What You Don’t Know Can Hurt You: Exploiting Asymmetric Information in Insurer Financing Decisions

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Abstract

When there is asymmetric information, insurers may have opportunities to benefit long-term shareholders at the expense of myopic shareholders. While such opportunities will typically fade over time, the opaque nature of loss reserves may provide insurers with market timing incentives. Management can benefit long-term shareholders by issuing (retiring) equity to take advantage of favorable (unfavorable) insurance market conditions. This type of capital structure swap involves management issuing (retiring) equity and retiring (issuing) liabilities. However, unlike non-financial corporate debt, most insurance liabilities are stochastic. Our model suggests that under certain conditions, managers can benefit shareholders by issuing (retiring) shares and reducing (expanding) net underwriting.

1 Introduction

Non-financial firms typically finance corporate assets using equity and conventional debt instruments. However, a key feature of financial firms, such as insurers and banks, is the use of stochastic, debt-like instruments that are senior to equity with contingent, rather than fixed, liabilities. For example, the bulk of insurer liabilities comprise loss reserves, which represent estimates of future contingent claims based on insured losses suffered by

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policyholders. Similarly, demand deposits created by banks, and pension obligations created by employers represent future contingent claims owed to depositors and pensioners. This study focuses on insurers, but the results generalize to any firm with stochastic liabilities under asymmetric information.

An insurer’s policyholders can only make claims when they experience insured losses, which vary in both value and time. Similarly, banks must satisfy claims on demand deposits at the discretion of depositors, and firms with pension obligations do not know \textit{a priori} how long pensioners will live to collect on their pensions. Regulators and ratings agencies monitor insurers, banks, and pension plans in an attempt to ensure solvency in the face of large contingent claims; properly implemented, regulatory oversight increases the likelihood that claims will be honored when they arise. One method insurers frequently use to satisfy regulators and other stakeholders involves the purchase of reinsurance.\footnote{Reinsurance-like transactions, such as retrocession and catastrophe bonds, can serve a similar purpose.} Reinsurance provides a further buffer beyond the insurer’s capital against large losses; thus, it serves as both a risk management and capital management tool by enhancing insurer solvency. Banks can reduce default risk on deposits by securitizing assets such as mortgages, auto loans, and credit card receivables, and defined benefit pension plans can be converted to cash balance plans. Such transactions are forms of capital structure swaps; i.e., the exchange of equity for debt. Debt can be exchanged for equity by reversing these transactions. For example, insurers can swap debt for equity by expanding net premiums written and applying expected underwriting profits to retiring equity. Similarly, by warehousing instead of securitizing assets such as mortgages, auto loans, and credit card receivables, banks effectively exchange debt for equity, as pension plans could (in theory) if they expand their defined benefit pension plan offerings. Managers may undertake capital structure swaps when debt ratios deviate from the firm’s target capital structure. Capital structure swaps may also be appealing when managers observe security prices that they believe are not in line with intrinsic values.

In this article, we examine the impact of information asymmetry on potential benefits
associated with capital structure swaps. We develop a model that managers can use to analyze changes in shareholder wealth resulting from issuing new policies or reinsuring existing policies. While models in prior literature regarding information asymmetry primarily focus on information asymmetry around asset values (i.e. expected cash flows from projects), in our model, the primary source of information asymmetry between insiders and outsiders pertains to a divergence of beliefs about expected value and variability of insurer loss reserves. Specifically, we show that if traders’ beliefs of joint probability distributions for asset values and loss reserve liabilities deviate from management’s estimates, the wealth of long-term shareholders can be positively affected by dynamically retiring or issuing equity as appropriate.

In this article, we motivate the idea of capital structure swaps within the broader context of capital structure theory as it applies to insurers. Further, we develop the theoretical structure of the model, and present numerical illustrations of various capital structure swap scenarios. The model has practical implications for insurers considering capital structure adjustments under asymmetric information. Under certain scenarios, we obtain the counterintuitive result that issuing undervalued equity may increase long-term shareholder wealth.

2 Motivation

Capital structure theory suggests that in the absence of market “frictions” such as taxes, bankruptcy costs, transactions costs, and agency conflicts, capital structure decisions should not affect corporate value (Modigliani and Miller, 1958), although debt is preferred to equity in the presence of frictions such as interest payment tax-deductibility (Modigliani and Miller, 1963). This static “trade-off” framework implies that capital structure swaps either do not affect shareholder wealth per se, or affect shareholder wealth to the extent that friction-related financing costs and benefits can be traded off in such a way that a net positive benefit is conveyed.

3
In later reviews of their work, Miller (1988) and Modigliani (1988) examine the potential of information content in dividend announcements and, by extension, capital structure adjustments. As Miller suggests in his review paper, “management-initiated actions on dividends or other financial transactions might then serve, by implication, to convey to the outside market information not yet incorporated in the price of the firm's securities.” The notion that asymmetric information motivates capital decision-making lies at the heart of the so-called “pecking order” theory advanced by Myers (1984), Myers and Majluf (1984), and others. Pecking order theory provides an alternative dynamic framework under which asymmetric information motivates firms to prefer internal to external financing, and debt to equity when issuing securities, cet. par.

Much of the earlier research on capital structure policies for insurers is firmly rooted in the static trade-off framework. For example, Garven (1987) applies this framework to the determination of the insurer’s optimal capital structure in the absence and presence of various frictions such as taxes and costs of contracting. Under costless contracting and no taxation, he finds that there is no such thing as an optimal capital structure for the insurer, a result which is logically consistent with Modigliani and Miller (1958). Furthermore, since reinsurance enables the insurer to further adjust the insurer’s capital structure, it follows as a logical corollary that reinsurance policy is also irrelevant in the absence of frictions. On the other hand, with taxes, the rational insurer will employ as little capital as possible, à la Modigliani and Miller (1963). However, in the presence of various (mostly asymmetric) frictions such as redundant tax shields, bankruptcy costs, and agency costs, the result is an interior optimum in which positive quantities of capital and reinsurance are employed. Two more recent articles in this vein include important contributions by Plantin (2006) and Froot (2007). Plantin shows that in equilibrium, optimal financial structures for insurers consist of reinsurance, along with capital provided by outside investors, and this is certainly the perspective adopted in this paper. Froot describes a market setting in which the insurer’s optimal pricing, risk allocation, and capital structure decisions are all endogenously
determined. Froot’s model is noteworthy in that it rigorously incorporates aspects of both the static trade-off and pecking order frameworks.

In insurance markets, information asymmetries between managers and external investors give rise to various capital structure swap opportunities. For example, insurers can engage in pseudo-swaps without immediate public disclosure, for example, using excess cash to purchase value-adding reinsurance rather than paying a dividend or by disclosing only one side of the swap by applying proceeds of an equity issue to the purchase of value-adding reinsurance.² Substantial literature on seasoned equity offerings, most notably work by Loughran and Ritter (1995), generally shows that equity offerings provide poor returns relative to other investment opportunities. Even when the proceeds of equity issues are used to reduce leverage, Masulis (1980) finds that loss of tax shields associated with reducing debt counteracts the benefits of reduced financial distress costs.

Moreover, there is conflicting evidence regarding the valuation effects of seasoned equity offerings in the insurance industry. Akhigbe, Borde, and Madura (1997) examined two-day stock market valuation effects of insurer equity offerings between 1977 and 1992 and found small negative returns that were not different from zero at any standard level of significance. However, they find that when compared to a matched sample of industrial firms with a similar equity offering around the same time, that industrial firm returns are lower than insurer returns, at the 1% significance level. In contrast, Polonchek and Miller (1995) found that the average two-day stock market valuation effect of insurer equity offerings was -3.09%, which underperformed issuance effects of both banks and non-financial companies during the same time frame. Polonchek and Miller (1995) use a sample of securities issues from 1975 to 1993 and attribute their result to the information asymmetry prevalent in the insurance industry, relative to that of commercial banks. Both studies employ a one-factor market model, with returns compared to a broad market portfolio. The samples for the two firms

²Using slack cash to purchase reinsurance deploys retained earnings to retire liabilities (loss reserves). Since this is an equity-for-liabilities trade, it has the same effect as a capital structure swap that issues equity to accomplish the same purpose. Following pecking order theory (Myers, 1984), using slack cash instead of external equity enables the insurer to avoid incurring the high costs of external finance.
was not the same, with the Polonchek and Miller (1995) study analyzing only one-third of the number of equity issues analyzed by Akhigbe, Borde, and Madura (1997). However, the results of both studies suggest that the use of proceeds from equity issues may explain the divergence of results from industrial firms and banks.

Staking and Babbel (1995, 1997) further demonstrate that insurance managers can engage in capital structure arbitrage by exploiting asset and liability duration mismatches within their portfolios. The notion that managers are likely to have more information than traders is borne out by general conservative reserving practices identified by Grace and Leverty (2012). They show that firms tend to over-reserve in high rate-regulation jurisdictions and under-reserve when financially weak. They further show that on average, insurers over-reserve relative to settled claims by nearly 8 percent (using the error method suggested by Weiss (1986), based on ultimate payments over a five-year horizon) or 1 percent (using the error method suggested by Kazenski, Feldhaus, and Schneider (1992), based on changed reserve estimates over a five-year horizon).

We exploit insurers’ ability to change capital structure with limited signaling effects; e.g., by issuing new policies to increase leverage or purchasing reinsurance to reduce leverage. The analysis is further motivated by the observation of Babbel and Merrill (2005), who show that the market value of an insurer’s assets is the sum of its franchise value and the market value of its tangible assets, while its market value of liabilities is the expected present value of the firm’s liabilities. We model the firm’s equity as an option to use its assets to settle insured losses. Thus, we extend the existing literature by examining the availability of insurance and reinsurance as leverage-increasing and leverage-reducing tools for insurers in the context of insurance capital structure swaps.

Rather than focus on the franchise value, we model changes to the value of the exchange option *per se*. In our model, the implied value of loss reserves is the difference between the value of the insurer’s assets and the value of the exchange option held by the insurer. Since the reinsurance market allows the insurer to lay off risks in exchange for a premium
payment, leverage reduction is possible without public announcement, possibly through a series of relatively small transactions. Including the covariance between the insurer’s assets and liabilities, we examine situations in which the insurer can benefit from reinsurance simply due to the reinsurer’s comparative advantage in bearing risk. We also examine the potential shareholder wealth effects from management exploiting information asymmetries between primary insurers and policyholders, as well as between primary insurers and reinsurers.

Prior work provides guidance for this study. Fischer (1978) develops an extension to the Black-Scholes (Black and Scholes, 1973) option pricing model, in which the risk-free rate is replaced by the difference between the expected return on a hedge asset and the expected rate of increase of the exercise price of the option. However, difficulty finding an appropriate hedge asset for loss reserves limits the usefulness of the Fischer model for this application. Merton (1973) and Margrabe (1978) suggest an extension of the Black-Scholes option pricing model that estimates the value of an option to exchange one asset for another, when the value of each asset is a random variable. Margrabe specifically suggests that this model is appropriate for valuing margin accounts, which accurately describes any firm with financial or operating leverage, including insurance companies. We will refer to this model as the “Merton-Margrabe” model.

Although Froot and O’Connell (2008) and Weiss and Chung (2004) show that reinsurance is typically priced at levels above expected loss, Mayers and Smith (1990) suggest that there may be times when reinsurance adds value for the ceding company. For example, insurers with concentrated ownership (e.g., Lloyd’s syndicates and risk retention groups) and firms with less geographic concentration demand more reinsurance. Thus, reinsurance purchase may result from comparative advantage in risk-bearing (the reinsurer has greater diversification opportunities) or efficiency in providing real services (economies of scale allow the reinsurer to provide underwriting and claims services at lower cost). The relationship between the primary insurer’s ceded losses and the reinsurer’s other loss reserves may allow the reinsurer to assume these risks at a lower premium than charged to the primary poli-
This may be especially true for excess reinsurance, in which the ceding insurer typically transfers only the tails of the claim to the reinsurer. Alternatively, the ceding insurer may benefit from information asymmetry, if management knows the underwriting experience for the losses while the reinsurer does not. In such cases, a ceding insurer may have a different estimate of ceded pool’s expected loss and/or its volatility, compared with the assuming reinsurer. Any of these cases may create capital structure arbitrage opportunities similar to those suggested by O’Brien, Klein, and Hilliard (2007) for non-financial firms. Furthermore, unlike the signaling equilibrium problems in executing otherwise optimal publicly-traded security transactions, reinsurance purchases are not announced immediately but are revealed ex post in accounting and statutory reports. The absence of signaling effects relative to other capital structure transactions could intensify the incentives to purchase reinsurance.

3 Theoretical Development

Consider an insurer whose liquid assets consist solely of a “market” portfolio of tradable securities and liabilities consist solely of loss reserves.

Management’s objective is to maximize the wealth of long-term shareholders, and managers will undertake a capital structure adjustment when market conditions are favorable to achieve this end. The model, as shown in Figure 1, has three time points; t = 0, referring to the time prior to the capital structure swap when market values of equity and liabilities are observed, t = 1, referring to the time of the capital structure swap and t = 2, referring to the future point at which the actual losses are known and paid. Any assets remaining at t = 2 are distributed to the shareholders and the firm ceases to exist.

3 Theoretically, such opportunities would be easier to exploit in a single-period framework, since in multiple periods, reinsurers would learn that they had made a bad bet and subsequently close the opportunity. However, an insurer can get “lucky” for a limited number of consecutive periods, perpetuating the reinsurers’ belief in the managers’ estimates. See Garven, Hilliard, and Grace (2014) for an empirical assessment of how multi-period contracting between reinsurance counter-parties mitigates asymmetric information.

4 Long-term shareholders could include corporate insiders, but may also include external “buy-and-hold” investors such as institutional investors and passively managed equity funds.
The firm’s long-term shareholders are those who own shares at $t = 0$ and intentionally hold them to $t = 2$. There may be other shareholders at $t = 0$ and $t = 2$, but management will not have an incentive to consider their wealth objectives in the capital structure swap; this suggests that the long-term shareholders may benefit at the expense of myopic traders.\(^5\)

Nor is management constrained to consider the wealth objectives of policyholders, except to honor their contractual obligations and maintain regulatory compliance.\(^6\)

**Figure 1: Capital Restructuring Model Timeline**

Model timeline in which $E_M$ is the market’s estimate of the firm’s equity value, given publicly available information. $E_I$ is management’s estimate of the firm’s equity value, given their private information.

\[
\begin{array}{c c c}
| t = 0 | t = 1 | t = 2 |
\end{array}
\]

- Observe Asset Value
- Capital Structure Swap
- Pay Claims

\[
E_M \neq E_I \quad E_M = E_I
\]

In our model, at $t = 0$, management has its own unbiased estimate of the probability distribution of claims, including the volatility of loss reserves. Management also observes the price of reinsurance and the market price for new policies, reflecting the market estimate of the loss distribution. We assume that the policies are small-stakes, and naïve policyholders are price-takers who will neither pay a premium nor demand a discount for leverage. Such policyholders will purchase insurance from any insurer that is in compliance with regulatory solvency guidelines. Any discrepancy between management’s estimate and the market’s est-

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\(^5\)While the managers’ fiduciary responsibilities extend to all shareholders, since traders rarely vote their shares, they are less engaged in corporate governance. Consistent with the findings of Grossman and Hart (1980), passive shareholders with small relative stakes have an incentive to free-ride and not vote their shares systematically, which in turn makes their wealth objectives more difficult to enforce.

\(^6\)It is important to note the limits of such a model. In general, as this study analyzes optimal managerial behavior during a discrete period of time, and further assumes dissolution of the firm at the end of the timeline, the results do not easily generalize to a long-lived firm with multiple financing opportunities and indefinite life. If this model were extended to an indefinite number of periods, the reinsurer(s) would presumably eventually learn the insurer was sending bad risks and adjust prices accordingly. However, even with this limitation, this study shows how a firm might act in cases of financial distress or when management has private information relative to the distribution of their firm’s loss distribution. Since the outcome is by definition random, the “lucky” insurer may replicate such a strategy a few times before being discovered. The rational reinsurance decision in a repeated game is a subject for future research.
timate of loss volatility is expressed as $\beta$ ($\beta \neq 1$). If there is no discrepancy about volatility estimates, then $\beta = 1$. If $\beta > 1$ ($\beta < 1$), then the market estimate of volatility is higher (lower) than management’s estimate. Similarly, discrepancy between manager and market estimates of expected loss is expressed as $\gamma$. Note that disagreements about the estimated volatility of losses will also affect the estimated covariance between the firm’s assets and loss reserve. Based on observing such deviations, management determines whether an opportunity exists to increase the wealth of long-term shareholders by issuing or retiring equity and either purchasing reinsurance (i.e. laying off the risk at the cost of a certain payment and reducing liabilities) or issuing more policies (i.e. increasing liabilities). Management also observes market values for the company’s equity and loss reserves (i.e. the cost of purchasing reinsurance on part or all of its book of business). When management issues equity, they use the proceeds to reduce expected loss at a rate of $\alpha$ ($0 < \alpha \leq 1$) by purchasing a quota share reinsurance policy, in which the reinsurer assumes a $1 - \alpha$ proportion of the loss reserve in exchange for cash generated by the equity issue. Conversely, when management retires equity, they market and sell new policies, increasing expected loss at a rate of $1 + \alpha$ and using the proceeds to retire equity. At $t = 1$, the capital restructuring occurs (losses increase or decrease by a factor of $\alpha$) and at $t = 2$, all policies expire, claims are paid and any remaining loss reserves and other assets are distributed to the $t = 2$ shareholders.

We begin by noting that the value of the firm’s equity is the net value of its assets less the expected losses in its policy portfolio. This value remains constant until the random outcome is known at $t = 2$ and losses are paid out. Therefore, a change in the value of liabilities (caused by either issuing more policies or reinsuring some portion of the insurer’s book of business) at $t = 1$ will require an equal and opposite change in the value of the equity. We assume that management will not over-insure, that is, reduce expected losses below 0 by selecting $\alpha > 1$. Note that the difference between the management’s estimate of equity value and the market estimate of equity value may reflect management’s private information about
the probability distribution of the loss reserves and asset values. The insurer’s volatility estimate reflects managers’ private information about the firm’s loss reserves, whereas the market estimates reflects only publicly available information. When these values differ, management may have an opportunity to engage in a capital structure swap expected to benefit its long-term shareholders.

Considering an insurer’s simplified balance sheet, we can define the firm’s equity value as $E_j$ in equation (1). Here, $E$ is value of equity, $A$ is value of tangible, liquid assets and $L$ is the present value of expected claims. The subscript $j$ is either $M$ (market value) or $I$ (insider value):

$$E_j = A_j - L_j. \quad (1)$$

If the assets of the firm are investments in an index fund, fully disclosed to investors and regulators alike, they can be readily valued without dispute and market values equal insider values. We are left with $E_j$ sensitive to only $L_j$. When the estimates of expected losses differ, management’s estimate of firm equity value is defined by equation (2):

$$E_I = A - L_I, \quad (2)$$

and the market value is defined by equation (3):

$$E_M = A - L_M. \quad (3)$$

In a competitive market regulated both by state insurance departments and the Securities

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Footnotes:

7 Following Myers and Majluf (1984), we assume the existence of capital markets that are efficient with respect to publicly available information; this implies that the current market value of the firm corresponds to the discounted value of its expected future cash flows, conditional upon whatever publicly available information the market happens to possess about the firm.

8 Note that such an exchange does not necessarily represent an arbitrage opportunity, but an action based on different expectations regarding probability distributions. Long-term shareholders may indeed lose money as a result of such an action, but management is acting based on their own beliefs (which may include inside information) and assumptions about the dynamics of the firm’s loss portfolio.

9 If the insurer does not hold the market portfolio on the asset side, there may be additional opportunities for capital structure arbitrage that are not modeled here.
and Exchange Commission, some might argue that differences between the insider value and
the market value of expected losses should rarely exist. However, Weiss and Chung (2004)
suggest that probability updating for losses may drive such differences. For example, such
a situation occurred during the 2003 restatement of reserves for asbestos exposure across
the property and casualty insurance industry (Treaster (2003)). As firms realized that their
previous estimates of asbestos exposure were incorrect, they re-stated the true expected loss
related to asbestos. Prior to the completion of these reserve analyses, the market may have
estimated the expected value of the losses higher than did management. Differences between
the insider’s estimate of loss distribution and the market estimation of loss distribution may
occur under other circumstances. For example, management observes the details of the
policy and thus may have a better estimate of the insureds’ loss distributions. At the same
time, the market can only estimate the policy characteristics under limited access to the
underwriting files, prior loss experience, regulatory filings and ratings agency estimates.

Indeed, even if both the firm and the market agree on underlying expected losses, there
may be disagreement about loss variability, which could also impact assumptions about co-
variance between assets and losses. A prospective policyholder’s estimate of policy value may
vary based on the insurer’s access to capital and ability to diversify its loss portfolio. For per-
sonal lines policyholders and closely-held commercial lines policyholders, the policyholders’
risk aversion will also factor into the reservation price for insurance.

Doherty and Garven (1986), Babbel and Merrill (2005) and O’Brien (2004) show that
the value of an insurer’s equity is (at least partially) the value of an option to exchange the
firm’s assets for the policyholders’ losses, with the strike price being the future value of the
claims. The option can be valued using the standard Black-Scholes option pricing model.

In cases where either the market’s estimation of expected loss or asset return volatility
differs from management’s estimation (the insider value), management may consider making
a capital structure swap to enhance the wealth of $t = 0$ shareholders who will hold their
shares until $t = 2$. 
3.1 Valuation When Assets and Liabilities are Risky

As shown by Rubinstein (1976) and Cox, Ross, and Rubinstein (1979), option pricing principles can be used to value capital budgeting projects and securities with or without limited liability. Some may suggest that these models require continuous trading and publicly tradable securities, based on no-arbitrage and replication arguments in a continuous time model. First, Rubinstein (1976) derives the option pricing model in a discrete time framework. Second, while it may not seem obvious at first, loss reserves are increasingly tradable. There has been a liquid reinsurance market in the developed world for decades, constantly swapping risks and trading risk for cash. Moreover, a liquid market for catastrophe bonds has emerged, in which losses are bundled and sold to investors in exchange for risk-free returns plus risk premium coupons. Thus, these constraints do not apply to the application of the option pricing framework in this context.\(^{10}\) Furthermore, if the insurer is investing its assets in at least some risky securities, the strike price for the exchange option is also a random variable and may be valued using the “preference-restricted” version of the Merton-Margrabe model (cf. Merton (1973) and Margrabe (1978)). The Merton-Margrabe model shows that an option to exchange one risky asset for another can be valued according to the following formula:\(^{11}\)

\[
E_j = A_j N(d_1) - L_j N(d_2).
\]

In equation (4), \(E_j\) is value of equity, \(A_j\) is current value of assets and \(L_j\) is expected value of loss reserves. The function \(N(\bullet)\) is a draw from the standard normal distribution function.

\(^{10}\)In fact, tradability is not a strict requirement to apply the option pricing framework used here. Stapleton and Subrahmanyam (1984) show that standard no-arbitrage justifications are not necessary for applying models such as Merton-Margrabe to such analyses. Specifically, the functional form of the Merton-Margrabe model still obtains so long as assets and liabilities are jointly lognormally distributed, and investors have constant relative risk aversion (CRRA) preferences, which is assumed in this example.

\(^{11}\)Fischer (1978) derives a model similar to Merton (1973) and applies it to the valuation of indexed bonds. Insurance loss reserves are essentially indexed bonds, with the final payoff being indexed to the cost of settling any losses.
Additional parameters of the Merton-Margrabe Model are defined below:

\[ d_{1j} = \frac{\ln \left( \frac{A_j}{L_j} \right) + 0.5V_j^2t}{V_j \sqrt{t}}, d_{2j} = d_{1j} - V_j \sqrt{t}, \text{ and} \]

\[ V_j^2 = \sigma_{jA}^2 + \sigma_{jL}^2 - 2\sigma_{jAL}, \]

where \( j \) takes the value of \( M \) for market value of equity and \( I \) for insider value of equity, \( \sigma_{jk} \) is the standard deviation of the variable \( k \) (either \( A \) for assets or \( L \) for losses) under \( j \), \( \sigma_{jAL} \) is the covariance between assets \( A \) and losses \( L \) under \( j \), and \( t \) is time to policy expiration. Since \( \beta \) and \( \gamma \) reflect degrees of information asymmetry, market estimates of pre-swap valuation inputs for \( d_{1M}, d_{2M}, \) and \( V_M^2 \) would be:

\[ d_{1M} = \frac{\ln \left( \frac{A_I}{L_I} \right) + 0.5V_M^2t}{V_M \sqrt{t}}, d_{2M} = d_{1M} - V_M \sqrt{t}, \]

and

\[ V_M^2 = \sigma_A^2 + \beta^2 \sigma_L^2 - 2\beta \sigma_{AL}. \]

Note that \( V_j^2 \) is the variance (estimated independently by management and investors) of the portfolio of long assets and short liabilities, and for simplicity, probability distributions for assets and liabilities are stable over time.

### 3.2 The Swap

When management chooses to undertake a capital structure swap, they will essentially increase or reduce the expected value of the loss reserves by some proportion \( \alpha \). When \( 0 < \alpha < 1 \), management is purchasing reinsurance funded by an equity issue. When \( \alpha > 1 \), management is issuing new policies and using the proceeds to retire equity. Thus, managers believe that the post-swap value of the firm is adjusted by \( \alpha \), investors will evaluate the change in value based on their estimates of \( \beta \) and \( \gamma \). In the context of equation (4), we propose lemma 1.
Lemma 1. The post-swap value of equity is a decreasing function of $\alpha$.

Proof. The relationship between post-swap value of equity and $\alpha$ is determined by taking the partial derivative of equity value:

$$
\frac{\partial E}{\partial \alpha} = A \frac{\partial N (d_1)}{\partial d_1} \frac{\partial d_1}{\partial \alpha} - \gamma L [N (d_2)] - \alpha \gamma L \frac{\partial N (d_2)}{\partial d_2} \frac{\partial d_2}{\partial \alpha}. \tag{5}
$$

Since

$$
d_1 = \frac{\ln \frac{A}{\alpha \gamma L} + 0.5 V^2 t}{V \sqrt{t}}, \quad \frac{\partial N (d_1)}{\partial d_1} = n (d_1), \quad \frac{\partial N (d_2)}{\partial d_2} = n (d_2),
$$

and

$$
\frac{\partial d_1}{\partial \alpha} = \frac{\partial d_2}{\partial \alpha} = - \frac{1}{\alpha V \sqrt{t}},
$$

it follows that

$$
d_1 V \sqrt{t} = \ln \frac{A}{\alpha \gamma L} + 0.5 V^2 t, \quad d_1 V \sqrt{t} - 0.5 V^2 t = \ln \frac{A}{\alpha \gamma L},
$$

and

$$
A = \alpha \gamma L e^{d_1 V \sqrt{t} - 0.5 V^2 t}. \tag{6}
$$

Therefore,

$$
\frac{\partial E}{\partial \alpha} = A \frac{n (d_1)}{V \sqrt{t}} - \alpha \gamma L \cdot N (d_2). \tag{7}
$$

Substituting the right-hand side of equation (6) for $A$ in equation (7) and expanding the $n(\bullet)$ operator, we obtain

$$
\frac{\partial E}{\partial \alpha} = - \frac{\alpha \gamma L}{\alpha V \sqrt{2 \pi t}} e^{d_1 V \sqrt{t} - 0.5 V^2 t} - \frac{\gamma L}{V \sqrt{2 \pi t}} e^{-0.5 (d_1 - V \sqrt{t})^2} - \alpha L \cdot N (d_2)
$$

$$
= - \frac{\gamma L}{V \sqrt{2 \pi t}} \left( e^{-0.5 (d_1 - V \sqrt{t})^2} - e^{-0.5 (d_1 - V \sqrt{t})^2} \right) - \alpha \gamma L \cdot N (d_2)
$$

$$
= - \alpha \gamma L \cdot N (d_2). \tag{8}
$$

Thus, as long as liabilities are positive, equity value decreases in proportion to liabilities.
changed and any deviation between insider and market estimates of expected loss.

\[ \square \]

**Lemma 2.** The post-swap value of equity is an increasing function of \( \beta \) for firms with low risk-neutral default probabilities.

**Proof.** The relationship between post-swap value of equity and \( \beta \) is determined by taking the partial derivative of equity value:

\[
\frac{\partial E}{\partial \beta} = A \frac{\partial N (d_1)}{\partial d_1} \frac{\partial d_1}{\partial \beta} - \alpha \gamma L \frac{\partial N (d_2)}{\partial d_2} \frac{\partial d_2}{\partial \beta}.
\]

Using definitions from the previous proof, as well as the observations that:

\[
\frac{\partial d_1}{\partial \beta} = -w_L d_2 \quad \text{and} \quad \frac{\partial d_2}{\partial \beta} = -w_L d_1,
\]

and similar steps used to derive equation (8), we can show that:

\[
\frac{\partial E}{\partial \beta} = A \cdot \frac{n (d_1)}{w_L} \cdot w_L d_2 + \alpha \gamma L \cdot n (d_2) \cdot w_L d_1
\]

\[
= -\alpha \gamma L e^{d_1 V \sqrt{t - .5 V^2 t}} e^{-0.5 d_1^2} w_L d_2 + \alpha \gamma L e^{-0.5 d_2^2} w_L d_1
\]

\[
= \alpha \gamma L w_L n (d_2) [d_1 - d_2]
\]

As long as \( w_L > 0 \), increasing the trader’s estimate of loss volatility increases the trader’s implied value of equity.

\[ \square \]

Two examples follow in which expected management estimates of volatility and expected loss (policy face value) differ from market estimates.

If management believes that reinsurance will add value for the firm, they may be able to increase value for long-term shareholders by purchasing reinsurance with the proceeds of a new equity issue. However, a firm can use excess cash to adjust to a desired capital structure.
without incurring flotation costs. Alternatively, management could increase value for long-term shareholders by selling more policies, using the proceeds to reduce outstanding equity and thereby increase leverage if they believed that they could sell policies at a sufficient premium or retire equity at a sufficient discount. Management need not retire equity to make such a swap worthwhile; they could instead use policy-generated cash to finance new projects or increase capital levels to satisfy regulators.

Efficient market theory, especially Ross (1977), suggests that announcement of an equity issue or equity repurchase should signal management’s private information to the market and prices should immediately adjust to reflect that new information. However, empirical evidence (See, for example, Lakonishok and Vermaelen (1990); Ikenberry, Lakonishok, and Vermaelen (1995); Loughran and Ritter (1995); Spiess and Affleck-Graves (1995), and other literature summarized by Klein, O’Brien, and Peters (2002)) suggest that market responses are not necessarily immediate. With particular application to insurance companies, Miller and Shankar (2005) find that positive excess returns persist for several months following equity repurchase announcements.

In order to test the impacts of capital structure shifts, we assume that management will undertake these transactions without signaling frictions (for example, purchasing reinsurance or issuing new policies) and that the market will become aware of the loss reserve outcome at \( t = 2 \).\(^{12}\) Benefits accruing to long-term shareholders will decline in the presence of signaling frictions.\(^{13}\) At \( t = 1 \), management is maximizing shareholder wealth given expectations of \( t = 2 \) outcomes. Since all outcomes will become known at \( t = 2 \), the market value and the insider value will be equal, \( E_{M2} = E_{I2} \), so we will suppress the \( j \) subscript for expected values at \( t = 2 \).

The intuition for this analysis is clearest when we assume that the manager purchases

\(^{12}\)Becoming aware of the outcome does not indicate that either management or the market actually knew the \textit{a priori} loss distribution.

\(^{13}\)This model assumes no other frictions. Any transaction costs associated with purchasing reinsurance (a premium loading by the reinsurer to cover administrative expenses and premium taxes) or selling policies (commissions paid to agents and brokers, as well as premium taxes), will further reduce any benefit to long-term shareholders, and may reverse the benefit if those costs are sufficiently high.
reinsurance on a quota share basis. That is, the manager will cede some portion of its loss reserve. There is no disagreement on the proportion of the book being reinsured, so that a 20% quota share policy reduces both insider estimate of loss by 20% and the market estimate of loss by 20%. The proportion of the book being reinsured is indicated by \( \alpha \), which is constant over all periods and agreed upon by all participants.

To motivate our signaling friction restrictions, consider a firm whose managers have superior information and are long-term shareholders.\(^{14}\) The managers of such a firm, with compensation tied to changes in the final value of shares held by these long-term shareholders, may seek to expropriate wealth from less informed myopic traders. This can be done by issuing or retiring equity when managers believe the market conditions are best suited to maximizing long-term shareholder wealth. Furthermore, insurance companies typically hold cash and marketable securities in sufficient quantity such that equity market transactions need not be contemporaneous with cash flow shocks within the firm.

The definition of terminal long-term shareholder wealth depends on the type of swap. When the firm issues equity and uses the proceeds to buy reinsurance, the long-term shareholders’ wealth is diluted. Their diluted ownership interest proportion is the ratio of market value of equity at \( t = 0 \) to market value of equity at \( t = 1 \). Their overall change in wealth is the diluted value of their equity after the swap less the value of equity prior to the swap, given as \( \Psi_D \) in equation (10):

\[
\Psi_D = \frac{E_{M0}}{E_{M1}} E_2 - E_{I0}. \tag{10}
\]

Management should engage in the swap only when diluted \( t = 2 \) wealth exceeds undiluted \( t = 0 \) wealth.

When the firm issues new policies and uses the proceeds to retire equity, the transaction is accretive to the long-term shareholders: after the transaction, they own a larger percentage of

\[^{14}\text{Here, we recognize the contribution of Campa and Hernando (2008) for this illustration. Their framework provides the logical justification needed for a distinction between “long-term” and transactional (myopic) shareholders, which in turn could motivate capital structure swaps of the kind considered in this paper.}\]
the firm’s equity than they did prior to the swap. The initial wealth of long-term shareholders is the ratio of market value of equity at \( t = 1 \) to the market value of equity at \( t = 0 \), multiplied by the \( t = 0 \) insider (subscript \( I \)) value of the firm’s equity, and the change in wealth, given as \( \Psi_A \) in equation (11):

\[
\Psi_A = E_2 - \frac{E_{M1}}{E_{M0}} E_{I0}.
\]  

Equation (11) represents the value of their portion of the firm’s equity prior to the swap less the proportion of total equity market value after the swap, and reflects the change in value of the long-term shareholders’ equity. Again, management will engage in the swap only when the \( t = 2 \) long-term shareholders’ wealth exceeds the \( t = 0 \) wealth.

For firms issuing equity and using proceeds to purchase reinsurance, the change in long-term shareholder wealth as a function of expected losses is:

\[
\frac{\partial \Psi_D}{\partial \alpha} = \frac{E_{M0}}{E_{M1}} \frac{\partial E^{-1}_M}{\partial \alpha} E_2 + \frac{E_{M0}}{E_{M1}} \frac{\partial E_2}{\partial \alpha} = \frac{E_{M0} E_2}{E_{M1}^2} \alpha \gamma L \cdot N (d_2) - \frac{E_{M0}}{E_{M1}} \alpha L \cdot N (d_2) \\
= \frac{E_{M0}}{E_{M1}} \alpha L \cdot N (d_2) \left[ \frac{E_2}{E_{M1}} - 1 \right].
\]  

(12)

The unsimplified version of equation (12) provides the intuition; the first term on the right-hand side represents the change in value of the long-term shareholders’ equity value for each unit change in expected loss (given traders’ information asymmetry), whereas the second term represents the cost or benefit (dilution or accretion) resulting from the equity issue. If a value of \( \alpha \) can be found that sets makes these two terms are equal, there is an optimal swap. The second version facilitates signing the derivative and predicting the change. The ratio outside the square brackets is strictly not negative since, as option values, neither the numerator nor denominator of the fraction can be negative. Inside the brackets, \( \gamma \geq 0 \) by definition and both numerator and denominator of the fraction are non-negative. The sign
of equation (12) depends on the ratio of terminal ($t = 2$) value of equity to the market value of equity immediately after the swap ($t = 1$), scaled by the traders’ level of information asymmetry regarding expected losses ($\gamma$).

When retiring equity, we take the partial derivative of equation (11) with respect to $\alpha$:

\[
\frac{\partial \Psi_A}{\partial \alpha} = \frac{\partial E_2}{\partial \alpha} - \frac{\partial E_{M1}}{\partial \alpha} \frac{E_{I0}}{E_{M0}} - \frac{\partial E_{M0}^{-1}}{\partial \alpha} - \frac{E_{M0}}{E_{M1}} \frac{\partial E_{I0}}{\partial \alpha}
\]

\[
= -\alpha L \cdot N(d_2) + \alpha \gamma L \cdot N(d_2) \frac{E_{I0}}{E_{M0}}
\]

\[
= \alpha L \cdot N(d_2) \left[ \gamma \frac{E_{I0}}{E_{M0}} - 1 \right]
\]

(13)

Again, the unsimplified version of equation (13) provides an intuitive explanation: the first term represents the change in the long-term shareholders’ portion of the post-swap equity. The second term represents the increase in shareholder wealth that results from reducing number of shares outstanding.

Let us first consider, for example, the case in which traders believe that loss volatility is higher than managers do. We will refer to this deviation as $\beta > 1$, where $\beta = 1$ indicates no disagreement. Option valuation mechanics suggest that option value increases in volatility, so a higher market estimate of volatility indicates that equity is overvalued in the market and equity issue would be accretive. We now demonstrate this relationship with a proposition.

**Proposition 1.** When traders believe that loss pool volatility is higher than managers do ($\beta > 1$), and managers issue equity to purchase reinsurance (i.e., $\alpha$ decreases), long-term shareholder wealth will increase.

**Proof.** To determine the sensitivity of long-term shareholder wealth changes resulting from equity issue to differences in volatility estimate, we find first-order conditions shareholder wealth changes with respect to $\alpha$, proportion of loss portfolio reinsured and $\beta$, level of deviation between management and market estimates of volatility.

Setting the first-order conditions equal to zero, a closed-form solution for $\alpha$ is available (given one equation and one unknown) but intractable for general purposes. The intractabil-
ity arises from the fact that several of the partial derivatives contain functions of \( \alpha \) that are not readily factored. However, the solution can be discovered using linear programming or software solutions such as a spreadsheet’s “Goal Seek” or “Solver” function. Omitting the solvency constraint for explanation purposes, the managers will find a value of \( \alpha \) that solves the equation (14), given their observation of implied information asymmetry to identify the values of \( \beta \) and \( \gamma \):

\[
\frac{E_{M0}E_2}{E_{M1}^2} \left( \frac{\partial E_{M1}}{\partial \alpha} + \frac{\partial E_{M1}}{\partial \beta} \right) = E_2 \frac{\partial E_{M0}}{\partial \beta} + E_{M0} \frac{\partial E_2}{\partial \alpha}
\]  

(14)

Such a value of \( \alpha \) will generate a benefit from purchasing reinsurance that offsets the dilution effects of issuing equity. Such an interior solution will exist when \( \beta \) is sufficiently higher than \( \gamma \) but both are greater than 1.

Now, let us consider the impact of retiring equity when loss volatility is overstated.

**Proposition 2.** When management believes that the market has overstated loss volatility \((\beta > 1)\), and issues new policies to retire equity (i.e., \( \alpha \) increases), long-term shareholder wealth will decrease.

**Proof.** To determine the sensitivity of long-term shareholder wealth from equity issue to differences in volatility estimate, we take the cross-partial derivative of long-term shareholder wealth changes with respect to \( \alpha \), proportion of loss portfolio reinsured and \( \beta \), level of deviation between management and market estimates of volatility. To accomplish this, we will take the partial derivative of equation 13 with respect to \( \beta \).

\[
\frac{\partial^2 \Psi_P}{\partial \alpha \partial \beta} = \frac{\partial}{\partial \beta} - \alpha L \cdot N \left( d_2 \right) + \frac{\partial \alpha \gamma L \cdot N \left( d_2 \right) E_{10}}{E_{M0}} \frac{E_{10}}{E_{M0}}
\]

\[
= \alpha L \cdot n \left( d_2 \right) w_L d_1 - \alpha \gamma L \cdot n \left( d_2 \right) \frac{E_{10}}{E_{M0}} - \alpha^2 \gamma^2 L^2 N^2 \left( d_2 \right) \frac{E_{10}}{E_{M0}^2}
\]

(15)
The counterfactual of Lemma 1 suggests that equity value falls when the firm retires equity using funds generated from issuing shares. This makes intuitive sense; when management believes that market estimates of loss volatility are overstated, the value of equity will be higher. Retiring overvalued equity is typically a poor use of shareholder funds, and would reduce long-term shareholder wealth.

We will forgo formal statement of propositions about the shareholder wealth effects of issuing and retiring equity when disagreements exist about expected losses. The intuition is similarly straightforward. If managers believe that investors have overstated expected losses, the price of reinsurance will be high and managers would not want to purchase it. Similarly, if potential policyholders believe that expected losses are higher than managers do, managers can inflate premiums and sell more insurance, using the extra proceeds to retire equity.

Now, we will examine the inter-connections between sources of information asymmetry. First, we will look at the change in equity value when both managers’ known expected loss and volatility differ from market beliefs.

Proposition 3. For a solvent insurer, market values of equity will decrease upon issuance of new policies when investor estimates of expected loss and volatility exceed those of managers.

Proof. It can be shown that the third partial derivative of equity value with respect to change in expected losses (\(\alpha\)), deviation of beliefs regarding expected losses and deviation of beliefs regarding loss volatility is:

\[
\frac{\partial^3 E}{\partial \alpha \partial \beta \partial \gamma} = L \cdot w_L \cdot n(d_2) \left[ d_1 - \frac{d_1 d_2}{V \sqrt{t}} - \frac{\sqrt{V}}{\sqrt{t}} \right],
\]

(16)

where \(w_L = \frac{\beta \sigma^2 L - \sigma_{AL}}{V^2} < 0\),\(^{15}\) which represents the weight of losses in the firm’s hedged portfolio that minimizes risk for the insurer, under the market’s estimate of loss volatility and management’s estimate of covariance\(^{16}\).

\(^{15}\)Here, we assume that assets and losses are positively correlated.

\(^{16}\)According to Clairaut’s Theorem, it does not matter which order we take multivariate partial derivatives. However, we achieve the same result when we calculate \(\frac{\partial^3 \partial E}{\partial \alpha \partial \beta \partial \beta}\).
The equity value decrease arises from a negative sign on the derivative shown above. Losses ($L$), time ($t$), volatility ($V$) and $n(d_2)$ are always positive. For a solvent firm ($A > L$), $d_2 > 1$, therefore, the bracketed term will be positive. Thus, the derivative’s negative sign arises from the negative sign on $w_L$.

If increasing expected losses destroys shareholder value, managers would optimally choose not to do so. However, it may be prudent to issue equity and use the proceeds to purchase reinsurance if shareholder wealth would be enhanced by such a move. The next proposition explores such a transaction.

Proposition 4. For a solvent insurer, market values of equity will increase upon issuance of equity and simultaneous purchase of reinsurance.

The proof for this proposition follows from the previous proof. However, when considering long-term shareholder wealth impacts, we must be concerned about the dilution effects of issuing new equity. Referring to equation 12, recall that the first term represents the change in market value of equity resulting from the swap, whereas the second term represents the dilution effect. Therefore, long-term shareholder wealth may be improved by such a transaction, as long as the benefits of purchasing “cheap” reinsurance are not overwhelmed by the dilution effect. A series of numerical examples is presented in the next section to illustrate long-term shareholder wealth changes resulting from a series of possible transactions.

4 Numerical Examples

In this section, we analyze capital structure adjustments based on management private information about the value of the firm’s assets, liabilities and the covariance between the two. These results suggest possible wealth-enhancing transactions. We establish a base case in which management’s private information does not deviate from market values and reinsurers neither add nor remove value relative to the firm retaining the risk. We then
allow market valuations to deviate, showing the value-maximizing action. In each case, we assume that the firms' assets are invested in the market portfolio, with $\sigma = 0.19$, with no disagreement about their value.\(^{17}\)

### 4.1 Base Case

First, we consider a case where management and outside investors\(^ {18}\) agree about the risk and value of assets and losses, and the covariance between assets and losses. To begin, we assume an asset pool (consisting of investments in the market portfolio, $\sigma = 0.19$) of $1,500, and a portfolio of insurance policies with an expected loss of $1,000 and $\sigma = 0.4$. In this case, management may issue $500 in equity and use the proceeds to purchase reinsurance, effectively reducing the firm's expected loss portfolio $500, without changing the value of the assets. Alternatively, the firm may sell $200 in new policies and use the cash to retire equity, again without changing the value of assets. Assuming no taxes or market frictions for simplicity, we show in table 1 that shareholder wealth is not affected by leverage choices. These results are consistent with the predictions of Modigliani and Miller (1958) that in the absence of frictions, source of funding is irrelevant to shareholder value.\(^ {19}\)

\(^{17}\)Since the volatility of assets enters into the valuation equation in the $V^2$ term, it is important to use a reasonable estimate for the risk of the firm's assets. If the firm holds treasury securities, the risk of the asset portfolio would go away and the model would simplify to a simple Black-Scholes put option held by the policyholders. If the firm holds a specialized portfolio of risky securities, the wealth change will be related to the relative risk of the assets and losses as well as their covariance. However, since none of our swap examples include a change in asset holdings, nor a disagreement about the riskiness of the asset pool, the impact of our asset standard deviation parameter choice should be minimal. We use a long-run estimate of the standard deviation of annual returns on the market portfolio, calculated from the data available on Ken French's website.

\(^{18}\)Here, we assume that outside investors have homogeneous information and expectations that may differ from those of management.

\(^{19}\)Note that these results rely on the strong assumptions of Modigliani and Miller (1958) and Modigliani and Miller (1963), namely that there are no transaction costs, individuals and corporations can borrow and lend at the same rate, and investors and management have access to the same information. In succeeding cases, the assumption of information is relaxed, giving rise to arbitrage opportunities envisioned by Miller (1988), by which investors would eventually become aware of inside information.
Table 1: No Disagreement about Expected Loss or Volatility
Changes in insider shareholder wealth following recapitalizations of insurance companies. Calculated using Merton-Margrabe model. The first model shows the capital structure of the firm and equity and loss value estimates of both management (insider) and outside investors (market). The second model shows the change in shareholder wealth resulting from issuing $500 in equity at the market per-share price and using the proceeds to purchase reinsurance at the market price. The third model shows the change in shareholder wealth resulting from selling $200 in new policies at the market price and using the proceeds to retire equity at the per-share market price.

<table>
<thead>
<tr>
<th></th>
<th>Base Case</th>
<th>Issue Equity</th>
<th>Retire Equity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mgr.</td>
<td>Trader ($\beta = 1$)</td>
<td>Mgr.</td>
</tr>
<tr>
<td>Asset Value</td>
<td>$1,500.00</td>
<td>$1,500.00</td>
<td>$1,500.00</td>
</tr>
<tr>
<td>Expected Loss</td>
<td>1,000.00</td>
<td>1,000.00</td>
<td>500.00</td>
</tr>
<tr>
<td>Asset Volatility</td>
<td>19%</td>
<td>19%</td>
<td>19%</td>
</tr>
<tr>
<td>Loss Volatility</td>
<td>40%</td>
<td>40%</td>
<td>40%</td>
</tr>
<tr>
<td>Time</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Asset/Loss Covariance</td>
<td>0.152%</td>
<td>0.152%</td>
<td>0.152%</td>
</tr>
<tr>
<td>Equity Value</td>
<td>$551.06</td>
<td>$551.06</td>
<td>$1,000.75</td>
</tr>
<tr>
<td>Loss Value</td>
<td>948.94</td>
<td>948.94</td>
<td>499.25</td>
</tr>
<tr>
<td>Long-term portion of initial equity</td>
<td>55.06%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Long-term portion of ending equity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change in long-term wealth</td>
<td>$0.00</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4.2 Volatility Estimates Differ (Market Volatility Higher)

In table 2, we consider two swaps when management believes that reinsurance adds value for the firm due to differences in estimates of volatility. This is reasonable when management knows the contents of the underwriting files better than reinsurers, who rationally assume higher volatility, or when policyholders overestimate their risk. In the first case, management issues $500 of equity and use the proceeds to purchase reinsurance in the same amount. In the second case, management sells $200 in new business and use the cash proceeds to retire equity. In either case, the capital structure has changed and shareholder wealth is impacted. Specifically, issuing equity and using proceeds to purchase reinsurance increases the wealth of the long-term shareholders, while issuing new policies and using proceeds to retire equity diminishes wealth. Management’s objective is to maximize wealth for long-term shareholders (defined earlier as the pre-swap shareholders that still hold shares after the swap). Thus, the firm can increase the value of long-term shareholders’ equity by issuing equity and using the proceeds to purchase reinsurance.20

4.3 Volatility Estimates Differ (Market Volatility Lower)

We now reverse the relative valuations and show that when insurers are able to charge prices above expected loss, they can sell more policies and use the proceeds to retire equity, keeping assets constant. This might be particularly appealing to management who wish to write a more risky line of business that also provides additional diversification benefits. As shown in table 3, when management can sell higher-priced policies and use the proceeds to retire equity, long-term shareholders will gain wealth.

20We acknowledge that these results largely mirror those of a similar exercise in O’Brien (2004). However, while that study allowed for equity and debt to be misvalued in the same direction, that result is not possible when the value of the asset pool is known to all without information asymmetry. We thank an anonymous reviewer for pointing out this distinction.
Table 2: Volatility Estimates Differ (Market Volatility Higher)
Changes in insider shareholder wealth following recapitalizations of insurance companies. Calculated using the Merton-Margrabe model. The first model shows the capital structure of the firm and equity and loss value estimates of both management (insider) and market participants (market). The second model shows the change in shareholder wealth resulting from issuing $500 in equity at the market per-share price and using the proceeds to purchase reinsurance at the market price. The third model shows the change in shareholder wealth resulting from selling $200 in new policies at the market price and using the proceeds to retire equity at the per-share market price.

<table>
<thead>
<tr>
<th></th>
<th>Volatility Estimates Differ</th>
<th>Issue Equity</th>
<th>Retire Equity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mgr.</td>
<td>Trader (β = 1.5)</td>
<td>Mgr.</td>
</tr>
<tr>
<td>Asset Value</td>
<td>$1,500.00</td>
<td>$1,500.00</td>
<td>$1,500.00</td>
</tr>
<tr>
<td>Expected Loss</td>
<td>1,000.00</td>
<td>1,000.00</td>
<td>500.00</td>
</tr>
<tr>
<td>Asset Volatility</td>
<td>19%</td>
<td>19%</td>
<td>19%</td>
</tr>
<tr>
<td>Loss Volatility</td>
<td>40%</td>
<td>60%</td>
<td>40%</td>
</tr>
<tr>
<td>Time</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Asset/Loss Covariance</td>
<td>0.152%</td>
<td>0.228%</td>
<td>0.152%</td>
</tr>
<tr>
<td>Equity Value</td>
<td>$551.06</td>
<td>$616.30</td>
<td>$1,000.75</td>
</tr>
<tr>
<td>Loss Value</td>
<td>948.94</td>
<td>883.70</td>
<td>499.25</td>
</tr>
<tr>
<td>Long-term portion of initial equity</td>
<td>61.12%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Long-term portion of ending equity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change in long-term wealth</td>
<td>$60.61</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 3: Loss Volatility Understated

Changes in Insider shareholder wealth following recapitalizations of insurance companies. Calculated using Merton-Margrabe model. The first model shows the capital structure of the firm and equity and loss value estimates of both management (Insider) and outside investors (market). The second model shows the change in shareholder wealth resulting from issuing $500 in equity at the market per-share price and using the proceeds to purchase reinsurance at the market price. The third model shows the change in shareholder wealth resulting from selling $200 in new policies at the market price and using the proceeds to retire equity at the per-share market price.

<table>
<thead>
<tr>
<th></th>
<th>Volatility Estimates Differ</th>
<th>Issue Equity</th>
<th>Retire Equity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mgr.</td>
<td>Trader ($\beta = 0.75$)</td>
<td>Mgr.</td>
</tr>
<tr>
<td>Asset Value</td>
<td>$1,500.00</td>
<td>$1,500.00</td>
<td>$1,500.00</td>
</tr>
<tr>
<td>Expected Loss</td>
<td>1,000.00</td>
<td>1,000.00</td>
<td>500.00</td>
</tr>
<tr>
<td>Asset Volatility</td>
<td>19%</td>
<td>19%</td>
<td>19%</td>
</tr>
<tr>
<td>Loss Volatility</td>
<td>40%</td>
<td>20%</td>
<td>40%</td>
</tr>
<tr>
<td>Time</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Asset/Loss Covariance</td>
<td>0.152%</td>
<td>0.076%</td>
<td>0.152%</td>
</tr>
<tr>
<td>Equity Value</td>
<td>$551.06</td>
<td>$510.08</td>
<td>$1,000.75</td>
</tr>
<tr>
<td>Loss Value</td>
<td>948.94</td>
<td>989.92</td>
<td>499.25</td>
</tr>
</tbody>
</table>

Long-term portion of initial equity 51.01%
Long-term portion of ending equity 67.15%
Change in long-term wealth -$40.60 $43.76
4.4 Differences Regarding Both Expected Loss and Volatility (Market Lower)

Until now, we have assumed that management and outside investors differ only in their assumptions about volatility of losses. We now introduce another layer of uncertainty: the expected loss of the policy portfolio. Management has access to claim files and become aware of shifts in loss values and probability estimates before investors and policyholders. As long as there is a set of less informed myopic traders, management may be able to expropriate wealth from them to the benefit of long-term shareholders. Even if we assume that management could not trade on this information without moving markets, there are other motivations for purchasing reinsurance when prices are high. In particular, the comparative advantages in real services offered by reinsurers and the decreased probability of financial distress costs may motivate reinsurance purchase, even when its price is above expected loss (as noted by Mayers and Smith (1990)).

For completeness, we also consider the swap that may be available when the insurer prices policies above the market price. While on its face, we might assume that these policies will not sell in the marketplace. However, firm-specific and policy-holder characteristics and transaction costs might make these policies appealing. In particular, a reputation for superior service or high financial ratings may facilitate sale of otherwise overpriced policies, as will status quo bias (Samuelson and Zeckhauser, 1988).

For example, consider the same swaps examined earlier when managers believe that the market has underestimated both its expected losses and volatility, resulting in overvalued equity. Under conventional thinking, equity issuance typically signals management belief that equity is overvalued in addition to shareholder concerns about ownership dilution. Past empirical work finds a corresponding drop in stock price on such an issue. However, in this case, as shown in table 4, we find that the indicated swaps improve long-terms shareholder wealth no matter which direction the swap is initiated. In the next section, we will explore this finding as we examine figures illustrating the range of results of swaps.
Table 4: Differences Regarding Both Expected Loss and Volatility (Market Lower)

Changes in Insider shareholder wealth following recapitalizations of insurance companies. Calculated using Merton-Margrabe model. The first model shows the capital structure of the firm and equity and loss value estimates of both the manager (Insider) and market participants (market). The second model shows the change in shareholder wealth resulting from issuing $500 in equity at the market per-share price and using the proceeds to purchase reinsurance at the market price. The third model shows the change in shareholder wealth resulting from selling $200 in new policies at the market price and using the proceeds to retire equity at the per-share market price.

<table>
<thead>
<tr>
<th></th>
<th>Expected Loss and Volatility Lower</th>
<th>Issue Equity</th>
<th>Retire Equity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mgr.</td>
<td>Trader ($\beta = 0.5, \gamma = 0.75$)</td>
<td>Mgr.</td>
</tr>
<tr>
<td>Asset Value</td>
<td>$1,500.00</td>
<td>$1,500.00</td>
<td>$1,500.00</td>
</tr>
<tr>
<td>Expected Loss</td>
<td>1,000.00</td>
<td>750.00</td>
<td>500.00</td>
</tr>
<tr>
<td>Asset Volatility</td>
<td>19%</td>
<td>19%</td>
<td>19%</td>
</tr>
<tr>
<td>Loss Volatility</td>
<td>40%</td>
<td>20%</td>
<td>40%</td>
</tr>
<tr>
<td>Time</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Asset/Loss Covariance</td>
<td>0.152%</td>
<td>0.076%</td>
<td>0.152%</td>
</tr>
<tr>
<td>Equity Value</td>
<td>$551.06</td>
<td>$750.51</td>
<td>$1,000.75</td>
</tr>
<tr>
<td>Loss Value</td>
<td>948.94</td>
<td>749.49</td>
<td>499.25</td>
</tr>
<tr>
<td>Long-term portion of initial equity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Long-term portion of ending equity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change in long-term wealth</td>
<td>$116.56</td>
<td></td>
<td>-$29.54</td>
</tr>
</tbody>
</table>
4.5 Differences Regarding Both Expected Loss and Volatility (Market Higher)

When managers believe that investors have over-estimated losses on both expected loss and volatility, they will observe that the company’s market value is lower than its insider value. When this happens as a result of overall market sentiment about loss distributions, we would expect that policyholders may be willing to pay more than the expected value for policies. In such cases, the conventional advice would be to take advantage of policyholders by issuing new policies at a high price, using the proceeds to retire bargain-priced equity or as funding for new projects. However, in table 5, we show two swaps, both destroying shareholder value in either direction.

4.6 Swap Example Charts

Figures 2 through 4 illustrate the range of possible long-term shareholder effects from the swaps discussed in the prior section. In these figures, we hold all values constant except the insider and market value of liabilities, preserving the spread between the market and insider values when a deviation exists. The graphs show the change in shareholder wealth resulting from swaps that issue equity and reinsure losses on the left, to swaps that issue new policies and use cash proceeds to retire equity on the right.

Figure 3 provides intuition for the counter-intuitive results in table 4 (in which capital structure swaps in either direction benefit long-term shareholders) and table 5 (in which capital structure swaps in either direction diminished shareholder wealth). In the latter graphs, we can see that the arbitrary swaps chosen for the numerical examples resulted in either destroying or adding value no matter which swap was executed. From figure 3, we can see that interior extremes explain this interesting result. In the case where both expected loss and volatility are overstated, managers can increase long-term shareholder value by issuing equity and purchasing reinsurance, but at some point, the dilution from
Table 5: Differences Regarding Both Expected Loss and Volatility (Market Higher)

Changes in Insider shareholder wealth following recapitalizations of insurance companies. Calculated using Merton-Margrabe model. The first model shows the capital structure of the firm and equity and loss value estimates of both the manager (Insider) and market participants (market). The second model shows the change in shareholder wealth resulting from issuing $500 in equity at the market per-share price and using the proceeds to purchase reinsurance at the market price. The third model shows the change in shareholder wealth resulting from selling $200 in new policies at the market price and using the proceeds to retire equity at the per-share market price.

<table>
<thead>
<tr>
<th></th>
<th>Expected Loss and Volatility Higher</th>
<th>Issue Equity</th>
<th>Retire Equity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mgr.</td>
<td>Trader (\beta = 1.5, \gamma = 1.1)</td>
<td>Mgr.</td>
</tr>
<tr>
<td>Asset Value</td>
<td>$1,500.00</td>
<td>$1,500.00</td>
<td>$1,500.00</td>
</tr>
<tr>
<td>Expected Loss</td>
<td>1,000.00</td>
<td>1,100.00</td>
<td>500.00</td>
</tr>
<tr>
<td>Asset Volatility</td>
<td>19%</td>
<td>19%</td>
<td>19%</td>
</tr>
<tr>
<td>Loss Volatility</td>
<td>40%</td>
<td>60%</td>
<td>40%</td>
</tr>
<tr>
<td>Time</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Asset/Loss Covariance</td>
<td>0.152%</td>
<td>0.228%</td>
<td>0.152%</td>
</tr>
<tr>
<td>Equity Value</td>
<td>$551.06</td>
<td>$556.14</td>
<td>$1,000.75</td>
</tr>
<tr>
<td>Loss Value</td>
<td>948.94</td>
<td>943.86</td>
<td>499.25</td>
</tr>
</tbody>
</table>

Long-term portion of initial equity: 57.77%
Long-term portion of ending equity: 79.71%
Change in long-term wealth: $27.09 - $25.46
Table 6: Differences Regarding Both Expected Loss (Market Lower) and Volatility (Market Higher)

Changes in Insider shareholder wealth following recapitalizations of insurance companies. Calculated using Merton-Margrabe model. The first model shows the capital structure of the firm and equity and loss value estimates of both the manager (Insider) and market participants (market). The second model shows the change in shareholder wealth resulting from issuing $500 in equity at the market per-share price and using the proceeds to purchase reinsurance at the market price. The third model shows the change in shareholder wealth resulting from selling $200 in new policies at the market price and using the proceeds to retire equity at the per-share market price.

<table>
<thead>
<tr>
<th></th>
<th>Expected Loss Lower and Volatility Higher</th>
<th>Issue Equity</th>
<th>Retire Equity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mgr. (β = 1.5, γ = 0.75)</td>
<td>Mgr. (β = 1.5, γ = 0.75)</td>
<td>Mgr. (β = 1.5, γ = 0.75)</td>
</tr>
<tr>
<td>Asset Value</td>
<td>$1,500.00</td>
<td>$1,500.00</td>
<td>$1,500.00</td>
</tr>
<tr>
<td>Expected Loss</td>
<td>1,000.00</td>
<td>750.00</td>
<td>500.00</td>
</tr>
<tr>
<td>Asset Volatility</td>
<td>19%</td>
<td>19%</td>
<td>19%</td>
</tr>
<tr>
<td>Loss Volatility</td>
<td>40%</td>
<td>60%</td>
<td>40%</td>
</tr>
<tr>
<td>Time</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Asset/Loss Covariance</td>
<td>0.152%</td>
<td>0.228%</td>
<td>0.152%</td>
</tr>
<tr>
<td>Equity Value</td>
<td>$551.06</td>
<td>$793.43</td>
<td>$1,000.75</td>
</tr>
<tr>
<td>Loss Value</td>
<td>948.94</td>
<td>706.579</td>
<td>499.25</td>
</tr>
<tr>
<td>Long-term portion of initial equity</td>
<td>70.40%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Long-term portion of ending equity</td>
<td></td>
<td></td>
<td>86.02%</td>
</tr>
<tr>
<td>Change in long-term wealth</td>
<td>$153.42</td>
<td></td>
<td>-$60.23</td>
</tr>
</tbody>
</table>
Table 7: Differences Regarding Both Expected Loss (Market Higher) and Volatility (Market Lower)

Changes in Insider shareholder wealth following recapitalizations of insurance companies. Calculated using Merton-Margrabe model. The first model shows the capital structure of the firm and equity and loss value estimates of both the manager (Insider) and market participants (market). The second model shows the change in shareholder wealth resulting from issuing $500 in equity at the market per-share price and using the proceeds to purchase reinsurance at the market price. The third model shows the change in shareholder wealth resulting from selling $200 in new policies at the market price and using the proceeds to retire equity at the per-share market price.

<table>
<thead>
<tr>
<th>Expected Loss Higher and Volatility Lower</th>
<th>Issue Equity</th>
<th>Retire Equity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mgr.</td>
<td>Trader ($\beta = 0.5, \gamma = 1.5$)</td>
<td>Mgr.</td>
</tr>
<tr>
<td>------------------------------------------</td>
<td>-------------</td>
<td>--------------</td>
</tr>
<tr>
<td>Asset Value</td>
<td>$1,500.00</td>
<td>$1,500.00</td>
</tr>
<tr>
<td>Expected Loss</td>
<td>1,000.00</td>
<td>1,500.00</td>
</tr>
<tr>
<td>Asset Volatility</td>
<td>19%</td>
<td>19%</td>
</tr>
<tr>
<td>Loss Volatility</td>
<td>40%</td>
<td>20%</td>
</tr>
<tr>
<td>Time</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Asset/Loss Covariance</td>
<td>0.152%</td>
<td>0.076%</td>
</tr>
<tr>
<td>Equity Value</td>
<td>$551.06</td>
<td>$162.92</td>
</tr>
<tr>
<td>Loss Value</td>
<td>948.94</td>
<td>1,337.08</td>
</tr>
<tr>
<td>Long-term portion of initial equity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Long-term portion of ending equity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change in long-term wealth</td>
<td>-$333.82</td>
<td></td>
</tr>
</tbody>
</table>
Table 8: Comparative Statics
Comparative statics showing the predicted optimal capital structure swap given managers’ private
information about expected loss and volatility estimates of loss reserve. “Market higher” means
that compared with loss or volatility estimates under private information, managers believe the
market has overstated the expected loss or volatility. “No difference” means that the managers'
private information agrees with market estimates. “Market lower” means that managers believe
the market estimates of loss and volatility are too low.

<table>
<thead>
<tr>
<th>Volatility:</th>
<th>Expected Loss:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Market Higher ($\gamma &gt; 1$)</td>
</tr>
<tr>
<td>Market Higher ($\beta &gt; 1$)</td>
<td>Issue equity in some cases</td>
</tr>
<tr>
<td>No Difference ($\beta = 1$)</td>
<td>Always retire equity</td>
</tr>
<tr>
<td>Market Lower ($\beta &lt; 1$)</td>
<td>Always retire equity</td>
</tr>
</tbody>
</table>
issuing equity eliminates the gains from buying cheap reinsurance and long-term shareholder value declines.

In figures 5 and 6, we illustrate how the potential wealth transfers vary over the range of potential levels of disagreement. Figure 5 shows wealth transfers available when traders believe that losses will end up lower than managers do. The dotted line in figure 3 is a cross-section of this chart at $\beta = 1.5$. Regions shaded in gray represent wealth transfers to long-term shareholders while regions shaded in black represent long-term shareholder wealth losses. We can see that when traders believe that losses are over-stated by managers ($\gamma < 1$), the best choice is to issue equity and use the proceeds to purchase reinsurance ($\alpha < 1$). The benefit to long-term shareholders is intensified when traders believe that loss volatility is under-stated by managers ($\beta > 1$).

Moving to figure 6, we see a different situation. Here, traders believe that losses will end up higher than investors do ($\gamma = 1.25$). The solid line in figure 3 is a cross-section of this chart at $\beta = 0.5$. In the south corner of the chart, we can see that the region over which shareholder value increases is represented by selling more policies and using the proceeds to retire equity ($\alpha > 1$). Note that there are also value-enhancing swaps that involve buying reinsurance, but any capital structure swap above a certain level of disagreement about volatility in this direction will destroy value for long-term shareholders. This is seen most prominently in the east corner of the chart where the value surface drops below the zero wealth transfer plane.

5 Conclusion

Prior research has demonstrated that in most cases, firms that issue equity do so at the expense of the long-term shareholders. Some research, however, has demonstrated that insurance company investors, in particular, may benefit from a different regulatory system that addresses many of the information asymmetry problems associated with new equity
Figure 2: Volatility Deviations
Examples of long-term shareholder wealth changes following capital structure swaps. The solid line corresponds with the swaps illustrated in table 2 and the dashed line corresponds with the swaps illustrated in table 3. Points on the left side of the graph correspond with swaps in which the firm issues equity and uses the proceeds to purchase reinsurance. Points on the right side of the graph correspond with swaps in which the firm sells new policies and uses the proceeds to retire equity.
Figure 3: Expected Loss and Volatility Deviations – Same Direction
Examples of long-term shareholder wealth changes following capital structure swaps. The solid line corresponds with the swaps illustrated in table 4 and the dashed line corresponds with the swaps illustrated in table 5. Points on the left side of the graph correspond with swaps in which the firm issues equity and uses the proceeds to purchase reinsurance. Points on the right side of the graph correspond with swaps in which the firm sells new policies and uses the proceeds to retire equity.
Figure 4: Expected Loss and Volatility Deviations – Different Directions

Examples of long-term shareholder wealth changes following capital structure swaps. The plane represents no wealth transfer. The uneven surface expands the analysis from tables 4 and 5, showing wealth changes at varying levels of $\beta$ while holding $\gamma$ constant at 0.75. Points on the left side of the graph ($\alpha < 1$) correspond with swaps in which the firm issues equity and uses the proceeds to purchase reinsurance. Points on the right side of the graph ($\alpha > 1$) correspond with swaps in which the firm sells new policies and uses the proceeds to retire equity.
Figure 5: Expected Loss and Volatility Deviations – Same Direction
Examples of long-term shareholder wealth changes following capital structure swaps. The surface expands the analysis from tables 4 and 5, showing wealth changes at varying levels of $\beta$ while holding $\gamma$ constant at 0.75. Points on the north corner of the graph ($\alpha < 1$ and $\beta > 1$) correspond with situations in which traders believe that loss volatility is higher than do managers, and when the firm issues equity and uses the proceeds to purchase reinsurance. Points on the south corner of the graph ($\alpha > 1$ and $\beta < 1$) correspond with swaps in which traders believe that loss volatility is lower than do managers, and when the firm sells new policies and uses the proceeds to retire equity. Points colored gray indicate a transfer of wealth to the long-term shareholders, while points colored in black indicate loss of long-term shareholder wealth.
Figure 6: Expected Loss and Volatility Deviations – Same Direction
Examples of long-term shareholder wealth changes following capital structure swaps. The surface expands the analysis from tables 4 and 5, showing wealth changes at varying levels of $\beta$ while holding $\gamma$ constant at 1.5. Points on the north corner of the graph ($\alpha < 1$ and $\beta > 1$) correspond with situations in which traders believe that loss volatility is higher than do managers, and when the firm issues equity and uses the proceeds to purchase reinsurance. Points on the south corner of the graph ($\alpha > 1$ and $\beta < 1$) correspond with swaps in which traders believe that loss volatility is lower than do managers, and when the firm sells new policies and uses the proceeds to retire equity. Points colored gray indicate a transfer of wealth to the long-term shareholders, while points colored in black indicate loss of long-term shareholder wealth.
issues. Further research has shown that insurers gain many advantages from purchasing reinsurance, including comparative advantages in risk-bearing and provision of real services. When the managers can exploit risk aversion of potential policyholders to sell insurance at a premium to expected loss, they can increase the firm’s leverage and use the proceeds to retire equity or invest in new projects. At the same time, if managers can purchase value-adding reinsurance, they may choose to issue equity to raise the necessary cash to do so.

In this paper, we show that insurance companies have unique opportunities to engage in capital structure arbitrage by executing transactions that take advantage of market conditions and frictions. We use a (preference-restricted) version of the Merton-Margrabe option pricing model to analyze the impact of an exchange of risky assets. Contrary to the conventional rule, we show that long-term shareholders’ wealth can increase when management engages in some swaps, issuing undervalued equity or selling cheap insurance policies. Finally, we show that an interior solution exists in some cases to maximize long-term shareholder value when both equity and loss reserves are valued differently by myopic traders and potential policyholders.

These findings provide new rationale for the findings of Akhigbe, Borde, and Madura (1997). In addition to reduced information asymmetry due to regulation, differences in risk aversion, cost of real services and covariance between asset and loss portfolios can generate unique opportunities for capital structure swaps that are available to firms outside of the insurance and financial services sector.
References


