Institute of Actuaries of India

Subject ST5 – Finance and Investment A

November 2011 Examinations

INDICATIVE SOLUTIONS

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.

General comments:
Marks were given for alternative solutions where appropriate. Candidates are reminded that Investment is a more practical subject and they must be prepared to apply their knowledge to problems and situations which may initially seem unfamiliar.

- Question 2 was not well answered, with candidates demonstrating poor understanding of different risk measurement techniques and credit ratings.
- In Question 3, poor knowledge of options was demonstrated to address some of the situations presented. This was surprising given that candidates have had previous opportunities to develop skills in this area.
- The answers to Question 8 were particularly disappointing, since many candidates were unable to articulate a suitable strategy, despite relevant guidance being provided in the question. This sort of question requires candidates to consider higher level issues and relevant detail before framing a response.

Q. 1 (i) **Operations**
- Initial Margin is the sum of money that each party to a futures contract must deposit with the clearinghouse when a futures contract is opened
- As time progresses, the underlying asset price and hence the value of the future to each party is likely to change. This change in value might make it more likely that one party will fail to honor the contract.
- Through the 'marking to market' process of daily calculation of the market value of a trader's position, any fall in value is topped up with additional payments of cash, or other acceptable margin, to enable the clearinghouse to continue to give its guarantee These extra margin payments are known as 'variation margin'
- The other party will be less likely to default and so will be able to withdraw some of his initial margin from the clearing house (i.e. variation margin is negative for this party)
- The process of 'marking to market' means that the profit or loss on a future is realized over a period of time (i.e. as variation margin is paid or released) rather than simply at the delivery date

Limiting Credit Risk
- Following registration of a trade, each party has a contractual obligation to the clearinghouse rather than to the original counter party. In turn the clearinghouse guarantees each side of the original bargain
- By standing between the two parties the clearinghouse removes the immediate credit risk of individual participants to each other
- However it is important that the ability of the clearinghouse to honor its positions is not vulnerable to default by one or more traders
- Initial margin is a cushion against potential losses that the parties may suffer from future adverse price movements
- The payment of variation equal to any price movement ensures that the value (and hence credit exposure) of all open contracts is re-set to zero each day. The clearinghouse thus maintains the amount of initial margin as a cushion against daily price movements.

(ii)
- Using stock index futures the manager can adjust and subsequently readjust the portfolio's exposure between the two markets at a significantly lower cost.
- No tax is crystallised on equity capital gains and the long term profileof the fund remains intact.
- The investment decision can be executed immediately to catch all theanticipated movements in both markets whereas some of the benefits ofthe decision could be lost because of the time taken to process sales inthe underlying stocks in the relevant markets.
- In the case of a short term switch there would be of the order of four contract notes to be processed for each stock in one of the markets (assuming say 25 stocks are held in each market this would run to 100 contract notes to be processed); using index futures only four contract notes need to be processed.
- Futures markets are often more liquid than the market in the underlying stocks so it is possible to deal in size without moving the market. Stock index futures avoid the need to trade the underlying stocks and thereby avoid the movement in the market prices of stock associated with trading large volumes.
- In a very large investment house it may be virtually impossible to make substantial asset allocation switches without the use of futures.
- For a long term switch between markets, stock index futures can also be very useful.The switch can be achieved by selling stock index futures in the market the manager wishes to reduce his exposure to (say the US) and buying stock index futures in the market to which the manager wished to increase his exposure (say the UK).
- With this strategy, the manager is protected from falls in the US market because losses on the underlying securities are made up by gains on the short position. Gains on the UK market accrue to the fund through the long futures position.

- Having locked in his strategic asset profile the manager can now comfortably proceed with stock switching and unwind the futures positions appropriately as he proceeds. The fact that the manager does not have to sell large volumes of stock quickly, should allow the manager to do individual stock deals on more advantageous terms.
- This strategy allows the manager to ensure he locks in his long term view without losing the market opportunity while trying to fine tune his stock selection and switching process.
- As equity transactions are spread over a longer time period the pressure on the back office is reduced.

(iii) Manger needs short position in futures.

Number of contracts the fund manager should short
= beta of the portfolio (=0.87) x 50,000,000/(1250 x 250)
= 139.2

(iv)

(Note to markers - candidates may derive the forward exchange rate in terms of dollars per pounds or the inverse pounds per dollar; the notation needs to be correctly defined to fit the approach)

Let the variable S be the current price in pounds of 1 unit of the dollars; i.e. the current exchange rate, expressed in pounds per dollar.

Let K be the forward price agreed to in the contract.
Let T be the term of the forward contract: .
Let R be the continuously compounded risk free rate in pounds; and let r be the risk free rate in dollars.
Let ft be the value of the forward contract at time t. (now)

The two portfolios that enable us to price a forward contract on a foreign currency are:

A: One long forward contract plus an amount of cash equal to $Kexp(-R(T-t))$; and
B: An amount $Sexp-(r(T-t))$ of the foreign currency (US dollars).

Both of these portfolios will become worth the same as one unit of the foreign currency (ie, one dollar) at time T. Arbitrage free pricing means they must be equally valuable at time t.

Hence:

$$ft+Kexp(-R(T-t))=Sexp(-r(T-t))$$

Forward contracts are entered into at zero cost, i.e. $ft = 0$ which means that

$$K=Sexp((R-r)(T-t))$$

[14]

Q. 2
(i)
- The change in the value of an option is not linearly related to the change in the value of the underlying variables (stocks)
- Therefore even if the change in the value of the underlying variables (stocks) follows the normal distribution, the change in the value of the options will follow a non -normal distribution.
- Hence the linear model based on the normality assumption tends to provide only an approximate estimate of VaR for a portfolio containing options.

(ii)
- VaR methodology does not take into account the simultaneous increase in asset volatilities and correlations that are observed during extreme market events
- The risks that result from extreme market events can be identified and investigated using the process of financial stress testing. This involves subjecting a portfolio to extreme market moves by radically changing

the underlying portfolio assumptions and characteristics, in order to gain insight into portfolio sensitivities to pre defined risk factors. This pertains in particular to asset correlations and volatilities

- In other words, stress testing can be considered as a way of taking into account extreme events that do occur from time to time but that are virtually impossible according to the probability distributions assumed for the market variables. For example, a five standard deviation daily move in a market variable is one such extreme event. Under the assumption of a normal distribution, it happens about once every 7,000 years. But in practice, it is not uncommon to find a five standard deviation daily move once or twice (say) every 10 years.

- Back testing is an important reality check on VaR. It involves testing how well the VaR estimates would have performed in the past. Suppose that we are calculating a 1 day 99% VaR. Back testing will involve looking at how often the loss in a day exceeded the 1 day 99% VaR. If this happened on about 1% of the days, we can feel reasonably comfortable with the methodology for calculating VaR. If it happened on, say, 7% of the days, the methodology for calculating VaR is suspect.

(iii)
- Assume normal distribution of returns & square root of time rule for scaling up VaR across time horizons.
- Diversification impact on the VaR = $\sum$ VaRs for each asset (i.e undiversified VaR) – portfolio VaR

    Undiversified Var = Var (Domestic Hi-Tec) + Var (Global Fund)

    $= 1.645*11*0.05*\sqrt{10}+1.645*9*0.03*\sqrt{10} = 2.86+1.404 = $ Rs 4.265m

    Portfolio Var $= 1.645*\sqrt{\text{(portfolio variance)}}*\sqrt{10} = $ Rs 3.430 m

    (Where portfolio variance = $(11^2)*(0.05^2)+(-9^2)*(0.03^2)+2*(11)*(-9)*(-0.2)*(0.05)*(0.03) = 0.4348$)

    Diversification impact = 4.265 - 3.430 = Rs 0.835m

- Since there is negative correlation between the funds, holding a sizeable long position (e.g 7m-8m) in global fund would be most effective at reducing risk in the portfolio, reducing portfolio VaR and increasing any impact/benefit felt from diversification. There will be a limit to any increase.

- Award at least partial credit - to candidates who note that portfolio VaR will reduce as the short position in the Global Fund reduces (or long position increases). There will be a limit to any reduction in portfolio VaR

(iv)

- Risk appetite statement, or other company policy on credit risk i.e Rules in place for limits, what types of credit risk was appropriate, when collateral needs to be posted by counterparties.
- Controls to be at aggregate level over whole balance sheet and to apply equally to (for example) banks and reinsurers.
- Initial credit checks on counterparties - Using specialist credit agencies.
- Ongoing credit checks on counterparties - With alarm bells on bad news (including degrades).
- Monitoring of credit exposure by counterparty -With alarm bells on exceeding specified limits.
- Monitoring of potential credit exposure (in case of derivatives)
- Reinsurance treaties & derivative agreements to include special provisions saying what to do if credit exposure gets too big.

If corrective action is necessary, then:

- Credit exposure could be closed out completely (cancel reinsurance, move to another bank, etc.).
- Exposure could be reduced (e.g. require the posting of collateral for reinsurers).
- Default probability could be reduced using credit derivatives, third partyletters of credit, etc.
- Pre-agreed collateral requirements or close out requirements should kick in.

(v)
- The solution assumes that the bonds are uncorrelated.
- To determine the 99.9% Var, we need the 0.1% percentile of the portfolio
- The worst outcome is for the A-rated bond to get downgraded to BB (1% chance) and the BB bond to default (10% chance). The joint probability is 0.1*1% = 0.1%.
- Need to calculate the value of this portfolio if the ratings change in this way.

- Value of A rated bond if downgraded to BB after 1 year is: 90,000+
  90,000/(1.054)+90,000/(1.0615^2)+1,590,000/(1.0695^3) = 1,554,997
- If the BB bond defaults at the end of the year, its value is:2,000,000 *35% (recovery rate) = 700,000
- The stressed portfolio value is = 1,554,997+700,000=2,254,997
- Now need to calculate the portfolio value if no rating change.
- Value of the A rated bond if it remains A rated
  is:90,000+(90,000/1.0465)+(90,000/1.0535^2)+(1,590,000)/(1.0575^3) = 1,601,577
- Value of BB rated bond if remains BB =
  160,000+160,000/(1.0545)+(160,000)/(1.0615^2)+2,160,000/(1.0695^3)=2,219,405
- portfolio value if no change = 1,601,577+2,219,405 =3,820,982
- VaR= portfolio value – stressed portfolio value = 3,820,982-2,254,997=Rs 1,565,985

(markers should award any partial credit for candidates who show a reasonable idea/appreciation of how to solve the problem)

(vi)

- The biggest contributor to the fall in portfolio value in the stressed scenario (99.9%) is the default of the BB bond, since the recovery rate (35%) is low. This is therefore the main contributor to the calculated VaR.
- Ideally, Megalife should purchase a credit default swap on the BB bond, which pays out when the BB bond defaults. Adding this instrument to the portfolio will mitigate the impact of the default, therby increasing the calculated portfolio value in the stressed scenario. This will reduce the VaR and economic capital calculated above.

(award credit for any sensible suggestion)

(vii)

- Can use the Merton model to value the risky debt
- From the Merton Model = $VN(d1)-Dexp(-rT)N(d2)$
- And from the merton model, the risk neutral probability of default is $N(-d2)$ (note this is stated in the core reading)
- r=Risk free rate = 0.05
- V = market value of company asset = 21
- D= company debt+interest =17
- Sigma =volatility of company assets = 0.20
- T=1 year
- $d2= LN(V/D)+(R-0.5*sigma^2)/(sigma*T^0.5)$ = 1.2065
- $N(-d2)$ = 0.1138 = risk neutral probability of default.

[25]

Q.3

(i)

The risks involved with options could include:

- Market risk- The market price of options held by an investor on a standalone basis - e.g. for speculative purposes - may move in the opposite direction to that anticipated. For example, an investor purchases a call option in anticipation of a rise in the price of the underlying asset. If it instead goes down, then so will the value of the call option itself. The risk here is exaggerated by the highly geared nature of the returns produced by options.
- Default or counter-party risk– The counter-party to the option trade fails to meet his obligations under the trading agreement. This risk arises under none change traded (over-the-counter) options, but should be negligible under
- Exchange traded options, where the counter-party is the clearing house.
- Cross-hedging risk - It arises when an option is used to hedge against the adverse price movement of portfolio assets. It refers to the relation between the movements in the option price and those of the assets being hedged. These may not be exactly as predicted, so that perfect hedging is not possible.
- Currency risk - Investment in options denominated in overseas currencies will also involve the usual currency risk

(ii)

- **Maximising returns while reducing risk** For example – equity-linked products that turn into high yielding fixed income investments once they have secured some profits may be particularly attractive e.g. a structure that pays out coupons equal to the capped positive performance of the underlying equity markets,

so long as those markets don't fall below their starting levels. Even in a falling market scenario, the pension scheme still gets its initial investment back.

- **Diversification:** The best risk/return balance involves spreading your investments among a wide range of different asset classes, rather than attempting to pick individual investments with the most attractive individual return potential. Pension schemes can use Structured Products to access a wider variety of markets or economic factors in order to complement their existing investments.

- **Easier access:** Barriers to direct investment in an asset class, such as physical availability, taxes, lack of liquidity, regulation, make access difficult or simply unaffordable. However a pension scheme wishing to diversify into an overseas industrial property market can achieve this through a structure which offers a payout in line with the overseas property sector index – with capital guaranteed.

- **Cash flow match:** Pension funds are looking to remove duration and inflation risks from their pension obligations. A pension scheme which needs £1m a year, increasing in line with the retail price index to pay pensions for the next 30 years, can invest in a 30 year structured product that does just that. The product could also be structured to increase payments when mortality rates improve.

- **Reduce costs:** Products, once structured, need little maintenance or
  underlying trading so management costs fall significantly. A pension scheme that wants exposure to index equities (e.g FTSE 100/Sensex etc) could invest in a fund that "passively" tries to replicate the relevant index. Management and rebalancing costs are charged against returns as the manager needs to continuously rebalance the fund to keep proportions in line with the index.

   Alternatively the scheme could buy a product that guarantees that return (or even a small outperformance) for an initial fee much lower than the costs of the managed fund.

- **Flexibility/Customisation:** Structured products are sufficiently flexible to be tailored to any individual pension fund's risk appetite or to satisfy a particular regulatory target affecting the whole sector.

   For example, pension schemes may need to pay pension increases subject to a cap – there are no long-dated government bonds that pay out like this, but the scheme could buy a structured product that did.

   Alternatively the sponsor might like to limit the potential size of any reduction in surplus (or increase in the deficit) for their scheme to a specific value (to say £50m) during the year or over a period of years.

(iii)
- The client needs a collar structure – for each share held in the portfolio, he should hold one long put option (strike K(P), premium P) and hold one short call option (strike K(C), premium C) where K(C) is greater than K(P). The client will pay P-C for this structure
- Net of all hedging costs, the minimum payoff from the portfolio is K(P) – (p-c) and the maximum payoff is K(C) – (p-c).
- The client needs to trade in Rs 11,000,000/110 = 100,000 options.
- The portfolio floor value must satisfy 100,000*(K(p) – (p-c)) = 12,000,000 implying K(P) – (p-c) = 120
- The maximum portfolio value must satisfy 100,000*(K(c) – (p-c)) = 14,000,000 implying K(c) – (p-c) = 140
- The options which satisfy these conditions are in the table: K(p) = 135, p= 50 and K(c) = 155, c=35.
- The client should hold 100,000 long put options (strike Rs135), and should short 100,000 call options (strike 155).
- The total cost that the client should pay for this structure is 100,000*(50-35) =100,000*15 =Rs1,500,000

(iv)
- The question states this is a **speculative trade**. The main reason you will undertake it is that you may be slightly bearish on IMP stock – you may expect it to fall by say 10% from its current level of Rs 89 (you certainly don't expect a rise in stock price, otherwise you would lose a lot on the short call options).
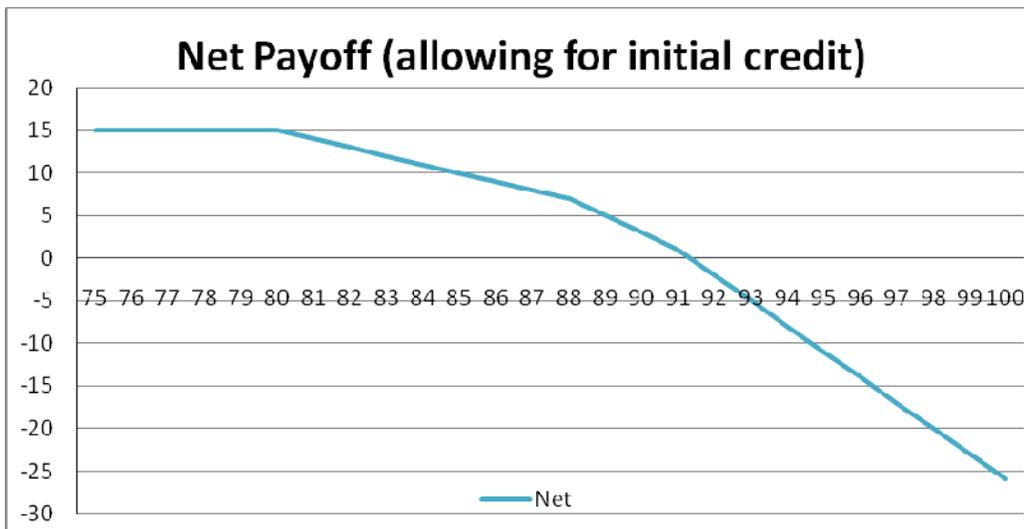
[15]

Q. 4

(i)

- Commodity futures and forward contracts are used for risk management by commodity producers who wish to reduce uncertainty in the future cash flows that they will receive for their product; and commodity consumers who wish to reduce the uncertainty in the amount they will have to pay for their future supplies.
- It has been argued that commodity futures should be considered as "short-term equities". They are real assets whose value is determined by short-term economic factors rather than expectations over the longer term.
- This gives some diversification from the traditional institutional real assets of property and equity shares.

(ii)

+ Investing in shares of these companies overcomes the problems of investing directly in the commodity itself (i.e storage, warehousing and shipping) and are generally less volatile than the commodity futures.

There are, however, a number of disadvantages:

-It is unlikely that there will be exposure to just one commodity.
-The company s management may alter the exposure via acquisitions or disposals or by hedging its position.
-The company s share price may be influenced by other factors.
-The company will incur various operating expenses which will dilute the overall return.
-Commodity shares will offer less "diversification", as they will have more correlation with equity market compared to other forms of commodity investment.

(iii)

- Having both subsidiaries fully hedge independently would be redundant. Both subsidiaries are in fact natural hedges for each other, in the context of the Resolver group.
- The net exposure should be hedged at the group level, since this achieves the same degree of risk mitigation as having each subsidiary fully hedge. Hedging the net exposure would be cheaper since it avoids transaction costs of purchasing hedges with natural offsets.
- Assuming all else is equal, profit contribution increases by Rs 10 (Rs20-Rs10) per unit increase in cotton price. Group profits are therefore exposed to a decrease in cotton prices; therefore the group needs to structure a "short" position in the forward contract which pays off when cotton prices fall.

[7]

Q.5 (i) Let $d(t)$ be the discount factors at time t. These can also be considered as the present values of unit payments made at time t, $t = 0, 1, 2$ etc. Of course, $d0 = 1$.

The forward rate at time t $f(t) = d(t)/ d(t-1) – 1$

This implies the forward rates (as percentages)

F(1) = 4.167%, *f*(2) = 4.348%, *f*(3) = 4.664%

(ii) (a) An *n*-year swap fixed coupon rate *Sn* is also the par coupon rate for the yield curve at time 0, so it satisfies the equation:

S(n) (d(1) +d(2)+…..d(n)) + d(n) = 1

Hence for *n* = 3, annual swap fixed rate
= (1 – 0.879) / (0.96 + 0.92 + 0.879) = 0.0438565, i.e. 4.386% to 3dp.

(b)

Assume f(3) falls from 4.664% by 25bps (1/4 percent) to 4.414%.

This will change the time 3 discount factor d(3)

As d(3) = d(2) * (1/(1+f(3)) so new value of d(3) = 0.920 * (1/1.0414) = 0.881108

Value of swap = Rs 100 m* (value of fixed – value of floating)

100 m * (0.04386* (d(1) + d(2) +d(3))+d(3)-1)   where the fixed rate is 4.386% as calculated in (ii) (a) and the floating leg has value of 1.

100 * (0.04386 * (0.960+0.920+0.881108)+0.881108 – 1) = Rs 0.22m

Market value of the swap was initially 0 when struck, but would now increase immediately to Rs 0.22m for the fixed rate receiver.

(iii) (a)
Forward swap rate R is solution to the following equation:

R(d(3)+ d(4) + d(5)) + d(5) = d(2)

R = (d(2) – d(5)) / (d(3) + d(4) + d(5))

R=   (0.920 – 0.804) / (0.879+0.840+0.804)

=0.045977 = 4.5977%

(b) Because the 4.75% rate within the forward agreement is higher than the forward swap rate calculated in (iii) (a), the forward agreement has negative value to the financial institution

[10]

Q.6 **(i) Three Reasons for Not Hedging:**

- If the company's competitors are not hedging , the CFO might feel that the company will experience less risk if it does not hedge.
- The CFO may be of the view that the company's shareholders have diversified the risk away.
- If there is a loss on the hedge and a gain from the company's exposure to the underlying assets the CFO might feel that he will have difficulty justifying the "decision to hedge" to other executives within the organization

(ii)
- The directors act on behalf of the shareholders and appoint managers as the agents to run the company on their behalf on a day-to-day basis.

- The separation of management and ownership has the advantages of freedom for ownership to change without affecting the operations and freedom to hire professional managers

- The main disadvantage is divergence in the interests of the management and the shareholders and give rise to agency costs

- These agency costs occur mainly (i) for monitoring the managers (ii) seeking to influence the actions of the managers (iii) incurred as managers do not act in the best interests of the shareholders

(iii)
- Corporate decisions are typically made not by a firm's owners but by employed managers
- Managers may choose to adopt risk management decisions in own interest and not in the best interests of shareholders
- For most managers, employment income is a major source of wealth, risk in employment income is important
- Under Flat salary (package (b)), manager is indifferent to any risk management decisions, assuming job security is not tied to any particular decision. Implementing the best strategy may affect job security / performance evaluations
- Under Incentive compensation, salary + stock (in package (c)), manager has direct monetary interest in the decision which favors shareholders. Manager will want to reduce their own risk and secure any efficiency gains from hedging
- Under salary + Stock options plan (package (a)), option is only worth money if the stock price >exercise price, manager has incentive not to hedge because it lowers value of their options. Manager would always want greater volatility
- (**Note to markers - Candidates should be given appropriate credit for any sensible interpretation based on the specific packages mentioned within the question**)

[10]

Q7:

(a) Main types of regulatory regimes are:

Unregulated regime: Herein no industry specific regulations are in place, market players are subjected to normal laws of the land.

Voluntary codes of conduct: Conduct codes are prescribed by the industry bodies itself.

Self-regulation: The regulatory regimes are organised and operated by the participants in the industry without government intervention.

Statutory regulation: Under this regime, government bodies set out the rules also regulates them.

(b) Difficult to provide definitive answers, marks will be awarded based on the quality of understanding of reasons for prescribing particularly type of regulation.

[9]

Q8:

- Trustees are the legal owner of the funds managed by a trust while members are the beneficiaries.
- Trustees are responsible for decision making regarding investment philosophy of the trust while keeping in mind the interests of the members.
- Though provident fund scheme is a DC scheme, but since the trusts have to at-least match the annual interest rate declared by EPFO, there is an element of defined benefit component in terms of interest rate guarantee.
- The investment pattern of assets of EPFO is defined by the Act. EPFO can only invest in fixed interest securities.
- Because fixed interest securities are valued at book value, the investment income of EPFO will consist of coupon received, interest accrued and amortization gains/losses.
- The trustee proposes to invest in real assets which carry market risk because the value of the assets will fluctuate depending upon prevailing market conditions.
- Therefore, if investments are made in real assets, many a times depending on market conditions, employers may have to make up the difference between interest rate declared by the EPFO and returns earned by the trust.
- But, since, employer can't withdraw the money in case of surplus, employer may only end up filling the gaps, if any.

- In the scenario of rising interest rates, equity market tend to underperform, therefore equity investments will induce further risks.
- Prescribed EPFO investment pattern induces a very small default risk, mainly from corporate bonds investment, but if the major portfolio is kept in equities and properties, the portfolio will carry substantial default risk.
- EPFO also doesn't carry much duration risk due to the size of the portfolio, but individual trusts can carry duration risk in case number of leaves exceeds the number of joiners.
- Therefore, retirement funds with underlying guarantees can go for equity investments only upto some small proportions depending upon risk appetite of the trustees and employers.
- The other proposal to invest in the shares of the employer itself will induce self investment risk for the members. If gold price reduces, it will not only affect the investment returns of the trust and hence financial security but due to the affect on financial position of the company will also affect the job security of the members.
- Assets of a trust should match the liability profile of the trust in terms of market, interest rate, inflation, duration, currency, actuarial and other risks.
- Therefore, in the given scenario, it is advisable to follow largely follow the EPFO investment pattern. Only small deviation depending upon financial strength of the employer and risk appetite of the trustees is acceptable, but that also needs to be closely monitored.

[10]

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