NANYANG TECHNOLOGICAL UNIVERSITY

SEMESTER 1 EXAMINATION 2024-2025

BR3213 Valuation and Risk Models

NOV 2024 Time Allowed: 2.5 Hours

INSTRUCTIONS

1. This paper contains **SIX(6)** questions and comprises **SEVEN(7)** 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

A financial analyst is considering using a normal distribution to model S&P500 daily returns for the coming year.

(a) According to historical observations, how does the daily return distribution differ from a normal distribution?

(2 marks)

(b) Instead of an un-conditional normal distribution, what are the two potential alternatives for the analyst to model the S&P500 daily returns?

(2 marks)

(c) The analyst is looking at the following data for estimating volatilities.

Date	Daily Return r_i	r_i^2	Average r_i^2 for previous 20 days (from the day before, excluding today)	Simple average volatility with m=20	EWMA volatility with $\lambda =$ 0.95
Jul 26, 2024	0.76%	0.00005756	0.0000486963	0.70%	0.68%
Jul 29, 2024	0.02%	0.00000003	0.0000515531	0.72%	0.69%
Jul 30, 2024	-0.39%	0.00001485	0.0000509493	0.71%	0.67%
Jul 31, 2024	1.33%	0.00017685	0.0000515336	??	??
Aug 1, 2024	-1.07%	0.00011447	0.0000589659	??	??

i) Calculate the missing values from the above. For the simple average method, use $m = 20$; for Exponentially weighted moving average (EWMA) method, use 0.05 as the weight on most recent observation, so that $\lambda = 0.95$.

(2 marks)

ii) For simple average method, discuss the implication of different m values. Specifically, what are the implications when m is chosen to be too small or too large?

(3 marks)

iii) Briefly describe and explain the key differences between this simple average and with EWMA approach to estimating volatility.

(3 marks)

Note: Question No.1 continues on page 3

Question 1 (Continued)

iv) Define and describe the Vasicek Model for estimating volatility. Indicate the key differences between the Vasicek Model and the EWMA model.

(3 marks)

(TOTAL: 15 marks)

Question 2

A modeler is examining the capital requirement for a given bank loan portfolio. It is assumed that all loans in this portfolio are identically distributed with the following information:

The amount borrowed in each loan is $1 million. The probability of default, p, is 0.05 for each loan, and the recovery rate, R, in the event of default, is 70%. The correlation coefficient, ρ, between pairwise loans is constant at 0.1. There are a total number of 10,000 loans included in this portfolio.

(a) Derive the mean and standard deviation of the credit losses for this portfolio, and clearly define any new notations used. Assuming that the loss follows a normal distribution, calculate the required amount of capital for unexpected losses at 99.9% quantile.

(6 marks)

(b) Basel II capital requirement specifies the following required capital calculation:

Required capital= (WCDR-PD)*LCD*EAD, where

WCDR: worst case default rate, the 99.9 percentile of the default rate distribution given by the Vasicek model formula $\Phi\left(\frac{\Phi^{-1}(p_i)+\sqrt{\rho}\Phi^{-1}(0.999)}{\sqrt{1-\rho}}\right)$,
PD: p_i , the individual average default rate,
LCD: loss given default,
EAD: total exposure at default (i.e., the sum of the principals of all the loans).

Calculate the Basel II capital requirement amount using the information above.

(4 marks)

(TOTAL: 10 marks)

Question 3

(a) State the key differences/ similarities between Stress testing and conventional Value at Risk (VaR) / Expected Shortfall (ES) from four aspects.

(2 marks)

(b) What is the difference between stressed VaR/ES versus conventional VaR/ES?

(2 marks)

(c) What is reverse stress testing?

(2 marks)

(d) The stress testing can be conducted via two approaches, namely the bottom-up approach and the top-down approach. Briefly describe each approach and specify the pros and cons of each approach.

(4 marks)

(TOTAL: 10 marks)

Question 4

(a) A treasury bill now has 37 days till maturity. The quoted bid is 4.92 and the quoted ask is 4.78. Calculate the market average cash price for this bond.

(2 marks)

(b) You are given the following information on the spot rate term structure for bond XYZ at time 0 (all rates are nominal annual rates, compounded semi-annually):

Maturity (in years)	Spot rate
0.5	5.5%
1	4.3%
1.5	3.8%
2	3.5%

i) Find the price of a bond XYZ that pays semi-annual coupons, with a 6% annual coupon rate and a $100 par value that matures at time 2.

(4 marks)

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

(2 marks)

Note: Question No.4 continues on page 5

Question 4 (Continued)

iii) Calculate the corresponding forward rates for the given spot rates above. (Rates should be nominal annual rates with semi-annum compounding.)

(2 marks)

iv) At time 0.5, the realized forward rates are given as below:

Maturity (in years)	New forward rate
0.5	3.80%
1.0	3.40%
1.5	3%

Perform a carry-roll-down analysis of bond XYZ at time 0.5, assuming forward rates at time 0 are realized. Hence perform a profit & loss analysis for bond XYZ at time 0.5 and fill the blanks in the table below.

Summary of P&L Decomposition	
Initial Price of Bond	
Carry Roll-Down	
Rate Changes	
Final Value of Bond	
Cash-Carry	
Total Gain	

(8 marks)

(TOTAL: 18 marks)

Question 5

Stock X is a non-dividend paying stock that has a current price of $S_0 = \$100$. Over the next year, the stock is expected to either increase by 10% with a 0.8 probability or decrease by 15%. In the subsequent year, the stock is expected to either increase by 20% with a probability of 0.5 or decrease by 10%.

A specially designed option is written on underlying stock X. The option holder will have the choice to enter a forward contract for stock X (long position) at time 1, with the forward strike price $K = 100$ and that the forward contract will mature at time 2. The holder can also choose to have the option lapsed at time 1.

Note: Question No.5 continues on page 6

Question 5 (Continued)

The continuously compounded risk-free interest rate is 3% per annum.

(a) Write down the binomial tree representing the stock price movement. By constructing replicating portfolios, decide whether and under what conditions should the option holder exercise the option at time 1.

(12 marks)

(b) Hence, calculate the value of the option at time 0.

(3 marks)

(TOTAL: 15 marks)

Question 6

Under the Black-Scholes model, let S_t be the stock price of a non-dividend paying stock at time $t, t \geq 0$. You are given that the stock's per annum mean return (μ) is 15% and volatility (σ) is 25%. The current stock price S_0 is \$37.

(a) State the distribution assumption for the return of S_t for a short period of time Δt. Hence find the approximated 95% confidence interval for the stock price at the end of ONE day.

(6 marks)

(b) For longer period $[0, t]$, state the actual distribution assumed for S_t and specify the key parameters for the distribution. Hence find the 95% confidence interval for the stock price in 2 years time, i.e. the 95% confidence interval for S_t where $t = 2$.

(6 marks)

(c) A European call option with a strike price of \$35 that matures in 6 months time is written on this stock.

i) Use the Black-Scholes formula to calculate the option price given that the continuously compounding risk free-rate is 4%.

(8 marks)

ii) How much is the intrinsic value and option value respectively for this option?

(2 marks)

iii) What is the Delta for this call option? If you wish to create a delta-hedged portfolio with 100 units of this call option together with some underlying stocks, how many units of the underlying stock should you long or short?

(6 marks)

Note: Question No.6 continues on page 7

Question 6 (Continued)

iv) If the underlying stock has a higher volatility than 25%, should the price of the call option be higher or lower and why?

(2 marks)

v) If the call option is an American option instead of a European option, how will this change the option price and why?

(2 marks)

(TOTAL: 32 marks)

– END OF PAPER –

APPENDIX: 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: $\dfrac{q - p}{\sqrt{npq}}$

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Appendix (continued)

Bernoulli distribution

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

Poisson distribution

Parameter: $\mu \ (\mu > 0)$

PF: $p(x) = \dfrac{e^{-\mu}\mu^x}{x!}, \ x = 0, 1, 2, \ldots$

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: $E(X) = \mu, \ \ \mathrm{var}(X) = \mu$

Coefficient of skewness: $\dfrac{1}{\sqrt{\mu}}$

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

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

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

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Appendix (continued)

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

Parameters: μ, σ^2 $(\sigma > 0)$

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

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

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

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

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

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

Coefficient
of skewness: 2

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

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

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.

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Appendix (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: $\frac{2(\beta-\alpha)}{(\alpha+\beta+2)}\sqrt{\frac{\alpha+\beta+1}{\alpha\beta}}$

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Appendix (continued)

Lognormal distribution

Parameters: $\mu,\ \sigma^2\ (\sigma > 0)$

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

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

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

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

Pareto distribution (two parameter version)

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

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

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

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

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

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

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

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

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

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

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

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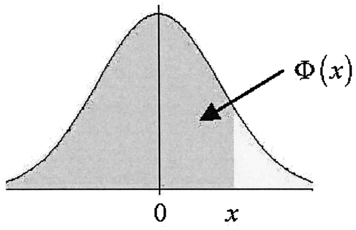
Appendix (continued)

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

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Appendix (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

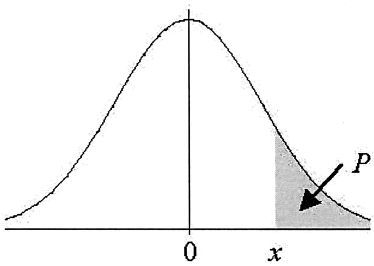
Appendix continues on page 18

Appendix (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

BR3213 VALUATION & RISK MODELS

CONFIDENTIAL

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.