
SOCIETY OF ACTUARIES
Quantitative Finance and Investment Advanced Exam

Exam QFIADV

AFTERNOON SESSION

Date: Thursday, November 3, 2016

Time: 1:30 p.m. – 3:45 p.m.

INSTRUCTIONS TO CANDIDATES

General Instructions

1. This afternoon session consists of 7 questions numbered 10 through 16 for a total of 40 points. The points for each question are indicated at the beginning of the question.
2. Failure to stop writing after time is called will result in the disqualification of your answers or further disciplinary action.
3. While every attempt is made to avoid defective questions, sometimes they do occur. If you believe a question is defective, the supervisor or proctor cannot give you any guidance beyond the instructions on the exam booklet.

Written-Answer Instructions

1. Write your candidate number at the top of each sheet. Your name must not appear.
2. Write on only one side of a sheet. Start each question on a fresh sheet. On each sheet, write the number of the question that you are answering. Do not answer more than one question on a single sheet.
3. The answer should be confined to the question as set.
4. When you are asked to calculate, show all your work including any applicable formulas. When you are asked to recommend, provide proper justification supporting your recommendation.
5. When you finish, insert all your written-answer sheets into the Essay Answer Envelope. Be sure to hand in all your answer sheets because they cannot be accepted later. Seal the envelope and write your candidate number in the space provided on the outside of the envelope. Check the appropriate box to indicate morning or afternoon session for Exam QFIADV.
6. Be sure your written-answer envelope is signed because if it is not, your examination will not be graded.

Tournez le cahier d'examen pour la version française.

****BEGINNING OF EXAMINATION****
Afternoon Session

10. (5 points) In 1988 BIS I (Basel I) was introduced to the banking industry worldwide and standardized capital requirements.

(a) (1 point) Outline four shortcomings of BIS I (Basel I) with respect to credit risk requirements and how BIS II (Basel II) attempted to rectify them.

ZED Company is testing different credit models to measure the credit risk exposure and manage the portfolio credit risk. The management is considering MKMV Portfolio Manager for required economic capital calculation, and you are asked to calculate the required economic capital for a portfolio with a market value of 50. Based on Monte Carlo simulation, the portfolio value after one year follows a normal distribution with mean 52 and sigma 3. Current one-year LIBOR rate is 2%, and the portfolio weighted average spread is 50 bps.

(b) (1 point) Calculate the portfolio's required economic capital at 99.8% confidence interval.

You are given the following:

- The portfolio above has two bonds;
- Bond 1 has a value of 15 and a maturity of two years;
- Bond 2 has a value of 35 and a maturity of three years;
- The correlation between bond 1 and bond 2 is 0.6.

Cumulative Mortality (Default)
 Losses from Year 1 to Year 3:

	1	2	3
Bond 1	0.23%	2.41%	
Bond 2	0.67%	2.07%	4.52%

	Yield to Maturity	Variance of Return
Bond 1	5.00%	4.00%
Bond 2	5.76%	5.00%

(c) (3 points) Calculate the portfolio's risk-reward ratio based on Altman's optimization approach.

11. (7 points) You are responsible for your company's risk management modeling.

- (a) (1 point) Outline three alternative non-stochastic approaches that could be used when it would be impractical to build the scenarios needed for stochastic modelling.

Your colleague Bob wants to understand the economic cost of a minimum fixed account interest rate guarantee in the product his team is designing. The fixed account assets are 100% invested in government bonds and investment-grade corporate bonds. Below are his considerations:

Step 1: Bob believes that stochastic modeling is the only way to understand the cost of minimum interest rate guarantees.

Step 2: Bob has chosen the average of future Risk Based Capital requirements from all scenarios as his risk metric.

Step 3: Bob uses a lognormal model to stochastically generate scenarios for S&P 500 returns.

Step 4: Another actuary uses 1,000 stochastic scenarios for quantifying the cost of the guarantee, so Bob has chosen to use the same number of scenarios.

- (b) (3 points) Critique Bob's methodology, including considerations he may have failed to identify and any steps that should have been done differently.

You are given the following information about a Regime-Switching Lognormal Model (RSLN):

	Mean	Volatility	Transition Probability
Regime 1	$\mu_1 = 15\%$	$\sigma_1 = 10\%$	$p_{12} = 5\%$
Regime 2	$\mu_2 = -20\%$	$\sigma_2 = 30\%$	$p_{21} = 15\%$

- Today's price is $S_0 = 50$.
- Uniform distribution random number: 0.3
- Standard Normal distribution random number: -0.1
- Assume that the probabilities of the process being in each regime at time zero are given by the stationary probabilities.

- (c) (1.5 points) Simulate the price at time 1 using the RSLN parameters above.
- (d) (1.5 points) Calculate the unconditional probability of being in Regime 2 at $t = 1$.

12. (5 points) The following information is known about company ABC:

- Asset value is 100 at time 0
- The volatility of asset value is 30% per year
- Debt consists of a single zero coupon bond that matures in one year
- The maturity value for the bond is 80
- Risk free rate is 4% per year compounded continuously

- (a) (1 point) Determine what additional assumptions must be added in order to use Merton's asset model to value the bond.
- (b) (1 point) Identify the positions of the equity holder and the bond holder in terms of options.
- (c) (2 points) Calculate the value of ABC's bond at time 0.
- (d) (1 point) Determine ABC's credit spread.

13. (5 points) You are working on a team responsible for managing target volatility funds.

The team is developing a new stochastic model to estimate guarantee costs. All agree that an exponential weighted moving average (EWMA) calculation should be used to estimate volatility for rebalancing and that the form of the formula should be the following:

$$\left(\hat{\sigma}_t^{equity}\right)^2 = \lambda\left(\hat{\sigma}_{t-\Delta t}^{equity}\right) + (1-\lambda)\frac{1}{\Delta t}\left(\ln\left(\frac{S_t}{S_{t-\Delta t}}\right)\right)^2$$

where S_t is the modeled equity index at time t , λ is a constant and $\Delta t = 1$ business day.

(a) (1 point) Describe the impact λ has in estimating future equity volatility in the EWMA calculation.

The team is debating the value of the parameter λ . Some team members believe the parameter should be 0.98 and others that it should be 0.85.

(b) (2 points) Recommend one of these values for λ . Justify your answer.

The team has agreed to use daily rebalancing and a stochastic volatility jump diffusion model (SVJD) to model equity returns.

Previously, a consultant used a Heston model for equity volatility and assumed monthly rebalancing. The team observes that the market consistent guarantee costs are now higher and that product guarantee charges consistent with the SVJD model may not be commercially viable.

(c) (2 points) Explain why the models produce different estimates of market consistent guarantee costs.

14. (6 points) You just joined XYZ Life Company as an investment actuary to manage the credit risk exposure. XYZ Company measures the exposure for a portfolio relative to its benchmark as contribution-to-duration overweights or underweights along a sector by quality. The Chief Risk Officer (CRO) heard that contribution to the Duration Times Spread (DTS) may be a better metric and asked you to do some research.

(a) (1 point) Explain why DTS is better than the current approach to control risk.

You decide to change to the DTS-based approach and develop a policy that limits the DTS contribution from any single issue to 3.

XYZ is going to launch a new product and you are asked to construct a portfolio that could be made up of corporate bonds and/or credit default swaps (CDS). After your research, you are considering buying the following three assets.

Asset	Rating	Duration	Spread Over Treasury (bps)	Absolute Spread Volatility
Bond 1	A	8	150	0.25
Bond 2	AAA	5	75	0.1
Bond 3	A	9	120	0.20

(b) (1 point) Calculate the percentages of the portfolio's market value that can be invested in each of the assets before they breach XYZ's credit limit.

(c) (1 point) Calculate an approximate volatility of excess returns for Bond 1.

(d) (1 point) Identify one disadvantage of issuer limits based on spreads and recommend one solution to avoid this issue.

Bond 1 and Bond 3 are within the same industry and the CRO expects Bond 1 to perform better than Bond 3. To hedge against market-wide spread changes, he proposed a hedge strategy by neutralizing dollar duration of Bond 1 and Bond 3.

(e) (1 point) Critique this hedge strategy.

The CRO now expects Bond 1 to be downgraded to BBB and its bond spread to widen by 75bps.

(f) (1 point) Evaluate the impact of the downgrade on the spread volatility of Bond 1.

15. (6 points) You are working with short rate models.

(a) (1 point) Compare and contrast Vasicek models and Cox-Ingersoll-Ross models.

You are asked to confirm the analytical tractability of the models, in terms of pricing bonds and bond options.

(b) (1 point) Explain this analytical tractability and identify consequences of its absence.

In one model, the short rate $r(t)$ follows

$$dr(t) = k(\theta - r(t))dt + \sigma dW(t)$$

where k , θ , and σ are positive constants and $W(t)$ is a Brownian motion.

You have that, with parameters $k = k_0$, $\theta = \theta_0$ and $\sigma = \sigma_0$:

- The expected value of the short rate at time $t=2$ is 0.04
- The standard deviation of the short rate at time $t=2$ is 0.02

If, instead, parameters $k = k_0$, $\theta = \theta_0$ and $\sigma = 1.5\sigma_0$,

(c) (2 points) Calculate the risk neutral probability that short rate at time $t=2$ is between 0.04 and 0.10.

15. Continued

You are given the following model where the short rate $r(t)$ follows

$$dr(t) = k(\theta - r(t))dt + \sigma\sqrt{r(t)}dW(t)$$

where k, θ , and σ are positive constants, $2k\theta > \sigma^2$, and $W(t)$ is a Brownian motion.

Let $P(r(t), t, T)$ be the market price of a zero-coupon bond with \$1 par that matures at time T and t the current time.

You are given:

- $P(0.05, 0, 1) = 0.9372$
- $P(0.10, 1, 2) = 0.9011$

(d) (2 points) Calculate $P(0.15, 2, 3)$. Show your work.

16. (6 points) You have been asked to review what benchmarks are available to evaluate the performance of alternative investments.

- (a) (1 point) Identify the common features of alternative investments.
- (b) (2 points) Describe the benchmarks available and their respective limitations for direct and indirect real estate investments.

Your company primarily sells Multi-Year Guarantee Annuities (MYGA) with duration equal to 3 years. In the current low interest rate environment, your company wants to add direct real estate investment to the strategic asset allocation to pick up additional yield.

- Current strategic asset allocation is 90% bonds and 10% common stock;
- Risk-free interest rate is 1.50%;
- Overall investment objective is to maximize pricing spread (i.e. net investment earned rate less crediting rate);
- Crediting rate is set at 100 bps above the risk-free rate.
- The entire bond portfolio is liquid.
- The company does not like to actively trade stocks and generally considers them illiquid for internal pricing exercises.

Measure	Bonds	Stocks	Real Estate	90/10 Bonds/Stocks	80/10/10 Bonds/Stocks/Real Estate
Expected return	3.6%	8.25%	7.25%		
Std. dev. of return				7.2%	7.8%

- (c) (1 point) Justify the decision to add real estate to the strategic asset allocation.
- (d) (1 point) Calculate the pricing spread with the 80/10/10 strategic asset allocation.

Your Chief Risk Officer (CRO) in the past has avoided direct investment in real estate preferring to obtain real estate exposure through indirect exposure. Currently he opposes the decision to add real estate investment to the strategic asset allocation.

- (e) (1 point) Justify the position of your CRO.

****END OF EXAMINATION****
Afternoon Session

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