Internal Model-Based Capital Regulation and Bank Risk-Taking Incentives

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Advocates claim bank internal model-based (IMB) capital regulation will reduce costs and remove the distortions that are created by standardized rule-based capital regulations. IMB capital regulation, however, does not eliminate investment incentives that are created by mispriced bank safety nets.

Analysis shows IMB capital estimates are biased by safety net-related funding subsidies when bank shareholders benefit from mispriced guarantees. Funding subsidies are not uniform across the risk spectrum, and as a consequence IMB capital regulation will induce distortions in bank lending behavior.

In the mid-1990s, banking regulators began using bank internal risk measurement models as a basis for setting market risk capital requirements. More recently, in the context of the Basel II regulatory capital debate, banking associations (including the Institute of International Finance and the International Swap Dealers' Association) and risk management consultants (including The Financial Services Roundtable and KPMG) have argued that banks should be allowed to use their internal credit risk model estimates as a basis for setting credit risk capital requirements.

Advocates of internal model-based (IMB) capital regulation argue that an IMB approach will allow regulatory capital requirements to be more closely aligned with the so-called economic capital allocations that bank managers set for operations purposes. Jones [2000] notes this alignment promises to reduce regulatory compliance costs and minimize the credit and securities markets distortions associated with capital regulation.

While the goal of harnessing banks' internal risk management processes for supervisory goals is appealing in many respects, the efficacy of an IMB approach for controlling externalities has yet to be demonstrated. Any assessment of the merits of IMB capital regulations should recognize the externalities that engender a need for bank regulation. In particular, it is important to understand how safety net-related externalities are mitigated using the internal processes that banks have designed for their own profit maximization objectives.

We analyze the IMB capital allocation process in a bank that sets its capital structure to satisfy a buffer stock capital constraint using value at risk (VaR) measures of risk exposure in both market and credit risk settings. This approach, which maximizes debt finance subject to a limit imposed by a maximum acceptable probability of default on the bank's funding debt, has become the commonly recognized standard for setting IMB economic capital allocations. The discussion revisits IMB capital allocation measures and shows that unbiased buffer stock capital requirements can be estimated using an appropriately constructed VaR measure augmented by an estimate of the equilibrium interest payments required by bank debt holders. The procedures required to set accurate buffer stock capital allocations differ, however, from those discussed in the VaR and regulatory capital literatures, and the differences that are identified provide a way to understand how externalities influence a bank's capital allocation decision.[1]

Funding cost subsidies enjoyed by banks—subsidies that are generated by implicit guarantees or underpriced explicit deposit insurance—reduce the optimal internal buffer stock capital allocations that banks select. If banks are allowed to use their internal models to set accurate buffer stock capital allocations consistent with a probability of default mandated by supervisors or international capital regulation, the required amount of bank capital will be lower than the capital that would be required in the absence of bank safety net-related subsidies.

Left to follow their own interests, bankers' IMB capital estimates will internalize funding cost subsidies and be biased downward compared to an institution that does not benefit from mispriced bank safety nets. This capital allocation bias will not only ensure that a bank's insurance guarantee is valuable, but it will also create distortions in a bank's optimal lending behavior. The interest rate subsidy that is captured by a bank under an IMB approach to capital differs among investments according to their risk characteristics. Consequently, IMB regulatory capital requirements will not remove regulation-induced distortions in bank lending behavior.

I. VALUE OF GOVERNMENT SAFETY NETS

We start with a review of the economics associated with the provision of underpriced safety net guarantees to banking institutions.

Background

We use the Merton [1977] framework to establish the value of an implicit or explicit fixed-rate deposit insurance guarantee to the shareholders of a participating bank under an IMB approach to capital regulation. It is assumed that the value of banks' liabilities is explicitly insured by a government agency. For simplicity, we assume insurance is provided at zero cost to the bank.[2] Following Merton, the analysis does not consider information asymmetries that may arise in the context of the valuation of bank shares and assumes that the values of bank assets are transparent to equity market investors.

To analyze capital requirements for market and credit risks, it is necessary to consider the market value of bank contingent claims under alternative bank investment opportunity sets. Market risk capital allocation is analyzed for a bank that is allowed to invest only in unleveraged equity-like instruments. In this instance, the deposit insurance valuation model is identical to Merton [1977]. In the case of credit risk, we generalize the Merton [1977] model to accommodate banks with investments that are restricted to risky Black and Scholes [1973] and Merton [1974] (BSM) discount bonds.

Asset Value Dynamics

Under the assumptions of the BSM models, the value of the firm's assets evolves as follows:

$$dA = \mu A dt + \sigma A dz \tag{1}$$

where dz is a standard Weiner process. If A_0 represents the initial value of the firm's assets, A_T the value of the firm's assets at time T, and $\phi[a, b]$ the normal density function with a mean of a and a standard deviation of b, the physical probability distribution for the value of the firm's assets is:

$$\tilde{A}_T \sim A_0 e^{\left(\mu - \frac{\sigma^2}{2}\right)T + \sigma\sqrt{T}\tilde{z}} \tag{2}$$

where $\tilde{z} = \phi[0, 1]$.

Equilibrium absence of arbitrage imposes restrictions on the underlying asset's drift rate, $\mu = r_f + \lambda\sigma$, where λ is the market price of risk associated with the firm's assets. Define $dA^\eta = (\mu - \lambda\sigma)A^\eta dt + A^\eta \sigma dz$ as the "risk- neutralized" process under the equivalent martingale measure. The underlying random end-of-period asset value after the equivalent martingale measure, $\tilde{A}^\eta_M$ is:

$$\tilde{A}^\eta_T \sim A_0 e^{\left(r_f - \frac{\sigma^2}{2}\right)T + \sigma\sqrt{T}\tilde{z}} \tag{3}$$

Deposit Insurance Value Under an Equity Investment Opportunity Set

In the absence of deposit insurance, Black and Scholes [1973] and Merton [1974] establish that a firm's risky debt and equity claims can be valued as derivative assets.[3] The market value of a firm's risky discount debt issue is equal to the market value the issue would have if it were default risk-free, less the market value of a Black-Scholes put option written on the value of the firm's assets. The default (put) option has a maturity equal to the maturity of the debt issue and a strike price equal to the par value of the discount debt.

Let B_0 represent the discount bond's initial equilibrium market value, and *Par* represent its promised payment at maturity date M. BSM establish that:

$$B_0 = Par\, e^{-r_f M} - Put(A_0, Par, M, \sigma) \tag{4}$$

where $Put(A_0, Par, M, \sigma)$ represents the value of a Black-Scholes put option on an asset with an initial value of A_0, a strike price of *Par*, a maturity of M, and an instantaneous return volatility of σ.

If the firm in question is a bank, and the bank can issue discount debt claims that are insured at zero cost by the government, Merton [1977] shows that deposit insurance provides the bank's shareholders with an interest subsidy on the bank's debt equal to $Put(A_0, Par, M, \sigma)$.[4] In this simple setting, absent any regulatory constraints, it is well known that bank shareholders maximize the ex ante value of their wealth by selecting the bank's investment assets and capital structure to maximize the present market value of the interest subsidy on the bank's debt, or equivalently by maximizing $Put(A_0, Par, M, \sigma)$.

Deposit Insurance Value When Banks are Exposed to Credit Risk

Merton's [1977] deposit insurance results are derived for a bank with investments that evolve in value according to Equation (2). These assets have return characteristics identical to BSM equity claims on unleveraged firms. It is straightforward to derive the value of costless deposit insurance under alternative bank investment opportunity sets. In the absence of an insurance premium, the deposit insurance value is equal to the value of the default option on the bank's insured debt. This default option value is in turn equal to the difference between the market value the debt would have if it were a risk-free claim and its equilibrium market value inclusive of credit (default) risk.

Assume that a bank may invest only in BSM risky discount bonds and that it funds these investments with equity and its own discount debt issue. When the bank's funding debt with par value Par_F is of a shorter maturity (T) than the risky discount bond purchased by the bank (maturity M and face value Par_p), the end-of-period cash flows that accrue to the bank's debt holders are given by:

$$Min\left[\left(\begin{array}{l} Par_P e^{-r_f(M-T)} - \\ Put\left(\tilde{A}_T, Par_P, M-T, \sigma\right) \end{array}\right), Par_F\right] \tag{5}$$

In the absence of any insurance guarantee, the initial equilibrium value of the funding debt is equal to the discounted value (at the risk-free rate) of the expected value of Equation (5) taken with respect to the equivalent martingale density $\tilde{A}_T^{\eta}$:

$$E^{\eta}\left[Min\left[\left(\begin{array}{l} Par_P e^{-r_f(M-T)} - \\ Put\left(\tilde{A}_T, Par_P, M-T, \sigma\right) \end{array}\right), Par_F\right]\right] e^{-r_f T} \tag{6}$$

and the ex ante value of the deposit insurance guarantee is given by:

$$\left[Par_F - E^{\eta}\left[Min\left[\left(\begin{array}{l} Par_P e^{-r_f(M-T)} - \\ Put\left(\tilde{A}_T, Par_P, M-T, \sigma\right) \end{array}\right), Par_F\right]\right]\right] e^{-r_f T} \tag{7}$$

In the special case when the bank's bond investment opportunity set is matched in maturity to the discount debt that the bank issues, the value of the costless insurance guarantee that accrues to bank shareholders simplifies to:

$$\left[Par_F - E^{\eta}\left[Min\left[Min\left(\tilde{A}_M, Par_P\right), Par_F\right]\right]\right] e^{-r_f M} \tag{8}$$

II. BUFFER STOCK CAPITAL ALLOCATION USING VALUE AT RISK

In the case of an equity or simple loan or bond investment, a buffer stock capital allocation is the equity portion of a funding mix that can be used to finance an asset (portfolio) in a way that maximizes the use of debt finance subject to a maximum acceptable probability of default on the funding debt.[5]

Value at risk (VaR) is commonly used to estimate a firm's buffer stock capital needs. VaR is defined as the loss amount that could be exceeded by at most a specified maximum percentage of all potential future value realizations at the end of a given time horizon (see Duffie and Pan [1997], Hull and White [1998], Jorion [1997], and Marshall and Siegel [1997]).

The VaR measure is defined as the difference between the mean of the asset's (or portfolio's) future profit and loss (P&L) distribution and a specific left-hand critical value (α) of the distribution. The quantity $(1 - \alpha)$ is referred to as the VaR coverage rate or confidence level. In short-horizon market risk calculations, the mean of the P&L distribution is often assumed to be zero. Buffer stock capital is typically set equal to a VaR estimate at a confidence level specified by management.

This approach, however, will not produce accurate estimates of buffer stock capital requirements. In a buffer stock capital application—in both the market and the credit risk setting—if the horizon is longer than perhaps a few weeks, it is important that VaR be measured relative to the initial market value of the asset or portfolio that is being funded.[6]

Consider the use of a 1% one-year VaR measure, and assume VaR is measured relative to the asset or portfolio's initial market value. By definition, there is less than a 1% probability that the asset's value at the horizon will reflect a loss that exceeds its 1% VaR risk exposure measure. Similarly, if the firm chooses an amount of equity finance equal to its 1% VaR, there is less than a 1% chance that any loss in the asset's value will exceed the initial value of the firm's equity. A common but flawed interpretation is that this equity financing share will ensure that there is at most a 1% chance that the firm will default on its debt.

If the firm sets the share of equity funding equal to the asset (or portfolio) α percent VaR measure, VaR(α), the amount of debt finance required to fund the asset would be $V_0 - VaR(\alpha)$. If the firm borrows $V_0 - VaR(\alpha)$ and interest rates are positive, it must pay back more than $V_0 - VaR(\alpha)$ if it is to avoid default. The simple intuition that underlies the VaR approach to capital allocation ignores the interest payment that must be made on funding debt. An unbiased buffer stock capital allocation rule is to set equity capital equal to VaR(α) (calculated relative to initial market value) plus the interest that accrues on the funding debt over the VaR horizon.

VaR Horizon

When calculating VaR for buffer stock capital purposes, the VaR horizon must be equal to the maturity of the bank's funding debt issue. Any other VaR horizon will produce capital allocations with technical insolvency rates that differ from the intended target (see Kupiec [2002]). Technical insolvency occurs when the value of the promised maturity payment on the bank's liabilities exceeds the equilibrium market value of the bank's assets.

Market Risk Capital

Let $\Phi(x)$ represent the cumulative distribution function for a standard normal random variable evaluated at x, and $\Phi^{-1}(\alpha)$the inverse of this function evaluated at $0 \leq \alpha \leq 1$. Define

$$Q(\alpha, T) = e^{\left(\mu - \frac{\sigma^2}{2}\right)T + \sigma\sqrt{T}\Phi^{-1}(\alpha)}$$

$A_0Q(\alpha,T)$ defines the α quantile value of the physical value distribution of $\tilde{A}_T$. For an equity investment in an unleveraged firm, the market risk VaR measure consistent with a target default rate of α for the bank's funding debt of maturity of T is given by:

$$VaR(\alpha, T) = A_0[1 - Q(\alpha, T)] \tag{9}$$

$A_0 - VaR(\alpha, T) = A_0Q(\alpha, T)$ is the maximum par value of discount debt that can be issued without violating the firm's target default rate. The BSM debt pricing condition [Equation (4)] is used to determine the initial market value of this debt issue. The difference between the initial market value of the debt and its par value is the equilibrium interest compensation that must be offered to the firm's debt holders. In the BSM model setting, the interest payments are:

$$A_0Q(\alpha, T)\left[1 - e^{-r_f T}\right] + Put\left(A_0, A_0Q(\alpha, T), T, \sigma\right) \tag{10}$$

The interest amount, Equation (10), must be added to $VaR(\alpha, T)$ to calculate the true equity capital allocation needed to achieve the target default rate on funding debt with a maturity of T:

$$A_0\left[1 - Q(\alpha, T)e^{-r_f T}\right] + Put\left(A_0, A_0Q(\alpha, T), T, \sigma\right) \tag{11}$$

Credit Risk Capital

Recall that B_0 represents the initial market price of a BSM risky discount bond with par value Par_p. Define a notation for credit VaR with three arguments: the target funding debt default rate α; the maturity of the funding debt issue, T; and the maturity of the credit-risky asset, M, $T_* \leq M$:

$$VaR_{Credit}(\alpha, T, M) = B_0 - \left(Par_P e^{-r_f(M-T)} - Put\begin{pmatrix} A_0 Q(\alpha, T), \\ Par_P, M-T, \sigma \end{pmatrix} \right) \tag{12}$$

$B_0 - VaR_{\text{Credit}}(\alpha, T, M)$ determines the maximum admissible par value of the funding debt, $Par_F(\alpha, T, M)$, that can satisfy the target default rate constraint α:

$$Par_F(\alpha, T, M) = Par_P e^{-r_f(M-T)} - Put\begin{pmatrix} A_0 Q(\alpha, T), \\ Par_P, M-T, \sigma \end{pmatrix} \tag{13}$$

The arguments in $Par_F(\alpha, T, M)$ conform with those in $VaR_{\text{Credit}}(\alpha, T, M)$. The initial market value of the funding debt issue is:

$$E^\eta\left[Min\left[\begin{pmatrix} Par_P e^{-r_f(M-T)} - \\ Put\left(\tilde{A}_T, Par_P, M-T, \sigma\right) \end{pmatrix}, Par_F(\alpha, T, M) \right]\right] e^{-r_f T} \tag{14}$$

and the equilibrium required interest payment on the funding debt is:

$$Par_F(\alpha, T, M) - E^\eta\left[Min\left[\begin{pmatrix} Par_P e^{-r_f(M-T)} - \\ Put\left(\tilde{A}_T, Par_P, M-T, \sigma\right) \end{pmatrix}, Par_F(\alpha, T, M) \right]\right] e^{-r_f T} \tag{15}$$

Equations (12) and (15) are added to estimate the equity capital allocation necessary to achieve a target default rate of α on funding debt of maturity T:

$$B_0 - E^\eta\left[Min\left[\begin{pmatrix} Par_P e^{-r_f(M-T)} - \\ Put\left(\tilde{A}_T, Par_P, M-T, \sigma\right) \end{pmatrix}, Par_F(\alpha, T, M) \right]\right] \tag{16}$$

If $T = M$ the credit VaR horizon is identical to the maturity of the underlying credit, and the equity capital simplifies to:

$$B_0 - E^\eta\left[Min\left[Min\left(\tilde{A}_M, Par_P\right), A_0 Q(\alpha, M) \right]\right] e^{-r_f M} \tag{17}$$

III. SAFETY NET INSURANCE VALUE UNDER INTERNAL MODELS APPROACH TO CAPITAL

If the bank's liabilities are insured by an implicit or explicit government guarantee, we assume investors value these claims as risk-free. As a consequence, the initial market value of bank claims will increase relative to identical claims issued by a non-insured entity. In other words, given two banks that are identical in all respects except that one is (costlessly) insured and the other is not, the insured bank's shareholders will be able to invest less but still ensure that the bank's technical insolvency rate is no greater than α.

The interest rate subsidy insured banks enjoy has an important implication for buffer stock capital allocations. Suppose a regulatory authority mandates that an insured bank have sufficient capital to ensure that, at the end of some specific horizon, the bank remains technically solvent in at least $100(1 - \alpha)\%$ of all outcomes. If the insured bank takes into account the safety net-related interest subsidy in its IMB capital allocations, it can meet the regulatory mandated target solvency rate with less equity capital than would be required by an otherwise identical non-insured institution. The reduction in the buffer stock equity capital requirement is equal to the market value of the reduction in the interest cost on the bank's debt.

In the market risk capital allocation setting, in the context of the Merton model framework, the safety net-related reduction in the interest cost and equity capital is equal to:

$$Put\left(A_0, A_0 Q(\alpha, T), T, \sigma\right) \tag{18}$$

In the credit risk setting, the reduction in interest costs (and equity capital reduction) is:

$$\left[\begin{array}{l} Par_F(\alpha, T, M) e^{-r_f T} - \\ E^\eta\left[Min\left[\begin{pmatrix} Par_P e^{-r_f(M-T)} - \\ Put\left(\tilde{A}_T, Par_P, M-T, \sigma\right) \end{pmatrix}, Par_F(\alpha, T, M) \right]\right] \end{array} \right] e^{-r_f T} \tag{19}$$

Equation (19) is identical to Equation (7) evaluated at the par value for the bank's funding debt that satisfies the regulatory solvency requirement. When $T = M$ the value of the safety net subsidy simplifies to:

$$\left[A_0 Q(\alpha, M) - E^{\eta}\left[Min\left[Min\left(\tilde{A}_M, Par_P\right), A_0 Q(\alpha, M)\right]\right]\right] e^{-r_f M} \tag{20}$$

IV. BANK RISK-TAKING INCENTIVES UNDER AN IMB APPROACH TO CAPITAL

IMB regulatory capital requirements create a variety of potential distortions in bank lending activities.

Equity Issuance Costs and Wealth Maximization

Equations (18)-(19) represent, respectively, the deposit insurance values that a bank generates under IMB regulatory capital requirements for market and credit risks when a deposit insurance guarantee is costless to the bank. In each case, the insurance value depends on the risk characteristics of the bank's investments. Thus, banks' demands for investments may in part be determined by their associated insurance subsidy (and capital) benefits.

Our analysis assumes bank shareholders choose investments to maximize their wealth. If equity markets are competitive, and there are no asymmetric information costs associated with new equity issuance, the current bank shareholders will capture the safety net subsidies associated with all new investments, and they will maximize their wealth by raising new equity capital and investing in all assets that generate a positive safety net funding subsidy.

If there are costs associated with issuing new equity shares, however, the current shareholders' maximization problem must recognize the trade-offs between the transactions and asymmetric information costs required to raise outside equity and the corresponding benefits that can be attained from exploiting available safety net guarantees. In the extreme case, where outside equity issuance costs are prohibitive, current shareholders are capital-constrained and will allocate their equity capital across investments in order to maximize the value of the insurance subsidy per dollar of equity invested.

Market Risk

The safety net subsidy under an IMB market risk capital requirement [Equation (18)] depends among other things on the volatility of the equity investment (σ) and the market price of risk (λ), two asset characteristics that are implicitly selected by the bank.[7]

Exhibit 1 plots the insurance value surface for alternative values of volatility and the market price of risk assuming that the asset has an initial value of 100 and the risk-free rate is 5%. The value of the insurance subsidy increases with the market price of risk and is a concave function of asset volatility. Conditional on the market price of risk, there is an interior value of asset volatility that maximizes the value of the safety net subsidy generated by the investment.

The relationship between the market price of risk and the optimal choice of asset volatility is illustrated in Exhibit 2.

Exhibit 3 plots the same insurance value surface measured in basis points per dollar of invested bank shareholder equity under alternative combinations of values for σ and λ. It shows that, under the IMB capital requirement, the value of the insurance subsidy per dollar of bank invested equity is an increasing function of the market price of risk and a declining function of asset volatility. The most profitable bank investments—measured per dollar of required equity capital—are assets with low volatility and a high risk premium. Under an IMB capital requirement, these assets have low capital requirements, so a bank can use substantial leverage to increase expected return.

Credit Risk

Consider the insurance value generated under an IMB approach to regulatory capital for risky BSM bonds when the maturity of the bonds, T, is identical to the maturity of the bank's insured liabilities, M and both have a maturity of one year ($T = M = 1$). Results for $T > M$ (so-called mark-to-market credit VaR) are similar. The choice of a one-year VaR capital horizon ($M = 1$) is consistent with modern banking practices and proposed Basel II regulations regarding credit risk capital allocation.[8]

The value of the insurance subsidy depends on specific characteristics of the purchased bonds, including the bond's par value (Par_p), the initial market value of the bond's supporting assets (A_0), return volatility (σ), and the market price of risk (λ). The par value, initial asset value, and asset return volatility also determine the bond's credit risk as measured by the discount bond's default option value. The default option value is independent of the market price of risk.

Exhibit 4 plots the default option value surface of the underlying risky discount debt for alternative values of Par_p and σ when the supporting assets have an initial market value of 100 ($A_0 = 100$) and the risk-free rate is 5% ($r_f = 0.05$). It shows that the bond's credit risk is an

Exhibit 1
Deposit Insurance Value Under IMB Market Risk Capital Requirement

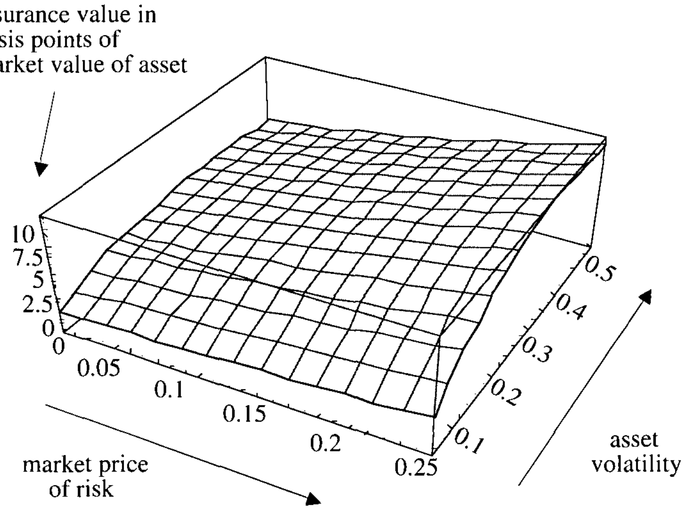


Exhibit 2
Asset Volatility Levels that Maximize Insurance Value for Alternative Market Prices of Risk

market price of risk	volatility that maximizes subsidy	maximum insurance value
0	0.339	0.045
0.05	0.334	0.052
0.1	0.349	0.061
0.15	0.354	0.072
0.2	0.359	0.084
0.25	0.365	0.098

increasing function of Par_p and σ, holding other parameters constant.

The insurance value surface generated under a one-year 1% internal model capital requirement for the one-year discount bonds is plotted in Exhibit 5, assuming $\lambda = 0.10$ and $r_f = 0.05$. A comparison of Exhibits 4 and 5 shows that the peak of the insurance value surface corresponds to a set of discount bonds that have only modest credit risk. Insurance value is enhanced because under a 1% IMB capital constraint, these bonds allow considerable funding leverage.

Exhibit 6 illustrates the trade-offs among insurance value, asset volatility, and the market price of risk for a BSM bond with a par value of 85 supported by assets with an initial market value of 100. The market price of risk has an influence on the insurance value in the credit risk setting, but this effect is second-order compared to the importance of asset volatility. Similar trade-offs are implicit for alternative BSM bond par value choices.

Exhibit 7 revisits the insurance value surface pictured in Exhibit 5 and plots the surface when insurance value is measured in basis points per dollar of required bank equity capital—the insurance value measure that is relevant for the shareholders of a capital-constrained bank. The face of the cliff in Exhibit 7 corresponds with the peak of the mountain ridge in Exhibit 5. The high plateau at the top of the cliff in Exhibit 7 corresponds to the bonds in the minimal credit risk (northeast) quadrant of Exhibit 5. The plateau actually represents truncation of the graph in this region.

Under the 1% IMB capital requirement, the bonds in this region can be fully financed with insured deposits. Since bank shareholders make no investment but accrue fully the credit risk premium paid by these bonds (however small), the bonds on the plateau above the cliff face in Exhibit 7 offer infinite insurance value per dollar of required equity capital investment.

V. CONCLUSIONS

If banks enjoy a funding cost subsidy from implicit guarantees or mispriced explicit government insurance, their internal models will produce downward biased estimates of the economic capital required to fund a risky

EXHIBIT 3

Deposit Insurance Value Per Dollar of Invested Equity Under IMB Approach

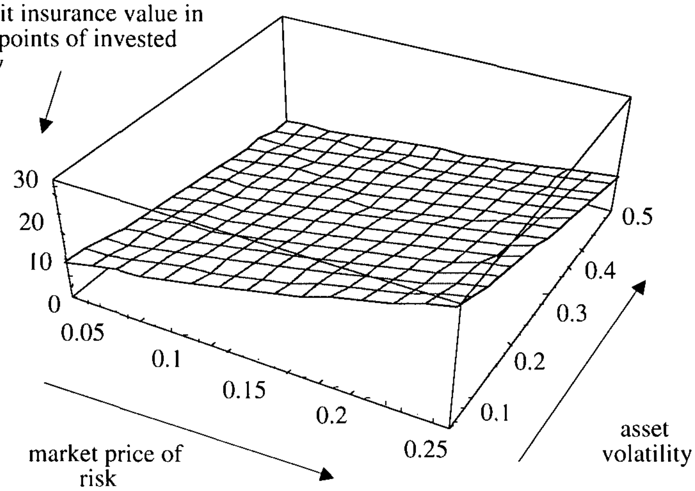
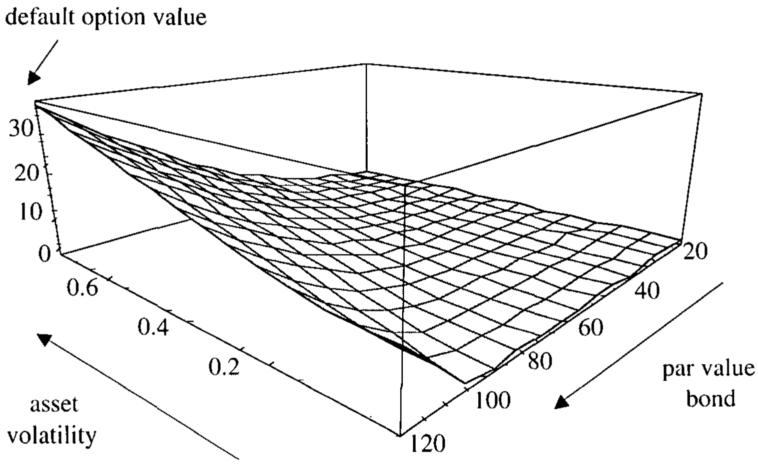


EXHIBIT 4

Bond Characteristics and Credit Risk



investment. These lower capital requirements can satisfy regulatory default rate constraints and still ensure that bank shareholders earn safety net-engendered profits. These profits represent transfers that ultimately are a potential expense of the insurer.

Shareholder profits generated under IMB capital regulation are not uniform with respect to the risk profiles of alternative market and credit risk investments. As a consequence, bank investment decisions will be influenced by the extent of the funding cost subsidies on alternative investment opportunities in addition to the true economic profits associated with these investment alternatives.

Supervisors have yet to fully embrace an IMB approach for credit risk regulatory capital requirements. The results of this analysis suggest an IMB approach will not eliminate regulation-induced distortions in bank lending behavior. Instead, IMB regulatory capital requirements will substitute a different set of economic distortions for those under the current 1988 Basel Accord rule-based system.

ENDNOTES

The views expressed here represent those of the author and do not necessarily reflect the opinions of the FDIC.

[1]"Credit Risk Modelling" [1999] describes survey results regarding banks' internal model processes for setting credit risk capital allocations.

EXHIBIT 5
Insurance Value Under IMB Capital Requirement

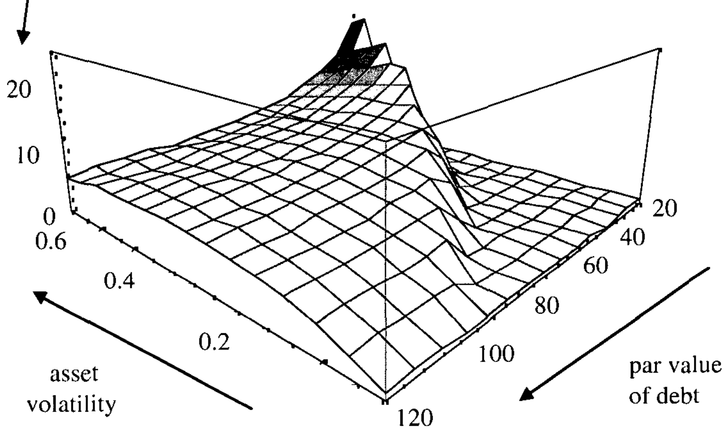
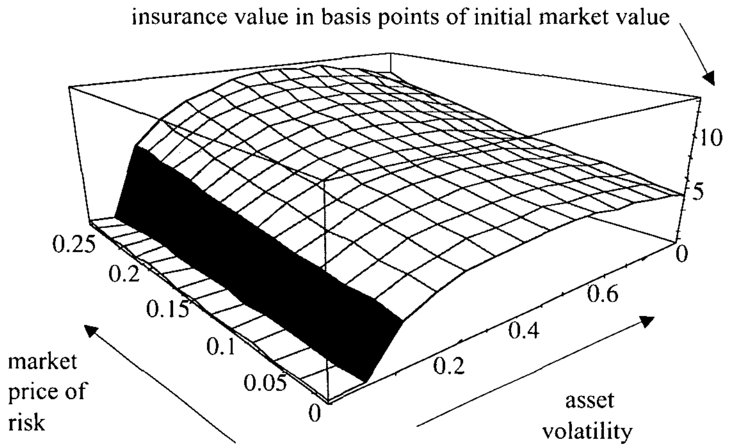


EXHIBIT 6
Insurance Value and Market Price of Risk Under IMB Capital Requirement



[2]Because insurance is costless, the model's results also directly apply to the case of implicit deposit insurance. Note that the U.S. deposit insurance premium rate is currently zero for well-capitalized banks.

[3]Other assumptions include: the firm's asset value evolves following Equation (2); there are no taxes; transactions are costless; unrestricted short sales are permitted; continuous trading is allowed; investors in asset markets act as perfect competitors; the firm issues only one class of discount debt; and the risk-free term structure is flat.

[4]If the insurer were to charge an ex ante fee for insurance coverage, the market value of the insurance subsidy would be given by $Put(A_0, Par, M, \sigma)$ less the ex ante fee.

[5]We make no claim that this objective function formally defines a firm's optimal capital structure—indeed, it almost certainly does not—but it is the objective function that is consistent with VaR-based capital allocation schemes and an approach commonly taken by banks according to the Basel Committee on Banking Supervision's "Credit Risk Modelling" [1999] survey results.

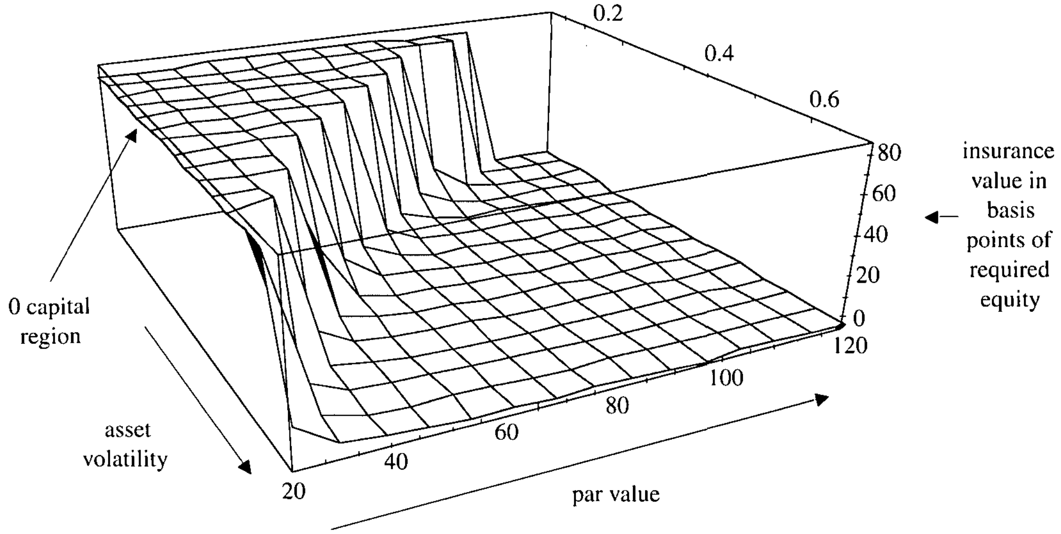
[6]See Kupiec [1999] for the issues that arise when VaR is measured relative to the expected value of the P&L distribution in long-horizon calculations.

[7]In a more general model that prices multiple risk factors in equilibrium, the bank may also be able to select which risk factor or factors it wishes to be exposed to.

[8]See "The New Basel Accord" [2001].

EXHIBIT 7

Insurance Value (in basis points) of Required Equity Capital



REFERENCES

Black, F., and M. Scholes. "The Pricing of Options and Corporate Liabilities." *Journal of Political Economy*, 81 (1973), pp. 637-654.

"CreditMetrics Technical Document." J.P. Morgan & Co., 1997.

"Credit Risk Modelling: Current Practices and Applications." Bank for International Settlements, Basel, Switzerland, 1999.

Duffie, D., and J. Pan. "An Overview of Value at Risk." *The Journal of Derivatives*, 4 (1997), pp. 7-49.

Hull, J., and A. White. "Value at Risk When Daily Changes in Market Variables Are Not Normally Distributed." *The Journal of Derivatives*, 5 (1998), pp. 9-19.

"An Internal Model-Based Approach to Market Risk Capital Requirements." Basel Committee on Banking Supervision, 1995.

"ISDA's Response to the Basel Committee on Bank Supervision's Consultation on The New Capital Accord." International Swap Dealers' Association, 2001. Available at www.bis.org.

Jones, David. "Emerging Problems with the Basel Capital Accord: Regulatory Capital Arbitrage and Related Issues." *Journal of Banking and Finance*, 24 (2000), pp. 35-58.

Jorion, Philippe. *Value at Risk*. New York: McGraw-Hill, 1997.

Kupiec, P. " Risk Capital and VaR." *The Journal of Derivatives*, 7 (1999), pp. 41-52.

——. "What Exactly Does Credit VaR Measure?" *The Journal of Derivatives*, 9 (2002), pp. 46-59.

Marshall, C., and M. Siegel. "Value-at-Risk: Implementing a Risk Measurement Standard." *The Journal of Derivatives*, 4 (1997), pp. 91-111.

Merton, Robert. "An Analytic Derivation of the Cost of Deposit Insurance and Loan Guarantees: An Application of Modern Option Pricing Theory." *Journal of Banking and Finance*, Vol. 1 (June 1977), pp. 3-11.

——. "On the Pricing of Corporate Debt: The Risk Structure of Interest Rates." *Journal of Finance*, 29 (1974), pp. 449-470.

"The New Basel Accord." Basel Committee on Banking Supervision, 2001.

"The New Basel Accord: Response to Consultative Documents dated January 2001." KPMG, 2001. Available at www.bis.org.

"Re: The New Basel Accord: January 2001 Consultative Papers." The Financial Services Roundtable, 2001. Available at www.bis.org.

"Report of the Working Group on Capital Adequacy." Institute of International Finance, Washington, D.C., 2001. Available at www.bis.org.