INSTITUTE OF ACTUARIES OF INDIA

EXAMINATIONS

15th May 2015

Subject ST6 – Finance and Investment B

Time allowed: Three Hours (10.15* – 13.30 Hrs)

Total Marks: 100

INSTRUCTIONS TO THE CANDIDATES

1. ***Please read the instructions on the front page of answer booklet and instructions to examinees sent along with hall ticket carefully and follow without exception.***
2. **** You have 15 minutes at the start of the examination in which you are required to read the questions. You are strongly encouraged to use this time for reading only, but notes may be made. You have then three hours to complete the paper.***
3. ***You must not start writing your answers in the answer sheet unless instructed to do so by the supervisor.***
4. ***The answers are not expected to be any country or jurisdication specific. However, if Examples/illustrations are required for any answer, the country or jurisdiction from which they are drawn should be mentioned.***
5. ***Attempt all questions, beginning your answer to each question on a separate sheet.***
6. ***Mark allocations are shown in brackets.***
7. ***Please check if you have received complete Question paper and no page is missing. If so, kindly get a new set of Question paper from the Invigilator.***

AT THE END OF THE EXAMINATION

Please return your answer book and this question paper to the supervisor separately.

Q. 1) A software company Intel Dynamics Ltd. (IDL) is expecting a payment of British Pounds (GBP) 500,000 in the next 6 months which have to be converted to Indian Rupees (INR) for domestic expenses. The current spot exchange rate of GBP is 1 GBP = Rs. 95 (INR/GBP = Rs. 95).

The company is also expecting to pay US Dollars (USD) 800,000 to a US client in next 3 months, which it will have to fund from a domestic INR account. The current spot exchange rate of USD is 1 USD = Rs. 65 (INR/USD = Rs. 65).

Conversion Bank Ltd. (an Indian Bank) offers a contract to reduce IDL's currency risk. The offer is a combination of

- A short position in a six-month GBP contract where:
  - if the spot rate of GBP after six months is less than SGB_1(where, SGB_1 = Rs. 90), then IDL sells GBP after six months at SGB_1, and if the spot rate of GBP after six months is greater than or equal to SGB_1, then IDL sells GBP after six months at the spot rate of GBP after six months.
  - if the spot rate of GBP after six months is greater than SGB_2(where, SGB_2 = Rs. 100), then IDL sells GBP after six months at SGB_2, and if the spot rate of GBP after six months is less than or equal to SGB_2, then IDL sells GBP after six months at the spot rate of GBP after six months.
- And a long position in a three-month USD contract where:
  - if the spot rate of USD after three months is less than SUS_1(where, SUS_1 =Rs. 60), then IDL purchases USD after three months at SUS_1, and if the spot rate of USD after three months is greater than or equal to SUS_1, then IDL purchases USD after three months at the spot rate of USD after three months.
  - if the spot rate of USD after three months is greater than SUS_2(where, SUS_2 =Rs. 70), then IDL purchases USD after three months at SUS_2, and if the spot rate of USD after three months is less than or equal to SUS_2, then IDL purchases USD after three months at the spot rate of USD after three months.

i) Express the payoff of the six-month GBP contract after six months as a function of spot rates of GBP after six months and plot the payoff function.

A combination of which options would lead to a similar payoff? (4)

ii) Express the payoff of the three-month USD contract after three months as a function of spot rates of USD after three months and plot the payoff function.

A combination of which options would lead to a similar payoff? (4)

After the contract has been in force for a month, IDL has decided to delay the US client payment by 3 months. The company decides to cancel the forward rate contracts and enter in new contract between GBP/USD.

iii) Estimate the pay-out require for cancelling the forward contracts. Use the following assumption

(INR/GBP volatility: 15%; INR/USD volatility: 25%; USD risk free short term rate= 0.5%, INR risk free short term rate = 8%, GBP risk free short term rate = 0.5%; INR/GBP spot rate = 90, INR/USD spot rate = 60) (12)

iv) IDL's risk team asked for a review of all risks of the new forward contract including possible risks of using the domestic bank for USD/GBP forwards. List the risks the company is exposed to with the new contract and how the main risks can be mitigated. (4)

[24]

Q. 2) An investment firm holds securities to track NIFTY with value of Rs. 1000 Cr when NIFTY is at 8600. The firm's board are concerned about a sudden market crash and are considering strategies which would limit the loss in the portfolio to 5% over the next 6 month.

i) State how this can be achieved by using active and passive hedging and discuss the advantages and disadvantages of each approach, considering the appropriateness, cost and residual risks of the strategies. (5)

ii) What are the initial expenses and possible portfolio rebalancing (buying options or risk free bonds) required if the company decides to adopt either a passive or an active approach? Use the following assumption :

- Dividend yield on NIFTY – 2% per annum (with continuous compounding)
- Risk-free rate of interest – 6% per annum (with continuous compounding)
- Volatility of NIFTY – 30% per annum (with continuous compounding) (6)

[11]

Q. 3) The board of Chandresh Ltd. has decided to invest in a 3 year at par (to be redeemed at nominal) bond of nominal Rs. 1000 with 5% per annum coupon and credit rating of A. Coupons are paid once a year. As part of the risk analysis, the quantitative team produces future transition matrices to estimate the default probabilities.

The matrix given below shows the cumulative transition and default for future 3 years (assuming 3 categories of bonds: A, B and C) with recovery rate of 50%.

Year 1	**A**	**B**	**C**	**Default**	**Year 2**	**A**	**B**	**C**	**Default**	**Year 3**	**A**	**B**	**C**	**Default**
A	80%	10%	8%	2%	A	65.8%	16.2%	12.7%	5.3%	A	55.5%	19.8%	15.4%	9.3%
B	10%	70%	15%	5%	B	16.5%	52.3%	20.2%	11%	B	20.5%	41.3%	21.3%	16.9%
C	10%	15%	60%	15%	C	15.5%	20.5%	39%	25%	C	18.4%	21.8%	27.7%	32.1%
Default	0%	0%	0%	100%	Default	0%	0%	0%	100%	Default	0%	0%	0%	100%

The above Table shows the cumulative percentage probability of a bond moving from one rating to another for future three years. For example, a bond that starts with an A credit rating has a 80% chance of still having an A rating by the end of year 1, a 10% chance of dropping to B by the year of end 1, an 8% chance of dropping to C by the year of end 1, and a 2% chance of defaulting by the end of year 1. Similarly, a bond that starts with a B credit rating has a 16.5% chance of improving to A by the end of year 2, a 52.3% chance of still having a B rating by the end of year 2, a 20.2% chance of dropping to C by the end of year 2, and a 11% chance of defaulting by the end of year 2.

i) The market is quoting a spread of 2% over the risk free rate for these bonds. Using the above transition matrix and cash flow IRR approach, estimate how much average profit the company can earn (per bond) by purchasing a portfolio of these bonds. [Please state any assumptions] (10)

ii) Describe the reasons for difference in market quoted value compared to value calculated by using transition matrices. Discuss possible limitations of the above approach. (4)

[14]

Q. 4) The interest rate curve for a particular economy is flat, in such a way that all zero coupon interest rates $i(t)$ are equal to some constant i, for all t. An arbitrage free environment can be assumed, and transaction costs, taxes and payment conventions can be ignored.

i) Derive the fixed payment c_1 on a standard five-year annual par swap, one which pays an annual fixed amount against an annual floating amount, set at the beginning of each period and paid in arrears. (3)

ii) Show that the fixed payment c_2 payable twice per year on a five- year semiannual par swap, otherwise on the same basis as in (i), is not (c_1/2). (1)

iii) Derive the fixed payment c_3 on a five-year annual par swap similar to that in (i) above, but for which the annual floating payment is set *in arrears* on the payment date itself. (This is known as a LIBOR-in-Arrears swap.) (3)

iv) Derive the fixed payment c_4 on a five-year annual par swap similar to that in (i) above, but for which the annual floating payment, set at the beginning of the period and paid in arrears, is calculated to be the level of the five year par swap as calculated in (i) above. (This is known as a Constant Maturity Index swap.) (3)

v) If the zero coupon interest curve is upwards sloping, i.e. $i(t_2) > i(t_1)$ for all $t_2 > t_1$, describe how the answer in sections (iii) and (iv) above will be affected. (2)

[12]

Q. 5) Let f, g be two non-income producing securities which depend on a single source of uncertainty, with:

$$df = \mu_f f dt + \sigma_f f dz$$

$$dg = \mu_g g dt + \sigma_g g dz$$

Define λ, the market price of risk; as:

$$\lambda = \frac{\mu_f - r}{\sigma_f} = \frac{\mu_g - r}{\sigma_g}$$

where r is the risk-free rate, and let $\phi = f/g$.

i) Define a martingale. (2)

ii) Explain the concept of numeraire assets in the context of the securities ϕ, f and g. (4)

iii) Using Ito's formula on $\ln \phi$, show that if $\lambda = \sigma$, then ϕ is a Martingale. (4)

iv) Suggest what might be meant by a security f being "forward risk neutral" with respect to a security g. (5)

[15]

Q. 6) **i)** State the Cameron-Martin-Girsanov Theorem for a **P**-Brownian motion process W_t , defining any symbols you use. (3)

ii) State the Martingale Representation Theorem for a **Q**-martingale process, defining any symbols you use. (2)

iii) Explain the significance of the Cameron-Martin-Girsanov and the Martingale Representation Theorems for the martingale approach to valuing derivatives (5)

[10]

Q. 7) An insurance company with substantial domestic pensions business is reviewing its policy with respect to derivatives across various asset classes.

The actuarial risk function is concerned about the amount of longevity and Limited Price Indexation (LPI) risk inherent in the pensions business. It has noted that most of the Over-the-counter (OTC) contracts available to manage these risks tend to be arranged with counterparties in the banking sector, which has been under stress recently.

i) Describe the main types of derivative instruments that can be used to hedge longevity risk. (5)

ii) Explain how counterparty risk originates in OTC contracts and how the insurance company can mitigate it. (4)

iii) **a)** Discuss the nature of the insurance company's LPI risk in a low inflation environment, commenting on potential ways of reducing it.

b) Identify institutions that might be natural hedgers of inflation risk in the financial markets, commenting on how likely it is that they would want to use inflation derivatives. (5)

[14]

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