NANYANG TECHNOLOGICAL UNIVERSITY

SEMESTER 1 EXAMINATION 2023-2024

BR3213 Valuation and Risk Models

November 2023

Time Allowed: 2 ½ Hours

INSTRUCTIONS

1. This paper contains **SIX(6)** questions and comprises **FIVE(5)** pages and **ONE(1)** Appendix of **ELEVEN(11)** pages.
2. Answer **ALL SIX(6)** questions.
3. This is a **Closed-book** examination.
4. The number of marks allocated is shown at the end of each question.
5. Begin your answer to each question on a separate page of the answer book.
6. Answers will be graded for content and appropriate presentation.

Note: Exam questions begin on Page 2.

Question 1

Consider Asset A and Asset B. The return of asset A over the next year is uniformly distributed between 6% and 18%. The return of asset B over the next year is exponentially distributed with mean of 12%.

Find the value at risk (in return percentages) for both A and B with a confidence level of 95%. Comment on the riskiness of A and B based on the value at risk calculated.

(7 marks)

Question 2

(a) Write down and briefly explain the three most significant operational risks faced by financial institutions that has been emphasized by Basel Committee.

(3 marks)

(b) An insurance company that provides operational risk insurance coverage may face the moral hazard issue.

i) Briefly define and describe the moral hazard risks associated with the operational risk insurance.

(2 marks)

ii) How is moral hazard typically handled in insurance contracts?

(2 marks)

(TOTAL: 7 marks)

Question 3

Briefly compare and contrast the stress testing and Value at Risk (VaR) assessments, from the perspectives of their nature, basis, number of scenarios considered and time-scale.

(8 marks)

Question 4

(a) A treasury bond pays semi-annual coupons with a coupon rate of 5% per annum. The investor obtained the bid quote and ask quote for this bond are 95.29 and 95.31 respectively. There have been 96 days since the last coupon payment and there are 183 days from the last coupon payment date to the next coupon payment date. Calculate the market average cash price for this bond.

(3 marks)

(b) You are given the following information on a couple of bonds at time 0:

Maturity (in years)	Coupon rate (per annum)	Market bid-ask quote
0.5	2.60%	99.7896
1	3.80%	100.7557
1.5	3.00%	99.3285
2	4.00%	100.1151

i) All bonds are paying semi-annual coupons. Calculate the discount factors for time 0.5, 1, 1.5 and 2 respectively.

(5 marks)

ii) Find the par rate of a bond that matures at time 2 using the information above.

(2 marks)

iii) Calculate the forward rate for investment between time 1 and time 2 using the information above.

(2 marks)

iv) A bond pays **annual coupon** at a rate of 5% has exactly 2 years to maturity. Given that the par value of the bond is $1000, calculate the price and the yield to maturity of the bond.

(4 marks)

(c) Write down the mathematical expression of the bond duration DV01 measure. What is the difference between effective duration and DV01? Briefly discuss when it is appropriate to use DV01 and when it is appropriate to use effective duration.

(6 marks)

(TOTAL: 22 marks)

Question 5

A stock is currently priced at \$46. After each period of time, the stock price either increases by 20% with a probability of 0.6, or decreases by 15%. At the end of each period, the stock pays a dividend of \$2 per share to the shareholders if the stock price has increased for the period. The risk-free continuously compounding interest rate is 4%.

Consider a two period European call option on this stock with strike price of $K = 46$.

(a) Write down the payoffs of the call option at time 2. Calculate the expected payoff.

(8 marks)

(b) Use the binomial tree method, construct replicating portfolios that replicates the payoff of the option at time 1 and time 2. Clearly indicate the units of stocks and cash to be held in this replicating portfolio. Hence or otherwise, calculate the price of this option at time 0.

(14 marks)

(c) At time 0, how much is the option's intrinsic value and how much is the option's time value?

(2 marks)

(TOTAL: 24 marks)

Question 6

(a) Let S_t be the stock price at time t, $t \geq 0$. Under the Black-Scholes model, the return for a non-dividend paying stock over a short period of time Δt is assumed to be normally distributed with mean return $\mu\Delta t$ and standard deviation $\sigma\sqrt{\Delta t}$.

i) What is the distribution of the log-return for period $[0, t]$, i.e. the distribution for $\ln \frac{S_t}{S_0}$? Specify the mean and standard deviation of the distribution.

(3 marks)

ii) What is the distribution of S_t, given the value of S_0? Specify the mean and variance of the distribution.

(6 marks)

iii) Suppose the current stock price S_0 is \$28. The estimated parameters are $\mu = 8\%$ and $\sigma = 15\%$ per annum. Find the 95% confidence interval for the stock price in 6 months time, i.e. the 95% confidence interval for S_t where $t = 0.5$.

(5 marks)

Note: Question No.6 continues on page 5

Question 6 (Continued)

iv) A European put option with a strike price of \$30 that matures in 6 months time is written on the stock with parameters mentioned in (iii). Use the Black-Scholes formula to calculate the option price given that the continuously compounding risk free-rate is 3%.

(8 marks)

(b) Write down the definition of the five Greeks, including Delta, Theta, Vega, Rho and Lambda, for analyzing the option values. For a European put option, briefly indicate and explain the sign (positive or negative) of each Greeks.

(10 marks)

(TOTAL: 32 marks)

– END OF PAPER –

APPENDIX 1: SELECTED FORMULAE

STATISTICAL DISTRIBUTIONS

Notation

PF = Probability function, $p(x)$
PDF = Probability density function, $f(x)$
DF = Distribution function, $F(x)$
PGF = Probability generating function, $G(s)$
MGF = Moment generating function, $M(t)$

Note. Where formulae have been omitted below, this indicates that (a) there is no simple formula or (b) the function does not have a finite value or (c) the function equals zero.

DISCRETE DISTRIBUTIONS

Binomial distribution

Parameters: n, p (n = positive integer, $0 < p < 1$ with $q = 1 - p$)

PF: $p(x) = \binom{n}{x} p^x q^{n-x}$, $x = 0, 1, 2, \ldots, n$

DF: The distribution function is tabulated in the statistical tables section.

PGF: $G(s) = (q + ps)^n$

MGF: $M(t) = (q + pe^t)^n$

Moments: $E(X) = np$, $\text{var}(X) = npq$

Coefficient of skewness: $\dfrac{q - p}{\sqrt{npq}}$

Note: Appendix 1 continues on page 7

Appendix 1 (Continued)

Bernoulli distribution

The Bernoulli distribution is the same as the binomial distribution with parameter $n = 1$.

Poisson distribution

Parameter:	μ $(\mu > 0)$
PF:	$p(x) = \dfrac{e^{-\mu}\mu^x}{x!}, \quad x = 0, 1, 2, \ldots$
DF:	The distribution function is tabulated in the statistical tables section.
PGF:	$G(s) = e^{\mu(s-1)}$
MGF:	$M(t) = e^{\mu(e^t - 1)}$
Moments:	$E(X) = \mu, \quad \text{var}(X) = \mu$
Coefficient of skewness:	$\dfrac{1}{\sqrt{\mu}}$

Note: Appendix 1 continues on page 8

Appendix 1 (Continued)

Uniform distribution (discrete)

Parameters: a, b, h ($a<b$, $h>0$, $b-a$ is a multiple of h)

PF: $p(x)=\dfrac{h}{b-a+h},\ x=a,a+h,a+2h,\ldots,b-h,b$

PGF: $G(s)=\dfrac{h}{b-a+h}\left(\dfrac{s^{b+h}-s^{a}}{s^{h}-1}\right)$

MGF: $M(t)=\dfrac{h}{b-a+h}\left(\dfrac{e^{(b+h)t}-e^{at}}{e^{ht}-1}\right)$

Moments: $E(X)=\dfrac{1}{2}(a+b)$, $\operatorname{var}(X)=\dfrac{1}{12}(b-a)(b-a+2h)$

CONTINUOUS DISTRIBUTIONS

Standard normal distribution – $N(0,1)$

Parameters: none

PDF: $f(x)=\dfrac{1}{\sqrt{2\pi}}e^{-\frac{1}{2}x^{2}},\ -\infty<x<\infty$

DF: The distribution function is tabulated in the statistical tables section.

MGF: $M(t)=e^{\frac{1}{2}t^{2}}$

Moments: $E(X)=0$, $\operatorname{var}(X)=1$

$$E(X^{r})=\frac{1}{2^{r/2}}\frac{\Gamma(1+r)}{\Gamma\left(1+\frac{r}{2}\right)},\ r=2,4,6,\ldots$$

Note: Appendix 1 continues on page 9

Appendix 1 (Continued)

Normal (Gaussian) distribution – $N(\mu, \sigma^2)$

Parameters: μ, σ^2 $(\sigma > 0)$

PDF: $f(x) = \dfrac{1}{\sigma\sqrt{2\pi}} \exp\left\{-\dfrac{1}{2}\left(\dfrac{x-\mu}{\sigma}\right)^2\right\}, \ -\infty < x < \infty$

MGF: $M(t) = e^{\mu t + \frac{1}{2}\sigma^2 t^2}$

Moments: $E(X) = \mu$, $\operatorname{var}(X) = \sigma^2$

Exponential distribution

Parameter: λ $(\lambda > 0)$

PDF: $f(x) = \lambda e^{-\lambda x}, \ x > 0$

DF: $F(x) = 1 - e^{-\lambda x}$

MGF: $M(t) = \left(1 - \dfrac{t}{\lambda}\right)^{-1}, \ t < \lambda$

Moments: $E(X) = \dfrac{1}{\lambda}$, $\operatorname{var}(X) = \dfrac{1}{\lambda^2}$

$$E(X^r) = \frac{\Gamma(1+r)}{\lambda^r}, \ r = 1, 2, 3, \ldots$$

Coefficient
of skewness: 2

Note: Appendix 1 continues on page 10

Appendix 1 (Continued)

Gamma distribution

Parameters: $\alpha,\ \lambda\ (\alpha > 0,\ \lambda > 0)$

PDF: $f(x) = \dfrac{\lambda^{\alpha}}{\Gamma(\alpha)} x^{\alpha-1} e^{-\lambda x},\ x > 0$

DF: When 2α is an integer, probabilities for the gamma distribution can be found using the relationship:

$2\lambda X \sim \chi^2_{2\alpha}$

MGF: $M(t) = \left(1 - \dfrac{t}{\lambda}\right)^{-\alpha},\ t < \lambda$

Moments: $E(X) = \dfrac{\alpha}{\lambda},\ \text{var}(X) = \dfrac{\alpha}{\lambda^2}$

$E(X^r) = \dfrac{\Gamma(\alpha + r)}{\Gamma(\alpha)\lambda^r},\ r = 1, 2, 3, \ldots$

Coefficient of skewness: $\dfrac{2}{\sqrt{\alpha}}$

Chi-square distribution – χ^2_{υ}

The chi-square distribution with υ degrees of freedom is the same as the gamma distribution with parameters $\alpha = \dfrac{\upsilon}{2}$ and $\lambda = \dfrac{1}{2}$.

The distribution function for the chi-square distribution is tabulated in the statistical tables section.

Note: Appendix 1 continues on page 11

Appendix 1 (Continued)

Uniform distribution (continuous) – *U(a, b)*

Parameters: $a, b \ (a < b)$

PDF: $f(x) = \frac{1}{b-a}, \ a < x < b$

DF: $F(x) = \frac{x-a}{b-a}$

MGF: $M(t) = \frac{1}{(b-a)}\frac{1}{t}(e^{bt} - e^{at})$

Moments: $E(X) = \frac{1}{2}(a+b), \ \mathrm{var}(X) = \frac{1}{12}(b-a)^2$

$E(X^r) = \frac{1}{(b-a)}\frac{1}{r+1}(b^{r+1} - a^{r+1}), \ r = 1, 2, 3, \ldots$

Beta distribution

Parameters: $\alpha, \ \beta \ (\alpha > 0, \ \beta > 0)$

PDF: $f(x) = \frac{\Gamma(\alpha+\beta)}{\Gamma(\alpha)\Gamma(\beta)} x^{\alpha-1}(1-x)^{\beta-1}, \ 0 < x < 1$

Moments: $E(X) = \frac{\alpha}{\alpha+\beta}, \ \mathrm{var}(X) = \frac{\alpha\beta}{(\alpha+\beta)^2(\alpha+\beta+1)}$

$E(X^r) = \frac{\Gamma(\alpha+\beta)\Gamma(\alpha+r)}{\Gamma(\alpha)\Gamma(\alpha+\beta+r)}, \ r = 1, 2, 3, \ldots$

Coefficient of skewness: $\frac{2(\beta-\alpha)}{(\alpha+\beta+2)}\sqrt{\frac{\alpha+\beta+1}{\alpha\beta}}$

Note: Appendix 1 continues on page 12

Appendix 1 (Continued)

Lognormal distribution

Parameters: μ, σ^2 $(\sigma > 0)$

PDF: $f(x) = \dfrac{1}{\sigma\sqrt{2\pi}}\dfrac{1}{x}\exp\left\{-\dfrac{1}{2}\left(\dfrac{\log x - \mu}{\sigma}\right)^2\right\}$, $x > 0$

Moments: $E(X) = e^{\mu + \frac{1}{2}\sigma^2}$, $\mathrm{var}(X) = e^{2\mu+\sigma^2}\left(e^{\sigma^2} - 1\right)$

$E(X^r) = e^{r\mu + \frac{1}{2}r^2\sigma^2}$, $r = 1, 2, 3, \ldots$

Coefficient of skewness: $\left(e^{\sigma^2} + 2\right)\sqrt{e^{\sigma^2} - 1}$

Pareto distribution (two parameter version)

Parameters: α, λ $(\alpha > 0,\ \lambda > 0)$

PDF: $f(x) = \dfrac{\alpha\lambda^\alpha}{(\lambda + x)^{\alpha+1}}$, $x > 0$

DF: $F(x) = 1 - \left(\dfrac{\lambda}{\lambda + x}\right)^\alpha$

Moments: $E(X) = \dfrac{\lambda}{\alpha - 1}$ $(\alpha > 1)$, $\mathrm{var}(X) = \dfrac{\alpha\lambda^2}{(\alpha-1)^2(\alpha-2)}$ $(\alpha > 2)$

$E(X^r) = \dfrac{\Gamma(\alpha - r)\Gamma(1 + r)}{\Gamma(\alpha)}\lambda^r$, $r = 1, 2, 3, \ldots$, $r < \alpha$

Coefficient of skewness: $\dfrac{2(\alpha+1)}{(\alpha-3)}\sqrt{\dfrac{\alpha-2}{\alpha}}$ $(\alpha > 3)$

Note: Appendix 1 continues on page 13

Appendix 1 (Continued)

BINOMIAL PRICING ("TREE") MODEL

Risk-neutral probabilities

Up-step probability $= \dfrac{e^{r\Delta t} - d}{u - d}$,

where $u \approx e^{\sigma\sqrt{\Delta t} + q\Delta t}$

and $\quad d \approx e^{-\sigma\sqrt{\Delta t} + q\Delta t}$.

BLACK-SCHOLES FORMULAE FOR EUROPEAN OPTIONS

Geometric Brownian motion model for a stock price S_t

$$dS_t = S_t(\mu dt + \sigma dz)$$

Black-Scholes partial differential equation

$$\frac{\partial f}{\partial t} + (r - q)S_t \frac{\partial f}{\partial S_t} + \tfrac{1}{2}\sigma^2 S_t^2 \frac{\partial^2 f}{\partial S_t^2} = rf$$

Garman-Kohlhagen formulae for the price of call and put options

Call: $\quad c_t = S_t e^{-q(T-t)}\Phi(d_1) - Ke^{-r(T-t)}\Phi(d_2)$

Put: $\quad p_t = Ke^{-r(T-t)}\Phi(-d_2) - S_t e^{-q(T-t)}\Phi(-d_1)$

where $d_1 = \dfrac{\log(S_t/K) + (r - q + ½\sigma^2)(T - t)}{\sigma\sqrt{T - t}}$

and $\quad d_2 = \dfrac{\log(S_t/K) + (r - q - ½\sigma^2)(T - t)}{\sigma\sqrt{T - t}} = d_1 - \sigma\sqrt{T - t}$

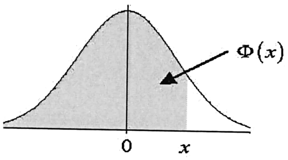
Note: Appendix 1 continues on page 14

Appendix 1 (Continued)

Probabilities for the Standard Normal distribution

The distribution function is denoted by $\Phi(x)$, and the probability density function is denoted by $\phi(x)$.

$$\Phi(x) = \int_{-\infty}^{x} \phi(t)\,dt = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{x} e^{-\frac{1}{2}t^2}\,dt$$



x	$\Phi(x)$	x	$\Phi(x)$	x	$\Phi(x)$	x	$\Phi(x)$	x	$\Phi(x)$
0.00	0.50000	**0.40**	0.65542	**0.80**	0.78814	**1.20**	0.88493	**1.60**	0.94520
0.01	0.50399	**0.41**	0.65910	**0.81**	0.79103	**1.21**	0.88686	**1.61**	0.94630
0.02	0.50798	**0.42**	0.66276	**0.82**	0.79389	**1.22**	0.88877	**1.62**	0.94738
0.03	0.51197	**0.43**	0.66640	**0.83**	0.79673	**1.23**	0.89065	**1.63**	0.94845
0.04	0.51595	**0.44**	0.67003	**0.84**	0.79955	**1.24**	0.89251	**1.64**	0.94950
0.05	0.51994	**0.45**	0.67364	**0.85**	0.80234	**1.25**	0.89435	**1.65**	0.95053
0.06	0.52392	**0.46**	0.67724	**0.86**	0.80511	**1.26**	0.89617	**1.66**	0.95154
0.07	0.52790	**0.47**	0.68082	**0.87**	0.80785	**1.27**	0.89796	**1.67**	0.95254
0.08	0.53188	**0.48**	0.68439	**0.88**	0.81057	**1.28**	0.89973	**1.68**	0.95352
0.09	0.53586	**0.49**	0.68793	**0.89**	0.81327	**1.29**	0.90147	**1.69**	0.95449
0.10	0.53983	**0.50**	0.69146	**0.90**	0.81594	**1.30**	0.90320	**1.70**	0.95543
0.11	0.54380	**0.51**	0.69497	**0.91**	0.81859	**1.31**	0.90490	**1.71**	0.95637
0.12	0.54776	**0.52**	0.69847	**0.92**	0.82121	**1.32**	0.90658	**1.72**	0.95728
0.13	0.55172	**0.53**	0.70194	**0.93**	0.82381	**1.33**	0.90824	**1.73**	0.95818
0.14	0.55567	**0.54**	0.70540	**0.94**	0.82639	**1.34**	0.90988	**1.74**	0.95907
0.15	0.55962	**0.55**	0.70884	**0.95**	0.82894	**1.35**	0.91149	**1.75**	0.95994
0.16	0.56356	**0.56**	0.71226	**0.96**	0.83147	**1.36**	0.91309	**1.76**	0.96080
0.17	0.56749	**0.57**	0.71566	**0.97**	0.83398	**1.37**	0.91466	**1.77**	0.96164
0.18	0.57142	**0.58**	0.71904	**0.98**	0.83646	**1.38**	0.91621	**1.78**	0.96246
0.19	0.57535	**0.59**	0.72240	**0.99**	0.83891	**1.39**	0.91774	**1.79**	0.96327
0.20	0.57926	**0.60**	0.72575	**1.00**	0.84134	**1.40**	0.91924	**1.80**	0.96407
0.21	0.58317	**0.61**	0.72907	**1.01**	0.84375	**1.41**	0.92073	**1.81**	0.96485
0.22	0.58706	**0.62**	0.73237	**1.02**	0.84614	**1.42**	0.92220	**1.82**	0.96562
0.23	0.59095	**0.63**	0.73565	**1.03**	0.84849	**1.43**	0.92364	**1.83**	0.96638
0.24	0.59483	**0.64**	0.73891	**1.04**	0.85083	**1.44**	0.92507	**1.84**	0.96712
0.25	0.59871	**0.65**	0.74215	**1.05**	0.85314	**1.45**	0.92647	**1.85**	0.96784
0.26	0.60257	**0.66**	0.74537	**1.06**	0.85543	**1.46**	0.92785	**1.86**	0.96856
0.27	0.60642	**0.67**	0.74857	**1.07**	0.85769	**1.47**	0.92922	**1.87**	0.96926
0.28	0.61026	**0.68**	0.75175	**1.08**	0.85993	**1.48**	0.93056	**1.88**	0.96995
0.29	0.61409	**0.69**	0.75490	**1.09**	0.86214	**1.49**	0.93189	**1.89**	0.97062
0.30	0.61791	**0.70**	0.75804	**1.10**	0.86433	**1.50**	0.93319	**1.90**	0.97128
0.31	0.62172	**0.71**	0.76115	**1.11**	0.86650	**1.51**	0.93448	**1.91**	0.97193
0.32	0.62552	**0.72**	0.76424	**1.12**	0.86864	**1.52**	0.93574	**1.92**	0.97257
0.33	0.62930	**0.73**	0.76730	**1.13**	0.87076	**1.53**	0.93699	**1.93**	0.97320
0.34	0.63307	**0.74**	0.77035	**1.14**	0.87286	**1.54**	0.93822	**1.94**	0.97381
0.35	0.63683	**0.75**	0.77337	**1.15**	0.87493	**1.55**	0.93943	**1.95**	0.97441
0.36	0.64058	**0.76**	0.77637	**1.16**	0.87698	**1.56**	0.94062	**1.96**	0.97500
0.37	0.64431	**0.77**	0.77935	**1.17**	0.87900	**1.57**	0.94179	**1.97**	0.97558
0.38	0.64803	**0.78**	0.78230	**1.18**	0.88100	**1.58**	0.94295	**1.98**	0.97615
0.39	0.65173	**0.79**	0.78524	**1.19**	0.88298	**1.59**	0.94408	**1.99**	0.97670
0.40	0.65542	**0.80**	0.78814	**1.20**	0.88493	**1.60**	0.94520	**2.00**	0.97725

Note: Appendix 1 continues on page 15

Appendix 1 (Continued)

Probabilities for the Standard Normal distribution

x	$\Phi(x)$	x	$\Phi(x)$	x	$\Phi(x)$	x	$\Phi(x)$	x	$\Phi(x)$	x	$\Phi(x)$
2.00	0.97725	2.40	0.99180	2.80	0.99744	3.20	0.99931	3.60	0.99984	4.00	0.99997
2.01	0.97778	2.41	0.99202	2.81	0.99752	3.21	0.99934	3.61	0.99985	4.01	0.99997
2.02	0.97831	2.42	0.99224	2.82	0.99760	3.22	0.99936	3.62	0.99985	4.02	0.99997
2.03	0.97882	2.43	0.99245	2.83	0.99767	3.23	0.99938	3.63	0.99986	4.03	0.99997
2.04	0.97932	2.44	0.99266	2.84	0.99774	3.24	0.99940	3.64	0.99986	4.04	0.99997
2.05	0.97982	2.45	0.99286	2.85	0.99781	3.25	0.99942	3.65	0.99987	4.05	0.99997
2.06	0.98030	2.46	0.99305	2.86	0.99788	3.26	0.99944	3.66	0.99987	4.06	0.99998
2.07	0.98077	2.47	0.99324	2.87	0.99795	3.27	0.99946	3.67	0.99988	4.07	0.99998
2.08	0.98124	2.48	0.99343	2.88	0.99801	3.28	0.99948	3.68	0.99988	4.08	0.99998
2.09	0.98169	2.49	0.99361	2.89	0.99807	3.29	0.99950	3.69	0.99989	4.09	0.99998
2.10	0.98214	2.50	0.99379	2.90	0.99813	3.30	0.99952	3.70	0.99989	4.10	0.99998
2.11	0.98257	2.51	0.99396	2.91	0.99819	3.31	0.99953	3.71	0.99990	4.11	0.99998
2.12	0.98300	2.52	0.99413	2.92	0.99825	3.32	0.99955	3.72	0.99990	4.12	0.99998
2.13	0.98341	2.53	0.99430	2.93	0.99831	3.33	0.99957	3.73	0.99990	4.13	0.99998
2.14	0.98382	2.54	0.99446	2.94	0.99836	3.34	0.99958	3.74	0.99991	4.14	0.99998
2.15	0.98422	2.55	0.99461	2.95	0.99841	3.35	0.99960	3.75	0.99991	4.15	0.99998
2.16	0.98461	2.56	0.99477	2.96	0.99846	3.36	0.99961	3.76	0.99992	4.16	0.99998
2.17	0.98500	2.57	0.99492	2.97	0.99851	3.37	0.99962	3.77	0.99992	4.17	0.99998
2.18	0.98537	2.58	0.99506	2.98	0.99856	3.38	0.99964	3.78	0.99992	4.18	0.99999
2.19	0.98574	2.59	0.99520	2.99	0.99861	3.39	0.99965	3.79	0.99992	4.19	0.99999
2.20	0.98610	2.60	0.99534	3.00	0.99865	3.40	0.99966	3.80	0.99993	4.20	0.99999
2.21	0.98645	2.61	0.99547	3.01	0.99869	3.41	0.99968	3.81	0.99993	4.21	0.99999
2.22	0.98679	2.62	0.99560	3.02	0.99874	3.42	0.99969	3.82	0.99993	4.22	0.99999
2.23	0.98713	2.63	0.99573	3.03	0.99878	3.43	0.99970	3.83	0.99994	4.23	0.99999
2.24	0.98745	2.64	0.99585	3.04	0.99882	3.44	0.99971	3.84	0.99994	4.24	0.99999
2.25	0.98778	2.65	0.99598	3.05	0.99886	3.45	0.99972	3.85	0.99994	4.25	0.99999
2.26	0.98809	2.66	0.99609	3.06	0.99889	3.46	0.99973	3.86	0.99994	4.26	0.99999
2.27	0.98840	2.67	0.99621	3.07	0.99893	3.47	0.99974	3.87	0.99995	4.27	0.99999
2.28	0.98870	2.68	0.99632	3.08	0.99896	3.48	0.99975	3.88	0.99995	4.28	0.99999
2.29	0.98899	2.69	0.99643	3.09	0.99900	3.49	0.99976	3.89	0.99995	4.29	0.99999
2.30	0.98928	2.70	0.99653	3.10	0.99903	3.50	0.99977	3.90	0.99995	4.30	0.99999
2.31	0.98956	2.71	0.99664	3.11	0.99906	3.51	0.99978	3.91	0.99995	4.31	0.99999
2.32	0.98983	2.72	0.99674	3.12	0.99910	3.52	0.99978	3.92	0.99996	4.32	0.99999
2.33	0.99010	2.73	0.99683	3.13	0.99913	3.53	0.99979	3.93	0.99996	4.33	0.99999
2.34	0.99036	2.74	0.99693	3.14	0.99916	3.54	0.99980	3.94	0.99996	4.34	0.99999
2.35	0.99061	2.75	0.99702	3.15	0.99918	3.55	0.99981	3.95	0.99996	4.35	0.99999
2.36	0.99086	2.76	0.99711	3.16	0.99921	3.56	0.99981	3.96	0.99996	4.36	0.99999
2.37	0.99111	2.77	0.99720	3.17	0.99924	3.57	0.99982	3.97	0.99996	4.37	0.99999
2.38	0.99134	2.78	0.99728	3.18	0.99926	3.58	0.99983	3.98	0.99997	4.38	0.99999
2.39	0.99158	2.79	0.99736	3.19	0.99929	3.59	0.99983	3.99	0.99997	4.39	0.99999
2.40	0.99180	2.80	0.99744	3.20	0.99931	3.60	0.99984	4.00	0.99997	4.40	0.99999

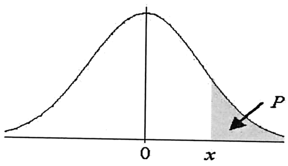
Note: Appendix 1 continues on page 16

Appendix 1 (Continued)

Percentage Points for the Standard Normal distribution

The table gives percentage points x defined by the equation

$$P = \frac{1}{\sqrt{2\pi}} \int_x^\infty e^{-\frac{1}{2}t^2}\,dt$$



P	x	P	x	P	x	P	x	P	x	P	x
50%	0.0000	5.0%	1.6449	3.0%	1.8808	2.0%	2.0537	1.0%	2.3263	0.10%	3.0902
45%	0.1257	4.8%	1.6646	2.9%	1.8957	1.9%	2.0749	0.9%	2.3656	0.09%	3.1214
40%	0.2533	4.6%	1.6849	2.8%	1.9110	1.8%	2.0969	0.8%	2.4089	0.08%	3.1559
35%	0.3853	4.4%	1.7060	2.7%	1.9268	1.7%	2.1201	0.7%	2.4573	0.07%	3.1947
30%	0.5244	4.2%	1.7279	2.6%	1.9431	1.6%	2.1444	0.6%	2.5121	0.06%	3.2389
25%	0.6745	4.0%	1.7507	2.5%	1.9600	1.5%	2.1701	0.5%	2.5758	0.05%	3.2905
20%	0.8416	3.8%	1.7744	2.4%	1.9774	1.4%	2.1973	0.4%	2.6521	0.01%	3.7190
15%	1.0364	3.6%	1.7991	2.3%	1.9954	1.3%	2.2262	0.3%	2.7478	0.005%	3.8906
10%	1.2816	3.4%	1.8250	2.2%	2.0141	1.2%	2.2571	0.2%	2.8782	0.001%	4.2649
5%	1.6449	3.2%	1.8522	2.1%	2.0335	1.1%	2.2904	0.1%	3.0902	0.0005%	4.4172

-End Of Appendix 1-

BR3213 VALUATION & RISK MODELS

Please read the following instructions carefully:

1. **Please do not turn over the question paper until you are told to do so. Disciplinary action may be taken against you if you do so.**

2. You are not allowed to leave the examination hall unless accompanied by an invigilator. You may raise your hand if you need to communicate with the invigilator.

3. Please write your Matriculation Number on the front of the answer book.

4. Please indicate clearly in the answer book (at the appropriate place) if you are continuing the answer to a question elsewhere in the book.