The Implied Bank Insurance Fund Under Credit Risk*

Athanasios Episcopos

Assistant Professor
Department of Economics
Athens University of Economics & Business
76 Patission Street, Athens 104 34, Greece
Tel: (+30) 10 8203364, Fax: (+30) 10 8203301
E-mail: episcopos@aueb.gr

* The author thanks the FDIC for kindly providing the data on the BIF and seminar participants at Athens University of Economics and Business for useful comments. Any remaining errors are the author's responsibility.

The Implied Bank Insurance Fund Under Credit Risk

Option models of deposit insurance pricing view assessment rates on banks as put option premiums. However, such models ignore the risk of guaranty fund default. This paper links premiums with insurance fund reserves by employing a methodology based on vulnerable options. The standard options premium is decomposed into an explicit, vulnerable part due to the tangible assets of the guaranty fund and an implicit one due to contingent funding. In addition, the implied, actuarially correct fund level is extracted under an exogenous insurance coverage rate as a policy parameter. The method is illustrated on a sample of forty large bank holding companies and an extension to the case of several insured banks is provided.

1. Introduction

Merton (1977) wrote of an isomorphism between options and deposit insurance, with actuarially correct premiums determined as European put options on insured bank assets. The main implication of the options approach was that premiums would depend on the relative size of insured deposits to assets and, more importantly, on bank asset risk. This was in contrast to the uniform premium policy followed by the Federal Deposit Insurance Corporation (FDIC) since the FDIC's inception. Later papers in the same strand of literature include Merton (1978), Markus and Shaked (1984), Ronn and Verma (1986), Pyle (1986), Allen and Saunders (1993) in banking and Cummins (1988) in insurance guaranty funds. The options model is a sound theoretical benchmark for risk-based deposit insurance pricing despite its practical shortcomings, e.g., the difficulty of estimating bank asset value.

The Savings & Loan and Banking crises of the 1980-94 period, during which more than 1600 banks and 1300 S&Ls failed, raised important questions about regulation and supervision, particularly assessment rates and solvency of guaranty funds. The policy response to the crises was culminated by passing the FDIC Improvement Act (FDICIA) in 1991. Regarding pricing, a mandate of the FDICIA was that the FDIC use a risk-based system in determining assessment rates. Indeed, the FDIC put in place an assessment system classifying banks by two criteria, namely, capital levels and supervisory ratings. Regarding reserves, the FDIC was since required to maintain a designated reserve ratio (DRR) of 1.25% of total deposits for the Bank Insurance Fund (BIF) and the Savings Associations Insurance Fund (SAIF) by raising premiums. This specific DRR was a remnant of the Depository Institution Deregulation and Monetary Control Act of 1980 and was originally based on the historical average of the reserve ratio. However, there has been no theoretical backing of this figure and some have even questioned the very practice of targeting fund reserves (e.g., Pennachi, 2000).

The issue of BIF capital adequacy has been addressed by actuarial models using the distribution of losses from bank failures (e.g., Sheehan, 1998, Kurizkes et al, 2002). The broad conclusion out of these studies is that the BIF reserves are adequate. However, a limitation shared by such approaches is their heavy dependence on past losses. Even though the number of bank failures is sufficient for simulations, the number of distinct major incidents and crises is very limited. Furthermore, one can argue that statistical loss distributions have changed especially after the wave of mergers after 1995 following the deregulation of banking. In fact, recent evidence indicates that systemic risk potential in the financial sector has increased due to consolidation in the last decade (De Nicolo and Kwast, 2002). Portfolio diversification may have reduced the probability of large bank failures but severity has increased and loss history is not the best guide anymore. Therefore, it is desirable to have a forward-looking, theoretical model that does not depend directly on past losses to a fund.

Existing options models do not address the connection between premiums and guaranty fund reserves. In search of a substitute, we are guided by some observations from deposit insurance history. Although insured deposits are government backed, full coverage of depositors by the FDIC reserves alone is impossible. There is always a small but distinct probability that extra funds will be needed in a major crisis and this has been amply demonstrated during the 1980-94 crises. In addition, the past volatility of the BIF naturally points to credit risk on the part of the guarantor. Such credit risk can be measured by vulnerable options, a partial literature on which includes Johnson and Stultz (1987), Jarrow and Turnbull (1995), Hull and White (1995) and Klein (1996) and we can turn to this field for answers.

The following methodology is proposed: Suppose a bank is insured by the assets, B, of the guaranty fund. The premium, P, corresponds to a full insurance coverage derived from a reference options model, e.g, Merton (1977) or Ronn-Verma (1986) adjusted for recent developments in regulation. The actuarially correct premium under credit risk would be a vulnerable put, $p(B, \theta)$, which is a function of the fund assets and θ is a set of parameters including the volatility and correlation between bank and BIF asset returns. By setting the coverage ratio, p/P, to an exogenous level desired by policy makers one can extract the implied fund level associated with such coverage. Meanwhile, banks are still required to pay the FDIC the standard options premium, which reflects the service they receive.

The proposed approach extends the options models of insurance pricing by incorporating credit risk of the guaranty fund. Thus, we can speak of an isomorphism between deposit insurance and vulnerable options with the standard models holding as a limiting case when credit risk is absent. Furthermore, the usefulness of the approach is in its implications: We now are able to say which part of the provided insurance is tangible and which part is not. The intangible part can materialize only through taxing, in effect, existing banks and/or taxpayers at large. Of course, the new approach has its own shortcomings, the most important of which is a natural limit on available computing speed, which impedes generalization to several banks (computer programming is straightforward and does not pose a problem). However, it is shown that projections based on calculations on a small number of banks are feasible.

The rest of the paper is organized as follows: The next section presents the standard and vulnerable options models of deposit insurance under the assumption that only one bank is insured. Section 3 discusses the data used in the analysis, which include a sample of forty large bank holding companies (BHCs). Section 4 gives estimates of the required funds needed to insure each BHC and computes an upper bound for the fund. Section 5 provides the extension to the case of several banks insured by the guaranty fund. Section 6 concludes.

2. The Implied BIF Under Credit Risk

Let us proceed with the main notation.

S = Post insurance asset value of a bank insured by the FDIC adjusted for dividends.

E = Market value of the bank's equity.

D = The bank's insured domestic deposits.

L = Total liabilities of the bank.

B = Size of the insurance fund.

T = Time to next FDIC review of the bank to set the assessment rate.

σ_E = Volatility of equity.

σ_S = Volatility of bank assets.

σ_B = Volatility of the insurance fund.

ρ = correlation coefficient between B and S.

$N(\bullet)$ = The standard normal cumulative distribution function.

$f_n(.)$ = the n-variate standard normal density function.

Following Ronn and Verma (1986), hereafter RV, the value of equity is given by

$$E = SN(x) - LN(x - \sigma_s \sqrt{T}) \qquad (1)$$

where

$$x = \frac{\ln(S/B) + \sigma_s^2 T/2}{\sigma_s \sqrt{T}}$$

and the volatility of the assets is

$$\sigma_s = \frac{\sigma_E E}{SN(x)} \tag{2}$$

Equations (1) and (2) are solved for the market value of assets and its volatility. Ronn and Verma (1986) assumed all debt to be of equal seniority. Thus, the deposit insurance premium is an option (with exercise price the total face value of debt and underlying asset the assets of the bank) scaled down by the proportion of insured deposits in the total debt. However, subsequent legislation through FDICIA and the Omnibus Budget Reconciliation Act of 1993 imposed a least-cost principle on the FDIC in bank resolutions and prohibited the use of FDIC money for open assistance unless a systemic risk reason was agreed upon by the top three national regulators. In addition, a priority of claimants in bank failures was set. In the event of a bank failure the claims priority in a receivership was, in descending order, receivership administrative expenses, secured creditors, depositors including the FDIC in the place of insured depositors, general creditors, subordinated creditors, and, finally, shareholders.

It is unclear whether depositor preference would reduce costs to the FDIC as creditors shift funds strategically and seek protection (Osterberg, 1996). After 1993, there has been no large bank failure in the USA and it is impossible to draw any conclusions as to the applicability of the new rules. Obviously, the correct option model to capture the spirit of the new legislation is a mixture of the Merton (1977) and RV models. The future value of insured domestic deposits can be the exercise price in the put option while assets and volatility can be derived from the RV Equations (1) and (2) above. Let us call that model MRV. Unfortunately, an empirical problem arises in that case because the assets of the companies in the sample include large amounts of non-deposit activities. This makes insured deposits artificially small and put options severely biased downwards. In addition, the bank component of these large financial holding companies is not always traded, and therefore, one cannot use their equity value in (1) and (2). Thus, for the purposes of this paper, the RV model without direct assistance is used instead. The value of deposit insurance is given by

$$P = D\left(N(y + \sigma_s \sqrt{T}) - (S / L) N(y)\right) \tag{3}$$

where

$$y = \frac{\ln(L / S) - \sigma_s^2 T / 2}{\sigma_s \sqrt{T}}$$

Because the present methodology uses *relative* option values, as shown in Equation (5) below, the choice of reference model probably would not severely affect the computed guaranty fund assets.

Suppose now the fund insures a single bank. The fund balance, *B*, follows a logarithmic diffusion correlated with the bank's assets. The assumption of *B* following a diffusion is needed to obtain a joint measure of guarantor and bank risks. The logarithmic diffusion assumption however is a reasonable approximation. Since its the establishment of FDIC, the fund balance has been varying due to a) receipts of premiums, b) refunds of premiums, c) expenses for direct assistance, d) administrative expenses, e) revenues from the sale of failed bank assets, f) revenues from investing funds in Treasuries and g) government infusions to the fund. All these capital flows into and out of the fund can be considered as random shocks varying in size and frequency. However, other stochastic formulations such as a mixed jump-diffusion process are feasible.

Debt guarantees have been examined in Johnson and Stulz (1987) as a special case in their seminal paper on vulnerable options. By modifying their formula to be useful for extensions it can be shown that the premium, *p*, in the vulnerable options case is given by

$$p = \left(\frac{D}{L}\right)\frac{1}{\sigma_1\sigma_2 T}\left[\int_0^L \frac{ds}{s}\int_0^{L-s} f_2 db + \int_0^L \frac{ds}{s}\int_{Max[L-s,0]}^{\infty} \frac{L-s}{b} f_2 db\right] \tag{4}$$

where

$$f_2 = f_2(x_1, x_2) = (2\pi)^{-1}|\Sigma|^{-1/2}\exp\left[-\frac{1}{2}(x_1, x_2)'\Sigma^{-1}(x_1, x_2)\right]$$

$$= (2\pi)^{-1}(1-\rho^2)^{-1/2}\exp\left[-\frac{1}{2(1-\rho^2)}\left(x_1^2 - 2\rho x_1 x_2 + x_2^2\right)\right]$$

is the density function of the standard bivariate normal distribution with mean (0,0) and correlation matrix $\sum = \begin{bmatrix} 1 & \rho \\ \rho & 1 \end{bmatrix}$, while the elements of vector (x_1, x_2) are given by

$$x_1 = \frac{\ln(S/s) - \sigma_s^2 T/2}{\sigma_s \sqrt{T}}$$

$$x_2 = \frac{\ln(B/b) - \sigma_s^2 T/2}{\sigma_B \sqrt{T}}$$

Equation (4) replaces Equation (3). By analogy to RV, the put option is calculated on the initial asset size, *S*, with exercise price all outstanding debt, *L*, and then scaled down by the proportion of insured deposits to total liabilities. In the first double integral of (4), the fund is not solvent when the bank fails and the payoff to insured depositors is *b*, which cancels out with *b* in the denominator. The second integral corresponds to the case where the fund is solvent. Notice that the risk free interest rate does not appear in the formula because deposits and all debt are treated as risk free, discount bonds. Thus, the interest rate indifference property of options models is carried over to the vulnerable case.

It is known that vulnerable options cannot be worth more than standard options (Johnson and Stulz, 1987). Thus, $p \leq P$. Of course, we expect that the limiting case of equality in the premiums will be rare. However, the lower value of the vulnerable premium is *not* to be interpreted as a recommendation that banks should pay less insurance. The new premium reflects the explicit value of insurance service provided by the fund itself, just as the premium in most life, health or casualty insurance policies depends on the policy coverage. The difference between *p* and *P* multiplied by insured deposits gives the expected value of the implicit component of the total guarantee provided per period. The point of this distinction is that now we are able to know which part of the government guarantee is tangible and which part is not. This has profound implications for policy because the implicit guarantee can eventually materialize only through an injection of funds to the BIF. Such an objective can be accomplished with a rapid collection of larger premiums from existing banks as the law provides and, possibly, with taxation.

Let us now define the metric

$$\alpha = \frac{p(B,\theta)}{P} \tag{5}$$

as the coverage[1] provided by the guarantor assets, *B*, where θ is a set of other parameters to be discussed later. Inspired by the implied volatility literature, we extract the implied values of *B* by fixing α at some specific level, say, 90%. We focus only on the implied guarantor assets although solving for other parameters such as the correlation between *S* and *B* could be potentially useful in other applications. To relate the issue to actuarial science, we note that insurance companies casually compute policy reserves based on the statistical distribution of historical losses. Now, if option

[1] The word "coverage" is justified: The value of European put option with α times the standard payoff is equal to α times the value of the standard option (Merton, 1973). Hence, the term borrowed from insurance contracts.

values give the actuarially fair premiums, the implied *B* would give the actuarially correct guarantor assets conditional on a specific coverage level.

Let us briefly reflect on the new method and the existing one. The original options approach to deposit insurance was meant to introduce some market-based method to assess the insurance premium by accounting for the risk of each bank. The vulnerable options approach is meant to account also for the credit risk involved. The procedure described above can be potentially useful in an effort to answer important questions such as "what should be the level of the BIF?", "What is the coverage provided by an insurance fund given the current fund size?", etc. But first let us turn to a discussion of the sample.

3. Description of Data and Variables

The sample consists of forty bank holding companies (BHCs) ranking at the top fifty BHCs in terms of asset size and includes only public companies. The market value of equity was calculated by multiplying price per share with the number of common shares outstanding at 12/31/2000. Sources for these variables were Reuters and 10-K reports filed with the Securities and Exchange Commission. Total liabilities and deposits are taken from FR Y-9 reports filed with the Federal Reserve Board. The percentage of domestic deposits that are insured is provided by the FDIC. The FDIC derives these estimates by adding the dollar value of deposits in accounts less than $100 thousand and the number of accounts that are larger than $100 thousand times $100,000.

The search for proxies for the model variables was guided by data availability. The fund volatility was computed from annual BIF balances from 1934 to 2000. This is an important issue because volatility of the guaranty fund is negatively related to the value of the put option. The model calls for a constant volatility but, unfortunately, the latter depends on the period under examination. In relatively calm periods such as 1934-1980 or 1995-2000, σ_B was 3.7% and 1.4%, respectively. However, in the crisis period 1981-1994, σ_B shot up to 34.9%. In the 67 years of its life, the fund had gone through several changes, sometimes major ones, as policy varied over time. Thus, it seems reasonable to use the long run volatility level of 16%.

The volatility of equity is computed from daily data covering 2000. This is taken for uniformity purposes, as many companies were affected by mergers in the 1990s and it would be difficult to have a meaningful measure of the true σ_E. Besides, it may be appropriate to use a recent volatility measure for companies, as did RV, because it would reflect the current risk composition of the companies' assets. Summary information on the basic variables is reported in the first seven colums of Table 1. A company that needed separate treatment is Wachovia. The original Wachovia merged with First Union in September 2001 and, therefore, figures for this entry in Table 1 are adjusted appropriately using weighted sums.

In order to compute the correlation of bank assets with the fund, it would be preferable to have daily data. The highest frequency BIF data available, though, was quarterly from 1992-2000 provided by the FDIC. Thus, the correlation of quarterly equity with the fund balance through that period was used as an estimate for ρ. Of course, we are interested in the correlation of the companies' *assets* with the fund.

However, because a call option and its underlying asset should be perfectly correlated based on Equation (1), the proxy is quite reasonable. The results are shown in the rightmost column of Table 1. The rather high correlation with the fund, 0.5, can be explained by the fact that recovery in the whole economy coincided with a quick re-capitalization of the BIF and a decline in the number of bank failures. In addition, from 1996 to 2000, a large proportion of the fund's revenue (93%) came from interest income thereby leading to a positive correlation of the fund with BHCs' stock.

4. Vulnerable Premiums and the Implied Guaranty Fund

Equations (1) and (2) are solved numerically for the market value of the assets and the asset volatility, σ_S. Results are shown in columns 8 and 9 of Table 1. These results are then used to compute the assessment rate for each BHC. The second and third columns of Table 2 show the RV premiums in cents per $100 of deposits (basis points) and in million dollars. In Figure 1, premiums are cast in percentage points to facilitate comparisons. The case of one bank is depicted with the curve labeled "1 ABHC". The vulnerable premium is lower than that of RV and approaches it asymptotically as *B* gets sufficiently large. The difference between the reference and vulnerable premiums is the value of implicit insurance provided by the fund and it gets progressively smaller with the fund size.

Suppose we liberally interpret the explicit insurance service as output and the BIF capital as input in the value function of Figure 1. Then, at low levels of *B*, the productivity of insurance capital is high but diminishing returns are observed soon. That is an important issue for policy makers if the model ever becomes part of a larger optimisation function: Expending part of the fund to assist a failing bank or to pursue other objectives reduces the coverage level for the system. It all depends on the size of the disbursement in relation to the fund size. Incidentally, this is a crucial point against actuarial models examining the strength of the BIF: If a crisis wipes off, say, 40% of the fund, the remaining capital could provide much less coverage than before, putting the whole system in a more precarious position.

For yet another perspective, a marginal dollar of explicit insurance corresponding to a high coverage level has a high incremental cost compared to a situation of low coverage (symmetrically for implicit insurance). The implications of these arguments for policy can be also seen from the following: Recently, the FDIC has made some proposals for deposit insurance reform (FDIC, 2001) including rebates to banks and fluctuating assessment rates for cyclical smoothing. If the total government guarantee as being spread over a long horizon, the new policies can be viewed as trade-offs between the implicit component of the guarantee of one period and the explicit component of another period. Of course, that would depend on the policy makers' optimization function regarding these components.

The above can also shed some light in the search for the optimal BIF balance. Columns 5-8 of Table 2 display the required fund levels if one BHC is insured at a time. In a sense, these funds could be thought as "earmarked" to perform a single insurance task. Notice the very large sums. Apparently this arrangement of exclusive use is the least economical one because it does not account for the correlation among banks. A much lower fund level can insure these banks jointly. Thus, the estimates provided should be considered as an upper bound to the true BIF for the forty BHCs.

Tables 1 and 2 include also information on two fictitious banks, which can be useful in summary calculations of Section 5. The Average BHC (ABHC) is the average company in the sample. However, ABHC's volatility, assets, premiums and the associated implied fund are derived by the model. The results for this company will be used later in Section 5. The market value of equity for the Index BHC is constructed as the sum of the equity of all forty BHCs in the sample. In other words, its equity is 40 times the equally weighted index. Notice the low correlation with the fund in Table 1. Looking at Table 2 , the Index BHC would be required to pay a small premium but would need a very large amount of reserves to guarantee its deposits because the reference premium is comparatively large. For such a company to fail, it would take either all of its components to fail or many large banks to fail, a rare event indeed. Yet, the amounts required to insure such a bank at various levels of coverage are very large and comparable to the sum of the individual BHC, particularly for low coverage levels. The upshot is that the single-bank approach may be useful to derive a rough estimate for the BIF even if several banks are involved.

5. Several Banks Insured

The way to apply the methodology above to the case of several banks is straightforward to implement. We have to compute the multivariate analogs of the vulnerable option, $p_{m,n}$ and the RV option, $P_{m,n}$ (in this section options are cast in dollars and not basis points, for convenience). Let us express these options for the case of two banks insured by the fund. When credit risk is absent, the RV option is given by the formula:

$$P_{m,2} = \left(\frac{D_1 + D_2}{(L_1 + L_2)\sigma_1\sigma_2 T} \right) \{ \int_0^{L_1} \int_{L_2}^{\infty} \left(\frac{L_1 - s_1}{s_1 s_2} \right) f_2 ds_2 ds_1 + \int_{L_1}^{\infty} \int_0^{L_2} \left(\frac{L_2 - s_2}{s_1 s_2} \right) f_2 ds_2 ds_1 + \int_0^{L_1} \int_0^{L_2} \left(\frac{L_1 - s_1 + L_2 - s_2}{s_1 s_2} \right) f_2 ds_2 ds_1 \} \quad (6)$$

The double integrals refer, in turn, to the case where the first, the second or both banks fail. The option is appropriately scaled down by the proportion of the total insured deposits to the total debt outstanding. The arguments of the standard bivariate normal density, f_2, are analogous to x_1 in Equation (3). A closed form for this formula is attainable under some assumptions to be provided in this section. The vulnerable option in the case of two banks is given by the following:

$$p_{m,2} = c_2 \{ \left(\int_0^{L_1} \int_{L_2}^{\infty} \int_0^{L_1 - s_1} \frac{f_3}{s_1 s_2} db ds_2 ds_1 + \int_0^{L_1} \int_{L_2}^{\infty} \int_{\max[L_1 - s_1, 0]}^{\infty} \left(\frac{L_1 - s_1}{s_1 s_2 b} f_3 \right) db ds_2 ds_1 \right) +$$
$$\left(\int_{L_1}^{\infty} \int_0^{L_2} \int_0^{L_2 - s_2} \frac{f_3}{s_1 s_2} db ds_2 ds_1 + \int_{L_1}^{\infty} \int_0^{L_2} \int_{\max[L_2 - s_2, 0]}^{\infty} \left(\frac{L_2 - s_2}{s_1 s_2 b} f_3 \right) db ds_2 ds_1 \right) +$$
$$\left(\int_0^{L_1} \int_0^{L_2} \int_0^{L_1 - s_1 + L_2 - s_2} \frac{f_3}{s_1 s_2 b} db ds_2 ds_1 + \int_0^{L_1} \int_0^{L_2} \int_{\max[L_1 - s_1 + L_2 - s_2, 0]}^{\infty} \left(\frac{L_1 - s_1 + L_2 - s_2}{s_1 s_2 b} f_3 \right) db ds_2 ds_1 \right) \}$$

where

$$c_2 = \frac{D_1 + D_2}{(L_1 + L_2)\sigma_1 \sigma_2 \sigma_B T^{3/2}}$$

and f_3 is the standard trivariate normal density (we omit details for exposition clarity).

In principle, one can derive the implied insurance fund for any number of banks by extending the above two equations and using (5). For exposition purposes, we apply the technique for up to five Average BHCs by making the assumption that these identical companies have a correlation of 0.54, the average correlation in the sample (1521 pairs of BHCs) among daily stock returns in 2000. With identical banks the scaling ratio of the sum of insured deposits to the sum of total liabilities is the same for all banks. This implies that $p_{m,n}$ equals the sum of the RV premiums regardless of the number of banks involved. The proof is based on a standard property of the multivariate normal distribution according to which the marginal distributions of are also normal (Johnston *et al*, 2001, Ch. 45). Thus, by "integrating out" the n-1 variables we are left with the *i*th option, which, applied to our model is the RV premium for the *i*th bank. For instance, in the case of two banks, Equation (6) becomes

$$P_{m,2} = \sum_{i=1}^{2} \frac{D}{L\sigma_i\sqrt{T}} \int_0^{L_i} \frac{L_i - s_i}{s_i} f_1 ds_i \qquad (6')$$

but this is the sum of the integral versions of the RV premiums for each of the two banks. The proof makes also financial sense because, when there is no credit risk on the part of the guarantor, the guarantee will be full regardless of the number of banks insured.

The above result helps relate the *n*-bank vulnerable premium faster. Table 3 displays the reserves required when the fund insures up to five ABHCs. To speed up calculations the options are computed only at fifteen fund levels and the results were approximated using third degree polynomials as shown in Figure 1. Looking at Table 3 we observe that the derived guaranty fund levels are more reasonable than in the single bank case. Fixing α at 50, 70, 90, and 99 percent allows us to make some inferences about the way B increases with the number of insured banks. An alternative would be to map the curves in Figure 1 to a family of curves, e.g., a weighted average of the so-called error function in B and then estimate and extrapolate their parameters, one of which would be the number of insured banks. Although no claims for prediction can be made in this paper due to the small number of observations, it is apparent that estimates of the fund are attainable.

For completeness purposes, the final comment is on computation. No worth mentioning problems were encountered during the numerical computations for this paper using the *Mathematica* software. Root finding algorithms are now standard and very accurate and none was sensitive to initial conditions. The estimation error of the quasi Monte Carlo method used on multiple integrals is more related to the number of observations drawn (one million in all cases) than in the integral dimension. Programming is clearly not an issue especially because modern software supplies the multivariate normal anyway. The only impediment is processing speed, which can be prohibitive for higher degree multiple integrals. The average BHC approach illustrated above is promising as available computing speed improves.

6. Concluding comments

The paper has proposed a new methodology to extract the actuarially correct balance of a bank guaranty fund given an exogenous coverage level. The model extends the related options literature on deposit insurance and contributes to the ongoing discussion about adequate funding of the BIF. By design, the new method does not propose a specific level for the BIF because that would depend on the coverage desired by the policy makers as well as the core options model. The model has certain advantages over actuarial approaches to estimating the BIF because it is forward looking and does not require estimates of any loss distribution especially in an environment of increasing loss severity.

7. References

Abramowitz, M., Stegun, I., 1972. Handbook of mathematical functions, Dover Publications, New York.

Allen, L., Saunders, A., 1993. Forbearance and the valuation of deposit insurance as a callable put, Journal of Banking and Finance 17, 629--643.

Cummins, J.R., 1988. Risk based premiums for insurance guaranty funds, Journal of Finance 43, 823--839.

De Nicolo, G., Kwast, M., 2002. Systemic risk and financial consolidation: Are they related?, Journal of Banking and Finance 26, 261-880.

FDIC, 2001. *Keeping the promise: Recommendations for Deposit Insurance Reform*, Washington, DC.

Hull, J., White, A., 1995. The impact of default risk on the prices of options and other derivative securities, Journal of Banking and Finance 19, 299--322.

Jarrow, R., Turnbull, S., 1995. Pricing derivatives on financial securities subject to credit risk, Journal of Finance 10, 53--85.

Johnson, H., Stulz, R., 1987. The pricing of options with default risk, Journal of Finance 42, 267--280.

Klein, P., 1996. Pricing Black-Scholes options with correlated credit risk, Journal of Banking and Finance 20, 1211--1229.

Kotz, S., Balakrishnan, N., Johnson, N., 2001. Continuous Multivariate Distributions Vol.1, Wiley, New York, NY.

Kuritzkes, A., Schuermann, T., Weiner, S., 2002. Deposit insurance and risk management in the U.S. banking system: How much? How safe? Who pays?, Working Paper 02-02, Wharton Financial Institutions Center.

Marcus, A., Shaked, I., 1984. The valuation of FDIC deposit insurance using option-pricing estimates, Journal of Money, Credit and Banking 16, 446--460.

Merton, R., 1978. On the cost of deposit insurance when there are surveillance costs, Journal of Business 51, 439--451.

Merton, R., 1977. An analytic derivation of the cost of deposit insurance and loan guarantees, Journal of Banking and Finance 1, 3--11.

Merton, R, 1973. Theory of rational option pricing, Bell Journal of Economics 4, 141--183.

Osterberg, W., 1996. The impact of depositor preference laws, Federal Reserve Bank of Clevaland Economic Review 32(3), 2--11.

Pennacchi, G., 2000. The effects of setting deposit insurance premiums to target insurance fund reserves, Journal of Financial Services Research 17(1), 153--180.

Pennacchi, G., 1987. A reexamination of the over- (or under-) pricing of deposit insurance, Journal of Money, Credit and Banking 19, 340--360.

Pyle, D., 1986. Capital regulation and deposit insurance, Journal of Banking and Finance 10, 189--202.

Ronn, E., Verma, A., 1986. Pricing risk-adjusted deposit insurance: An options-based model, Journal of Finance 41, 871--895.

Sheehan, K., 1998. Capitalization of the Bank Insurance Fund, Working Paper 98-01, FDIC.

Table 1. Basic Data and Results on the Sample of Forty Bank Holding Companies at 12-31-2000.

Bank Holding Company	Market Value of Common Equity	Face Value of Total Liabilities	Domestic Deposits	Percent Insured	Common Equity Dividends	Volatility of Equity	Volatility of Assets	Market Value of Assets	Correlation between Equity & BIF
Citigroup, Inc.	256,447	836,004	79,207	49.76	2,535	0.40	0.09	1,092,392	0.27
J.P. Morgan Chase & Co.	87,626	673,010	145,303	41.69	2,354	0.46	0.05	760,488	0.38
Bank of America Corporation	74,025	594,563	310,700	69.97	3,382	0.46	0.05	668,461	0.55
Wachovia Corporation*	38,572	306,570	175,834	67.48	2,351	0.44	0.05	345,096	0.71
Wells Fargo & Company	95,484	245,938	162,486	71.17	1,569	0.40	0.11	341,406	0.32
Bank One Corporation	42,479	250,665	142,110	60.80	1,454	0.45	0.07	293,092	0.67
FleetBoston Financial Corporation	34,069	163,347	82,331	60.88	1,111	0.49	0.09	197,343	0.49
SunTrust Banks, Inc.	18,665	95,257	59,815	68.90	352	0.42	0.07	113,911	0.47
The Bank of New York Company, Inc.	40,898	70,962	28,559	42.47	483	0.48	0.18	111,835	0.37
National City Corporation	17,514	81,765	51,535	80.56	520	0.41	0.07	99,272	0.67
U.S. Bancorp	17,485	78,696	52,613	65.80	645	0.51	0.09	96,132	0.36
KeyCorp	11,851	80,542	44,919	67.34	484	0.43	0.06	92,383	0.71
The PNC Financial Services Group, Inc.	21,188	63,260	45,404	69.90	530	0.41	0.10	84,442	0.65
State Street Corporation	10,043	66,036	11,987	3.96	112	0.51	0.07	76,044	0.42
Mellon Financial Corporation	23,941	46,412	33,018	45.72	421	0.47	0.16	70,340	0.45
BB&T Corporation	14,988	54,554	35,626	74.67	359	0.39	0.08	69,539	0.65
Fifth Third Bancorp	27,823	40,966	26,383	65.19	187	0.44	0.18	68,784	0.4
Northern Trust Corporation	18,120	33,560	12,828	42.40	124	0.53	0.19	51,652	0.36
Comerica Incorporated	9,319	38,025	26,531	53.01	250	0.40	0.08	47,341	0.56
Regions Financial Corporation	6,002	40,452	28,813	73.63	238	0.40	0.05	46,452	0.65
SouthTrust Corporation	3,439	41,794	27,351	65.80	168	0.46	0.04	45,226	0.48
AmSouth Bancorporation	5,701	36,155	25,986	79.07	102	0.45	0.06	41,848	0.34
Union Planters Corporation	4,817	31,801	23,113	84.37	271	0.38	0.05	36,617	0.41
UnionBanCal Corporation	3,832	31,958	24,904	44.32	161	0.63	0.07	35,728	0.32
M&T Bank Corporation	6,341	26,249	19,988	77.95	52	0.31	0.06	32,590	0.65
Huntington Bancshares Incorporated	4,061	26,233	19,369	79.14	189	0.46	0.06	30,287	0.56

(*Continued on next page*)

Table 1 continued

Bank Holding Company	Market Value of Common Equity	Face Value of Total Liabilities	Domestic Deposits	Percent Insured	Common Equity Dividends	Volatility of Equity	Volatility of Assets	Market Value of Assets	Correlation between Equity & BIF
Popular, Inc.	3,578	26,064	14,611	74.08	87	0.38	0.05	29,641	0.67
Marshall & Ilsley Corporation	5,228	23,836	16,811	68.23	107	0.40	0.07	29,062	0.97
Zions Bancorporation	5,438	20,159	14,932	66.41	41	0.53	0.11	25,579	0.32
Compass Bancshares, Inc.	2,888	18,543	14,057	70.78	106	0.44	0.06	21,428	0.45
Synovus Financial Corp.	7,668	13,491	11,162	61.53	125	0.37	0.13	21,158	0.34
First Tennessee National Corporation	3,726	17,172	12,190	54.93	114	0.56	0.10	20,876	0.47
National Commerce Financial Bancorporation	5,080	15,358	12,057	72.81	99	0.46	0.11	20,434	0.48
BancWest Corporation	3,254	16,468	13,868	65.64	85	0.45	0.07	19,718	0.37
Banknorth Group, Inc.	2,816	16,903	12,114	81.49	71	0.50	0.07	19,711	0.17
North Fork Bancoporation, Inc.	3,950	13,627	9,035	79.56	122	0.38	0.09	17,577	0.7
Hibernia Corporation	2,011	15,218	12,064	68.34	68	0.40	0.05	17,228	0.57
Associated Banc-Corp	2,008	12,160	9,292	78.92	76	0.41	0.06	14,167	0.42
Pacific Century Financial Corporation	1,408	12,725	6,500	74.26	56	0.52	0.05	14,127	0.52
The Colonial BancGroup, Inc.	1,186	10,984	8,135	80.20	49	0.42	0.04	12,169	0.58
Total	944,968	4,287,482	1,863,540		21,611			5,232,410	
Average	23,624	107,187	46,589	65.08	540	0.45	0.08	130,789	0.50
Average BHC	23,624	107,187	46,589	65.08	540	0.45	0.08	130,789	0.50
Index BHC	944,968	4,287,482	1,863,540	65.08	21,611	0.34	0.06	5,232,410	0.03

Figures in million dollars except for volatility, correlation and percent. Companies are ranked by market value of assets.
* Includes First Union.

Table 2. Actuarially Fair Premiums and Guaranty Funds.

Bank Holding Company	Premium*		Required Fund			
	In Cents per $100 of Deposits	In Million Dollars	α = 99%	α = 90%	α = 70%	α = 50%
Citigroup, Inc.	0.8	3.0	108,804	57,366	30,690	17,885
J.P. Morgan Chase & Co.	2.6	15.7	61,389	31,810	17,010	9,915
Bank of America Corporation	2.8	61.8	57,807	29,676	15,782	9,173
Wachovia Corporation	2.2	26.3	31,020	15,764	8,331	4,826
Wells Fargo & Company	0.7	8.6	38,459	20,272	10,842	6,317
Bank One Corporation	2.6	22.2	32,253	16,474	8,731	5,065
FleetBoston Financial Corporation	5.4	27.1	25,001	13,005	6,970	4,067
SunTrust Banks, Inc.	1.3	5.5	10,925	5,700	3,030	1,761
The Bank of New York Company, Inc.	3.7	4.5	18,096	9,714	5,256	3,081
National City Corporation	1.2	4.8	10,945	5,658	2,990	1,732
U.S. Bancorp	7.6	26.3	12,437	6,550	3,537	2,073
KeyCorp	1.7	5.2	8,790	4,536	2,395	1,387
The PNC Financial Services Group, Inc.	1.1	3.5	11,433	5,942	3,150	1,827
State Street Corporation	5.7	0.3	6,150	4,195	2,252	1,316
Mellon Financial Corporation	3.4	5.1	11,432	6,092	3,281	1,919
BB&T Corporation	0.7	1.8	7,716	4,180	2,208	1,278
Fifth Third Bancorp	1.3	2.2	9,827	5,456	2,935	1,715
Northern Trust Corporation	8.8	4.8	9,352	5,070	2,762	1,625
Comerica Incorporated	0.9	1.3	4,865	2,645	1,401	813
Regions Financial Corporation	0.9	1.9	3,722	2,011	1,060	614
SouthTrust Corporation	2.2	4.0	2,708	1,413	752	437
AmSouth Bancorporation	2.2	4.6	3,580	1,886	1,009	589
Union Planters Corporation	0.6	1.2	2,424	1,320	700	406
UnionBanCal Corporation	22.3	24.6	4,238	2,264	1,236	728
M&T Bank Corporation	0.0	0.0	1,981	1,332	697	402
Huntington Bancshares Incorporated	3.2	4.9	3,014	1,574	838	487
Popular, Inc.	0.5	0.5	1,926	1,137	598	346
Marshall & Ilsley Corporation	0.9	1.0	3,234	1,906	999	576
Zions Bancorporation	9.2	9.1	3,676	1,976	1,072	629
Compass Bancshares, Inc.	2.1	2.1	1,805	988	527	306
Synovus Financial Corp.	0.2	0.1	1,833	1,246	664	387
First Tennessee National Corporation	14.1	9.4	3,171	1,695	916	537
National Commerce Financial Bancorporation	3.2	2.8	2,770	1,528	818	477
BancWest Corporation	2.6	2.3	1,895	1,044	559	326
Banknorth Group, Inc.	5.5	5.4	1,857	998	541	318
North Fork Bancoporation, Inc.	0.5	0.4	1,599	1,080	569	329

(*Continued on next page*)

Table 2 continued.

Bank Holding Company	Premium*		Required Fund			
	In Cents per $100 of Deposits	In Million Dollars	α = 99%	α = 90%	α = 70%	α = 50%
Hibernia Corporation	0.8	0.7	1,107	657	347	201
Associated Banc-Corp	1.2	0.9	1,010	603	321	186
Pacific Century Financial Corporation	6.3	3.0	1,291	679	363	212
The Colonial BancGroup, Inc.	1.2	0.8	727	432	228	132
Total	134.14	309.9	526,267	277,875	148,368	86,401
Average	3.35	7.75	13,157	6,947	3,709	2,160
Average BHC**	2.37	7.18	14,789	7,747	4,130	2,403
Index BHC	0.11	14.1	296,406	200,000	153,707	82,180

Figures in million dollars at end 2000 unless otherwise indicated.
* Computed using the Ronn-Verma (1986) model. Multiplied by α they give the vulnerable premiums.
** Results for the Average BHC as defined in Table 1 and in the text.

Table 3. Approximate BIF Reserves Required

Coverage Level	1 ABHC	2 ABHCs	3 ABHCs	4 ABHCs*	5 ABHCs*
99%	15,046	20,272	25,501	29,710	35,000
90%	7,746	9,113	10,485	12,000	13,792
70%	4,130	4,616	5,089	5,329	5,880
50%	2,403	2,636	2,858	3,091	3,424

In million dollars at end 2000. Average BHCs are identical but have a correlation coefficient of 0.54, the average in the sample.

*Tentative.

Figure 1. Vulnerable Premium as a Function of BIF Assets