Strathmore
UNIVERSITY

STRATHMORE INSTITUTE OF MATHEMATICAL SCIENCES
BACHELOR OF BUSINESS SCIENCE IN FINANCIAL ENGINEERING
END OF SEMESTER EXAMINATION
BSF 4238 FINANCIAL INNOVATION AND STRUCTURED FINANCE

DATE:16TH DECEMBER 2024 Time: 2 Hours

Instructions

1. This examination consists of **FIVE** questions.
2. Answer **Question ONE (COMPULSORY)** and any other **TWO** questions.

QUESTION ONE (30 MARKS)

1. Derive the Pricing formulation of vanilla call option under the following approaches (15 marks)
   i) Hedging Approach
   ii) Replication Approach
   iii) Martingale Approach
2. Majority of financial innovations involve different ways of bundling or unbundling more basic instruments such as bonds, equities, commodities and currencies. Discuss 3 possible source drivers of financial innovation and a type of product that resulted from such innovation (6 marks).
3. "Africa is estimated to need an additional $500 billion to $1.2 trillion annually for sustainable finance for a range of SDG areas, including agriculture, renewable energy, transportation, water, health, and education. Climate change financing is a major need. Many parts of Africa are already suffering from its negative effects. Securitization could help raise that financing (Milken Institute, 2021)" Explain, giving an example of a product for the critical SDG areas, how securitization could help solve this financing concerns for Africa. (5 marks)
4. Discuss ethical considerations that institutions should observe when structuring and selling CDOs. (4 Marks)

QUESTION TWO (20 Marks)

1. Financial innovation is often driven by market inefficiencies and regulatory constraints. Using specific examples from the 2008 financial crisis and the post-2020 DeFi boom:
   i) Analyze how regulatory arbitrage led to the development of specific structured products (3 marks)
   ii) Evaluate the systemic risks that emerged from these innovations (3 marks)
2. Unit Investment Trust trading in the NYSE, has 80% of its holdings in fixed income instruments (bonds) and 20% in equities. Its holds the following bonds:

   5-Year 10% coupon bond of par 1000USD and yield to maturity of 12%
   10-year zero coupon bond of par12000 USD with yield to maturity of 14%
   20-year semi-annual 8% coupon bond of par 7000 USD with yield to maturity 10%.

   The trust had expenses amounting to 2% of the value of its equities holdings. And outstanding liabilities of 3,000 USD, with 3,500 shares outstanding. Calculate its share price, assuming its price is quoted as NAV. (6 marks)
3. You are a financial engineer at an African development bank tasked with designing innovative solutions for climate finance:
   i) Develop a structured product that combines weather and agricultural derivatives with green bonds (4 marks)
   ii) Analyze the risk decomposition and appropriate pricing methodology or architecture of the product (4 marks)

QUESTION THREE (20 Marks)

1. Develop a stress testing framework for structured and/or exotic products of your choice, explaining all the relevant steps (6 marks)
2. Differentiate the following structured products, clearly describing their payoff structures and conditions (8 Marks)
   i. Himalaya
   ii. Kilimanjaro
   iii. Twin-Win
   iv. Rainbow
   v. Phoenix
   vi. Wedding Cake
   vii. Shark Fin
   viii. Asian Spread
4. Discuss 3 benefits of holding and development of investment funds (6 marks)

QUESTION FOUR (20 Marks)

1. Consider two assets whose prices $S_{1,t}$ and $S_{2,t}$ at time $t \in [0,T]$ that follow geometric Brownian dynamics as follows:

$$dS_{1,t} = rS_{1,t}dt + S_{1,t}\sqrt{v_{1,t}}dW_{1,t}$$

$$dS_{2,t} = rS_{2,t}dt + S_{2,t}\sqrt{v_{2,t}}dW_{2,t}$$

where $W_{1,t}$, $t \in [0,T]$, and $W_{2,t}$, $t \in [0,T]$ are two standard Brownian motions with correlation $\rho \in [-1, 1]$ under a risk-neutral probability measure Q^* , with $dW_{1,t} \bullet dW_{2,t} = \rho dt$. The processes $v_{1,t}$ and $v_{2,t}$ are constants from a deterministic local volatility processes such that:

$$v_{1,t} = \frac{1}{T-t}\int_t^T v_{1,s}ds \text{ and } v_{2,t} = \frac{1}{T-t}\int_t^T v_{2,s}ds$$

Given that these volatility values were estimated to be $\hat{v}_1$ and $\hat{v}_2$.

Determine the risk-neutral valuation formula for the following derivatives on the underlyings (20 Marks):

i. The price of a spread option M_t with payoff at maturity of $S_{1,T} - S_{2,T}$ (10 marks)

ii. The price of a cash-or-nothing bivariate digital option B_t with payoff at maturity of X $S_{1,T} > k_1$ and $S_{2,T} > k_1$given a non-zero correlation coefficient (5 marks)

iii. The price of a cash-or-nothing bivariate digital option D_t with payoff at maturity of X if $S_{1,T} > k_1$ or of Y if $S_{2,T} > k_1$ (5 marks)

QUESTION FIVE (20 Marks)

1. In the context of a high-level conference on "*The Strategic Role of Financial Engineering in Advancing Market Depth and Resilience*", you are tasked with presenting on the complex advantages of asset securitization specifically for the African Financial Markets. Critically analyze three primary benefits of asset securitization. Support your analysis with examples pertinent to the African financial context. (6 marks)

2. Outline a comprehensive securitization process for a non-performing loan (NPL) portfolio of a large cap commercial bank, detailing each phase and the interaction of involved entities. Provide an in-depth explanation of the roles and functions of the Special Purpose Vehicle (SPV), Originators, Servicers, Credit Enhancers, Trustee, and Underwriters and other players. Incorporate relevant process diagrams to illustrate the flow and transformation of the asset pool from origination through to the issuance and distribution of securities. (8 marks)

3. Black swan events and contagious market disruptions pose profound challenges in the structuring, valuation, and management of complex financial products. Discuss four specific challenges these unpredictable events create in the design, pricing, and issuance of structured products. (8 marks)