INSTITUTE OF ACTUARIES OF INDIA

EXAMINATIONS

22nd November 2019

Subject SP6 – Financial Derivatives

Time allowed: 3 Hours 15 Minutes (10.15 – 13.30 Hours)

Total Marks: 100

INSTRUCTIONS TO THE CANDIDATES

1. ***Please read the instructions inside the cover page of answer booklet and instructions to examinees sent along with hall ticket carefully and follow without exception.***
2. ***The answers are not expected to be any country or jurisdiction specific. However, if Examples/illustrations are required for any answer, the country or jurisdiction from which they are drawn should be mentioned.***
3. ***Attempt all questions, beginning your answer to each question on a separate sheet.***
4. ***Mark allocations are shown in brackets.***
5. ***Please check if you have received complete Question Paper and no page is missing. If so, kindly get 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. You are not allowed to carry the question paper in any form with you.

Q. 1) A company holds a mixture of long term and short – term corporate bonds to back its liabilities. The regulator has directed the company to model its risk exposure due to these bonds and set aside capital equal to VaR over 1 year at 99.5% percentile.

i) Explain capital equal to VaR over 1 year at 99.5% percentile. (2)

Regulator is concerned about both default and transition (D&T) risk and spread risk.

ii) Differentiate between spread risk and the D&T risk. What is the relation between the bond price and D&T and spread risk? (3)

The regulator has proposed estimation of VaR (over 1 year) accounting for both D&T risk and Spread risk. The senior actuary has approached you to develop the model to estimate the VaR.

Stating the data requirements, assumptions, high level methodology and expert judgements, suggest an approach of estimating the VaR based on

iii) Spread risk only. (3)

iv) Default & Transition risk only. (3)

v) Suggest an approach to incorporate both Spread / Default & Transition risk. (3)

vi) What are the advantages of using T-Var over VaR as a risk measure? (2)

[16]

Q. 2) Answer the following questions with respect to yield curves.

i) What is a yield curve? Why are they generally upward sloping? (2)

ii) Describe what do you mean by the inverted yield curves? (2)

iii) State the possible reasons why yield curve inversion can happen. (2)

iv) The hypothetical yield curve for a country is as follows:

Year	1	2	3	4	5	6	7	8
Yield %	5	6	7	5	4	4	3.5	3.5

Estimate 1-year forward rates at the end of each year and comment on the results. (3)

[9]

Q. 3) As an asset Pricing actuary you wish to estimate the volatility market traded security for use in your pricing model.

i) List two different methods of estimating volatility. (2)

ii) Discuss when each of the above methods would be appropriate for use in your pricing model and highlight key limitation(s) in each case. (5)

[7]

Q. 4) Breta Company based in India has exposure to a country Triscal republic which is currently going through political turmoil. This has resulted in volatile exchange rates and hence increased the uncertainty of profit for Breta. The current exchange rate for Rs to Tdollar is 20 Rs to 1 TDollar. The interest rate in home country is 7% and in Triscal republic is 2%.

Suggest an approach to hedge the foreign exchange exposure and calculate expected forward rates on a no-arbitrage basis. **[5]**

Q. 5) **i)** Describe what Greeks for derivatives are. State by giving example for call option. (4)

ii) A company has written 50000 call options on a non-dividend paying stock and wants to hedge its exposure. Suggest the strategy based on Greeks to delta hedge the exposure.

Volatility= 25%
Duration = 3 months
Risk free rate = 6%
Strike price = 50
Current price of underlying = 47.5 (3)

[7]

Q. 6) Price the swaption with term 4 years and tenor 3 years with the following terms

a. Strike rate of 6.5%
b. Volatility 20%
c. Notional 100 cr
d. The Term structure is as follows:

	Annual compounding						
Time	1.0	2.0	3.0	4.0	5.0	6.0	7.0
curve	5%	5%	5.25%	6%	6.00%	6.50%	6.50%

[6]

Q. 7) Answer the following:

i) Connect the Vasicek model with the AR(1) process. (3)

ii) For any short rate model $dr = \mu(r, t)dt + \sigma(r, t)dW$ that produces zero coupon bond prices of the form $P(t, T) = A(t, T) \exp\{-B(t, T)\, r(t)\}$, show that the spot rate volatility structure is the curve $\sigma(r, t)B(t, T)/(T-t)$. (3)

iii) Suppose that the spot rate curve $r(r, a, b, t, T) = r + a(T - t) + b(T - t)^2$ is implied by a three factor model. Which of the factors r, a and b affects slope, curvature and parallel moves respectively? (3)

iv) Between a normal model and log-normal model, which overprices out – of – the money calls on bonds and under prices out – of – the – money puts on bonds and why? (2)

v) When pricing derivative on bonds under the HJM model, does the tree have to be built over the life of the longer – term underlying bond or just over the life of the derivative. (3)

[14]

Q. 8) A non-dividend paying stock has current price of 1000p. In any unit of time the price either increases by 25% or decreases by 20%. The risk – free interest rate is 5% per unit of time.

i) Find the risk neutral probability measure for the model. (2)

ii) Denoting stock price after t units of time by S_t:

a) Draw the stock price tree for this stock up to t = 2; i.e. 2 periods. (2)

b) Find the price of a path dependent option on the stock with expiry date t = 2 which pays $S_2 - M_2$, where $M_2 = \min_{0 \leq t \leq 2} S_t$. (3)

[7]

Q. 9) Answer the following:

i) What are digital options? Suppose an asset follows Brownian motion and there are no interest rates. What can be said about the relative prices of out – of – the money American and European digital calls? (4)

ii) Describe what is a barrier option and what are the various types of barrier options. Consider a portfolio of a European down – and – out option and a European down – and – in option with an identical barrier. You are required to come up with a "synthetic option" to represent the portfolio. What synthetic option will you consider? (4)

iii) Consider the following set of options:

- A down – and – out call with barrier at \$90 and strike at \$110.
- A down – and – in call with barrier at \$90 and strike at \$110.
- An up – and – in put with barrier at \$110 and strike at \$100.
- An up – and – in call with barrier at \$110 and strike at \$100.

Explain which of the above does not benefit from an increase in the stock price when the current stock price is \$100, and the barrier has not yet been crossed? (4)

[12]

Q. 10) Answer the following:

i) A standard synthetic CDO references a portfolio of 10 corporate names. Assume the following: The total reference notional is **X**, and the term is **Y** years. The reference notional per individual reference credit name is **X/10**. The default correlations between individual credit names are all equal to **1**. The single name CDS spread for each individual name is **100 bps**, for a term of **Y** years. The assumed recovery rate on default for all individual reference credits is zero in all cases. The synthetic CDO comprises of two tranches, a 50% Junior tranche (more risky) priced at a spread ***J***, and a 50% Senior tranche (relatively less risky) priced at a spread ***S***. All else constant, if default correlations between the individual reference credit names are reduced from **1.0** to **0.7**, what should be the effect on the relationship between the junior tranche spread ***J*** and the senior tranche spread ***S***? (3)

ii) Bank A enters into a CDS with Bank B that settles based on the performance of Company C. Assume that during the course of the CDS contract remaining in force, Bank B acquires Company C. What is the impact on the value of the CDS held by Bank A consequent to the acquisition of Company C by Bank B? You may assume that Bank B and Company C had the same initial credit ratings and everything else remains the same except the ownership of Company C. (3)

iii) Consider the following homogenous reference portfolio consisting of 100 reference entities. The CDS spread for the portfolio is, s: 150 bps and the recovery rate in the event of default is, f: 50%. Assume all defaults are independent of each other. On a single name, the annual default probability (PD) is constant over 5 years and obeys the relationship *"s = (1- f) * PD"*. Also, the expected number of defaulting entities over the next 5 years is the product of the number of reference entities and the cumulative probability of default.

a) What is the cumulative probability of default for the 5 years, rounded off to the lower integer? (1.5)

b) How much of the notional is expected to be wiped out by the expected number of defaulting entities? (1.5)

iv) Bank One has made a $200 million loan to a software company at a fixed rate of 12%. The bank wants to hedge its exposure by entering into a total return swap with a counterparty, Interloan Co., in which Bank One promises to pay the interest on the loan plus the change in the market value of the loan in exchange for LIBOR plus 40 basis points. If after one year the market value of the loan has decreased by 3% and LIBOR is 11%, what will be the net obligation of Bank One? (3)

[12]

Q. 11) Consider a European Bond Option with a maturity of 11.5 months on a 9.75 year bonds. The face value of the bond is Rs. 500 and the current price is Rs. 473.88. The strike price is Rs. 495. Further, the interest rate for the 11.5 month period is 9.8% per annum and the corresponding volatility is 8% per annum. The bond also pays a coupon of Rs. 25 each in three and nine months from today. The current 3 month risk free rate is 8.8% and the corresponding 9 month rate is 9.4%. You can assume that the current price and the strike price are both cash prices. Using this information and the Black's formula, compute the value of the call option. **[5]**

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