0.0	100	25.0	-30.0	0.0	0.0
25%	55%	55.0	100.0	25.0	0.0	0.0	100	25.0	-20.0	0.0	0.0
15%	70%	65.0	100.0	25.0	0.0	0.0	100	25.0	-10.0	0.0	0.0
10%	80%	75.0	100.0	25.0	0.0	0.0	100	25.0	0.0	0.0	5.0
5%	85%	90.0	100.0	25.0	0.0	0.0	100	25.0	15.0	15.0	20.0
5%	90%	110.0	100.0	25.0	0.0	0.0	100	25.0	35.0	35.0	40.0
5%	95%	150.0	100.0	25.0	0.0	0.0	100	25.0	75.0	75.0	80.0
5%	100%	200.0	100.0	25.0	0.0	0.0	100	25.0	125.0	125.0	130.0
	Expected Values:	70.0	100.0	25.0	0.0	0.0	100.0	25.0	-5.0	12.5	14.0

Sensitivity of Capital to Sliding Scale Commission Plan

Exhibit 4
Sheet 2

Scenario 2

Slide	Balanced
Prov Premium	100.0
Prov Ceding %	25.0%

Slide	Commission	LR
Min	20%	85%
Provision	25%	70%
Max	27%	50%

Results by Method	Fixed Prem Leverage	Fixed Loss Leverage	Stnd Dev UW Loss	Variance UW Loss	LSCC	DSCC
Capital	67.5	67.5	64.2	61.1	57.5	62.6
Prem Leverage	1.481	1.481	1.557	1.637	1.739	1.597
Loss Leverage	1.037	1.037				
Scale constant			122%	1.48%		

Probability	Cumulative Probability	Loss	Provisional Premium	Provisional Commission	Premium Adjustment	Commission Adjustment	Final Premium	Final Commission	UW Loss	Capped UW Loss	Capped UW Loss Xs of Expectation
10%	10%	25.0	100.0	25.0	0.0	2.0	100.0	27.0	-48.0	0.0	0.0
20%	30%	45.0	100.0	25.0	0.0	2.0	100.0	27.0	-28.0	0.0	0.0
25%	55%	55.0	100.0	25.0	0.0	1.5	100.0	26.5	-18.5	0.0	0.0
15%	70%	65.0	100.0	25.0	0.0	0.5	100.0	25.5	-9.5	0.0	0.0
10%	80%	75.0	100.0	25.0	0.0	-1.7	100.0	23.3	-1.7	0.0	3.5
5%	85%	90.0	100.0	25.0	0.0	-5.0	100.0	20.0	10.0	10.0	15.1
5%	90%	110.0	100.0	25.0	0.0	-5.0	100.0	20.0	30.0	30.0	35.1
5%	95%	150.0	100.0	25.0	0.0	-5.0	100.0	20.0	70.0	70.0	75.1
5%	100%	200.0	100.0	25.0	0.0	-5.0	100.0	20.0	120.0	120.0	125.1
	Expected Values:	**70.0**	**100.0**	**25.0**	**0.0**	**-0.1**	**100.0**	**24.9**	**-5.1**	**11.5**	**12.9**

Sensitivity of Capital to Sliding Scale Commission Plan

Exhibit 4
Sheet 3

Scenario 3

Slide	Avg Inc Cede
Prov Premium	100.0
Prov Ceding %	25.0%

Slide	Commission	LR
Min	20%	85%
Provision	25%	70%
Max	30%	50%

Results by Method

	Fixed Prem Leverage	Fixed Loss Leverage	Stnd Dev UW Loss	Variance UW Loss	LSCC	DSCC
Capital	67.5	67.5	63.1	58.9	57.5	62.6
Prem Leverage	1.481	1.481	1.586	1.697	1.739	1.597
Loss Leverage	1.037	1.037				
Scale constant			122%	1.48%		

Probability	Cumulative Probability	Loss	Provisional Premium	Provisional Commission	Premium Adjustment	Commission Adjustment	Final Premium	Final Commission	UW Loss	Capped UW Loss	Capped UW Loss Xs of Expectation
10%	10%	25.0	100.0	25.0	0.0	5.0	100	30.0	-45.0	0.0	0.0
20%	30%	45.0	100.0	25.0	0.0	5.0	100	30.0	-25.0	0.0	0.0
25%	55%	55.0	100.0	25.0	0.0	3.8	100	28.8	-16.3	0.0	0.0
15%	70%	65.0	100.0	25.0	0.0	1.3	100	26.3	-8.8	0.0	0.0
10%	80%	75.0	100.0	25.0	0.0	-1.7	100	23.3	-1.7	0.0	3.5
5%	85%	90.0	100.0	25.0	0.0	-5.0	100	20.0	10.0	10.0	15.1
5%	90%	110.0	100.0	25.0	0.0	-5.0	100	20.0	30.0	30.0	35.1
5%	95%	150.0	100.0	25.0	0.0	-5.0	100	20.0	70.0	70.0	75.1
5%	100%	200.0	100.0	25.0	0.0	-5.0	100	20.0	120.0	120.0	125.1
	Expected Values:	**70.0**	**100.0**	**25.0**	**0.0**	**1.5**	**100.0**	**26.5**	**-3.5**	**11.5**	**12.9**

Sensitivity of Capital to Sliding Scale Commission Plan

Exhibit 4
Sheet 4

Scenario 4

Slide	Avg Dec Cede
Prov Premium	100.0
Prov Ceding %	25.0%

Slide	Commission	LR
Min	20%	85%
Provision	25%	85%
Max	30%	50%

Results by Method

	Fixed Prem Leverage	Fixed Loss Leverage	Stnd Dev UW Loss	Variance UW Loss	LSCC	DSCC
Capital	67.5	67.5	62.8	58.4	57.5	62.6
Prem Leverage	1.481	1.481	1.593	1.713	1.739	1.597
Loss Leverage	1.037	1.037				
Scale constant			122%	1.48%		

Probability	Cumulative Probability	Loss	Provisional Premium	Provisional Commission	Premium Adjustment	Commission Adjustment	Final Premium	Final Commission	UW Loss	Capped UW Loss	Capped UW Loss Xs of Expectation
10%	10%	25.0	100.0	25.0	0.0	5.0	100	30.0	-45.0	0.0	0.0
20%	30%	45.0	100.0	25.0	0.0	5.0	100	30.0	-25.0	0.0	0.0
25%	55%	55.0	100.0	25.0	0.0	4.3	100	29.3	-15.7	0.0	0.0
15%	70%	65.0	100.0	25.0	0.0	2.9	100	27.9	-7.1	0.0	0.0
10%	80%	75.0	100.0	25.0	0.0	1.4	100	26.4	1.4	1.4	6.5
5%	85%	90.0	100.0	25.0	0.0	-5.0	100	20.0	10.0	10.0	15.1
5%	90%	110.0	100.0	25.0	0.0	-5.0	100	20.0	30.0	30.0	35.1
5%	95%	150.0	100.0	25.0	0.0	-5.0	100	20.0	70.0	70.0	75.1
5%	100%	200.0	100.0	25.0	0.0	-5.0	100	20.0	120.0	120.0	125.1
	Expected Values:	70.0	100.0	25.0	0.0	2.1	100.0	27.1	-2.9	11.6	13.2

Sensitivity of Capital to Swing Rated Premium Plan

Exhibit 5
Sheet 1

Scenario 1

	Swing	No Swing
Prov Premium		100.0
Prov Ceding %		25.0%

No Swing	
Min	100%
Prov	100%
Max	100%
Margin	5%
Load Factor	133%

Results by Method						
	Fixed Prem Leverage	Fixed Loss Leverage	Stnd Dev UW Loss	Variance UW Loss	LSCC	DSCC
Capital	67.5	67.5	67.5	67.5	62.5	67.5
Prem Leverage	1.481	1.481	1.481	1.481	1.600	1.481
Loss Leverage		1.037				
Scale constant			122%	1.48%		

Probability	Cumulative Probability	Loss	Provisional Premium	Provisional Commission	Premium Adjustment	Commission Adjustment	Final Premium	Final Commission	UW Loss	Capped UW Loss	UW Loss Excess of Expectation
10%	10%	25.0	100.0	25.0	0.0	0.0	100	25.0	-50.0	0.0	0.0
20%	30%	45.0	100.0	25.0	0.0	0.0	100	25.0	-30.0	0.0	0.0
25%	55%	55.0	100.0	25.0	0.0	0.0	100	25.0	-20.0	0.0	0.0
15%	70%	65.0	100.0	25.0	0.0	0.0	100	25.0	-10.0	0.0	0.0
10%	80%	75.0	100.0	25.0	0.0	0.0	100	25.0	0.0	0.0	5.0
5%	85%	90.0	100.0	25.0	0.0	0.0	100	25.0	15.0	15.0	20.0
5%	90%	110.0	100.0	25.0	0.0	0.0	100	25.0	35.0	35.0	40.0
5%	95%	150.0	100.0	25.0	0.0	0.0	100	25.0	75.0	75.0	80.0
5%	100%	200.0	100.0	25.0	0.0	0.0	100	25.0	125.0	125.0	130.0
	Expected Values:	**70.0**	**100.0**	**25.0**	**0.0**	**0.0**	**100.0**	**25.0**	**-5.0**	**12.5**	**14.0**

Sensitivity of Capital to Swing Rated Premium Plan

Exhibit 5
Sheet 2

Scenario 2

Swing	Balanced
Prov Premium	100.0
Prov Ceding %	25.0%

Balanced	
Min	95%
Prov	100%
Max	114%
Margin	7.0%
Load Factor	133%

Results by Method

	Fixed Prem Leverage	Fixed Loss Leverage	Stnd Dev UW Loss	Variance UW Loss	LSCC	DSCC
Capital	67.5	67.5	60.7	54.6	52.0	57.0
Prem Leverage	1.481	1.481	1.647	1.831	1.923	1.754
Loss Leverage		1.037				
Scale constant			122%	1.48%		

Probability	Cumulative Probability	Loss	Provisional Premium	Provisional Commission	Premium Adjustment	Commission Adjustment	Final Premium	Final Commission	UW Loss	Capped UW Loss	UW Loss Excess of Expectation
10%	10%	25.0	100.0	25.0	-5.0	-1.3	95	23.8	-46.3	0.0	0.0
20%	30%	45.0	100.0	25.0	-5.0	-1.3	95	23.8	-26.3	0.0	0.0
25%	55%	55.0	100.0	25.0	-5.0	-1.3	95	23.8	-16.3	0.0	0.0
15%	70%	65.0	100.0	25.0	-5.0	-1.3	95	23.8	-6.3	0.0	0.0
10%	80%	75.0	100.0	25.0	7.0	1.8	107	26.8	-5.3	0.0	0.0
5%	85%	90.0	100.0	25.0	14.0	3.5	114	28.5	4.5	4.5	9.5
5%	90%	110.0	100.0	25.0	14.0	3.5	114	28.5	24.5	24.5	29.5
5%	95%	150.0	100.0	25.0	14.0	3.5	114	28.5	64.5	64.5	69.5
5%	100%	200.0	100.0	25.0	14.0	3.5	114	28.5	114.5	114.5	119.5
	Expected Values:	70.0	100.0	25.0	0.0	0.0	100.0	25.0	-5.0	10.4	11.4

Sensitivity of Capital to Swing Rated Premium Plan

Exhibit 5
Sheet 3

Scenario 3

	Swing	Avg Dec Prem
Prov Premium		100.0
Prov Ceding %		25.0%

Balanced	
Min	95%
Prov	100%
Max	105%
Margin	7.0%
Load Factor	133%

Results by Method						
	Fixed Prem Leverage	Fixed Loss Leverage	Stnd Dev UW Loss	Variance UW Loss	LSCC	DSCC
Capital	67.5	67.5	64.0	60.7	58.8	63.8
Prem Leverage	1.481	1.481	1.562	1.647	1.702	1.569
Loss Leverage		1.037				
Scale constant			122%	1.48%		

Probability	Cumulative Probability	Loss	Provisional Premium	Provisional Commission	Premium Adjustment	Commission Adjustment	Final Premium	Final Commission	UW Loss	Capped UW Loss	UW Loss Excess of Expectation
10%	10%	25.0	100.0	25.0	-5.0	-1.3	95	23.8	-46.3	0.0	0.0
20%	30%	45.0	100.0	25.0	-5.0	-1.3	95	23.8	-26.3	0.0	0.0
25%	55%	55.0	100.0	25.0	-5.0	-1.3	95	23.8	-16.3	0.0	0.0
15%	70%	65.0	100.0	25.0	-5.0	-1.3	95	23.8	-6.3	0.0	0.0
10%	80%	75.0	100.0	25.0	5.0	1.3	105	26.3	-3.8	0.0	1.3
5%	85%	90.0	100.0	25.0	5.0	1.3	105	26.3	11.3	11.3	16.3
5%	90%	110.0	100.0	25.0	5.0	1.3	105	26.3	31.3	31.3	36.3
5%	95%	150.0	100.0	25.0	5.0	1.3	105	26.3	71.3	71.3	76.3
5%	100%	200.0	100.0	25.0	5.0	1.3	105	26.3	121.3	121.3	126.3
	Expected Values:	70.0	100.0	25.0	-2.0	-0.5	98.0	24.5	-3.5	11.8	12.9

Sensitivity of Capital to Swing Rated Premium Plan

Exhibit 5
Sheet 4

Scenario 4

Swing	Avg Inc Prem
Prov Premium	100.0
Prov Ceding %	25.0%

Balanced	
Min	95%
Prov	100%
Max	119%
Margin	7.0%
Load Factor	133%

Results by Method	Fixed Prem Leverage	Fixed Loss Leverage	Stnd Dev UW Loss	Variance UW Loss	LSCC	DSCC
Capital	67.5	67.5	58.9	51.4	48.3	53.3
Prem Leverage	1.481	1.481	1.698	1.946	2.073	1.878
Loss Leverage		1.037				
Scale constant			122%	1.48%		

Probability	Cumulative Probability	Loss	Provisional Premium	Provisional Commission	Premium Adjustment	Commission Adjustment	Final Premium	Final Commission	UW Loss	Capped UW Loss	UW Loss Excess of Expectation
10%	10%	25.0	100.0	25.0	-5.0	-1.3	95	23.8	-46.3	0.0	0.0
20%	30%	45.0	100.0	25.0	-5.0	-1.3	95	23.8	-26.3	0.0	0.0
25%	55%	55.0	100.0	25.0	-5.0	-1.3	95	23.8	-16.3	0.0	0.0
15%	70%	65.0	100.0	25.0	-5.0	-1.3	95	23.8	-6.3	0.0	0.0
10%	80%	75.0	100.0	25.0	7.0	1.8	107	26.8	-5.3	0.0	0.0
5%	85%	90.0	100.0	25.0	19.0	4.8	119	29.8	0.8	0.8	5.8
5%	90%	110.0	100.0	25.0	19.0	4.8	119	29.8	20.8	20.8	25.8
5%	95%	150.0	100.0	25.0	19.0	4.8	119	29.8	60.8	60.8	65.8
5%	100%	200.0	100.0	25.0	19.0	4.8	119	29.8	110.8	110.8	115.8
	Expected Values:	70.0	100.0	25.0	1.0	0.3	101.0	25.3	-5.8	9.7	10.7

Sensitivity of Capital to Changes in Share

Exhibit 6
Sheet 1

Scenario 1

Base Case	
Prov Premium	100.0
Prov Ceding %	25.0%

Results by Method						
	Fixed Prem Leverage	Fixed Loss Leverage	Stnd Dev UW Loss	Variance UW Loss	LSCC	DSCC
Capital	67.5	67.5	67.5	67.5	62.5	67.5
Prem Leverage	1.481	1.481	1.481	1.481	1.600	1.481
Loss Leverage		1.037				
Scale constant			122%	1.48%		

Probability	Cumulative Probability	Loss	Provisional Premium	Provisional Commission	Premium Adjustment	Commission Adjustment	Final Premium	Final Commission	UW Loss	Capped UW Loss	UW Loss Excess of Expectation
10%	10%	25.0	100.0	25.0	0.0	0.0	100	25.0	-50.0	0.0	0.0
20%	30%	45.0	100.0	25.0	0.0	0.0	100	25.0	-30.0	0.0	0.0
25%	55%	55.0	100.0	25.0	0.0	0.0	100	25.0	-20.0	0.0	0.0
15%	70%	65.0	100.0	25.0	0.0	0.0	100	25.0	-10.0	0.0	0.0
10%	80%	75.0	100.0	25.0	0.0	0.0	100	25.0	0.0	0.0	5.0
5%	85%	90.0	100.0	25.0	0.0	0.0	100	25.0	15.0	15.0	20.0
5%	90%	110.0	100.0	25.0	0.0	0.0	100	25.0	35.0	35.0	40.0
5%	95%	150.0	100.0	25.0	0.0	0.0	100	25.0	75.0	75.0	80.0
5%	100%	200.0	100.0	25.0	0.0	0.0	100	25.0	125.0	125.0	130.0
	Expected Values:	**70.0**	**100.0**	**25.0**	**0.0**	**0.0**	**100.0**	**25.0**	**-5.0**	**12.5**	**14.0**

Sensitivity of Capital to Changes in Share

Exhibit 6
Sheet 2

Scenario 2

Share Multiple	200.0%
Prov Premium	200.0
Prov Ceding %	25.0%

Results by Method

	Fixed Prem Leverage	Fixed Loss Leverage	Stnd Dev UW Loss	Variance UW Loss	LSCC	DSCC
Capital	135.0	135.0	135.0	270.0	125.0	135.0
Prem Leverage	1.481	1.481	1.481	0.741	1.600	1.481
Loss Leverage	1.037	1.037				
Scale constant			122%	1.48%		

Probability	Cumulative Probability	Loss	Provisional Premium	Provisional Commission	Premium Adjustment	Commission Adjustment	Final Premium	Final Commission	UW Loss	Capped UW Loss	Capped UW Loss Xs of Expectation
10%	10%	50.0	200.0	50.0	0.0	0.0	200	50.0	-100.0	0.0	0.0
20%	30%	90.0	200.0	50.0	0.0	0.0	200	50.0	-60.0	0.0	0.0
25%	55%	110.0	200.0	50.0	0.0	0.0	200	50.0	-40.0	0.0	0.0
15%	70%	130.0	200.0	50.0	0.0	0.0	200	50.0	-20.0	0.0	0.0
10%	80%	150.0	200.0	50.0	0.0	0.0	200	50.0	0.0	0.0	10.0
5%	85%	180.0	200.0	50.0	0.0	0.0	200	50.0	30.0	30.0	40.0
5%	90%	220.0	200.0	50.0	0.0	0.0	200	50.0	70.0	70.0	80.0
5%	95%	300.0	200.0	50.0	0.0	0.0	200	50.0	150.0	150.0	160.0
5%	100%	400.0	200.0	50.0	0.0	0.0	200	50.0	250.0	250.0	260.0
	Expected Values:	140.0	200.0	50.0	0.0	0.0	200.0	50.0	-10.0	25.0	28.0

Sensitivity of Capital to Changes in Share

Exhibit 6
Sheet 3

Scenario 3

Share Multiple	50.0%
Prov Premium	50.0
Prov Ceding %	25.0%

Results by Method						
	Fixed Prem Leverage	Fixed Loss Leverage	Stnd Dev UW Loss	Variance UW Loss	LSCC	DSCC
Capital	33.8	33.8	33.8	16.9	31.3	33.8
Prem Leverage	1.481	1.481	1.481	2.963	1.600	1.481
Loss Leverage	1.037	1.037				
Scale Constant			122%	1.48%		

Probability	Cumulative Probability	Loss	Provisional Premium	Provisional Commission	Premium Adjustment	Commission Adjustment	Final Premium	Final Commission	UW Loss	Capped UW Loss	Capped UW Loss Xs of Expectation
10%	10%	12.5	50.0	12.5	0.0	0.0	50	12.5	-25.0	0.0	0.0
20%	30%	22.5	50.0	12.5	0.0	0.0	50	12.5	-15.0	0.0	0.0
25%	55%	27.5	50.0	12.5	0.0	0.0	50	12.5	-10.0	0.0	0.0
15%	70%	32.5	50.0	12.5	0.0	0.0	50	12.5	-5.0	0.0	0.0
10%	80%	37.5	50.0	12.5	0.0	0.0	50	12.5	0.0	0.0	2.5
5%	85%	45.0	50.0	12.5	0.0	0.0	50	12.5	7.5	7.5	10.0
5%	90%	55.0	50.0	12.5	0.0	0.0	50	12.5	17.5	17.5	20.0
5%	95%	75.0	50.0	12.5	0.0	0.0	50	12.5	37.5	37.5	40.0
5%	100%	100.0	50.0	12.5	0.0	0.0	50	12.5	62.5	62.5	65.0
	Expected Values:	35.0	50.0	12.5	0.0	0.0	50.0	12.5	-2.5	6.3	7.0

Capital by Layer

Exhibit 7
Sheet 1

Scenario 1

Base Case	Combined
Prov Premium	100.0
Prov Ceding %	25.0%

Results by Method

	Fixed Prem Leverage	Fixed Loss Leverage	Stnd Dev UW Loss	Variance UW Loss	LSCC	DSCC
Capital	67.5	67.5	67.5	67.5	62.5	67.5
Prem Leverage	1.481	1.481	1.481	1.481	1.600	1.481
Loss Leverage		1.037				
Scale constant			122%	1.48%		

Probability	Cumulative Probability	Loss	Provisional Premium	Provisional Commission	Premium Adjustment	Commission Adjustment	Final Premium	Final Commission	UW Loss	Capped UW Loss	UW Loss Excess of Expectation
10%	10%	25.0	100.0	25.0	0.0	0.0	100	25.0	-50.0	0.0	0.0
20%	30%	45.0	100.0	25.0	0.0	0.0	100	25.0	-30.0	0.0	0.0
25%	55%	55.0	100.0	25.0	0.0	0.0	100	25.0	-20.0	0.0	0.0
15%	70%	65.0	100.0	25.0	0.0	0.0	100	25.0	-10.0	0.0	0.0
10%	80%	75.0	100.0	25.0	0.0	0.0	100	25.0	0.0	0.0	5.0
5%	85%	90.0	100.0	25.0	0.0	0.0	100	25.0	15.0	15.0	20.0
5%	90%	110.0	100.0	25.0	0.0	0.0	100	25.0	35.0	35.0	40.0
5%	95%	150.0	100.0	25.0	0.0	0.0	100	25.0	75.0	75.0	80.0
5%	100%	200.0	100.0	25.0	0.0	0.0	100	25.0	125.0	125.0	130.0
	Expected Values:	70.0	100.0	25.0	0.0	0.0	100.0	25.0	-5.0	12.5	14.0

Capital by Layer

Exhibit 7
Sheet 2

Scenario 2

Per Occ Layer	1
Prov Premium	68.9
Prov Ceding %	25.0%

Results by Method

	Fixed Prem Leverage	Fixed Loss Leverage	Stnd Dev UW Loss	Variance UW Loss	LSCC	DSCC
Capital	46.5	46.5	19.3	5.5	15.8	19.3
Prem Leverage	1.481	1.481	3.578	12.539	4.362	3.581
Loss Leverage	1.037	1.037				
Scale constant			122%	1.48%		

Probability	Cumulative Probability	Loss	Provisional Premium	Provisional Commission	Premium Adjustment	Commission Adjustment	Final Premium	Final Commission	UW Loss	Capped UW Loss	Capped UW Loss Xs of Expectation
10%	10%	25.0	68.9	17.2	0.0	0.0	69	17.2	-26.7	0.0	0.0
20%	30%	40.0	68.9	17.2	0.0	0.0	69	17.2	-11.7	0.0	0.0
25%	55%	45.0	68.9	17.2	0.0	0.0	69	17.2	-6.7	0.0	0.0
15%	70%	50.0	68.9	17.2	0.0	0.0	69	17.2	-1.7	0.0	1.8
10%	80%	55.0	68.9	17.2	0.0	0.0	69	17.2	3.3	3.3	6.8
5%	85%	60.0	68.9	17.2	0.0	0.0	69	17.2	8.3	8.3	11.8
5%	90%	65.0	68.9	17.2	0.0	0.0	69	17.2	13.3	13.3	16.8
5%	95%	70.0	68.9	17.2	0.0	0.0	69	17.2	18.3	18.3	21.8
5%	100%	75.0	68.9	17.2	0.0	0.0	69	17.2	23.3	23.3	26.8
	Expected Values:	48.3	68.9	17.2	0.0	0.0	68.9	17.2	-3.4	3.5	4.8

Capital by Layer

Exhibit 7
Sheet 3

Scenario 3

Per Occ Layer	2
Prov Premium	31.1
Prov Ceding %	25.0%

Results by Method

	Fixed Prem Leverage	Fixed Loss Leverage	Stnd Dev UW Loss	Variance UW Loss	LSCC	DSCC
Capital	21.0	21.0	50.4	37.6	46.7	48.3
Prem Leverage	1.481	1.481	0.617	0.827	0.665	0.644
Loss Leverage	1.037	1.037				
Scale Constant			122%	1.48%		

Probability	Cumulative Probability	Loss	Provisional Premium	Provisional Commission	Premium Adjustment	Commission Adjustment	Final Premium	Final Commission	UW Loss	Capped UW Loss	Capped UW Loss Xs of Expectation
10%	10%	0.0	31.1	7.8	0.0	0.0	31	7.8	-23.3	0.0	0.0
20%	30%	5.0	31.1	7.8	0.0	0.0	31	7.8	-18.3	0.0	0.0
25%	55%	10.0	31.1	7.8	0.0	0.0	31	7.8	-13.3	0.0	0.0
15%	70%	15.0	31.1	7.8	0.0	0.0	31	7.8	-8.3	0.0	0.0
10%	80%	20.0	31.1	7.8	0.0	0.0	31	7.8	-3.3	0.0	0.0
5%	85%	30.0	31.1	7.8	0.0	0.0	31	7.8	6.7	6.7	8.3
5%	90%	45.0	31.1	7.8	0.0	0.0	31	7.8	21.7	21.7	23.3
5%	95%	80.0	31.1	7.8	0.0	0.0	31	7.8	56.7	56.7	58.3
5%	100%	125.0	31.1	7.8	0.0	0.0	31	7.8	101.7	101.7	103.3
	Expected Values:	**21.8**	**31.1**	**7.8**	**0.0**	**0.0**	**31.1**	**7.8**	**-1.6**	**9.3**	**9.7**