

Institute of Actuaries of India

Subject SA5 – Finance

November 2008 Examination

INDICATIVE SOLUTION

Introduction

The indicative solution has been written by the Examiners with the aim of helping candidates. The solutions given are only indicative. It is realized that there could be other points as valid answers and examiner have given credit for any alternative approach or interpretation which they consider to be reasonable

Q No. 1 (a)

- The three important features of liabilities that need to be taken into account are
 - Nature
 - Term
 - Currency
- For this purpose we can define the Liability Outgo as Benefit Payments + Expense outgo – Premium Income
Nature of Liabilities :
 - The benefit payments can be subdivided into the following categories
 - Guaranteed in Money Terms: This will include the guaranteed benefit payments under all forms of without- profits (non-par) contracts and the accrued contractual benefits under with profit (par) contracts
 - Guaranteed in terms of an index of prices or similar index: This consists of benefits whose amount is directly linked to such an index.
 - Discretionary: This will consist of the future bonus payments under with profit contracts and surrender values where these are not guaranteed.
 - Investment Linked: This will consist of benefits under unit- linked and index linked contracts, the amount of which is determined directly by the value of the investments underlying the contracts.
 - Expense Payments tend to increase not necessarily in line with movements in price index. However for practical purposes they can be included with benefit payments guaranteed in terms of a price index or a similar index
 - Premium payments are usually fixed in monetary terms and hence can be thought of as negative benefit payments guaranteed in money terms.
- Term
 - From an investment standpoint it is useful to consider the discounted mean term (DMT) rather than the actual nominal term. To the extent it is feasible the investment strategy will be to match the discounted mean terms of the assets and the liabilities in order to mitigate the downside impact of interest rate risk on the surplus. (Surplus is defined as the value of assets less the value of the liabilities)
- Currency
 - Liabilities denominated on a particular currency should be matched by assets in the same currency in order to reduce any exchange rate (currency) risk
 - An alternative way of matching is to invest in overseas assets and then to hedge using appropriate currency derivatives

Q No. 1 (b)

Alternative Investment Strategies for Enhancing Returns:

- Higher fixed interest returns might be achieved by buying bonds like corporate bonds with a higher credit risk than comparable Government bonds in order to receive the credit spread

Historical evidence suggests that, on average, such bonds do provide higher actual returns even after allowing for higher level of actual defaults.

However the risk in this strategy is that the price of such bonds may fall as credit quality is perceived to deteriorate and ultimately such bonds may default.

- Similarly callable bonds may give higher returns but carries the risk of being called before maturity. In addition, if they are corporate callable bonds, then the credit risk issues as discussed above will apply.
- Policy switching may be a strategy for enhancing returns. For example, if the investment manager believes that interest rates are going to fall, then he can increase the duration of the bond portfolio relative to that of the annuity portfolio and vice versa if he believed that interest rate are going to rise
The risk in this strategy is that the prediction/belief can turn out to be incorrect in which case the investment manager will lose money. In other words the investment manager would need superior market timing skills to repeatedly call the market correctly.

Also the active pursuit of this strategy will result in frequent churning of the bond portfolio with the associated transaction (dealing) costs.

- Anomaly switching can be a strategy for enhancing returns. This will involve switching between similar bonds that appear temporarily mis- priced.
- This strategy will typically be effective in the less price- efficient segments of the bond market (ef: the small and medium size corporate bond issues).

However the risk associated with this strategy will be low because it will not involve any mis- matching of the liabilities

- Riding the yield curve can be a strategy for enhancing the returns. The investment manager can buy longer term bonds when the yield curve is upward sloping and shorter term bonds when the yield curve is downward sloping
The risk in this strategy is the duration mis- match between the assets and the liabilities.
- It may be possible to carry out the above switching strategies using traded derivatives so as to reduce the transaction costs involved.

Question (1)(c) (i)

Main Limitations of Basel II:

- The risk weighting bands used are rather crude. Therefore the risk weighting for any individual asset may not necessarily be an accurate reflection of the true credit risk of the asset. As a result some market distortions tend to remain.
- Base II ignores some risks to which a bank is exposed which can affect the solvency of the bank. Examples of such risks are settlement risk and liquidity risk.
- By adding up the credit risk weightings for different assets, Basel II ignores the possibility that diversification (e.g.: by sector) may allow a bank to reduce the overall impact of credit risk across its portfolio of loans

- Basel II does not provide adequate incentives for risk mitigation. Minimal capital relief is proposed for collateral. Some credit risk mitigation techniques (such as the use of credit derivatives) are discouraged.
- Basel II seems to favour larger banks over the smaller banks. This is because it is the larger banks that are likely to be able to use the more sophisticated computational approaches (e.g.: the internal models rather than the standardised approach) and hence will be able to benefit from the competitive edge resulting from lower regulatory capital requirements. Another possible limitation is whether the supervisory authority will be able to make a full and accurate assessment of the procedures, controls and risks faced by a bank via the proposed combination of onsite visits, examinations, off site surveillance and reviews of the work of internal and external auditors.

Question (1)(c) (ii)

Three Pillar Approach Underlying Solvency II Directives

- Pillar 1 requires insurance companies to hold sufficient capital to cover their insurance related risks and is very similar to the current approach to holding provisions, assets and minimum solvency requirements.
- Pillar 2 requires insurance companies to hold sufficient capital to cover all their risks even those which cannot be easily quantified. This will require insurance companies to develop their internal controls, risk management practices and models
- Under Pillar 3, insurance companies will need to disclose their solvency positions and related information publicly.

Question (1)(c) (iii)

Limitations of Estimating Solvency Capital Using Two Factor Approach:

- The two factor approach ignores the credit risk that may be inherent in the asset portfolio of the life insurance company.
- The two factor approach is appropriate as long as the products offered by the insurance market are simple (lacking complex guarantees) and homogeneous (the risks inherent in the products do not materially differ between companies)
- The factors linked to the mathematical reserves and sum at risk may be outdated and not consistent with recent experience
- The solvency capital estimated using the two factors approach may not be consistent with the required economic capital – the capital needed to meet future obligations with some degree of certainty over a defined time horizon. The solvency capital estimated using the two factor approach may be more than the required economic capital (which represents inefficient use of capital) or less than the required economic capital (which represents a threat to solvency)

Question (1)(c) (iv)

Issues in Implementing the VaR Methodology:

- **New Business:** The addition of new business will impact the capital required today. Hence the capital impact of new business needs to be considered while estimating capital using the VAR methodology.
- **Tail Definition:** The tail definition can have a significant impact on the capital levels generated. There are two popular approaches :

[a] VAR (Percentile) Approach which uses a defined value in the tail of the distribution that corresponds to the desired confidence level (e.g.: 99% VaR)

[b] Tail VAR (Conditions Tail Expectation or CTE) Approach which takes the average of the tail scenarios defined by the desired confidence level (e.g.: Tail VAR using a 95% confidence level will take the average of the values between 95% and 100%)

- **Confidence level:** Where one anchors the capital determination [e.g. 99% confidence level] will drive different absolute and relative levels of capital. Typically the anchor point is linked to a company a rating. This means that higher rated companies will require higher levels of capital.
Aggregation Techniques: How one aggregates the impact of the different sources of risk will be an issue to be resolved. Common approaches are simulations, the use of Copulas and correlation matrices.
- Also we need to consider how these correlation relationships will change under distress environments [the tails of the distribution]
- Portfolios exposed to credit risk or derivatives may exhibit non-normal distributions. The usefulness of VAR in these situations depends on modelling skewed or fat tailed distributions of returns, either in the form of statistical distributions (such as Gumbel, Frechet or Weibull distributions) or via Monte Carlo Simulations.

Question (1)(d) (i)

Structuring of Mortgage Backed Securities:

- Mortgage backed securities (MBS) are structured using a “pass through” structure whereby the issuer (originator) creates a portfolio into which the mortgage loans are transferred. This is then securitised and sold to the investors.
- The default risk may or may not be transferred to the investors. The payments of interest and capital (from the MBS) to the investors are sometimes guaranteed by a third party (E.g.: Ginnie Mae) so that the credit risk is removed
- The originator may take a certain % of the mortgage payments as servicing fees to cover its costs.
- MBS expose the investor to pre payment risk. In order to mitigate the pre payment risk to investors (which occurs when the mortgage loans in the portfolio are repaid early), different tranches (classes) of MBS can be created – the first tranche accepting the first layer of early repayments, the second tranche accepting the second layer of repayments and so on. Such securities are called Collateralized Mortgage Obligations (CMOs).

Question (1)(d) (ii)

Sources of Risk for MBS Investors:

- MBS is a medium to long term fixed interest investment. An investor- particularly the institutional investor- needs to consider the mismatching risk, by comparing the discounted mean term (DMT) of the MBS with the DMT of its liabilities
- MBS have a pre payment risk which means that the actual term of the MBS is not known upfront. If mortgages are repayable at any time (subject to early repayment penalties), investors will receive the capital early which means that the MBS will have a much shorter average term than expected.
- The investor needs to consider the default risk inherent in the MBS, which can arise as a consequence of default by the mortgage borrowers. The default risk might be insured as a part of the conditions of the “pass through” security. But if the guarantor is not a Government agency, there will still be some default risk.
- The investor also needs to consider the consequences of the originator (issuer) becoming insolvent.
- MBS can carry a marketability risk because it is usually an OTC (Over the Counter) instrument. It is also large and indivisible
- The investor faces a risk with respect to the interest rate charged to mortgage borrowers, if not all mortgages are fixed rate. If mortgage interest rates fall due to competitive pressures or due to a decline in short term interest rates, the available cash to service the MBS will fall.

Question (1)(d) (iii)

Methodology for valuing MBS where borrowers are expected to prepay their mortgage when refinancing rates fall below the loan interest rate.

- The two possible approaches for valuing a MBS are the Zero volatility spread (Z- spread) approach and the option adjusted spread (OAS) approach.
- The OAS approach is used for valuing MBS with a prepayment option and the borrowers are expected to prepay when refinancing rates fall below the loan interest rate.
- The OAS approach works as follows:
 - Monte-Carlo Simulations method is typically used to value the MBS since the periodic cash flows are path dependent (the cash flow received in one period is determined not only by the current

interest rate level but also by the path that interest rates took to get to the current level).

- The typical model used to generate random interest rate paths takes as input the prevailing term structure of interest rates and a volatility assumption
- The random paths of interest rates should be generated from an arbitrage free model of the future term structure.
- Under a given interest rate path, an interest rate and a mortgage refinancing rate are generated for each period
- The simulated interest rates and mortgage refinancing rates (obtained from the interest rate model) along with the loan characteristics are fed into a pre payment model to project the prepayments.
- Given the projected prepayments, the cash flows along an interest rate path can be determined. Given the cash flows on an interest rate path its present values of the cash flows can be calculated using the spot rates determined from the simulated interest rates. The spot rate is calculated using the formula:

$$Z(T_n) = \{ [1+f_1(n)] * [1+f_2(n)] * [1+f_3(n)] \dots * [1+f_T(n)] \}^{(1/T)-1}$$

Where Z (T_n) is the simulated spot rate for month T on path n and f_j(n) is the simulated future one month rate for month j on path n

- The present value for path “n” is the sum of the present values of the cash flows for each month on path “n”. The theoretical value of the MBS is determined by calculating the average of the present values of all the interest rate paths.
- The option adjusted spread is than the spread that will, when added to all the spot rates on all interest rate paths, make the average present value of all the paths equal to the observed market price (plus accrued interest, if any).
- In practice, a drift term is added to short term return generating process in order to generate arbitrage – free values for interest rates.

Mean reverting Models are used to limit the scope of the interest rates generated.

Variance reduction techniques are used to cut down the number of sample paths necessary to get a good statistical sample.

Representative path methods are used to reduce the computational time, i.e., a small representative number of interest rate paths are selected from the large number originally generated and the security is valued on each representative path. A weighted average of these security values is then used to calculate the average present value.

Question (1)(e)

Cost of the Credit Default Swap:

Current price of the Government Bond

$$= 9 \cdot a(10) + 100 \cdot v^{10} \text{ at } 6.75\% \text{ pa}$$

$$= 9 \cdot 7.1055 + 100 \cdot 0.5204$$

$$= 116$$

Issue price of the MBS

$$= 9 \cdot a(10) + 100 \cdot v^{10} \text{ at } 7.50\% \text{ pa}$$

$$= 9 \cdot 6.8641 + 100 \cdot 0.04852$$

$$= 110.3$$

Cost of the CDS

$$= 116 - 110.3$$

$$= 5.7$$

The value obtained above is only an estimate because this calculation

- Assumes that the difference between the Government Bond and the MBS price is entirely due to credit risk .
- Ignores the lower marketability of MBS
- Ignores the risk aversion of the investors
- Ignores the prepayment risk faced by the investors, which is an option against them
- Assumes that the bank selling the CDS is risk free and will not default on the swap
- Ignores transaction costs and the bank's profit loading, which will impact the cost of CDS

(Total 58 Marks)

Question 2 (a)

To: The Managing Director

From: Consulting Actuary

Date: 01/11/2008

Report on Risks of Leveraged Capital Structure:

The potential risks posed by a highly leveraged capital structure would include the following:

- Inability to service the debt obligations during market downturns

- Choosing high-risk investments and projects that benefit shareholders at the expense of the bondholders
- A tendency to exit promising lines of business in order to generate the cash required to tide over the liquidity crunch
- An incentive to produce goods of inferior quality which might result in the company losing its reputation as a “premier” market brand
- An incentive to provide a less safe work environment for employees, which can result in compensation claims against the company and lead to difficulties in recruiting & retaining the staff
- An incentive to cut back on research & development, advertising and promotional expenditure which can lead to a lack of innovation
- If the liquidity crunch is associated with substantial variability in corporate earnings, then it will have an adverse impact on the ability of the firm to take full advantage of the tax credits associated with high levels of gearing

Thus the true cost of the high gearing is the reduction in the value of the firm’s tangible and intangible assets caused by the presence of financial distress

Question No 2 [b]

Reasons for Hedging Financial Risk:

Economies of Scale: The firm may be able to hedge financial risk more cost effectively than the shareholders.

Asymmetric Information: The shareholder may not know the financial risks that can be hedged.

Customer Requirements: The firm’s customers might want the firm to be financially strong and stable [example: banks & insurance companies]. Therefore, not hedging sufficiently can be perceived by the customers as a threat to the financial stability/strength of the firm.

Employment Uncertainty: A firm may be able to attract and retain staff more effectively if it is perceived to be financially strong & stable.

Bankruptcy costs: The shareholders will have to bear the bankruptcy costs of the firm. Therefore the shareholder is economically incentivised to prefer a firm which hedges sufficient risks to avoid unnecessary bankruptcies.

Loan costs & Covenants: A firm may be economically motivated to hedge financial risks in order to borrow more cheaply and/or on more favourable terms & conditions.

Tax Aspects; A firm’s profit & losses may be taxed differently. For example there may be restrictions on losses that can be carried forward. Further capital gains/losses may be taxed differently from income gains/losses.

Question No 2 [c][i]Net Cash flows Associated with Leasing versus Borrowing:

[Rupees in Crores]

Year	0	1	2	3	4	5
A. Equipment Cost	60.00					
B. Depreciation		15.00	11.25	8.44	6.33	4.75
C. Depreciation Tax Shields		4.50	3.38	2.53	1.90	1.42
D. Lease Rentals		18.00	18.00	18.00	18.00	18.00
E. Tax Shield on Lease Rentals		5.40	5.40	5.40	5.40	5.40
F. Net Salvage Value						6.00
G. Net cash Flows Associated with Leasing =A-C-D+E-F	60.00	(-)17.10	(-)15.98	(-)15.13	(-)14.50	(-) 20.02

Net Advantage of Leasing = Present Value of the Net Cash flow Stream at 8%

= Rs.(-)5.83 crores

Since the net advantage of leasing is negative, the recommendation is not to lease the equipments.

Question No 2 [c][ii]

The CFO's argument is that the leased asset and the corresponding liability need not be disclosed in the balance sheet of the lessee. Hence the leasing option does not result in increasing the gearing ratio [debt to equity ratio] of the company [the lessee].

This argument is flawed for two reasons:

First whether the company opts for the financial lease or for the borrowing & buying alternative it incurs a similar liability. This is so because the financial lease is non-cancellable

for a certain period [called the primary period] and the lease rentals payable during this period are structured in such a way that the lessor recovers the cost of the asset plus his required rate of return. Hence in reality the borrowing capacity of the company is reduced under both the alternatives.

Second, the Accounting Standards in most countries [including India & the International Accounting Standard] on Lease Accounting & Reporting require a financial lease to be capitalised in the books of the lessee. In other words a financial lease is not an off balance sheet transaction.

Question No 2 [d] [i]

Exercising Callable Bonds & Safeguards:

The circumstances under which the issuer will exercise the call option will include the following:

- Fall in the general level of Long term Interest Rates. Under this scenario the issuer can borrow at the lower rates of interest and use the proceeds to pay off the existing bond issue.
- The company's credit rating may have improved. This could lead to it being able to borrow more cheaply even if the general level of interest rates has remained unchanged.
- A change in the business profile [example: a significant new project or restructuring] may necessitate a change in the capital structure – in particular a lower level of gearing. This can result in the company raising money by way of an equity issue and using the proceeds to pay off the callable bonds by exercising the call option.
- Changes in the regulatory or tax environment can render borrowing relatively less attractive which can result in the company exercising the call option.

The safeguards to protect the investors can include:

- Repayment Penalty: The issuer may have to pay an amount in excess of the face value in order to redeem the bond issue early. In other words the option to call is an option held by the borrower and the repayment penalty can be considered as the premium for this option.
- Deferment Period: A call deferment period is a minimum period after issue during which the issuer does not have the right to call the bond.

Question No 2 [d] [ii]

A callable bond will have a higher yield to maturity [ytm] than a non-callable bond with identical maturity and coupon.]

The callable bond price will be equal to that of the non-callable bond less the value of the borrower's option [to exercise the call]. In other words the price will be lower than that of the non-callable bond. Therefore the ytm will be higher.

The yield difference will be greatest when the price difference is greatest, which is when the option value is greatest.

The option value will increase as the call comes close to being at-the-money (when long – term interest rates are very close to the coupon rate on the bond). The option value will become even larger when the call moves in –the- money.

But the call option embedded in a callable bond is an American option and will be exercised before the option moves in-the – money. Thus the yield difference will be at its greatest when interest rates are close to the coupon rate on the bond because the bond will be called once the interest rates fall below the coupon rate.

Question No 2 [e] [i]

Equations Underlying the Default Based Approach Assuming Full Default

The equation can be expressed as follows:

$$B(t, T) = P(t, T) * \{ [1 - q(t, T)] + q(t, T) * r \}$$

Where $B(t, T)$ is the price of the risky bond of term T at time t

$P(t, T)$ is the price of the risk-free bond of term T at time t

$q(t, T)$ is the probability of default occurring at time t

r is the recovery rate from the bond in the event of default

The default process is described either by a square root diffusion process or by a jump diffusion process

The recovery rate “ r ” can be a fraction of the debt’s face value or the market value of a default-free security at termination. In the above formula, the recovery rate is applied to the value of the default-free bond.

The formula given above specifies the price of the risky bond in terms of the price of the risk-free bond which can be calculated using the market risk-free spot rates. In the event of a default at time t the bond will have price

$B(t, T) = P(t, T) * r$ and this happens with the probability $q(t, T)$. In the event of no default the price of the bond will be $B(t, T) = P(t, T)$ and this occurs with a probability of $[1 - q(t, T)]$.

Question No 2 [e] [ii]

Modifying the Default Based Approach

The above model can be modified to incorporate changes in credit ratings. The modified version is also referred to as the Ratings Transition Approach

This approach prices the bond based on a particular credit rating which the bond is assumed to progress to at time t .

Because it does not assume full default rather a rating transition

- It addresses the fact that ratings and credit spreads can change without a full default occurring. This cannot be captured in the basic default-based model

- It can be used to value credit derivatives as well as bonds. It is well suited to this because many credit derivatives can be exercised on occurrence of a specified credit event such as a rating downgrade or cross default of another bond rather than full default.

The formula underlying the rating transitions approach is similar to the default based model and can be expressed as:

$$B(t, T) = P(t, T) * \{ [1 - q(t, T)] + q(t, T) * r \}$$

Where $q(t, T)$ is the probability that the bond has a credit rating “i” at time t.

The value of the bond at time t would be the sum of the expression across all possible credit ratings “i”.

$q(t, T)$ can be modelled either as a jump diffusion process or as a square root diffusion process.

This approach uses a ratings transition matrix. Current market spreads of bonds with certain credit ratings are used to parameterise the model so that the model gives values that are consistent with observable market prices of bonds [or credit derivatives].

(Total 42 Marks)

[Total 100 Marks]

*****END*****