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Managing the Invisible: Identifying Value-Maximizing Combinations of Risk and Capital

William H. Panning
ERMetrics, LLC, Prospect, Kentucky

This article demonstrates the linkage—often asserted but seldom described—between Enterprise Risk Management (ERM) and maximizing a firm's value. I show that knowing a firm's aggregate risk exposure (via ERM), when combined with a valuation model like the one presented here, can enable the firm's managers to identify and choose value-maximizing combinations of risk and capital. Using value maximization as the criterion for choosing a firm's capital structure is quite distinct from rules of thumb that CFOs often use for such decisions. The valuation model shows that increasing an insurer's surplus from an initially low level typically increases the present value of future cash flows that take into account the probability of impairment from extreme losses. In contrast to traditional literature on the risk of ruin, impairment here is taken to mean a loss of creditworthiness such that the firm's business model is no longer sustainable, whether or not the firm is solvent. However, beyond a certain optimal level relative to a firm's risk, further increases in surplus actually reduce a firm's value added measured in this fashion. Sensitivity analyses presented here show how these conclusions are affected by changes in the values of crucial variables. In particular, the article shows how managers can use this model to identify specific actions that their firm can take to increase its value added, and it emphasizes the practical importance of making a firm's value both visible and manageable.

1. INTRODUCTION

The purpose of computing is insight, not numbers.—Richard Hamming, computer scientist

Enterprise Risk Management (ERM) is a body of knowledge—concepts, methods, and techniques—that enables a firm to understand, measure, and manage its overall risk *so as to maximize the firm's value to shareholders and policyholders*. The purpose of this article is to demonstrate this asserted linkage between ERM on the one hand and maximizing a firm's value on the other.

Most existing literature on ERM focuses on specific concepts, methods, and techniques for measuring particular risks and constructing an aggregate risk distribution for the firm as a whole. Important issues include the selection of appropriate risk measures, techniques for measuring the distribution of particular risks, alternative ways of representing dependencies among different risks, methods for producing an aggregate measure of firm-wide risk, and whether and how to allocate capital among alternative sources of risk within a firm.

Implicit in this rapidly growing body of work is the assumption that measuring its overall risk exposures will enable a firm to "better" manage its risk and that this capability will "add value." Typically missing is any concrete explanation or demonstration of what this specifically means and how it will come about. Notably scarce, for example, are papers that describe what is meant by "adding value" and that propose specific ways that this could be implemented and measured in practice or even in principle.

[1]This definition is quite similar to that of the CAS Advisory Committee on ERM: "ERM is the process by which organizations in all industries assess, control, exploit, finance, and monitor risks from all sources for the purpose of increasing the organization's short and long term value to its stakeholders."

The original version of this article was presented at the CAS/SOA/PRMIA Enterprise Risk Management Symposium in April 2006, where it received the first ERM Research Excellence Award, an annual prize established by The Actuarial Foundation. I am indebted to Richard Goldfarb and Richard Derrig for valuable discussions and encouragement in preparing the original version. Since then, stimulated by discussions with David Ingram, Daniel Bar Yaacov, and Chuck Thayer, and especially by an anonymous referee's superb comments and suggestions, I have substantially extended it to encompass new results. As with all my work, SDG.

Address correspondence to William H. Panning, Founder and Principal of ERMetrics, LLC, 7305 Blakemore Court, Prospect, KY 40059. E-mail: Bill@ERMetrics.com

What I demonstrate in this article is that there are optimal combinations of risk and capital—optimal in that they maximize the value of the firm. Specifically, for a given level of risk there is a value-maximizing amount of capital. Alternatively, if capital is the constraint, then for a given level of capital there is an optimal (value-maximizing) level of risk exposure for the firm. *ERM therefore can add to a firm's value because, by measuring the firm's aggregate risk exposure, it enables the firm's managers to identify and choose value-maximizing combinations of risk and capital.*

This demonstration takes the form of an explanatory model that presumes that the ERM group at the modeled firm has successfully measured its risk exposures and has correctly constructed from them an aggregate distribution of potential firm-wide losses. The model shows how to use this aggregate distribution, together with other financial information about the firm, to identify value-maximizing combinations of risk and capital. It is an *explanatory* model because it is deliberately simplified so that the virtues and defects of its fundamental logic will be readily apparent. If I have constructed this model correctly it should lead to approximately the same conclusions as an *elaborated* model, which includes numerous complexities found in most actual firms, or a *calibrated* model, which is an elaborated model with details and parameters that match those of a particular firm. In contrast to an elaborated or calibrated model, the principal purpose of an *explanatory* model is insight, not numbers.

Not all firms are alike, and not all insights can be readily transferred from one industry to another. Here my focus will be on ERM as applied to a property-casualty insurer and on surplus as the critical component of its capital structure. Although I recognize that reinsurance, debt, and various hybrid securities can be important components of an insurer's capital structure, I will treat them in a subsequent article rather than add to the length and complexity of this one. Despite these limitations, I hope that the model and conclusions presented here add substantially to our understanding of the "M" in ERM.

2. CAPITAL STRUCTURE IN THEORY AND PRACTICE

> I have become a bit disenchanted with the indiscriminate use of superrationality as the foundation for models of financial behavior.—Franco Modigliani (1988), Nobel Prize–winning economist

It may seem foolhardy to speak of "optimal capital structure" when the phrase itself is considered an oxymoron by many financial economists and their present and former students. Indeed, Modigliani and Miller were honored with Nobel prizes in part for their assertion and proof of what is sometimes called the "capital structure irrelevance theorem," which is taught to virtually every MBA student. The theorem is indeed valid, but—and this crucial qualification is typically forgotten or ignored—only under circumstances that are rarely if ever encountered.[2] When bankruptcy and its associated costs are possible, the irrelevance theorem is itself irrelevant. But the influence of M&M's original work was so powerful and pervasive that, even today, bankruptcy is virtually ignored in many of the leading textbooks on corporate finance! Even in the recent professional literature, bankruptcy is treated as one among a number of supposed "frictional costs" that cause the real world to deviate from the conditions originally assumed by Modigliani and Miller.[3] But, given the rarity of convincing attempts to clarify or quantify frictional costs, most CFOs would be hard-pressed to draw any practical conclusions from the corporate finance literature generated since the early 1980s, if not before. As a consequence, the term "oxymoron" is perhaps better suited to the phrase "applied corporate finance."[4]

In the absence of useful academic guidance, CFOs necessarily adopt pragmatic principles as guides to decision making concerning capital structure. Here are a few and the difficulties inherent to each:

a. *Maintain roughly the same financial ratios as peer companies.* This criterion shifts the task from determining the right financial ratios to determining the right peer companies, which may be different from the companies that currently are the most similar to one's own. In practice this criterion works only because firms *assume* a set of peer companies to which they compare themselves.

b. *Maintain the financial ratios consistent with our corporate risk tolerance.* This is often mentioned but virtually never specified. What is a corporate risk tolerance? How is it measured? How is such a measure related to possible financial ratios? Who is consulted in these decisions? Note that executives, policyholders, bond holders, and stockholders may disagree considerably on specifications of this criterion.[5]

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[2]The real significance of these authors' path-breaking work was its use of arguments based on arbitrage—arguments that have fundamentally affected the evolution of finance as well as of financial securities and markets. For succinct reviews of portions of the voluminous relevant literature see Rubinstein (2003), Modigliani (1988), and Giesecke and Goldberg (2004).

[3]Examples of this literature include Hancock, Huber, and Koch (2001), Chandra and Sherris (2007), Yow and Sherris (2007, 2008), Smith, Moran, and Walczak (2003), Exley and Smith (2006), and Major (2009a, 2009b), who further extend this emerging frictional cost framework to considerations of pricing, optimal capitalization, and firm value.

[4]A refreshingly frank admission is found in Copeland, Weston, and Shastri (2005), p. 611: "How Does a Practitioner Use the Theory to Determine Optimal Capital Structure? The answer to this question is the Holy Grail of corporate finance. There is no completely satisfactory answer."

[5]I am indebted to Richard Goldfarb for his numerous insights on this topic.

c. *Maintain the financial ratios required to achieve or maintain a target financial rating.* Using target ratings ignores the problem of choosing which rating to have, which may, in turn, depend on the clients that the firm serves or wishes to attract, the nature of the products offered by the firm (short-term versus long-term and any guarantees associated with each), and the type of distribution system that it has established (agents may be sensitive to credit quality).

d. *Maintain a target beta and associated target cost of capital, as defined by the capital asset pricing model (CAPM).* This seems plausible except for the fact that, by assuming the validity of CAPM, it confronts and is refuted by the original Modigliani and Miller arguments. In my view, the story we tell ourselves to make "measuring relative stock market performance" equivalent to "measuring our cost of capital" requires, like many stories, a suspension of disbelief that is difficult to sustain. But rather than defending such heretical doubts, I here attempt the more constructive task of outlining part of an alternative story that may prove more useful.

I propose the following decision criterion: *For a given set of risk exposures, select the capital structure that maximizes shareholder or policyholder value.* This restatement of the problem assumes that risk exposures are fixed and that capital structure is flexible. An alternative but equivalent criterion is as follows: For a given capital structure, select the aggregate risk exposure that maximizes the value of the firm to shareholders and policyholders. The two problems are mathematically equivalent—a fact that is analogous to the duality theorem in linear programming—but not necessary identical in practice.

For this alternative criterion to be practical (i.e., one that can be implemented), we need a measure of value that can be derived from obtainable data (unlike risk tolerance), that is understandable by senior executives (unlike beta), and that can be used to explore and evaluate alternative capital structures and corporate strategies.

3. VALUING A PROPERTY-CASUALTY INSURANCE FIRM

Point of view is worth 80 IQ points.—Alan Kay, a computer science pioneer

Like an unwelcome guest at an elegant dinner party, a central question in corporate finance is almost universally ignored: how to measure the value of a firm.[6] In practice there are two ways of answering this question. One might be called the *cross-sectional approach*, since it deals with the firm at a given point in time. This approach starts with the accounting balance sheet of a firm, adjusts it for differences between book value and economic value, and uses the result as an estimate of the firm's value. For a property-casualty insurer, this approach is implemented by estimating the market value of the firm's assets and subtracting from that the estimated present value of the firm's liabilities (obtained by discounting the forecast liability cash flows). The result is considered the current economic value of the firm. This approach was developed and widely adopted in the domain of asset-liability management, where the objective was to protect this economic value of the firm from potential loss due to changes in interest rates.[7] An alternative, described in greater detail below, is the *longitudinal* or *going-concern approach*, in which the value of the firm is the survival-adjusted present value of its future earnings or cash flows.

The cross-sectional approach ignores two important but inconvenient facts that it cannot explain. First, the market value of a firm's equity may exceed the value of its assets. From a cross-sectional point of view such a situation would be absurd, since the value of equity is equal to the market value of the firm's assets less the market value of its liabilities. Even if the firm had no liabilities at all, its equity value could not exceed the value of its assets. The inconvenient fact, however, is that one firm in our industry recently had $12 billion in assets, $9 billion in liabilities, and therefore $3 billion in net worth. Since the firm's assets and liabilities were both relatively short term, their book and market values were virtually identical, so that the firm's economic value was roughly $3 billion, according to the cross-sectional point of view. And yet this firm's market capitalization was approximately $14 billion, some $2 billion more than its total assets!

A second inconvenient fact is that, from a cross-sectional point of view, firms that directly market insurance to their clients behave irrationally; that is, in ways that appear to reduce, rather than increase, the economic value of the firm. I became acutely aware of this puzzle when, as a quantitative financial analyst for a large insurer, I was asked to help build a financial planning model for a new division that would directly market auto insurance.[8] The firm's existing model, based on GAAP (Generally Accepted Accounting Principles), showed that the division's prospective earnings would be unacceptably low, since every new policy written would lose money and add to the deficit already created by the considerable startup expenditures. But slowing the rate of growth only postponed the day when the operation would become profitable. At first, glance, there appeared to be no way to salvage an initiative on which the CEO had staked his reputation with the board.

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[6] In finance, the phrase "value of the firm" refers to the value of its assets, not the value of its equity. Here, by contrast, I will use the phrase to mean the value of a firm to its shareholders, as imperfectly reflected in its market capitalization—the aggregate value of its stock—either as observed or as estimated by the model presented later.

[7] For a critique of and correction to that approach, see Panning (1994, 2006).

[8] The experience described here has also been discussed in Panning (2003a).

The solution, it turned out, lay in thinking about the problem in an entirely different way. The key was to think about the business longitudinally—as a going concern—rather than cross-sectionally, at a given point in time. From a cross-sectional point of view it made no sense at all to spend $100 in marketing costs to sell a policy that would, apart from those costs, make, say, $50 in profit. But for a going concern considered longitudinally, such a strategy made enormous economic sense, for the original $100 in marketing costs was a one-time expenditure. Those who purchased policies had a very high probability of renewing them even in the absence of subsequent additional marketing costs and despite the lack of any contractual obligation to renew. So in the second and subsequent years, each new policy generated $50 in profits, with a renewal probability of some 90%. At the time of the original sale, the present value of these future profits far exceeded the initial $100 marketing cost.

Since neither GAAP nor statutory accounting recognizes the value of future renewals (because policyholders are not legally obligated to renew), from a cross-sectional accounting perspective there was no convincing reason to sell policies at all under the circumstances just described. But from a longitudinal going-concern perspective, it made sense to sell as many policies as possible, since doing so would maximize the present value of future earnings.

In the *longitudinal* or *going-concern approach*, the value of a firm is the present value of its expected future earnings or cash flows, adjusted for the probability of survival. Here we will focus on earnings, since they are easier to assess than cash flows, and particularly since insurance regulators typically permit dividends that are proportional to earnings rather than cash flows. For convenience we will focus on a firm with expected earnings $E[X]$ at the end of the current year and every future year, absent default or crippling impairment, with constant annual survival probability p and a risk-free interest rate i. The survival-adjusted present value of future earnings is equal to $E[X]p/(1 + i - p)$. Incorporating a modest rate of growth further explains how a firm's market capitalization can exceed the value of its assets.[9] If a firm's annual expected earnings grow by a factor $(1 + g)$, where g is the annual growth rate, the survival-adjusted present value of future earnings is $E[X]p/(1 + i - p(1 + g))$.

From a longitudinal or going-concern point of view, then, the market value of a firm can considerably exceed the economically adjusted current accounting value of its net worth. This going-concern value can be called the firm's *franchise value*, since it includes the present value of profits from business that the firm has not yet written but can reasonably be expected to write.[10] A rough but reasonable measure of a firm's franchise value is its market value, actual or estimated, although this measure may incorporate additional variables that may be empirically important to market participants but, from a strictly theoretical point of view, are irrelevant or tangential.

Alan Kay was entirely correct: Adopting the right point of view matters enormously. The cross-sectional accounting point of view fails to explain how a firm's equity value can exceed the value of its assets or how a firm that directly sells insurance to consumers can survive and prosper. By contrast, viewing an insurer as a going concern immediately solves both puzzles and, as we will show, has important implications for strategies to maximize the value of an insurance operation.

4. A GOING-CONCERN VALUATION MODEL

Here I present a detailed valuation model that incorporates the longitudinal point of view. In this model, the value of an insurance firm is the survival-adjusted present value of its expected future earnings plus the present value of any residual assets that may remain should the firm be reorganized. The foregoing statement contains within it several important features of the model that need to be stated explicitly:

1. The principal focus of this valuation model is earnings rather than cash flow because the firm is assumed to pay dividends to its shareholders equal to its annual after-tax net income, if positive.
2. These anticipated future dividend payments are discounted, at the risk-free rate, to obtain their present value.
3. These anticipated future dividend payments are further adjusted to reflect the fact that the stream of expected dividend payments will end if the firm is reorganized or dissolved due to an extraordinary loss. Given its surplus, pricing, expenses, and other

[9]Growth is an issue with numerous facets that cannot be adequately treated in the space available and so will be treated in a subsequent article. One well-known issue is that high growth rates cannot be sustained indefinitely. Dealing with this issue requires a more complex model than the one presented here.

[10]For an earlier model of franchise value see Panning (1994), which focused on the risk to franchise value of changes in interest rates. Unfortunately, the concluding equation of that paper is marred by an egregious printing error. The correct equation is readily derived from the two that precede the final one. Panning (2006) is a briefer and more sophisticated treatment of that topic, which corrects that error but likewise excludes consideration of default risk. Hancock, Huber, and Koch (2001), Smith, Moran, and Wolczak (2003), and Exley and Smith (2006) present results very similar to some of those presented here and that are based on current financial theory and its rather strong assumptions rather than on the simpler approach adopted here. Fernandez (2002) provides a thorough survey of the huge variety of valuation approaches that have been proposed or are in use. Damodaran (2005) provides a survey of rival approaches and associated evidence. Leibowitz (2004) presents a synthesis of his earlier work on estimating franchise value, and Koller, Goedhart, and Wessels (2010) provide textbook models for valuing corporations. Avanzi (2009) provides a valuable review of the extensive literature on dividend discount models and the strategies they imply, and Dickson (2005) surveys the huge relevant actuarial literature on the risk of ruin and its implications for firm strategy and valuation. The links between corporate strategy, risk, and valuation are explored in books by Coleman (2009), Pettit (2007), Schroeck (2002), Segal (2011), and Woolley (2009). Major (2011) provides an excellent overview of the principal approaches to modeling the effect of risk on valuation. Venter and Underwood (2010), Bodoff (2011), and Ingram and Bar Yaacov (2012) extend the model presented here to strategy choice and risk hedging. Finally, articles such as Brockman and Turtle (2003) and Episcopos (2008) present models for pricing corporate securities based on a barrier option pricing framework, which has important similarities to the model presented here.

parameters, in every year there is some likelihood—typically quite small—that the firm's losses will exceed some critical amount that triggers reorganization or bankruptcy. If this occurs, the firm is essentially dissolved, and the stream of dividend income will cease permanently. Each future dividend payment is therefore multiplied by the probability that it will occur or, equivalently, the probability that reorganization has been avoided in the current and prior years.

4. By reorganization I simply mean that the firm ceases to exist as a going concern. Its assets are liquidated to pay policyholders. Any cash that remains after these are paid (i.e., any residual surplus) is distributed to shareholders.

The model presented here incorporates an important simplifying assumption. I assume that every year the firm begins with a given amount of surplus and writes the same volume of business with the same expense ratio, the same expected losses, and therefore the same expected net income after tax as in prior years. Its actual losses, and therefore its actual net income, are stochastic. If the firm's net income is positive, it dividends that amount to shareholders; if negative, it raises sufficient capital (from existing shareholders) to restore its surplus to the amount held at the beginning of the year. Consequently, it begins every year with the same surplus as it held a year earlier.

Further details of this valuation model are as follows.

4.1. Underwriting

1. The firm writes 100 units of premiums every year; a unit is some fixed amount in dollars: $1 million, for example.
2. All policies are written on January 1 and take effect at 12:01 AM that day.
3. All policies have a term of one year and expire at midnight on December 31.
4. At midnight on December 31, the losses associated with these policies become known precisely and are paid immediately.

As a consequence of these assumptions it follows that accident-year, policy-year, and calendar-year financials are identical for this hypothetical firm.

4.2. Cash Flow and Earnings

5. All premiums are paid when the policies are written; for example, at 12:01 on January 1.
6. All expenses are known precisely and paid immediately, at the inception of the policy.
7. The firm earns investment income, at the risk-free rate, on its cash balance during the year. This cash balance consists of written premiums, less expenses, plus surplus.
8. The firm pays taxes on positive net income and receives tax rebates on net losses. Here I assume that the firm can utilize net operating loss carryovers to obtain tax recoveries on negative pre-tax income. In reality this is not always the case.
9. The firm's after-tax net income is known at midnight on December 31 (recall that losses are known and paid at that time, as stated in assumption 4).
   a. When after-tax net income is positive, the firm immediately pays a dividend in that amount to its shareholders.
   b. When after-tax net income is negative but the loss is less than some specified critical percentage of surplus, the firm immediately sells additional shares (to existing shareholders) to bring its surplus to the level that existed at the beginning of the year. The firm therefore has a constant surplus from one year to the next.
   c. If the firm's operating loss exceeds some specified critical percentage of its beginning surplus, then a reorganization occurs that results in liquidation of the firm through bankruptcy or purchase by some third party.
   d. The costs of reorganization are here assumed to be zero, although this is seldom true in reality.
   e. If reorganization occurs, any assets remaining after losses are paid are sold at fair value and the proceeds returned to shareholders.

4.3. Losses and Enterprise Risk

10. The only stochastic feature of this firm's operation is the value of its claims or losses (L), which are lognormally distributed with a known mean and standard deviation. (In reality, these two parameters are estimates that can be wrong.) These lognormally distributed losses are a net result of *all* of the risks—not just claims—that affect the earnings and cash flow of the firm. They encompass multiple lines of business as they are affected by pricing risk, credit risk from policyholders and suppliers, operational risk, catastrophe risk, and the like. Losses, then, are a random draw from an enterprise-wide distribution of potential losses, estimated by ERM staff.
11. Assuming that these aggregate losses are lognormally distributed is a convenience, not a necessity. It enables the results presented here to be calculated directly rather than through the use of simulation. Many aggregate distributions can also be closely approximated by a mixture of parametric distributions. Doing so here, where the objective is to produce a convincing explanatory model, would have made the results more complex and less transparent, with no offsetting benefit. But doing so could certainly make sense when the objective is to produce an elaborated or calibrated model.

TABLE 1
Input Parameters and Their Initial Values

A	B	C	Symbol	Definition
100	100	100	P	Premiums (written and earned)
50	80	110	S_0	Surplus (initial)
25	25	25	E	Expense
6%	6%	6%	i	Interest rate (risk free)
35%	35%	35%	t	Tax rate
35%	35%	35%	c	Critical percentage loss of surplus
			L	Losses: stochastic, lognormally distributed
70	70	70	$E[L]$	Expected loss $= \exp(\mu + \sigma^2/2)$
0.25	0.25	0.25	v	Loss volatility: (Standard deviation of loss)/(Expected loss)
306.25	306.25	306.25	$V[L]$	Variance of loss $= \exp(2\mu + \sigma^2)[\exp(\sigma^2) - 1] = v^2E[L]^2$
4.22	4.22	4.22	μ	Mean of $\ln(L)$
0.246	0.246	0.246	σ	Standard deviation of $\ln(L)$
17.5	28	38.5		Critical dollar loss of surplus $= cS$
32.5	52	71.5	S_c	Critical surplus: minimum surplus required to survive

4.4. The Value of the Firm

The value of the firm has two components. One is *franchise value*, the survival-adjusted present value of the firm's after-tax net income, which is paid as dividends to shareholders so long as the firm survives. The other is *residual value*, the present value of whatever residual payments shareholders receive when the firm is terminally reorganized. In the analysis that follows I will conveniently assume that the costs of reorganization are zero and allow the reader to assume whatever alternative estimate they prefer.

4.5. Essential Input Parameters

The input parameters for the model are shown in column A of Table 1. The assumed values for premiums (P), initial surplus (S_0), expense (E), the interest rate (i), and the tax rate (t) are all raw inputs (i.e., not derived from any other values within the model), as are expected loss and loss volatility, the latter defined as the standard deviation of losses as a percentage of expected loss. The mean (μ) and standard deviation (σ) of the logarithms of losses are calculated using the well-known standard formulas in Table 1. The tax code is complex and here represented by a simple tax rate that is applied both to net profits, which are taxed, and net losses, which result in a tax recovery.

A remaining raw input is the critical percentage loss of surplus (c). The rationale for this parameter is that a firm can remain solvent but experience financial weakness that results in a ratings downgrade or abandonment by credit-sensitive clients, so that its business model is no longer viable. Under these circumstances the firm must be reorganized or sold and so will no longer exist in its earlier form.

4.6. Implications: Conditional Expected Losses and Net Income

Given the input parameters just described, and given the losses it actually experiences during the year, a firm will end the year in one of three states. In state 1 its net income is such that its surplus remains above the critical level that triggers reorganization. Consequently, the firm survives to write business the following year. But before doing so it distributes a dividend or raises capital sufficient to restore its surplus to its initial value, S_0. In state 2 it experiences losses sufficiently severe to trigger reorganization but not so severe as to render it insolvent. In this case it ceases to survive, and any remaining surplus is paid as a dividend to its existing shareholders or policyholders. Finally, in state 3 its losses have rendered it insolvent, so that remaining surplus is zero but, thanks to limited liability, not negative. The firm is reorganized, but there is no residual surplus to distribute.

To calculate a firm's value we need to obtain the annual probability of each of these three states, the present value of the firm's expected earnings during each year that it continues to survive, and the present value of its expected residual surplus after it has experienced a critical loss.

A critical loss occurs when the firm's net income $N \le -cS$. From the parameters in Table 1 we can determine l_c, the smallest loss that triggers reorganization, as follows:

$$l_c = (P - E)(1 + i) + Si + cS/(1 - t) = (75)(1.06) + (50)(0.06) + (0.35)(50)/(1 - 0.35) = 109.42.$$

We can likewise determine l_s, the smallest loss that would reduce the firm's surplus to zero:

$$L_s = (P - E)(1 + i) + Si + S/(1 - t) = (75)(1.06) + (50)(0.06) + (50)/(1 - 0.35) = 159.42.$$

For the parameters in Table 1, the firm's annual probability of survival (state 1) is

$$\Pr[L \leq l_c] = \Phi((\ln(l_c) - u)/\sigma) = 0.9737,$$

where Φ is the cumulative normal probability distribution. The firm's probability of experiencing a loss that triggers insolvency (state 3) is

$$\Pr[l_s < L] = 1 - \Phi((\ln(l_s) - u)/\sigma) = 0.0003.$$

It follows that the probability of state 2, in which the firm is reorganized but not ruined, so that there is a residual distribution to shareholders, is $\Pr[l_c < L \leq l_s]$, or 0.0261.

For all firms, net income (N) after tax at the end of any single time period is

$$N = ((P - E)(1 + i) + Si - L)(1 - t),$$

from which it follows that $L = ((P - E)(1 + i) + Si - L)(1 - t)$.

The next several results are based on the fact[11] that, for any lognormal random variable X, with parameters μ and σ^2, where $E[X] = \exp(\mu + \sigma^2/2)$, the expected loss for losses less than $M = l_c$ are

$$\int_0^M x f_x(x) dx = e^{\mu + \sigma^2/2} \Phi\left(\frac{\log M - \mu - \sigma^2}{\sigma}\right),$$

so that

$$E[L|L \leq l_c] = (1/\Pr[L \leq l_c]) \exp(\mu + \sigma^2/2) \Phi((\ln(l_c) - \mu - \sigma^2)/\sigma).$$

The firm's expected annual loss in state 1, in which it survives, is therefore

$$(1/0.9737)\,(70)\Phi((\ln(109.42) - 4.21 - 0.246^2)/0.246) = 68.63,$$

so that its expected annual net income while surviving is 9.02.

The firm's expected annual loss if it remains solvent (states 1 or 2) is 69.97, which corresponds to an expected loss in state 2 of 120.12 and an expected net income in state 2 of −24.45. It follows that in state 3 its expected loss is 169.99 but, due to limited liability, its expected net income in state 3 is limited to −50, the negative of the firm's initial surplus.

So, given the assumed parameters, there is a probability of $1 - \Pr[L \leq l_c] = 0.0263$ that a critical loss will occur, comprising a probability of $\Pr[l_c < L \leq l_s] = 0.0261$ that the residual surplus dividend to shareholders will be $(50 - 24.45) = 25.55$ and a probability of $\Pr[l_s < L] = 0.0003$ that this dividend will be zero, since no surplus will remain. This implies that the expected dividend to shareholders s_r when a critical loss occurs is $((0.0261)(25.55) + (0.0003)(0))/(0.026 + 0.0003) = 25.29$.

4.7. Implications: Net Income and Valuation

The value of the firm is the sum of its franchise value and its residual value. The franchise value of the firm consists of the present value of future dividends, paid annually, and discounted for time value and survival probability. The residual value of the firm is paid once, when a critical loss occurs, and consists of the probability weighted present value of the residual surplus that is paid as a final dividend to owners.

To simplify notation, I will represent the probability of survival as p and the probability of reorganization as q. Dividends paid annually while the firm survives will be N_s, the firm's expected annual income while it survives. Further, I will let $d = 1/(1 + i)$, the time discount factor. The firm's franchise value, as an annuity, is therefore $V_{\text{franchise}} = N_s dp/(1 - dp) = 101.66$. By contrast,

[11] See Boland (2007), p. 48, for details.

TABLE 2
Key Results and Their Values

A	B	C	Symbol	Definition
109.42	127.38	145.33	l_c	Loss l_c that produces a critical dollar loss of surplus
159.42	207.38	255.33	l_s	Loss l_s that triggers insolvency
0.9737	0.9947	0.9990	$\Pr[S_1 \geq S_c]$	Probability of state 1: survival (year-end surplus $S_1 \geq S_c$)
0.9997	1.0000	1.0000	$\Pr[S_1 > 0]$	Probability of state 1 *or* state 2
0.0261	0.0053	0.0010	$\Pr[S_c > S_1 > 0]$	Probability of state 2 (reorganizing but still solvent)
0.0003	0.0000	0.0000	$\Pr[S_1 = 0]$	Probability of state 3 (insolvency)
68.63	69.64	69.91	$E[L\|L \leq l_c]$	Expected losses in state 1
69.97	70.00	70.00	$E[L\|L < l_s]$	Expected losses in state 1 *or* state 2
120.12	138.08	155.91	$E[L\|l_c < L < l_s]$	Expected losses in state 2
169.99	218.27	266.80	$E[L\|l_s \leq L]$	Expected losses in state 3
9.02	9.53	10.52	$E[N\|L \leq l_c]$	Expected net income after tax in state 1
−24.45	−34.96	−45.38	$E[N\|l_c < L \leq l_s]$	Expected net income after tax in state 2
−50.00	−80.00	−110.00	$E[N\|l_s < L]$	Expected net income after tax in state 3
−24.71	−34.98	−45.38	$E[N\|l_c < L]$	Expected net income after tax in state 2 *or* state 3
25.29	45.02	64.62	s_r	Expected remaining surplus in state 2 *or* state 3
101.66	145.15	172.30	$V_{\text{franchise}}$	Present value of future dividends while surviving
7.72	3.66	1.06	V_{residual}	Present value of expected surplus remaining after critical loss
109.38	148.82	173.36	V_{total}	Total present value of dividends and residual surplus
59.38	68.82	63.36	V_{added}	Value added $= V_{\text{total}} - S$

the present value of the one-time payment of the firm's residual surplus is $V_{\text{residual}} = s_r dq//(1 - dp) = 7.72$. The firm's total value is the sum of these two quantities: $V_{\text{total}} = V_{\text{franchise}} + V_{\text{residual}} = 109.38$.

Column A in Table 2 provides a summary of the principal results of the model just described.[12]

4.8. Implications: Market Valuation

Now that we have calculated a value for the firm by estimating the survival-adjusted present value of its future earnings and dividends, what do we do with it? This question really has two parts. First, what is the relationship between the value we have calculated and the actual market value of the firm, if it is publicly traded? Second, if there are important factors omitted from the model presented here, can a firm that improves its modeled value be nonetheless reasonably confident that doing so will improve its real-world market valuation as well?

I suspect that the value of a firm, as calculated using this model, may be somewhat overestimated relative to the value of that firm's shares in the market. This suspicion is based on the fact that yield spreads on corporate bonds typically exceed the break-even spreads necessary to compensate for the historically experienced probabilities of default for bonds of different credit qualities. This difference is usually described as a risk premium. The model presented here presumes the absence of any such risk premium, since it incorporates only a time-value discount and a discount for the probability of survival. If investors require some risk premium as well, then the resulting value of the firm will be lower than estimated by this model. Of course, this is a matter for empirical investigation rather than armchair speculation.[13]

Whether or not a risk premium exists and, if it does, whether it is large or small, it is nonetheless plausible to assume (pending empirical studies) a reasonably high correlation between the value of the firm as derived from this model and its value in the marketplace. If so, then actions taken to improve the modeled value of the firm should also improve the actual market value of

[12]One additional implication is worth pointing out. Expected losses conditional on the firm's survival are necessarily lower than unconditional expected losses. Consequently, observed rates of return on premiums or on surplus are likely to be biased upwards. Firms that experience extremely high losses will be reorganized and disappear from view. So unless the underlying data-gathering process is extremely thorough, both the industry and the firms within it will appear to be more profitable than underlying risk exposures would warrant. A similar phenomenon occurs in the investment world, where funds that significantly underperform market averages are liquidated or merged, and statistics concerning their poor results disappear with them. Given the cyclical nature of property-casualty insurance, such upward bias could significantly distort the view and actions of both regulators and investors. Seminal papers on survival bias include Brown et al. (1992) and Brown, Goetzmann, and Ross (1995).

[13]See Elton et al. (2001) for an analysis of the components of a risk premia on bonds, Derrig and Orr (2004) for a comprehensive review of the empirical literature on the equity risk premium, and Eling (2012) for a compendium of post-2004 research on risk premia.

the firm. In this respect the model can be a useful guide to market-value-improving strategies without necessarily being a perfect predictor of market value.

5. MANAGING CAPITAL TO MAXIMIZE VALUE

Having a valuation model enables management to ascertain the likely consequences of alternative actions or strategies. In this section I will demonstrate how the model can be used in three ways: (1) to estimate how much surplus the firm should have, (2) to estimate the consequences for the firm's value and optimal surplus of changing various input variables, taken separately, and (3) to estimate the consequences of simultaneously changing multiple variables, as occurs in many strategic decisions.

5.1. Maximizing Value Added

In Section 2 I described and critiqued four practical principles that CFOs use to determine the amount of surplus their firm should have. I also proposed an alternative principle: Choose the level of surplus that maximizes value for shareholders or policyholders. The model presented in Section 4 makes this alternative principle feasible. We must be careful how we implement that principle, however, for a reason that is subtle but important. If we use V_{total} as the variable we wish to maximize, then adding surplus is always beneficial, for it increases the value of the firm's assets as well as its investment income and makes the firm less likely to default or reorganize. The important question is whether the value of these benefits exceeds the dollar cost of the added surplus. Beyond some point, adding an additional dollar to surplus creates additional value of less than a dollar. In this case, shareholder value is better served by distributing the additional dollars as a dividend rather than retaining them to increase surplus. To address this important question of *marginal* costs and benefits we need to focus on maximizing V_{added}, which equals V_{total} minus surplus (S). To maximize shareholder value, a firm should add (or reduce) surplus so long as doing so increases V_{added}.

The relationship between surplus and V_{added} is shown graphically in Figure 1 for the firm in our continuing example, still based on column A in Tables 1 and 2. This firm has an initial surplus of 50 units and an initial V_{added} of 59. This graph shows that the firm can maximize its V_{added} at 69 by increasing its surplus to 80. Beyond that point, however, each additional dollar of increased surplus adds less than a dollar of additional value: Adding more surplus reduces V_{added}.

Although an increase in surplus affects value added in numerous direct and indirect ways, two are especially important. One, the *income effect*, reduces value added. Each additional dollar of surplus increases after-tax investment income by $(i)(1-t)$ dollars, an amount that is adjusted downward to reflect the probability of survival and then discounted at the pre-tax risk-free rate. The present value of this additional income is necessarily less than a dollar, so that the resulting value added is lower than before. Offsetting this, however, is the *survival effect*: increasing surplus increases the firm's probability of survival, which in turn increases its franchise value. When the firm's initial survival probability is sufficiently less than one, this increase in franchise value exceeds the income effect and so produces an increase in value added. But as the firm's survival probability approaches one, the impact of surplus additions on franchise value diminishes, so that the resulting changes in value added become negative.

Columns B and C in Tables 1 and 2 illustrate the income and survival effects, along with several indirect consequences of changes in a firm's surplus. In Table 1, surplus increases from 50 in column A, the base case, to 80 in column B and 110 in column C. The other input parameters are unchanged.

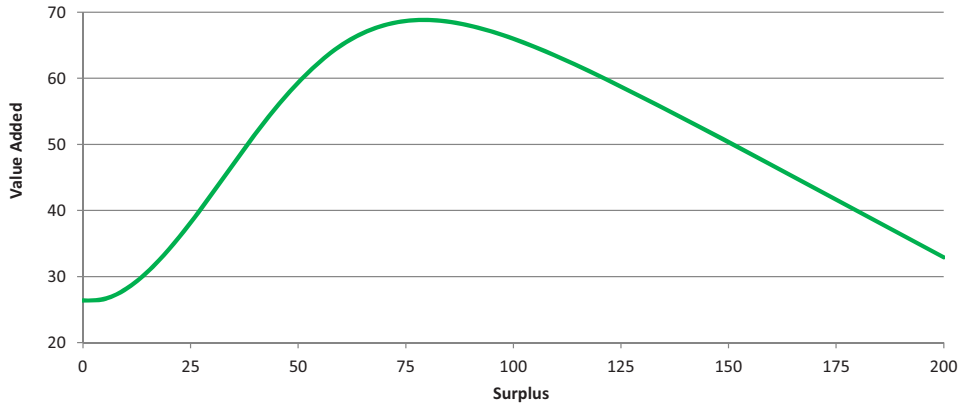

FIGURE 1. Effect of Surplus on Value Added. (color figure available online)

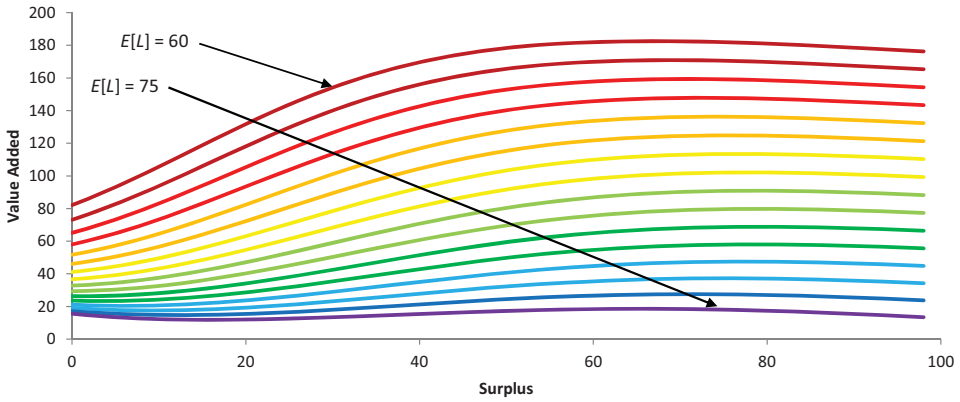

FIGURE 2. Effect of Surplus on Value Added for Varying Expected Losses. (color figure available online)

Table 2 shows the consequences of these surplus changes.[14] In column B, adding 30 to the base case surplus in column A increases the firm's survival probability by 2.1% to 99.47%. This in turn increases franchise value by 43.49 but reduces residual value by 4.05, for a net gain of 39.44 in total value. So value added has been increased by (39.44 – 30) = 9.44. Adding another 30 to surplus, as in column C, increases survival probability to 99.9%, a gain of only 0.43%. Consequently, franchise value increases by only 27.15 while residual value is reduced by 2.60, for a net gain of 24.54 in total value. This is less than the addition to surplus, so value added is reduced by 5.46.[15]

5.2. The Effect of Other Variables: Sensitivity Tests and Strategic Alternatives

A simple but effective way to determine the precision of a result is to perform a sensitivity test: How much would the result change if the value of another variable in the model is changed from its current value? But the answer to that question has another use as well: it can inform managers concerning the effect on optimal surplus and value added of deliberately changing other variables—for example, by altering the firm's mix of business to change its loss ratio, its expense ratio, or the variability of its losses.

Figure 2 shows the relationship between surplus and value added for expected losses ranging from 60 (the top line) to 75 (the bottom line). As expected losses approach 75, the lines in the graph become rather flat, so that it becomes difficult to ascertain just where on the curve value added is maximized. So the results are presented somewhat differently in Figure 3, which shows, for alternative values of expected losses, the maximum value added and the amount of surplus needed to produce that maximum. As expected losses increase, the maximum value added decreases considerably, in a nearly linear fashion, as one would expect. But, surprisingly, as expected losses increase from 60 to roughly 70, optimal surplus increases and then subsequently decreases as expected losses increase further. When expected losses are about 76 or higher, optimal surplus suddenly falls to zero.

Figure 3 also shows that the estimated optimal surplus is nearly constant for expected losses ranging from the upper 60s to the low 70s. This has two implications. One is that modest potential error in estimating expected loss is not terribly crucial so long as expected loss is within this range. The other is that attempts to change optimal surplus by altering the firm's expected loss will have very little success when expected loss is in this range.

Figure 4 shows how the relationship between surplus and value added is affected by different levels of expenses, ranging from 15 to 31 in increments of 1. As one would anticipate, the results are very similar, although not identical, to those obtained for different levels of expected loss. Figure 5 shows that as expenses increase from 15 to 25 or so, optimal surplus remains virtually constant at 80, while value added (with optimal surplus) decreases, as one would anticipate. However, when expenses increase beyond that level, optimal surplus decreases and suddenly falls to zero as expenses reach 31.

[14]The numerical precision of the results shown in Table 2 is misleading, since the precision of a model's results depends upon the correctness of the valuation model and the precision with which its inputs are measured. The several decimal places shown for the values in Tables 1 and 2 are intended to enable readers to check the model and are not indicative of the precision with which the model's inputs can actually be estimated or its results applied to real firms. I note, however, that most of the key inputs to the model can be reasonably measured or estimated. Consequently, it would not be unreasonable to conclude that, for this hypothetical firm, optimal surplus is likely to be closer to 80 than to 50 or 110.

[15]Optimal surplus is not always positive. The model implies that there are certain circumstances—partly defined by combinations of expected loss and standard deviation of loss—in which optimal surplus is zero. In other words, there are boundaries beyond which risks are, in effect, economically uninsurable or expected profits are so low as to preclude a viable business model.

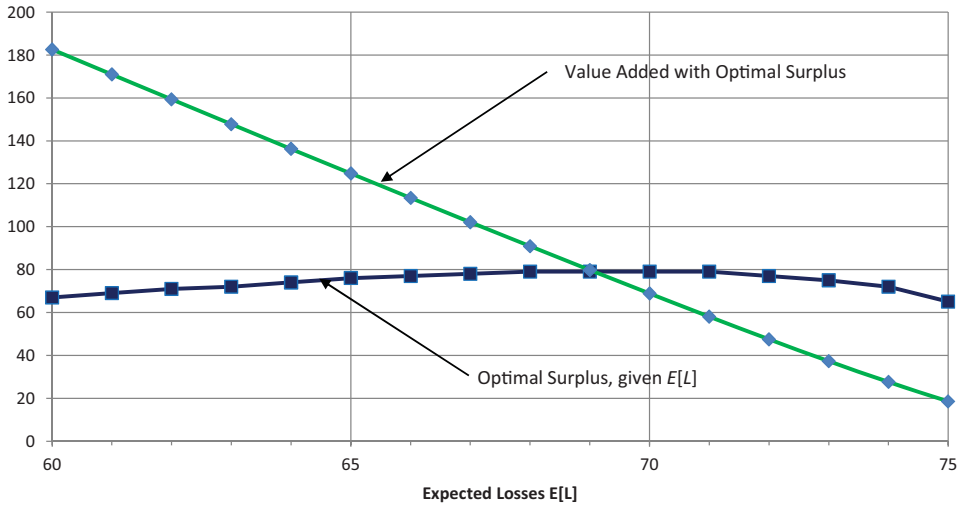

FIGURE 3. Effect of Expected Losses on Optimal Surplus and Value Added. (color figure available online)

Figure 6 shows the relationship of surplus to value added for different levels of investment yield, ranging from 3% (the highest curve) to 13% (the lowest) in increments of half a percent. Higher yields increase investment income but nonetheless reduce value added because they reduce the present value of future income.

What is especially noteworthy about Figure 6 is the point on the left side of the figure where all the curves closely converge. At that point, achieved when the firm's surplus is about 42, the firm's value added—and therefore its total value as well—is virtually constant regardless of potential changes in interest rates. Given that level of surplus, the firm's value and value added is essentially immunized, provided that the other variables in the model (apart from interest rates) remain at their assumed values. Equally notable, however, is the fact that this point is suboptimal for *all* of the interest rates shown in Figure 6. To maximize shareholder value, optimal surplus for this firm ranges from roughly 110 when the yield is 3% to 47 when the yield is 13%. What this strongly suggests is that *immunizing a firm's value from potential changes in interest rates, whatever its merits when considered alone, may be a suboptimal strategy when considered within the broader framework of maximizing a firm's value or value added.* This raises questions that clearly warrant further investigation.

Figure 7 shows that optimal surplus and value added (given optimal surplus) both decrease when investment yields increase from 3% to 13%.

Figure 8 shows the relation of surplus to value added for different levels of loss volatility, here defined as the standard deviation of losses (in dollars rather than in logarithms of dollars) as a percentage of expected losses (also in dollars). The curves shown are

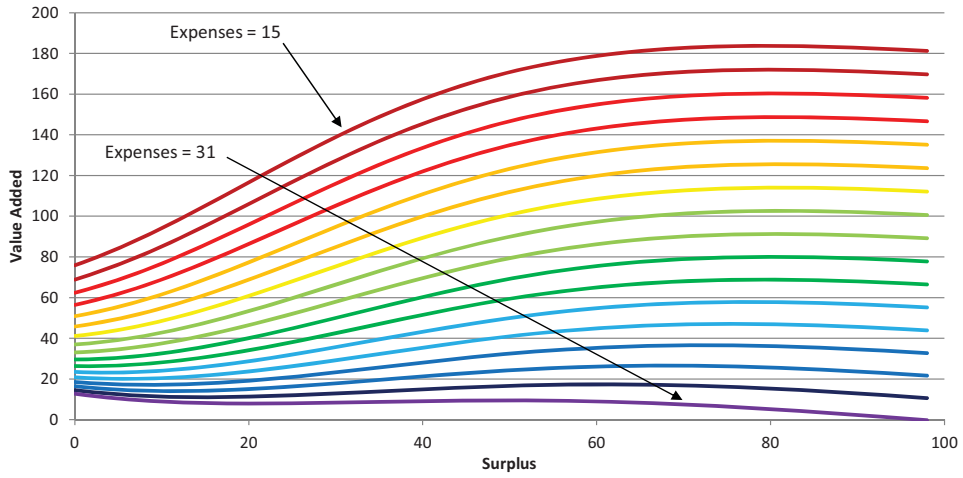

FIGURE 4. The Effect of Surplus on Value Added for Varying Expenses. (color figure available online)

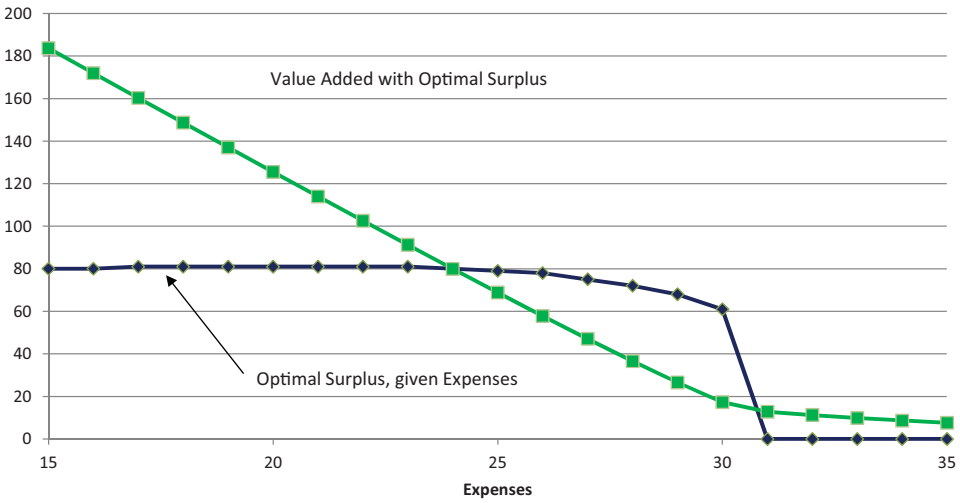

FIGURE 5. Effect of Expenses on Optimal Surplus and Value Added. (color figure available online)

for levels of loss volatility ranging from 20% to 50%. Consistent with Figure 9, as loss volatility increases, optimal surplus also increases, but value added, given optimal surplus, decreases.

A direct implication of Figures 8 and 9 is that managing a firm's standard deviation of losses can have an extremely important impact on its value added, potentially equivalent in importance to managing its loss and expense ratios. Reinsurance is certainly one way to accomplish this objective, but it introduces complexities that are beyond the scope of this article.

5.3. The Combined Impact of Changing Multiple Variables

Strategic choices often involve changes in multiple key variables. The model presented here can assist managers in identifying combinations of changes that best achieve particular goals. This is illustrated in Figure 10 for just two key variables: loss standard deviation and expected loss. The two lines in the graph show the combinations of these two variables that produce value added of 50 (top line) and 100, respectively. Graphs of this sort (which can be extended to multiple variables) are useful in several ways. Suppose that an insurer has a current value added of 50, with a loss volatility of 40% and an expected loss of 68. Further suppose that management wants to double its value added from 50 to 100, without changing the firm's surplus. Figure 10 shows that this can be accomplished by lowering expected losses from 68 to just under 62 or, alternatively, by lowering its loss volatility from

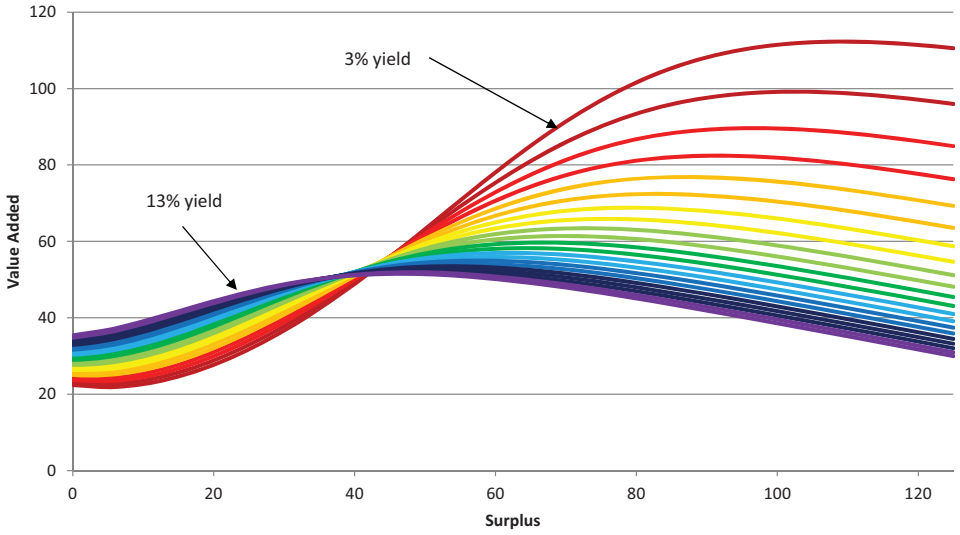

FIGURE 6. Effect of Surplus on Value Added for Varying Yields. (color figure available online)

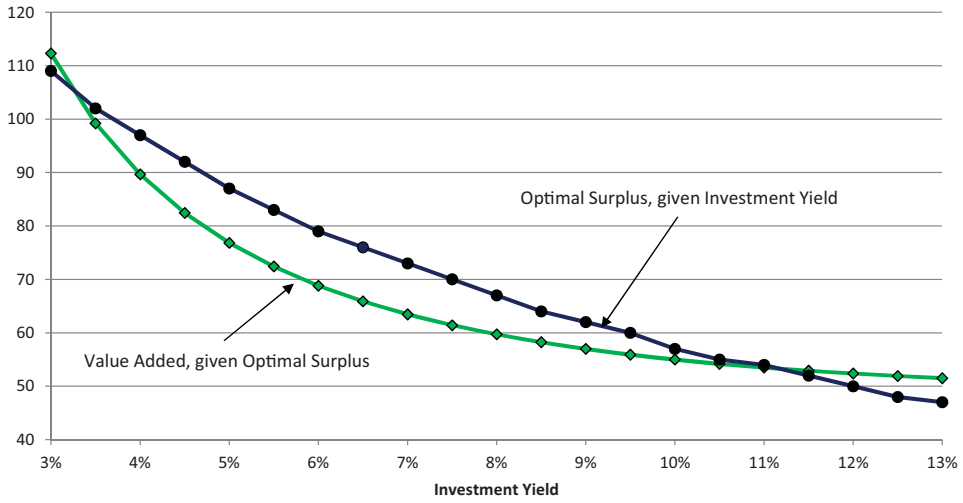

FIGURE 7. Effect of Investment Yield on Optimal Surplus and Value Added. (color figure available online)

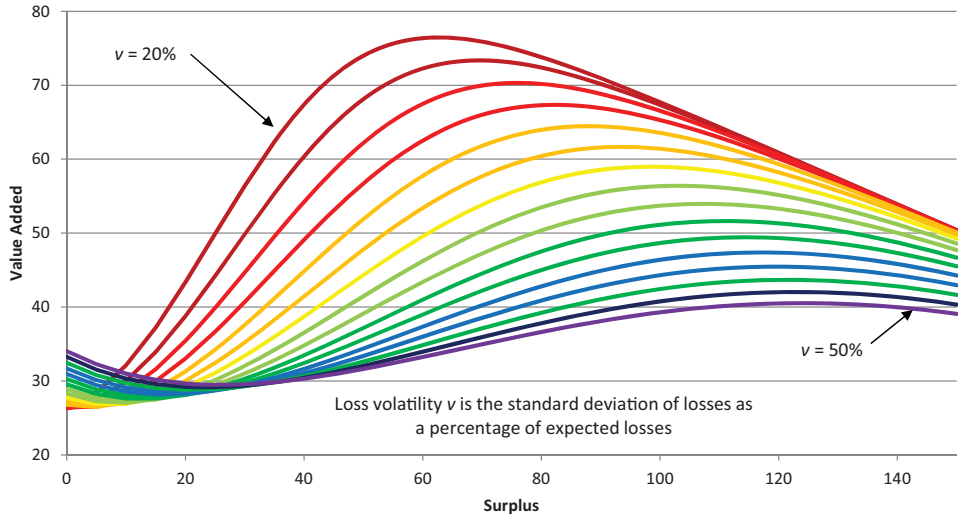

FIGURE 8. Effect of Surplus on Value Added for Varying Loss Volatilities. (color figure available online)

40% to 20% or by some combination of these two strategies. Further, they could consider combinations of these two strategies with other changes that affect expense ratios, reinsurance, and the like. The point here is that the model results shown in this graph or others similar to it can assist managers in clarifying strategic alternatives and quantifying their impact on value added.

6. IMPLICATIONS: MANAGING THE INVISIBLE

Ultimately, managers effectively manage only what they can see and measure.[16] Visibility and quantification are both crucial. Things that are invisible typically fail to win managerial attention, always a scarce resource. Moreover, without quantification, effective management becomes nearly impossible, for a manager cannot know whether his actions have brought about intended improvements or even whether conditions are improving or deteriorating.

What is visible at virtually every insurance firm is what has to be reported in the firm's statutory and/or GAAP financial statements. But these financial statements are essentially cross-sectional and focus only on income statement and balance sheet

[16]Some of the ideas stated here draw on Panning (2003a, 2003b).

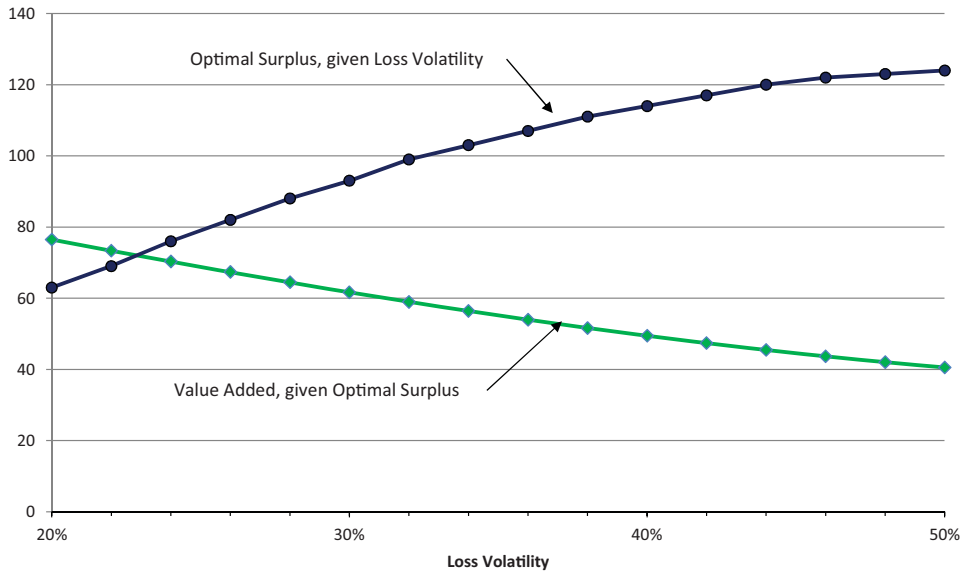

FIGURE 9. Effect of Loss Volatility on Optimal Surplus and Value Added. (color figure available online)

values that reflect business already written. While changes in these accounting values from one period to the next can indicate potential trends that may need attention, there is little, apart from claims handling, that managers can do about business already written. Ironically, then, the numbers that managers typically and most frequently see pertain to matters over which they have very little influence. Whatever the value of GAAP and statutory financial statements for audiences outside the firm, their value for managing a firm's future is somewhat dubious.

Consider, by contrast, the potential value to managers of the valuation model presented in Section 4 and of the sensitivity and strategy analyses presented in Section 5. A firm's value added as calculated in the model is derived from a longitudinal valuation of the firm as a going concern, and the analyses focus managerial attention on the variables with the greatest potential impact on value added and other key statistics. Analyses like these have several important consequences. First, because the model focuses on the survival-adjusted present value of future income, it addresses the future of the firm, which can be managed, in contrast to accounting values that reflect the results of past decisions. Second, the model provides managers with a visible and quantitative estimate of the firm's franchise value and its sensitivity to the various significant variables that management can influence. It

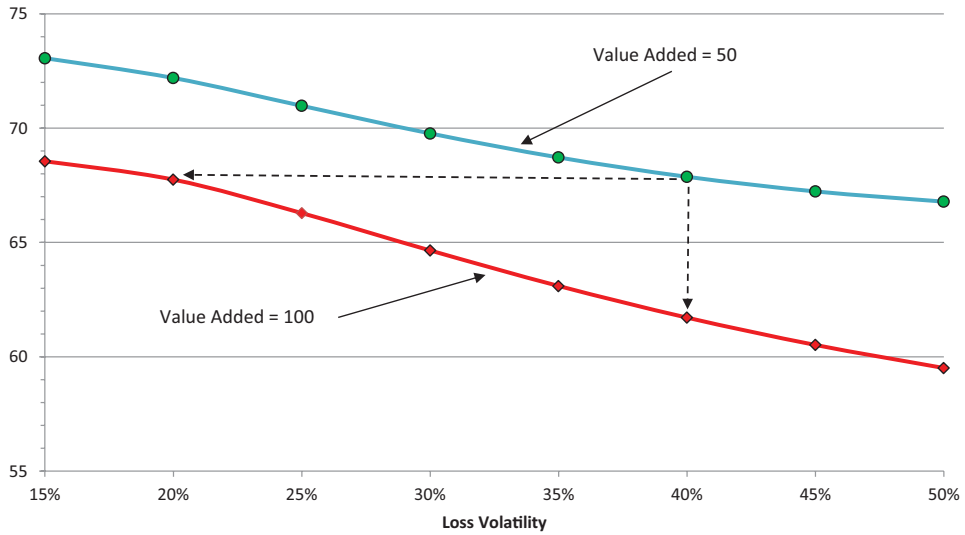

FIGURE 10. Constant Value-Added Combinations of Expected Loss and Loss Volatility. (color figure available online)

therefore provides managers with a sound basis for decisions concerning capital structure, in contrast to the typically used rules of thumb described in Section 2.

But the third and, to me, most compelling feature of the model presented here is that *it provides an understandable dollar-based measure of the cost of risk*. The classical problem with risk-return analysis is that it provides no compelling reason for choosing a particular level of risk exposure, since risk and return are incommensurable. This is why appeals to risk tolerance or other rules of thumb are thought to be essential. By contrast, *in the model presented here there is a quantifiable cost of risk, measured in dollars*. Specifically, *if we change the mean or standard deviation (as a percentage of the mean) of the firm's aggregate loss distribution, we can use the model to calculate the consequences of doing so, in dollars, for the firm's value and value added.*

This point may be somewhat obscured by the way in which I have approached the problem—as one of optimizing surplus relative to a given level of risk. As I emphasized at the beginning, this problem is mathematically equivalent to one in which surplus is given and the level of risk is the variable to be managed in order to maximize value added. My rationale for approaching the problem in the way I have is that most insurers will find it easier to change their level of surplus (or reinsurance, for that matter) than to alter their portfolio of business and its characteristics. The latter strategy depends on costly changes to an existing infrastructure (including a distribution system and internal underwriting, pricing, and reserving capabilities) geared toward an existing mix of business. I could equally well have presented the model as one in which surplus was fixed (as for a mutual insurer) but premium volume was variable (since the crucial assumptions are all stated relative to written premiums). In that case the key objective would be to identify the optimum premium-to-surplus ratio.

In the absence of a model like the one presented here, or an equivalent model in which surplus is fixed and risk exposure is variable, the consequences of changing a firm's capital structure are matters of guesswork and are therefore in practice typically ignored, in favor of actions that change the anticipated distribution of aggregate losses, a domain where consequences are considered more visible and quantifiable.

There are numerous ways of extending the model presented here: (a) by incorporating a sophisticated model of reorganization costs; (b) by incorporating more sophisticated assumptions concerning the tax status of the firm; (c) by taking into account the fact that dividends are taxed differently from ordinary income and so may be more valuable to shareholders than is taken into account here; (d) by incorporating customer preferences, and willingness to pay higher premiums, for policies from firms with low probabilities of default; (e) by incorporating various reinsurance strategies; (f) by incorporating a more sophisticated approach to the effects of growth on the value of a firm; (g) by incorporating stochastic interest rates; (h) by taking into account strategies for coping with an underwriting cycle; (i) by incorporating more flexible ways of representing the firm's aggregate loss distribution, and so on. Although I could suggest even more ways to amend and improve the valuation model presented here, I hope that this brief list indicates my recognition that there is much potentially valuable work yet to be done.

Above all, I hope that the model and analysis presented here will have a significant impact on the goals and practice of Enterprise Risk Management. ERM is, in my view, potentially the most significant development in risk analysis and risk management in decades. My greatest concern about the future of ERM is that it will be a victim of excessive hype, based on an implicit assumption that its benefits will somehow become evident to senior management. I strongly believe that what ERM needs to hedge this risk is a compelling value proposition—an answer to the question "What are the benefits to my firm of embracing ERM?" The answer I have proposed and (I hope) demonstrated here is that ERM, *done properly*, does two things. First, it makes visible a firm's franchise value and so stimulates and enables managers to focus attention on managing the survival-adjusted present value of the firm's future income. Second, it enables managers to anticipate and measure the consequences of alternative actions and strategies intended to maximize shareholder value, as estimated by a pragmatic valuation model whose parameters are observable or reasonably estimated. In essence, *value-focused* ERM, as proposed and demonstrated here, can provide managers with reliable tools that can increase the scope and effectiveness of their decisions.

Is this ambitious goal indeed practical, or is it merely wishful thinking? Two facts are strongly encouraging. One is that models similar to the one presented here, although considerably more complex, are already pervasive in significant areas of the capital markets. A second is that managers who attempt to increase shareholder value cannot avoid reliance on a model but instead face an inevitable choice between an implicit and impressionistic mental model or, as I propose here, an explicit and empirically verifiable model subject to professional scrutiny and improvement. If Enterprise Risk *Management* is to be more than a passing fad, it must, in my view, accept responsibility for making this second alternative a reality and so provide managers with the tools that they need to quantify and manage what is now invisible to them.

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