Appendix 6.1: Cost models

Deriving the fair value of guarantees

Scenario analysis

The scenario analysis presented in Chapter 7 takes as its starting point an industry group with an aggregate balance sheet of the following form:

Assets in Australia	A_a		Insured deposits / Policy liabilities	$D_i = xD$	
Assets overseas	A_o		Uninsured deposits / Policy liabilities	$D_u = (1-x)D$	
Total assets		A	Total deposits/ Policy liabilities		D
			Other liabilities	OL	
			Total liabilities		L
			Equity		E

It considers the effects of the failure of one institution in that industry and considers a number of cases for the characteristics of that institution.

Specifically:

- $y = A_i / L_i$ is the total assets/total liabilities ratio of the institution post-failure and a range of values less than unity are considered.
- m = market share of the institution pre-failure.

It is assumed that failure arises from a decline in asset value from a pre failure value of $A_i^0 = mA$ to post failure value of A_i. Liabilities are assumed unchanged, although because the results are driven by the ratio $y = A_i / L_i$, they can also be interpreted as arising from an increase in liabilities (as might occur in the case of insurance).

Total dollar losses to non-equity stakeholders in the failed institution are given by:

Shortfall (\$) = $L_i - A_i = mL - yL_i = mL - ymL$

Shortfall (\$)= mL(1 - y)

(Note that total losses to all stakeholders, including equityholders, are A_i^0 - A_i, which is greater than L_i - A_i. The focus here, however, is upon losses faced by other stakeholders including a guarantee scheme).

Total losses as a proportion of the equity capital of the remaining institutions is of interest because it illustrates the severity of the failure and indicates the ability of the industry to contribute to the cost of the failure. The shortfall as a percentage of equity of surviving institutions is given by:

Shortfall (% of capital) = Shortfall (\$)/(Capital of surviving institutions)

Shortfall (% of capital) = mL(1-y)/((1-m)E)

If a guarantee scheme is in operation, the net payouts involved depend upon the extent of the fall in asset values, the nature of depositor (or policyholder) preference arrangements and the proportion of deposit (policyholder) liabilities covered under the scheme. Denote the proportion of total liabilities covered by the scheme by x. If the ratio of total liabilities/(deposits (policyholder liabilities)) is denoted by z then the proportion of deposits (policyholder liabilities) covered by the scheme is xz. If depositor preference applies, such that all depositors rank ahead of other creditors (and the guarantee scheme assumes the place of insured depositors), payouts are given by:

Payout (\$) = Max [0, P]

where $P = xzD_i - xzA_i$.

In this expression, xzD_i is the payments made to depositors and xzA_i is the amount recovered by the guarantee fund from the failed institution's assets (which are A_i and of which the guarantee scheme is entitled to a share of xz).

Noting that $D_i = mD$ and $A_i = yL_i = ymL = ym(D+OL)$

$P = mxz (D - y(D+OL))$

Payout (\$) = Max [0, mxz(D - y(D+OL)] = Max [0, mxz(D-yL)]

It is also instructive to calculate the payout as a percentage of equity of surviving institutions, in order to consider the ability of scheme participants to fund such payouts and the impact of contributions on their capital position.

The net payout can be expressed as a proportion of the equity of surviving institutions as:

Payout (% of remaining equity) = Payout($)/(Equity of surviving institutions)

Payout (% of remaining equity) = Max [0, mxz(D - y(D+OL)]/ ((1-m)E)

Option pricing

The option pricing approach uses the equivalence between cash flows of a guarantee and of a put option written on the assets of the scheme member to estimate a 'fair value' for the guarantee. (Merton (1977) pioneered this approach). If the liabilities are fixed (as is often assumed in the application to deposit insurance), this approach requires as inputs the market value of assets, and the volatility of assets. Neither of these is directly observable, but can be estimated in the case of institutions for which share price data is available.

If liabilities are themselves stochastic, as is particularly relevant for insurance, but also applicable for depository institutions, the approach is more complicated. However, interpreting the volatility estimate as the volatility of net capital (assets minus liabilities) incorporates, in an *ad hoc* way, some of these complications. Because asset and liability values are less than perfectly correlated, it may be expected that a higher volatility figure applies to insurance firms (particularly general insurance) than to depository institutions. (Cummins (1988) applied the option pricing approach in a more rigorous fashion to insurance guarantee funds, and also allowed for the possibility of one-off catastrophic events).

The option pricing approach provides a 'fair value' estimate of guarantees, typically expressed as a fraction (basis points per dollar) of guaranteed liabilities. Unlike the expected loss approach, it assumes that the writer of the option is compensated for the systematic risk associated with the return on the option. This occurs because the option price is calculated by using the fact that the option is a derivative product based upon the underlying asset, and the systematic risk characteristics of the underlying asset will be reflected in the option price and expected rate of return on the option. Unless there is no systematic risk associated with the option, the 'fair value' will exceed the expected loss value. The option pricing approach also assumes no possibility of default risk of the guarantor (option writer).

It is also possible to 'back out' probability of defaults (PDs) and losses given defaults (LGDs) from the option pricing model. The option pricing model provides an estimate of the PD under an assumption of risk neutral pricing. To convert this into an estimate of the actual PD, it is necessary to adjust the risk neutral PD by a factor related to the excess return (over the risk free rate) of the underlying asset.

In what follows, the option pricing approach is applied to a 'typical' institution within each financial intermediary group. While this ignores important differences between institutions within each group, which is at heart of risk-based pricing, this approach provides 'ball park' estimates of the average cost of guarantees for different intermediary groups. In essence it assumes that there is no systematic difference in the risks associated with large and small institutions within the same group. The approach also highlights some of the problems associated with constructing and funding guarantee schemes for certain classes of intermediaries.

An important feature of the option pricing approach in estimating the cost of guarantees for coverage of part of deposit liabilities should be noted. Assume that x per cent of deposit liabilities are guaranteed, that the guarantee scheme has equal priority with uninsured depositors, and that all other creditors have junior status. Failure of the bank involves the guarantor in a net payout equal to x per cent of the gap between assets and total deposits. Hence, the partial guarantee G_p has total value equal to x per cent of a guarantee over total deposits (G_t), ie $G_p = xG_t$. If the guarantee is expressed as a proportion of the value of insured deposits D_p, where $D_p = xD_t$, it can be seen that $g = G_p/D_p = G_t/D_t$. The fair value per dollar of insured deposits is independent of the proportion of deposits guaranteed. In aggregate terms, the total value of the guarantee will change in direct proportion to changes in the coverage ratio.

Deposit insurance pricing with limited coverage and preference rules

Consider a bank with the balance sheet shown below.

Assets	A	Insured deposits	D_i
		Uninsured deposits	D_u
		Other creditors	C
		Equity	E

Letting r,ρ, and μ represent the interest rates promised to insured depositors, uninsured depositors, and other creditors respectively means that $B_i = D_i e^{rT}$,

$B_u = D_u e^{\rho T}$, and $B_c = Ce^{\mu T}$ are amounts promised by the bank for payment at date T.

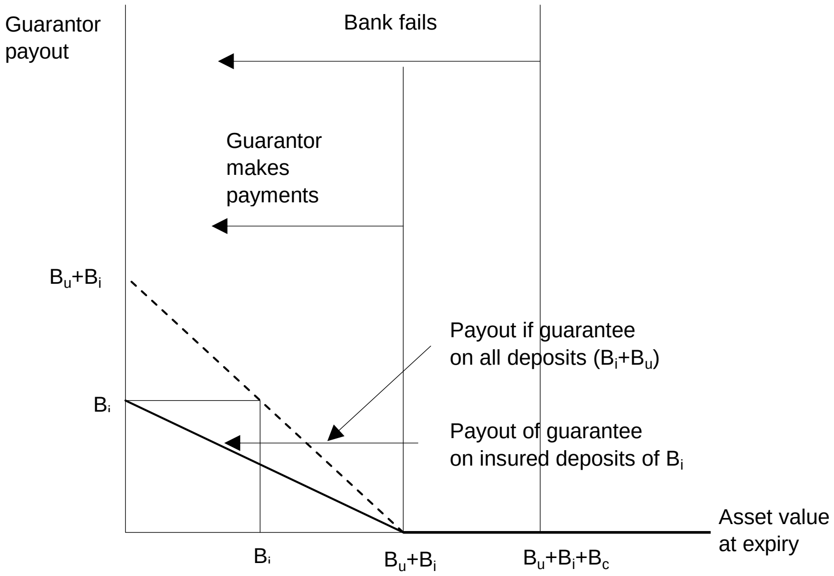
There exist depositor preference rules which mean that depositors have priority over other creditors. In the event of failure, the deposit insurer pays out insured depositors and takes over their claim on the assets, with equal priority to uninsured depositors.

The payout by the deposit insurer (depicted in Figure 1) is thus:

$$\text{Payout} = Max[0, B_i - \frac{B_i}{B_i + B_u} A] = \frac{B_i}{B_i + B_u} Max[0, B_i + B_u - A] \qquad (1)$$

Note that the bank could 'fail' in the sense that total liabilities (B_i+B_u+B_c) could exceed assets, but there may be no net payout by the deposit insurer, since assets still exceed deposit liabilities.

Figure 1: Payouts on Limited Guarantee



Equation (1) corresponds to a proportion of a put option on the bank's assets with a strike price equal to total deposits. The proportion is the ratio of insured deposits to total deposits. Note that the payout per insured deposit (Payout/B_i) is unaffected by the proportion of deposits covered (and hence the value of the guarantee per dollar of insured deposits is also unaffected). In contrast, the total payout (and total value of the guarantee) is affected by the proportion of deposits covered. These results reflect the assumption that the guarantee scheme has equal priority with uninsured depositors and seniority over other creditors. If uninsured depositors had preference over the guarantee scheme (which was still senior to other creditors) the cost of the guarantee would increase. The case where depositors (and the guarantee scheme) rank equally with other creditors is considered later.

If the value of a put option on the bank's assets with strike price equal to total deposits is denoted by P, the present value of the deposit insurer's guarantee, denoted by G, is:

$$G = \frac{B_i}{B_i + B_u} P \qquad (2)$$

and the required premium per dollar of insured deposits $g = \frac{G}{D_i}$ is:

$$g = \frac{G}{D_i} = \frac{e^{rT}}{B_i + B_u} P \qquad (3)$$

It is well known that P can be expressed using the Black-Scholes formula as:

$$P = (B_i + B_u)e^{-rT} N(d_2) - AN(d_1)$$

where

$$d_1 = \frac{\ln \frac{B_i + B_u}{A} - (r + \frac{1}{2}\sigma^2 T)}{\sigma \sqrt{T}}, and\ d_2 = d_1 + \sigma \sqrt{T}$$

σ is the volatility of assets per annum, T is the term of the option, r is the risk-free interest rate, and N(x) is the cumulative normal distribution evaluated at x.

Hence,

$$g = N(h_2) - \frac{N(h_1)}{d}$$

where $d = \frac{(B_i + B_u)e^{-rT}}{A} = \frac{D_i + D_u e^{(\rho - r)T}}{A}$

$$h_1 = \frac{\ln d - \frac{1}{2}\sigma^2 T}{\sigma \sqrt{T}}, and\ h_2 = h_1 + \sigma \sqrt{T}$$

If it is assumed that uninsured deposits also pay the risk-free interest rate (that is, $\rho = r$), then d is the ratio of (total deposits/assets).

This approximation (adopted by Ronn and Verma (1986) in their widely followed approach) does not substantially affect the resulting estimates. If, additionally, it is assumed that the institution pays a dividend equal to δA just prior to the end of the year, the value of the guarantee becomes:

$$g = N(y_2) - (1-\delta)\frac{N(y_1)}{d}$$

where $d = \frac{D_i + D_u}{A}$ is the deposit/asset ratio

$$y_1 = \frac{\ln[d(1-\delta)] - \frac{1}{2}\sigma^2 T}{\sigma \sqrt{T}}, and\ y_2 = y_1 + \sigma \sqrt{T}$$

This is the model used for the estimates contained in Chapter 7.

Implementing the approach requires estimates of the market value of assets (A) and the volatility of assets (σ). Ronn and Verma (1986) demonstrated a method for calculating these values from stock market information about the value and volatility of bank equity prices.

It is well known from option pricing theory that $N(y_1)$ can be interpreted as the 'risk neutral' probability of the option finishing in the money (the institution defaulting and the guarantee being used). That risk neutral probability is calculated on the assumption that all assets have the same expected rate of return regardless of risk. To calculate an actual probability of default, it is necessary to make an adjustment to reflect the fact that risky assets have a higher expected return than risk-free assets. (In the context of the Black-Scholes model, the drift rate of the underlying asset's value will be higher than the risk-free rate.)

Calibrating that adjustment requires, in principle, an estimate of the systematic risk (the beta) of the underlying asset. Assuming bank equity betas of around 1.2, and a ratio of assets to equity of around 16, the bank asset beta would be in the order of 0.08. Assuming an equity market risk premium of 6 per cent per annum, this would give an excess return on bank assets of around 0.5 per cent per annum. As an alternative approach, it can be noted that the reported (accounting) return on assets of Australian banks is around 1 per cent per annum. This is the excess return, after operating costs, over deposit interest costs, and corresponds to the excess return on assets in the option pricing framework.

For convenience, a risk premium on bank assets of 1 is used later for converting risk neutral to actual probabilities.

Some alternative deposit insurance models

Merton (1977) argues for interpreting the maturity of the put as the length of time until the next audit of the bank. Ronn and Verma (1986) model the bank equity as a call option on the assets and simultaneously estimate the asset volatility (σ) and the deposit guarantee (g), assuming a maturity of one year for both the call option (equity) and the put option (g). Their model also allows for forbearance on the part of the regulator. Merton (1978) models the insurance premium as a perpetual American put option with possible exercise at discrete intervals. Allen and Saunders (1993) also assume an infinite maturity American put option, and further extend the model to account for forbearance in the form of the insurer forcing exercise of the put option (at a different exercise price from that at which the bank would voluntarily close). They model the deposit guarantee as a callable put option. Dermine and Lajeri (2001) argue that if bank assets are loans with credit risk, there will be a non-symmetric distribution of returns on bank assets. They argue that the limited upside for bank asset values means that standard option pricing approaches can significantly understate the fair value of deposit insurance, particularly so for concentrated loan portfolios involving exposures to highly leveraged borrowers.

The effect of removing depositor preference rules

Suppose that it were the case that depositor preference were removed and (for simplicity of exposition) that other creditors ranked equally. Then failure of the institution would mean that available assets (A) would be shared proportionally among the guarantee scheme (with a claim of B_i), uninsured depositors (B_u), and other creditors (C). In terms of equation (1) this would mean that the strike price of the option was now (B_i+B_u+C). Essentially, other creditors and uninsured depositors can be aggregated for the purposes of valuing the deposit guarantee. Hence the only change is to redefine d as the ratio of deposits and other creditors to assets. The value of the guarantee will increase accordingly.

Calculating fair premiums for Australian financial institutions

Authorised deposit-taking institutions

Applying the option pricing approach to ADIs requires estimates of the deposit/asset ratio (d) and asset volatility (σ).

Banks

The ratio of Australian Assets/Australian Deposit Liabilities (both measured using book value) is generally in excess of 2, or higher if only household deposits are considered. The market value of assets and volatility of assets can be calculated for each bank using stock market data on bank equity prices. For current purposes, however, where a figure is required for an 'average' bank, and because of the balance sheet structure of the banks, it is adequate to use a range of estimates derived from other sources.

For the volatility of assets, estimates in the range 2-5 per cent per annum are used. This range is compatible with (the lower end of) estimates made for Australian banks by Gizycki and Goldsworthy (1999) and recent estimates of bank asset volatility for a sample of banks in the United States (Pennachi 2002).

The market value of assets can be calculated as book value of liabilities plus market value of equity, with the latter being calculated as book value of equity multiplied by an estimate of price/net tangible assets (NTA).

While a bank would 'fail' if liabilities exceeded assets, it is only if deposits exceed assets that the guarantee involves net payments in excess of recoveries to the guarantor. In this regard, estimates of probability of default from an option pricing model relate not to probability of failure of the bank, but to probability of a failure in which asset value has fallen below deposit liabilities.

Several caveats should be noted regarding the option pricing approach.

First, the implicit assumption that non-deposit liabilities (or uninsured deposits) would not decline as a bank approached failure is open to question.

If market discipline is effective, it would be expected that suppliers of such funds would, where possible, withdraw them as a bank's financial position deteriorated. Shibut (2002) cites several studies which demonstrate a decline in uninsured liabilities prior to bank failures in the USA. The likely size of the buffer provided in failure situations by the level of uninsured liabilities may thus be somewhat overstated by using data from normal situations.

Second, the market value of assets used in the option pricing model incorporates both tangible assets (for example loans and securities) as well as intangible assets such as the value placed by the stock market on bank charter value (as reflected in price/NTA ratios in excess of unity). In a failure situation, the value of those intangible assets shrinks markedly or disappears. Precise modelling of this effect could be undertaken at significant cost of complexity, but can be adequately captured for current purposes by examining results for higher volatility and/or lower price/NTA assumptions.

Third, the option pricing approach assumes that estimates of asset values found in bank balance sheets are correct. As the Federal Deposit Insurance Corporation (2000, p 17) notes,

> 'Reported information at times has been notoriously inaccurate. The FDIC's most costly bank failures in recent years have occurred rather abruptly among institutions that had consistently reported strong earnings or capital.'

To the extent that such reported misvaluations are possible, the option pricing model, which takes the figures at face value, will understate the probability of failure and the fair value of the guarantee.

Using asset volatilities in the range of 2-5 per cent and deposit/asset ratios of 0.8 or less, the fair value of deposit insurance as estimated using the option pricing approach, **given their current balance sheet structures**, is negligible (consistently less than one basis point per dollar of insured deposits). This reflects the strong buffer of equity and claims junior to insured (and uninsured) depositors. However, the results do hinge upon the validity of the model applied, which is not particularly well suited to incorporating the impact of a one-off, unimagined, crisis event, since it models failure as the cumulative outcome of a continuing sequence of small events.

These results do not imply that introduction of a limited guarantee should not occur. Imposing a limited guarantee provides protection to taxpayers and/or other banks as contributors to a scheme should a bank fail. It can increase the credibility of statements that other deposits are not guaranteed.

What the results indicate is that on a risk based pricing approach, the current rate of contribution from banks would be expected to be quite small. Capital adequacy requirements, firm prudential supervision (implicit in the one year horizon used in the calculation of the guarantee value) and depositor preference combine to reduce the probability of failures of a magnitude which would involve costs to the guarantee fund to virtually zero.

It should, however, be noted that the model results hinge crucially upon the assumptions contained therein, which do not really allow for the possibility of a catastrophic one-off fall in bank asset values (perhaps combined with an exodus of funds due to other creditors) as opposed to more gradual deterioration. Building in some probability of such an event would increase the probability of failure and the value of any guarantee — but such modelling would involve a degree of arbitrary judgement. Under current depositor preference rules, and with reasonable assumptions, it is unlikely that fair value figures in excess of a few basis points would result. Also relevant is the fact that even if such contributions were made under a pre-funded scheme it would take significant time before reserves accumulated which were sufficient to meet the costs of an unexpected failure.

The effect of removing depositor preference

If depositor preference were removed, the strike price of the option involved in deposit insurance now becomes the sum of deposits and other creditors. This makes a significant difference. For example, using an asset volatility (σ) of 3 per cent per annum, and equity/assets of 8 per cent such that d = (deposits and other creditors)/assets = 0.92 the actual probability of failure calculated is around 0.002 (1 in 500), and the fair value of the guarantee per dollar of insured deposits is around 6 basis points per dollar of insured deposits.

Note that removing depositor preference does not *ceteris paribus* alter the probability of bank failure (liabilities exceeding assets) but increases the probability that the guarantee fund and uninsured depositors would lose money. This is offset by other creditors experiencing smaller losses in the event of failure.

It could be expected that, were depositor preference removed and limited guarantees put in place, other creditors would lower the promised return demanded on their investments in reflection of the smaller loss-given-default they face. Whether this reduction would be of a scale (relative to the higher cost of deposit insurance) to be a net benefit to Australian banks is a matter for conjecture. Also important from a public policy perspective is the impact such a change would have on market discipline and external monitoring of banks. It could be anticipated that, if anything, market discipline exerted by other creditors may fall marginally, while uninsured depositors would increase monitoring.

Building Societies and Credit Unions

Building societies and credit unions have significant capital buffers, but relatively little in the way of other liabilities junior to deposits. Moreover, it is generally not possible to use stock market data to estimate asset value or volatility. Given the particular specialisation of lending business (primarily to retail customers), it is arguable that the volatility of assets would be at the lower end of the range assumed earlier for banks. Given the mutual status of most of the industry, it seems appropriate to take book value of assets as the best estimate of market value of assets.

These institutions have a strong capital position and some (but a much lower level of) other junior liabilities, such that the ratio of 'priority resident liabilities'/assets is in the order of 0.85-0.9. This means that the fair value of guarantees (for reasonable parameter values) is again quite small. Even assuming a high asset volatility estimate of 5 per cent per annum, the fair value estimates are below 2 basis points per dollar of insured deposits.

Insurance

The option pricing approach is more complicated for insurance companies because of the need to allow (*inter alia*) for stochastic liabilities, (imperfect) correlation of asset and liability values, and greater possibility of one-off catastrophic events. A further complication is that the promised (liability) amount cannot be assumed to increase over time at the nominal risk free rate of interest. Finally, the underlying premise of the option pricing approach that a perfectly hedged position is possible for the writer of an option is called into some doubt by the nature of insurance liabilities. Nevertheless, some insights into approximate costs can be obtained by *ad hoc* adjustments into the deposit insurance pricing model.

General insurance companies

For general insurance companies, asset and liability values may exhibit relatively low correlation. Assuming a volatility of the capital position higher than that for banks, perhaps of around 7 per cent, would thus seem appropriate. At the same time, the ratio of priority liabilities/assets for the industry is in the order of d = 0.7 due to capital adequacy and solvency requirements. For those assumed values, the fair value calculation again gives extremely small results of less than 1 basis point. The strong capital position assumed is the dominant factor driving such results; assuming instead that d = 0.9 leads to a fair value premium of around 23 basis points. Simultaneously assuming a higher volatility leads to significantly higher values. International experience of significant shortfalls in cases of general insurance failures and discrepancies between reported and eventual values of liabilities (and assets) illustrate difficulties in appropriately calibrating the option pricing approach.

Life insurance companies

Analysis of life insurance companies is complicated by the existence of statutory funds which hypothecate assets related to certain sets of policy liabilities. In considering policyholder protection it is thus appropriate to focus on the position of a typical statutory fund. Compared to general insurance, life offices have a higher ratio of priority assets/liabilities such that d = 0.8. At the same time, there is likely to be less volatility in the value of liabilities, such that an assumption of a lower volatility of the capital position is appropriate. Again, because of the strong capital adequacy and solvency conditions, the fair value of premiums are also extremely small.