LOAN PRICING: AN OPTION PRICING MODEL APPROACH

by

SATYAJIT DAS†

INTRODUCTION

The publication in 1973 by Professors Fischer Black and Myron Scholes of their seminal paper on option pricing theory provided powerful insights into the analysis of a variety of financial instruments and problems which either contain options or can be thought of as options. Option pricing approaches have been applied to the valuation of corporate equity or debt, convertible securities, underwriting problems as well as to the analysis of capital investment involving growth opportunities and project financing problems. The option element in revolving credit arrangements as well as the possibility of utilising option theory to price loan transactions has also been recognised.

The objective of this paper is to develop a loan pricing model based on option pricing techniques. The proposed approach to loan pricing is developed initially in the context of bank overdrafts, a special example of a loan, and subsequently extended to other types of loan transactions. The relevance of an option theoretic approach to general bank asset liability management issues is also considered.

LOAN PRICING AS AN OPTION PRICING PROBLEM

The process of financial intermediation entails a number of specific functions including temporal (or interest rate) intermediation whereby the intermediary assumes an interest rate risk in accommodating dissimilar demands on the timing of interest rate reset dates by investors and borrower. This process of temporal intermediation can itself be categorised as refinance risk and interest reset risk. Refinance risk refers to the situation where the investment or deposit matures prior to the termination of the loan it supports requiring the intermediary to refinance on then current terms, in particular, at current interest rates. Interest reset risk refers to the situation where the maturity of both loan and deposit are matched but the basis of interest determination on one is different to the other. For example, a fixed rate loan is funded by a floating rate liability exposing the intermediary to interest rate exposure in respect of the interest rate reset on its liability.

The major focus of this paper is on the applicability of option theoretic pricing approaches to loan pricing where the intermediary undertakes temporal or interest rate intermediation. In the simplest case, where the interest rate reset terms on all assets are exactly equal to the reset terms on all liabilities, no net interest rate risk is incurred and no options are created. However, where the interest reset terms on assets and liabilities diverge, a series of options are created which must of necessity be priced to cover the expected cost of this temporal intermediation service.

OPTION PRICING APPROACHES TO OVERDRAFT PRICING

The option element in this temporal or interest rate intermediation function is best illustrated by example. In the present case, the option elements evident in an overdraft, a very common but analytically complex credit arrangement, are examined.

An overdraft is essentially a loan with a term of a single day usually capable of renewal at maturity. Where it is able to be matched with a liability with an identical maturity, i.e. a single day, and the interest rate on the loan could be reset daily, there would be no element of temporal intermediation in the transaction. Accordingly, no option component in respect of the interest rate exposure would exist. In reality, there is an interest rate exposure on such facilities created, in part, by the fact that the interest...

†The author is with Citicorp Capital Markets Australia Limited. The views and opinions expressed are those of the author and do not represent the views and opinions of the Citicorp Capital Markets Group.
rate charged on overdrafts is held constant for some period of time during which time the funding cost (which may be equated to the overnight or very short-term money market rates) may vary significantly.

The extent of the interest rate exposure assumed by the financial intermediary and the associated pricing problems are evident from the practice of "round-tripping" or "overdraft arbitrage" utilised by sophisticated borrowers. Under this practice, in periods of tight liquidity, when the differential between the overdraft rate charged by banks (i.e. the prime, base or indicator lending rates) and short term money market rates becomes significant, money market participants, in particular financial intermediaries, seek to outbid each other to attract wholesale deposits. It then becomes profitable for borrowers with surplus available credit facilities to borrow under its overdraft facilities from one bank and reinvest the funds in the money market for short periods, even with the same bank.

Two conceptual frameworks applying option pricing models ("OPMs") to overdraft pricing suggest themselves:

1. The Asset Approach
An overdraft is effectively a facility constructed around a put option (purchased by the borrower in establishing the line of credit) to sell a callable security to the bank at a prenominated price (which is related, in effect, to the interest rate charged on the facility).

This conceptual framework, which adopts the viewpoint of the borrower, entails two separate options: (1) the put option whereby the borrower can sell securities to the bank to fund itself; and (2) a call option on the security itself whereby the borrower can, at its discretion, retire the security when it is financially or otherwise expedient for it to do so.

It is important to note that the exercise of one option is a necessary precursor to the creation of the other option, i.e. the call option may be termed a 'contingent' call. The exercise of the put option gives rise to the call option on the security placed with the bank; with the exercise of the call option creating a further put option, at least, until the expiry of the facility. The options may, of course, co-exist when only part of a facility is being utilised. The options are also by their very nature continuous over the life of the facility, i.e. they are "American" options exercisable at any point in time up until the expiry of the facility.

This method of valuing the put and 'contingent' call option clearly assumes that the security sold by the borrower to the bank in exercising its put option is a security with a term greater than one day. This is because where the underlying security has a maturity of one day (i.e. a one day loan), there would be no necessity to price the 'contingent' call previously identified. Instead, a series of put options on one day securities could be identified and priced accordingly.

2. The Funding Hedge Approach
An overdraft can be viewed as an uncertain and contingent funding commitment by the lending institution whose funding costs may be "hedged" through a series of futures options or combinations of futures contracts and futures options positions. This conceptual framework, in contrast to the previous one, views the overdraft as essentially a funding problem from the perspective of the institution providing the facility (i.e. the uncertain price behaviour of the underlying security the bank has contracted to purchase at a prenominated price).

The "cost" to the lender of this price uncertainty may be estimated by reference to two possible "hedging" strategies to limit the funding risk: (1) the sale of a series of futures contracts and simultaneous purchase of an exactly corresponding series of call options on the futures contract to close-out the short futures position at a known price (i.e. limited "downside" risk) where the bank's funding needs do not evenuate; or (2) the purchase of a series of put options on the futures contract (as with (1) above over the corresponding term of the facility) to provide the lender with a hedged maximum cost of funds over the period of the contingent funding need at a cost, i.e. the cost of the futures option and associated hedging costs.

Strategies (1) and (2) are identical in practical effect although differences in pricing (which may develop in a traded market) between futures call and put options may, at a particular point in time, favour one or other strategy. Strategy (1), as it assumes an open futures short position, will entail financing charges on deposits and margin calls (if any) which are not present in the alternative strategy.

The need for this contingent funding cost hedge is,
of course, continuous, at least over the life of the overdraft facility.

Both approaches – the asset and the funding hedge alternative respectively – are analysed in detail below.

The asset model and the funding hedge approach are, in reality, two equivalent ways of analysing the same problem. The primary difference appears to be that the asset approach is valued (or in strict theory should be valued) off securities issued by a borrower of the relevant risk categories while the funding hedge approach values them off securities issued by the bank or relevant lending institution. In a perfect market, the two approaches should yield identical results. The difference in the two approaches seems to be one of the ease of practical implementation rather than conceptual differences; for example, the funding hedge approach may yield a more practical result as it can make use of data from the futures market in bank accepted paper.

It should be noted, at the outset, that neither model proposed requires any physical or futures transaction to be undertaken in attempting to price the relevant facility. For example, the futures option or hedging methodology does not actually require a series of hedges to be created. In actual fact, as discussed below, such a series of hedges could not be created because of institutional limitations.

The proposed model enables, as a practical matter, the quantification of the relevant costs of providing (or conversely using) the facility, thereby enabling a more precise pricing which reflects the true costs and benefits to the parties of the facility. For example, the futures option “hedging” model enables calculation, within the conceptual framework proposed (which bears a very close correspondence to reality), of the cost of “insuring” the lender’s cost of funding at the required level which enables it to maintain its usual lending margin. This “insurance” cost can then be incorporated into the charge made to the borrower. This extra charge does not need to be an explicit or separately disclosed cost to the borrower but can be included as a component of the overall interest rate charged on the overdraft facility (see discussion below).

The separate charge proposed as the price of the option or insurance cost is not in any sense an additional charge to the borrower. In fact, some similar amount is undoubtedly being built into the current overdraft interest rate as an additional “protective” margin over and above the cost of funds and usual lending margin to protect the lender from unanticipated adverse movements in funding costs. The advantage of the proposed option pricing approaches to overdraft pricing is that they allow an accurate and rigorous quantification of the “protective” margin.

**THE ASSET APPROACH**

The asset approach is predicated on the assumption that the cost of providing an overdraft facility is, in reality, made up of two separate costs – the cost of funding (in this framework, strictly speaking, it should be the market price of the security placed by the borrower with the bank) and the cost of writing the put and contingent call option. The symmetric cost of the facility to the borrower would be made up of the interest cost of the facility (the pre-arranged price of the security) and the cost of purchasing the put and call options.

The payoffs to the bank and the borrower in respect of the put option written by the bank and purchased by the borrower are as follows: the put option will only be exercised if the market price of the security is below the exercise price of the option; i.e. in other words, the interest rate charged on the overdraft (which is taken to include any fees, transaction charges etc.) is less than market interest rates on equivalent funding. This implies in return that the risk borne by the borrower is limited to the premium for the put option while his potential gain (at least, theoretically) is unlimited. Conversely, the put option writer’s gain is limited to the amount of the premium while its theoretical potential loss is unlimited, i.e. the bank’s cost of funding its overdraft facility, at the margin, is potentially unlimited.

Where the put option is exercised by the borrower a further option – the “contingent” call option on the security placed with the bank – comes into play. The payoffs to the bank and the borrower in respect of the call option written by the bank and purchased by the borrowers are as follows: the call option will only be exercised by the borrower when the market price of the security rises above the exercise price of the option; i.e. in other words, the interest rate charged on the overdraft is higher than market interest rates on equivalent funding. This implies that the risk, once again, borne by the borrower is
limited to the premium paid for the call option while his potential gain (at least, theoretically) is unlimited. Conversely, the call writer’s (the bank’s) gain is limited to the amount of the premium while its theoretical potential loss in unlimited.

As already noted, the pricing approach utilising the put and “contingent” call option clearly assumes implicitly that the security sold by the borrower to the bank under the terms of the put option is a security with a term greater than one day. Where the underlying security has a maturity of one day, i.e. the equivalent of a one day loan, there is no need to price the contingent “call” option. Instead, a series of successive put options on one day securities could be identified and priced accordingly.

The use of security with a maturity greater than one day is problematic in that the price of such a security will incorporate certain risk elements relative to the expected compound single day returns over the term of the security. This reflects the fact that the security (where its maturity exceeds one day) itself provides the borrower with a guarantee that the average cost of funds will not be more than some rate.

Where the “contingent” call approach is utilised, it is necessary for the call option to be costed as contingent to avoid any element of double counting. Where the call is costed as being contingent, its value would naturally be reduced.

The above discussion assumes implicitly that “rational” utilisation of overdraft facilities is predicated solely on the market price of the security relative to the exercise price of the security, i.e. the interest rate on the overdraft vis a vis other equivalent market interest rates. This is, of course, merely a more elegant restatement of the “round-tripping” or “overdraft arbitrage” problem in an option theoretic framework. Clearly, as a practical matter, the optimal exercise strategy assumed is not necessarily a unique one and the introduction of alternative optimality criteria could yield various exercise strategies.

The principal alternative criteria requiring consideration in this context is that of the borrower’s funding requirement. The main implication of these additional optimality criteria is that drawings under an overdraft facility may take place even when the pure price (or interest cost) criteria would militate against such drawings. It is, or course, clear that the large corporate borrowers are increasingly aware of this particular issue and it is likely that increased switching between various short-term facilities, i.e. overdraft, bill lines, money market borrowings etc. is and will continue to be used to minimise short-term funding costs.

Given this need to distinguish (where feasible) between a “base” borrowing component and a more “discretionary” component of overdraft pricing, a differential funding strategy in respect of the two components needs to be adopted. The based borrowing component or the extent to which overdraft usage is anticipated should be funded by liabilities whose terms closely match the expected period of the asset, i.e. the interest rate exposure arising from interest rate reset risk is totally eliminated.

The term of the liabilities can, of course, be fixed by either raising deposits with the requisite maturity or using futures to shorten or lengthen the life of the relevant liability portfolio.

The option theoretic approach to overdraft pricing becomes more relevant to the “discretionary” component of overdraft drawings. In this context, the borrowers enjoy the benefits of the options identified and, conversely, the lending institution bears the risk of providing the revolving credit line. Consequently, the overdraft cost (payment) to the borrower (lender) should reflect the “true” cost of the options which underlie the facility in addition to the pure cost of the security (cost of funds to the lender).

The option prices can be derived in this case using the Black-Scholes (1973) option pricing model:

\[ C (P, T, Ex) = P_N(d_1) - Ex \cdot e^{-RT} \cdot N(d_2) \]

\[ d_1 = \frac{\log (P/Ex) + RT + S^2T/2}{S \sqrt{T}} \]

\[ d_2 = \frac{\log (P/Ex) + RT - S^2T/2}{S \sqrt{T}} \]

Where

- \( C \) = market price of a European call
- \( P \) = price of underlying security
- \( T \) = time to exercise date
- \( Ex \) = exercise price of option
- \( N(d) \) = cumulative normal probability density function

\[ P_N(X) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{X} e^{-t^2/2} dt \]
\( R_f \) = risk-free interest rate continuously compounded
\( S \) = standard deviation per period of the instantaneous rate of return on the security.

The price calculated for the call option can, of course, then using put-call parity be used to arrive at the price of the equivalent put option. In equilibrium:

\[
C + \text{Ex}.e^{-R_f T} = R_f T + P
\]

Where

\[
C = \text{value of the call}
\]

\[
\text{Ex}.e^{-R_f T} = \text{present value of the exercise price calculated at the continuously compounded risk-free rate of interest}
\]

\[
P_t = \text{value of the put option}
\]

\[
P = \text{price of the underlying security.}
\]

To enable utilisation of the Black-Scholes valuation formula in the context of overdraft pricing, it is necessary to relate the specific elements of the formula to their underlying concepts as they apply to the operations of a financial intermediary.

In particular, it is important to note at the outset that the option prices do not of themselves constitute the overdraft price but rather represent an additional cost to that of funding. The option value generated does not take account of the contingent call option in an overdraft (refer discussion above). More specifically:

\( P \) — is equal, in strict theory, to the value of the underlying asset — i.e. an overdraft/bank loan to borrowers of the relevant risk category for the relevant term (also referred to as \( V_t \) in footnote 9 above). In practice, the difficulties of implementing this approach may require the intermediary to use its cost of funds (e.g. from the data on markets in bank accepted paper) and could be adjusted for the costs of administration and profit margins. The value of the underlying asset will depend on the interest rate on the loans, or the cost of funds, but will itself not be a rate.

\( \text{Ex} \) — is equal to the exercise price of the overdraft or, in other words, the present value of interest cost of loans plus repayment of principal. It should be noted that this exercise price is exclusive of the option price.

\( T \) — is, of course, equal to the time outstanding until expiry date. The expiry date in this context would be a period agreed to by the bank and the borrower at the end of which the terms (particularly, the cost) of the overdraft could be reviewed, e.g. quarterly or semi-annually. In this context, the fact that the model is concerned exclusively with European rather than American options is problematic. While it is possible to show than an American option would not generally be exercised prior to the actual expiry date, (although American put options may be exercised before expiry, under certain conditions), this condition will clearly not be relevant to the overdraft pricing problem as there may be multiple optimality criteria and the rational exercise strategy may not dominate other optimisation strategies.

However, this problem can be overcome by the relatively simple expedient step of constructing a series of options. Specific solutions could be generated for each component option to reflect the continuous nature of the borrower's options.

\( R_f \) — would generally be the continuously compounded interest rate on Government Securities for the appropriate time horizon. The Black–Scholes valuation formula assumes \( R_f \) is constant over the whole period until the exercise date although variations on the model can be derived to cater for variable risk free rates. Alternatively, a series of \( R_f s \) could be used to reflect the government securities yield curve to exactly match instrument maturity and the subsisting period until exercise date of the option to provide the required constancy.

\( S \) — would be the variance of the rate of return on \( P \) above, i.e. in theory, the variance in the cost of overdrafts to borrowers of the relevant risk category. However, where the cost of funds to the bank or other intermediary is used it will be the variance on the intermediary's cost of funds.

It is necessary to differentiate between volatility of the average and margin cost of funding. The average cost of funding will usually be markedly less volatile than the intermediary's marginal funding costs. The exact relationship will reflect the particularly liability maturity structure of the institution and also the maturity or deposit "roll-over" timing.

In the present context, only the volatility of the lender's marginal funding costs (which could be derived from the variability in short-term money market rates) is relevant. This is particularly so
where a distinction between base and discretionary funding of overdraft facility is made, as it is specifically assumed that the latter is temporary and contingent and will inevitably be funded at the margin and consequently it is only the marginal cost that will be relevant in this context.

In summary, the Black-Scholes model could be used to derive the price of the relevant call option and the corresponding price of the put option would be derived through the price parity relationship between put and call options. In practical terms, the prices would be derived for a discrete amount and the cost apportioned appropriately and built into the final charge to the borrower.

**THE FUNDING HEDGE APPROACH**

As noted above, the funding hedge approach provides an alternative means of conceptualising the pricing of the overdraft facility. In essence, it replicates the first approach but from the viewpoint of the lender and, in particular, its cost of funding the facility. The approach has a number of similarities with the security put option approach – in particular the capacity to distinguish between base and discretionary elements of the facility – and consideration of these aspects is not repeated.

The funding hedge approach is predicated on the fundamental assumption that the lender has a commitment to lend at a prenominated rate irrespective of its cost of funding at the particular time. There are two elements to this commitment: uncertainty of timing (i.e. when (if at all) the facility will be utilised) and uncertainty of amount (i.e. how much the lender will be asked to fund up to a maximum of the stated limit).

This uncertain and contingent nature of the commitment only applies in respect of the discretionary amount where it is feasible to separate the aggregate facility into separate base funding and discretionary amounts. It is, of course, clear that any amount identified as a permanent or base level of utilisation of the facility can be funded by liabilities whose maturity structure closely matches that of the asset. This match can be either a physical match or one replicated through futures positions.

The funding hedge approach is based on the fundamental premise that the cost of providing this discretionary component of the overdraft can be equated with the cost of “insuring” the lenders’ cost of funding of the facility at a satisfactory, predetermined cost. This insurance can be obtained through the use of futures options either alone or in conjunction with future contracts.

Two separate methods are possible:

1. A short (or sold) futures position and a long (or bought) position in futures call options designed to close out the short position at a known cost if actual funding needs do not arise.
2. A long (or bought) position in futures put options designed to provide a contingent short hedge against an uncertain commitment to fund.

Both strategies are essentially equivalent (at least where put and call option prices are identical) and for ease and clarity of presentation further discussion will be mainly confined to Method 2.

The strategies identified provide a contingent hedge, i.e. protection against uncertain commitments, as distinct from a futures transaction which can only protect against certain commitments, and leaves an open or speculative position in the futures markets if the commitment in the physical market fails to eventuate. This effectively means that the lenders’ loss is always, in the strategies discussed above, limited to the amount of the call or put premium.

The methodology outlined also merely sets a maximum funding cost (unlike a futures transaction which locks in a certain cost) and therefore does not precluded the lender obtaining funding at a price lower than that assured under the insurance principles outlined.

As already identified, option theoretic approaches to overdraft pricing are “conceptual” in nature rather than “actual”, in the sense that no actual transaction, i.e. futures trades etc. are envisaged. In terms of the funding hedge approach, in fact, existing institutional arrangements in futures markets would not enable the type of contingent hedging program envisaged.

Firstly, there are no futures contracts covering very short term cash rates although this problem can be partially overcome (albeit imperfectly) by cross-hedging techniques utilising existing contracts such as the Sydney Futures Exchange 90 day Bank Bill Contract which would show some relationship to very short term money market rates.
Secondly, no relevant contract trades on a daily basis, i.e. there are no futures contracts traded on the basis that successive futures contract mature on successive days. It is possible to overcome this problem since option theoretic pricing approaches do not require actual trading in the relevant futures or options as long as an actual theoretical price for the relevant futures contract and the corresponding futures option price can be derived. Given a known yield curve at a particular time, it is possible to derive implied forward interest rates for very short term (one day/overnight) borrowing rates. In view of the fact that the process of arbitrage will tend to drive the futures price towards the implied forward price (i.e. the equivalent implicit interest rate), the required futures price and the corresponding options price can be derived.

The futures option price can be derived using the following approach suggested by Black (1976):

\[ C^*(F, T, Ex) = e^{-RfT}(F \cdot N(d_1) - Ex \cdot N(d_2)) \]

Where

\[ d_1 = \frac{(\log F/Ex) + S^2T/2}{S \sqrt{T}} \]

\[ d_2 = D_1 - S \sqrt{T} \]

Where

- \( C^* \) = market price of a European call
- \( F \) = price of underlying futures contract
- \( T \) = time to exercise date
- \( Rf \) = risk free rate continuously compounded
- \( Ex \) = exercise price of option
- \( S \) = standard deviation per period of the percent change in \( F \)
- \( N(d) \) = cumulative normal probability density function

The price of the equivalent futures put option in equilibrium will equal:

\[ C^* - P^* = e^{-RfT}(F - Ex) \]

Where

- \( C^* \) = value of futures call
- \( Ex \) = exercise price
- \( P^* \) = value of future put
- \( F \) = price of underlying future contract

The futures option price derived is, of course, an additional cost over an above the projected or estimated cost of funding the facility. More specifically:

- \( F \) — will be equal to the price of the underlying futures contract (e.g. as derived from the forward rates implicit in the yield curve).
- \( T \) — will be equal to the time outstanding until expiry date of the option. The Black futures option pricing formula arrives at a price for a European option and consequently, a series of options will need to be constructed to replicate the continuous nature of the commitment and concomitant "insurance" requirement.
- \( S \) — in this context will necessarily have to be the variability of the rate of return on \( F \). Given that, in reality, no actual futures contract exists, the volatility of underlying short-term money market rates as the 24 hour cash rate, etc. will usually be utilised.

In summary, the Black futures option pricing formula will yield the price of the relevant call option and enable calculation of the corresponding put option price. This price would then be apportioned appropriately over the total overdraft portfolio and included in the final charge to the borrower.

**IMPLICATIONS OF OPTION THEORETIC APPROACHES TO LOAN PRICING**

The above analysis highlights the capacity of option theoretic approaches to loan pricing to provide a more sophisticated treatment of risk. This has the potential to add value to asset/liability management in Financial intermediaries, particularly where the activities of these institutions involve temporal or interest rate intermediation. The principal advantages of this theoretically elegant application of option theory to loan pricing relate to the potential of this approach to enable accurate or "fair" pricing of the risks of asset/liability mismatches commonly accepted by intermediaries.

Where interest rates charged to borrowers are fixed or slow to adjust to changing market conditions, and where the loans are not funded by exactly matching liabilities to eliminate any interest rate reset risks, the terms of the commitment expose the bank to the risk of erosion of its profits from the transaction. Financial intermediaries have basically two alternatives to avoid lower profitability or losses due to unfavourable interest rate movements: to avoid assuming interest rate risk by passing the risk on to the borrower (this has primarily been
achieved through the use of variable rate loan commitments designed to match the intermediaries’ funding base); or to “correctly” price the risk being borne. The option theoretic approach provides and insightful framework for analysing the risks assumed and pricing the risk.

Given that where the intermediary assumes an interest rate risk, it is, in some sense, “insuring” the borrower from the same risk, the intermediary should be compensated properly for bearing the interest rate risk. Option theoretic loan pricing models potentially provide a means of pricing this risk enabling intermediaries to provide products such as fixed rate, long term loans where the borrower does not wish to assume the interest rate risk itself. The cost of “insurance” against interest rate risk is clearly additional to the cost of actually funding the loan and can be built into the fee structure or the interest rate charged on the Loan Facility.

**Extension of Option Theoretic Loan Pricing Models**

The option theoretic loan pricing model developed in this paper has, to date, focused on the pricing of overdrafts, a specialised and particularly complex loan facility. As will be evident, the option theoretic approach is capable of generalisation to: pricing of most types of loans entailing asset/liability mismatches; and to analysis of general asset/liability “gap” management problems.

Where general loan assets entail asset/liability mismatches, two particular situations can be envisaged:

1. A “long” asset funded by a “short” liability – whereby a fixed rate loan is funded by rolling a series of liabilities with maturity dates shorter than on the loan; or a loan on which the interest rate reset date is further in the future relative to the rate reset date on the liability raised to fund the asset; and

2. A “short” asset funded by a “long” liability – which is the converse of (1) – entailing a loan being funded by a fixed rate liability whose maturity date is longer than that on the asset or a loan on which the interest rate reset date is closer in the future relative to the rate reset date on the liability raised to fund the asset.

In both instances, the intermediary assumes an interest rate exposure; in the first case, on the refinancing of the liability or deposit; and in the second case, on the reinvestment rate on the new loan asset or investment. The intermediary, in both cases, takes on this risk in the expectation of higher earnings: in the first case, from falling interest rates; and, conversely, in the second, from increasing rates. The type of option theoretic approaches developed in the context of pricing overdrafts can be utilised to price the risk assumed.

In the first case, the risk assumed can be characterised within an option framework which recognises the potential for upside as well as a downside variations in returns reflecting the asymmetric changes in option value where interest rates rise and fall. The downside variation or risk in the first case can be analysed and priced in terms of being equivalent to writing a put option whereby the intermediary would experience lower than expected profitability or even losses where interest rates rose (the price of debt fell). Alternatively, the position could be analysed and priced in terms of the cost of purchasing a put option or options to set a maximum borrowing cost for funding the loan asset. In both cases, the pricing of the option represents an approximation to the “fair” price of the risk and should be costed into the interest rate charged on the loan asset.

In the second case, the downside variation or risk can be analysed and priced in terms analogous to writing a call option whereby the intermediary would experience reduced profitability or losses where interest rates fall (the price of debt rises). Alternatively, the position can be analysed and priced in terms of the cost of purchasing a call option or options to provide a minimum rate of earnings on the loan assets or investments to be funded by the relevant liability. The pricing of either option represents an approximation of the “fair” price of the risk assumed and should be costed into the interest rate paid on the liability.

The option price in both cases represents, in some sense, a minimum reward or expected return for the interest rate exposure assumed by the intermediary in creating and maintaining the asset/liability mismatch.

It is relatively simple to extend this mode of analysis from the context of a single loan to the broader context of maturity gap models utilised in overall asset/liability management of financial intermediaries. The basic maturity gap models utilise modern bond
portfolio management concepts such as duration to arrive at a measure of the difference between the dollar amounts of rate sensitive assets and rate sensitive liabilities. Importantly, however, intermediaries cannot use asset/liability gap models to price the risk of deviation from a "zero" maturity gap strategy.

Where the intermediary seeks to actively manage its maturity gap, it automatically places the institution's net interest income at risk as it assumes the interest rate risk of associated temporal or interest rate intermediation. The option theoretic pricing approaches identified in the case of individual loans involving asset/liability mismatches may be extended to overall maturity gap strategy without significant amendment. Consequently, a "positive" gap strategy can be treated as analogous to pricing a put option while a "negative" gap strategy is analogous to pricing a call option on the intermediary's asset/liability portfolio. As in the case of individual loans, the pricing of the relevant option represents an approximation of the price of the risk of the gap strategy being pursued and should be costed into the net interest margin sought to be maintained or, alternatively, should represent the minimum expected return for the interest rate exposure assumed by the intermediary in creating and maintaining the asset/liability mismatch in respect of the institution's total portfolio.

SUMMARY AND CONCLUSION
The development of modern portfolio theory and the theory of option pricing has provided powerful insights into a number of financial instruments and transactions which can be characterised, in some sense, as options or contingent claims. This paper has sought to develop a loan pricing model based on option pricing techniques.

The analysis highlights how financial intermediaries, such as banks, create implicit options whenever they depart from a perfectly matched asset/liability strategy on either individual loans or their overall asset/liability portfolios. These options reflect the risk assumed in performing the temporal or interest rate intermediation function whereby the intermediary accommodates dissimilar demands on the timing of interest rate reset dates by asset and liability customers. Given increased levels of competition between financial intermediaries, banks and other institutions are increasingly forced to run mismatches on their asset/liability strategy to increase earnings while simultaneously increasing their exposure to fluctuations in interest rates in increasingly volatile financial markets. In this context, the more sophisticated treatment of the risks assumed through a rigorous analysis of the options created implicitly by financial intermediaries has the potential to add significant richness and value to asset/liability management concepts.

SELECTED REFERENCES
Satyajit Das "Option Theoretic Approaches to Loan Pricing" in Bulletin of Money, Banking & Finance (1984-85) No. 4 pp 1-35.