

ACST3006_Assignment

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Abstract

There were cases where leaving % figures in plain decimal figures seemed more reasonable. In this way, not all % figures are not in % form and I hope you would inspect with caution and understanding and I only hope this does not confuse the examiner in any way.

There were some instances where it seemed more reasonable to show the answers in the Excel spreadsheet, rather than listing all of them in the report. Since all of the Excel worksheets are screenshot and attached after each relevant section of the questions, the answers are made easily observable for the examiners.

I have aimed to receive a full mark on this assignment, so please remain patient and thorough with my work until the end. I have tried to make things look as simple as possible for your convenience. Please enjoy! :)

Question 1

The optimal risky portfolio

Precisely following the instructions set out in the lectures regarding the Lagrange Function, the calculations should reach (I understand the theory so I will skip to the conclusions to make it as short as possible):

$$Var(R_p) = \frac{C \cdot \{E(R_p)\}^2 - 2B \cdot E(R_p) + A}{D}$$

where

$$\begin{aligned} A &= E(\mathbf{R})'V^{-1}E(\mathbf{R}), \\ B &= E(\mathbf{R})'V^{-1}\mathbf{1} = \mathbf{1}'V^{-1}E(\mathbf{R}), \\ C &= \mathbf{1}'V^{-1}\mathbf{1}, \\ D &= \begin{vmatrix} A & B \\ B & C \end{vmatrix} = AC - B^2, \\ E(R_p) &\neq E(\mathbf{R})^* \end{aligned}$$

* $E(R_p)$ is the expected return on efficient portfolio p and $E(\mathbf{R}) = \begin{bmatrix} E(R_1) \\ E(R_2) \end{bmatrix} = \begin{bmatrix} 0.015 \\ 0.008 \end{bmatrix}$.

$$V = \begin{bmatrix} Cov(R_1, R_1) & Cov(R_1, R_2) \\ Cov(R_2, R_1) & Cov(R_2, R_2) \end{bmatrix}, K = \begin{bmatrix} A & B \\ B & C \end{bmatrix}$$

Since a covariance of one value is equivalent to a variance itself, $Cov(R_1, R_1) = \sigma_{R_1}^2 = 0.1^2 = 0.01$. Given $\rho_{R_1, R_2} = 0.4$ and that $Cov(R_1, R_2) = \rho_{R_1, R_2} \cdot \sigma_{R_1} \cdot \sigma_{R_2}$,

$$Cov(R_1, R_2) = Cov(R_2, R_1) = 0.4 \cdot 0.1 \cdot 0.05 = 0.002.$$

$$\therefore V = \begin{bmatrix} 0.01 & 0.002 \\ 0.002 & 0.0025 \end{bmatrix}$$

$$V^{-1} = \frac{1}{0.01 \cdot 0.0025 - 0.002^2} \begin{bmatrix} 0.0025 & -0.002 \\ -0.002 & 0.01 \end{bmatrix} = \begin{bmatrix} 119.0476 & -95.2381 \\ -95.2381 & 476.1905 \end{bmatrix}$$

Breaking down

$$\begin{aligned}
A &= E(\mathbf{R})'V^{-1}E(\mathbf{R}) = \begin{bmatrix} 0.015 & 0.008 \end{bmatrix} \begin{bmatrix} 119.0476 & -95.2381 \\ -95.2381 & 476.1905 \end{bmatrix} \begin{bmatrix} 0.015 \\ 0.008 \end{bmatrix} \\
&= \begin{bmatrix} 0.015 & 0.008 \end{bmatrix} \begin{bmatrix} 1.02381 \\ 2.380952 \end{bmatrix} \\
&= 0.034405
\end{aligned}$$

$$\begin{aligned}
B &= E(\mathbf{R})'V^{-1}\mathbf{1} = \mathbf{1}'V^{-1}E(\mathbf{R}) = \begin{bmatrix} 1 & 1 \end{bmatrix} \begin{bmatrix} 119.0476 & -95.2381 \\ -95.2381 & 476.1905 \end{bmatrix} \begin{bmatrix} 0.015 \\ 0.008 \end{bmatrix} \\
&= \begin{bmatrix} 1 & 1 \end{bmatrix} \begin{bmatrix} 1.02381 \\ 2.380952 \end{bmatrix} \\
&= 3.404762
\end{aligned}$$

$$\begin{aligned}
C &= \mathbf{1}'V^{-1}\mathbf{1} = \begin{bmatrix} 1 & 1 \end{bmatrix} \begin{bmatrix} 119.0476 & -95.2381 \\ -95.2381 & 476.1905 \end{bmatrix} \begin{bmatrix} 1 \\ 1 \end{bmatrix} \\
&= \begin{bmatrix} 1 & 1 \end{bmatrix} \begin{bmatrix} 23.80952 \\ 380.9524 \end{bmatrix} \\
&= 404.7619
\end{aligned}$$

$$\begin{aligned}
D &= AC - B^2 = 0.034405 \cdot 404.7619 - 3.404762^2 \\
&= 2.333333
\end{aligned}$$

$$\begin{aligned}
Var(R_p) &= \frac{C \cdot \{E(R_p)\}^2 - 2B \cdot E(R_p) + A}{D} \\
&= \frac{404.7619 \cdot \{E(R_p)\}^2 - 2 \cdot 3.404762 \cdot E(R_p) + 0.034405}{2.333333}.
\end{aligned}$$

The portfolio return that minimizes $Var(R_p)$ is the $E(R_p)$ that finds $\frac{d Var(R_p)}{d E(R_p)} = 0$. The efficient frontier only considers $E(R_p) > E(R_p^G)$ where

$$\Rightarrow \frac{d Var(R_p)}{d E(R_p)} = \frac{404.7619 \cdot 2}{2.333333} \cdot E(R_p) - \frac{2 \cdot 3.404762}{2.333333} = 0$$

$$E(R_p^G) = \frac{2 \cdot 3.404762}{2.333333} \cdot \frac{2.333333}{404.7619 \cdot 2} = 0.008412$$

$$\sigma_{R_p^G} = \sqrt{\frac{404.7619 \cdot 0.008412^2 - 2 \cdot 3.404762 \cdot 0.008412 + 0.034405}{2.333333}} = 0.049705$$

Confirming the minimum variance at $E(R_p^G)$:

$$\frac{d^2 \text{Var}(R_p)}{d E(R_p)^2} = \frac{2C}{D} = 346.9388 > 0$$

The capital allocation line

Omitting theory and proof, the Capital Allocation Line (for the optimal risky portfolio) is given by

$$E(R_p) = E(R_p^Z) + \frac{D \sigma_{R_p^*}}{C E(R_{p^*}) - B} \times \sigma_{R_p}$$

where $E(R_p^Z) = 0.004$ (given) and R_{p^*} refers to the tangency portfolio $\left[\begin{smallmatrix} \sigma_{R_p} \\ E(R_p) \end{smallmatrix} \right]$.

Solving for the tangency portfolio,

$$E(R_p^Z) = \frac{B E(R_{p^*}) - A}{C E(R_{p^*}) - B}$$

$$0.004 = \frac{3.404762 \cdot E(R_{p^*}) - 0.034405}{404.7619 \cdot E(R_{p^*}) - 3.404762}$$

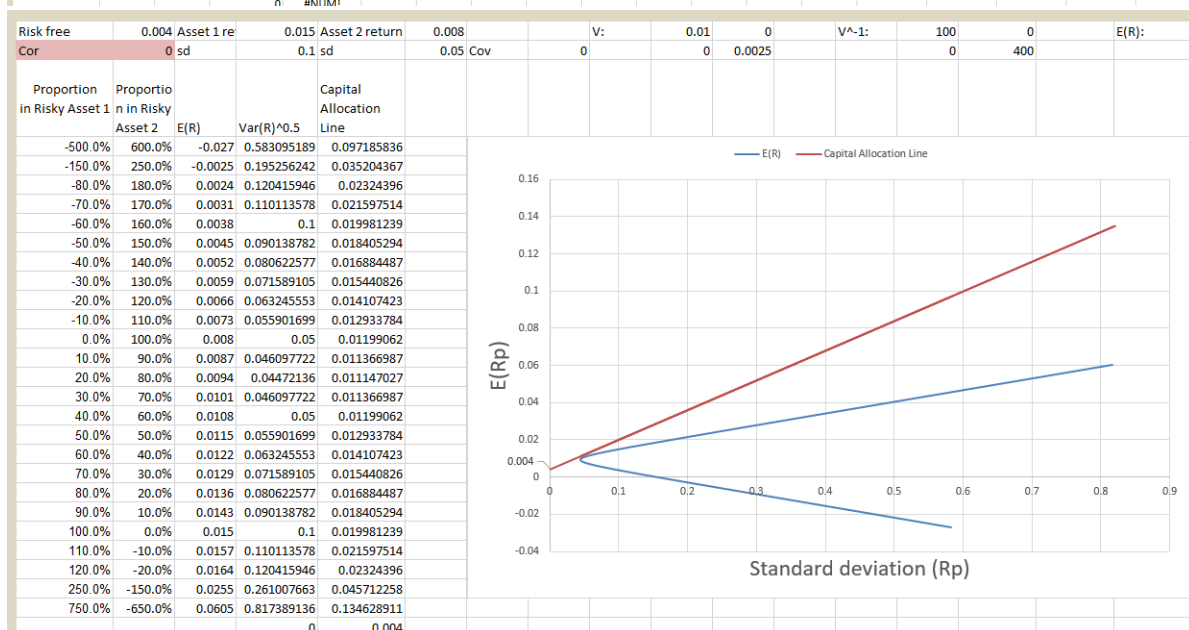
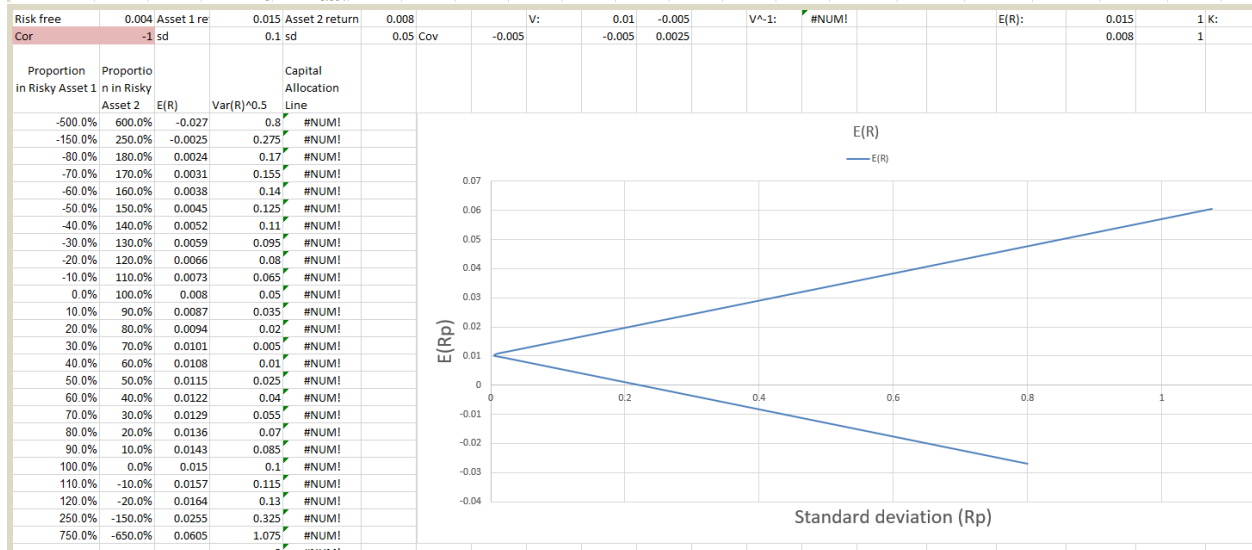
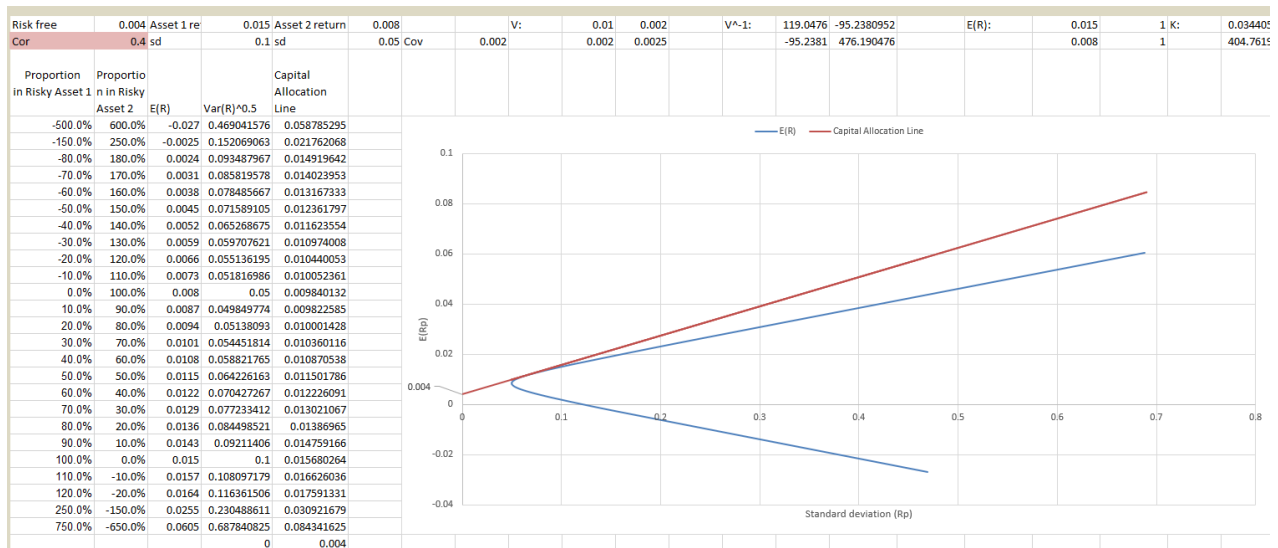
$$E(R_{p^*}) = 0.01164$$

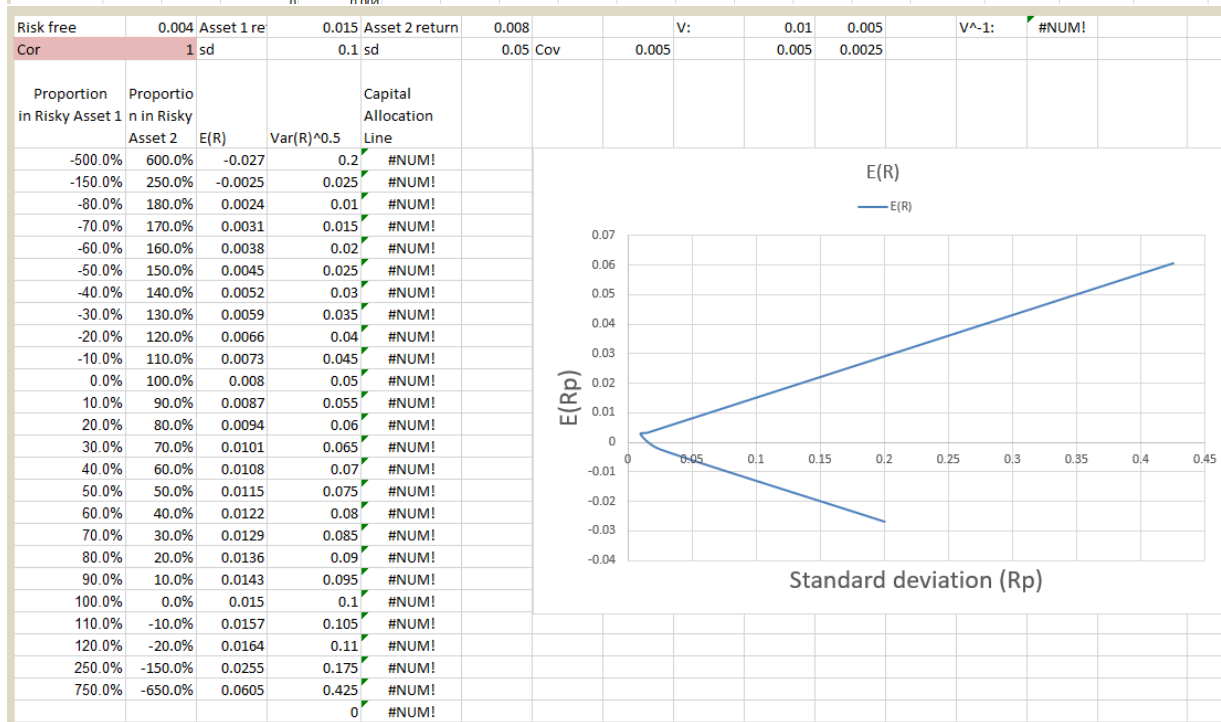
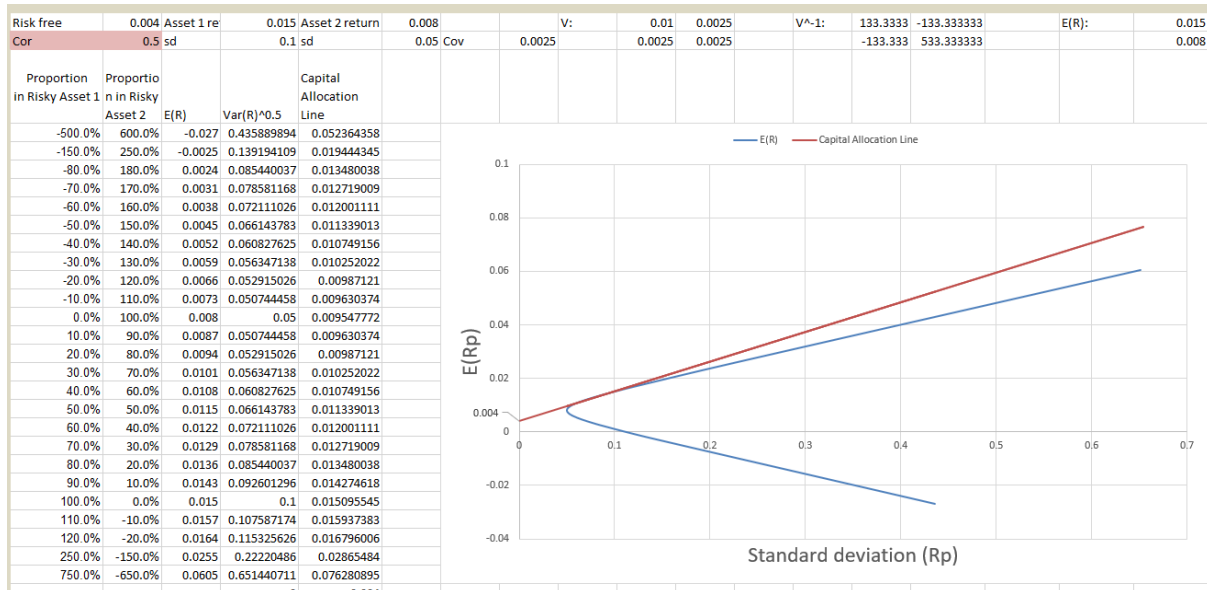
$$\sigma_{R_{p^*}} = \sqrt{\frac{404.7619 \cdot 0.01164^2 - 2 \cdot 3.404762 \cdot 0.01164 + 0.034405}{2.333333}} = 0.06540948$$

The Capital Allocation Line is now

$$E(R_p) = 0.004 + \frac{2.333333 \cdot 0.06540948}{404.7619 \cdot 0.01164 - 3.404762} \times \sigma_{R_p} = 0.004 + 0.1168026 \cdot \sigma_{R_p}$$

The graph is supplied in the attached Excel screenshot. Regarding the other portfolios for scenarios of -100%, 0%, 50% and 100% correlation, all the relevant values and graphs are also supplied.





Question 2

Question 2 i

Please refer to the attached screenshot of the Excel file.

For correlations and covariances among the risky assets, I put them in a matrix form. These figures exist for every pair, so the number of figures would need to be $\binom{19}{2}=171$. They take up quite a large area, so please understand some complexity.

The means, standard deviations, correlations, and variances/ covariances among the risky assets are all listed nicely in the Excel screenshot. Since there is a large number of answers, I have not listed them in the report. Please refer to the Excel screenshot and you will find all of them there nicely listed.

Also, there is an additional screenshot to show the function that I used to find the covariance between the risky assets. As it was emphasized in the announcement, `COVARIANCE.S()` was used.

		15	Stock	Stock	Stock	Stock	Stock	Stock	US Portfolio	US Portfolio	US Portfolio	US Portfolio	US Portfolio	US Portfolio	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country Port	Country 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Question 2 ii

a

For Country Portfolio - Australia, the equation of the efficient frontier is

$$Var(R_p) = \frac{C \cdot \{E(R_p)\}^2 - 2B \cdot E(R_p) + A}{D}$$

where

$$\begin{aligned} A &= E(\mathbf{R})'V^{-1}E(\mathbf{R}), \\ B &= E(\mathbf{R})'V^{-1}\mathbf{1} = \mathbf{1}'V^{-1}E(\mathbf{R}), \\ C &= \mathbf{1}'V^{-1}\mathbf{1}, \\ D &= \begin{vmatrix} A & B \\ B & C \end{vmatrix} = AC - B^2, \\ E(R_p) &\neq E(\mathbf{R})^* \end{aligned}$$

$$*E(R_p) \text{ is the expected return on efficient portfolio p and } E(\mathbf{R}) = \begin{bmatrix} E(R_1) \\ E(R_2) \\ E(R_3) \\ E(R_4) \\ E(R_5) \\ E(R_6) \end{bmatrix} = \begin{bmatrix} 0.0115 \\ 0.0079 \\ 0.0136 \\ 0.0042 \\ 0.014 \\ 0.0082 \end{bmatrix}.$$

$$V = \begin{bmatrix} Cov(R_1, R_1) & Cov(R_1, R_2) & Cov(R_1, R_3) & Cov(R_1, R_4) & Cov(R_1, R_5) & Cov(R_1, R_6) \\ \vdots & & & & & \vdots \\ Cov(R_6, R_1) & Cov(R_6, R_2) & Cov(R_6, R_3) & Cov(R_6, R_4) & Cov(R_6, R_5) & Cov(R_6, R_6) \end{bmatrix}, K = \begin{bmatrix} A & B \\ B & C \end{bmatrix}$$

Since a covariance of one value is equivalent to a variance itself, $Cov(R_1, R_1) = \sigma_{R_1}^2 = 0.05004263^2 = 0.00250426$ and so on.

The other covariances like $Cov(R_1, R_2)$ and $Cov(R_1, R_3)$ are calculated on the Excel spreadsheet using the function COVARIANCE.S using each of the column of monthly returns, then the correlations are derived using the relationship $\rho_{R_1, R_2} = \frac{Cov(R_1, R_2)}{\sigma_{R_1} \sigma_{R_2}}$ and are combined on a 19 X 19 plane.

$$\therefore V = \begin{bmatrix} 0.002504264 & 0.002390442 & 0.001546055 & 0.001685552 & 0.002210671 & 0.0015686 \\ 0.002390442 & 0.006137229 & 0.001515461 & 0.002154257 & 0.002585894 & 0.002156413 \\ 0.001546055 & 0.001515461 & 0.004009131 & 0.000851911 & 0.002376791 & 0.001793284 \\ 0.001685552 & 0.002154257 & 0.000851911 & 0.003491381 & 0.001637559 & 0.001282067 \\ 0.002210671 & 0.002585894 & 0.002376791 & 0.001637559 & 0.004593321 & 0.001955539 \\ 0.0015686 & 0.002156413 & 0.001793284 & 0.001282067 & 0.001955539 & 0.002116982 \end{bmatrix}$$

$$V^{-1} = \begin{bmatrix} 1081.705507 & -144.3777141 & -72.11590133 & -219.0229114 & -210.612872 & -266.1512403 \\ -144.3777141 & 301.6613409 & 55.25862767 & -45.06811878 & -31.7798752 & -190.4611488 \\ -72.11590133 & 55.25862767 & 455.2117242 & 61.51499813 & -119.7185491 & -315.125691 \\ -219.0229114 & -45.06811878 & 61.51499813 & 450.3450969 & -19.67645873 & -98.47205015 \\ -210.612872 & -31.7798752 & -119.7185491 & -19.67645873 & 457.2963775 & -120.6656782 \\ -266.1512403 & -190.4611488 & -315.125691 & -98.47205015 & -120.6656782 & 1301.627469 \end{bmatrix}$$

Now for A, B, C, and D (skipping details where necessary),

$$A = E(\mathbf{R})'V^{-1}E(\mathbf{R})$$

$$= E(\mathbf{R})' \begin{bmatrix} 1081.705507 & -144.3777141 & -72.11590133 & -219.0229114 & -210.612872 & -266.1512403 \\ -144.3777141 & 301.6613409 & 55.25862767 & -45.06811878 & -31.7798752 & -190.4611488 \\ -72.11590133 & 55.25862767 & 455.2117242 & 61.51499813 & -119.7185491 & -315.125691 \\ -219.0229114 & -45.06811878 & 61.51499813 & 450.3450969 & -19.67645873 & -98.47205015 \\ -210.612872 & -31.7798752 & -119.7185491 & -19.67645873 & 457.2963775 & -120.6656782 \\ -266.1512403 & -190.4611488 & -315.125691 & -98.47205015 & -120.6656782 & 1301.627469 \end{bmatrix} \begin{bmatrix} 0.0115 \\ 0.0079 \\ 0.0136 \\ 0.0042 \\ 0.014 \\ 0.0082 \end{bmatrix}$$

⋮

$$= 0.07479308$$

Similarly,

$$B = E(\mathbf{R})'V^{-1}\mathbf{1} = \mathbf{1}'V^{-1}E(\mathbf{R}) = 4.85386548$$

$$C = \mathbf{1}'V^{-1}\mathbf{1} = 574.898349$$

$$D = AC - B^2 = 19.438409$$

$$\begin{aligned} Var(R_p) &= \frac{C \cdot \{E(R_p)\}^2 - 2B \cdot E(R_p) + A}{D} \\ &= \frac{574.898349 \cdot \{E(R_p)\}^2 - 2 \cdot 4.85386548 \cdot E(R_p) + 0.07479308}{19.438409}. \end{aligned}$$

The portfolio return that minimizes $Var(R_p)$ is the $E(R_p)$ that finds $\frac{d Var(R_p)}{d E(R_p)} = 0$. The efficient frontier only considers $E(R_p) > E(R_p^G)$ where

$$\Rightarrow \frac{d \text{Var}(R_p)}{d E(R_p)} = \frac{574.898349 \cdot 2}{19.438409} \cdot E(R_p^G) - \frac{2 \cdot 4.85386548}{19.438409} = 0$$

$$E(R_p^G) = \frac{2 \cdot 4.85386548}{19.438409} \cdot \frac{19.438409}{574.898349 \cdot 2} = 0.008443$$

$$\sigma_{R_p^G} = \sqrt{\frac{574.898349 \cdot 0.008443^2 - 2 \cdot 4.85386548 \cdot 0.008443 + 0.07479308}{19.438409}} = 0.041707$$

Confirming the minimum variance at $E(R_p^G)$:

$$\frac{d^2 \text{Var}(R_p)}{d E(R_p)^2} = \frac{2C}{D} = 59.15076 > 0$$

Question 2 ii b

Please refer to the Excel screenshot. It contains the graph in (a) as well as the minimum variance portfolio $E(R_p) - \sigma_{R_p}$ pair, which is highlighted on the graph in (a) as a label. The variance is also included in the screenshot.

A	0.07479308
B	4.85386548
C	574.898349
D	19.438409

Equation:

$$Var(R_p) = \frac{C \cdot \{E(R_p)\}^2 - 2B \cdot E(R_p) + A}{D},$$

$$\begin{aligned} Var(R_p) &= \frac{C \cdot \{E(R_p)\}^2 - 2B \cdot E(R_p) + A}{D} \\ &= \frac{574.898349 \cdot \{E(R_p)\}^2 - 2 \cdot 4.85386548 \cdot E(R_p) + 0.07479308}{19.438409}. \end{aligned}$$

solving for E(Rp):

$$E(R_p) = \frac{B}{C} \pm \sqrt{\frac{D \cdot Var(R_p) + \frac{B^2}{C} - A}{C}}$$

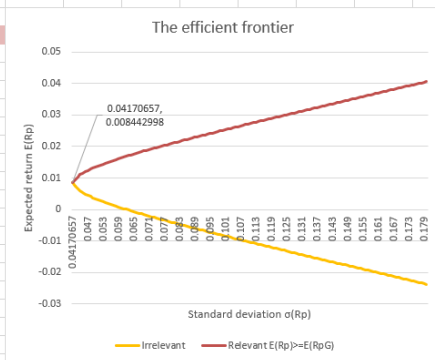
E(Rp)- just refers to

$$E(R_p) = \frac{B}{C} - \sqrt{\frac{D \cdot Var(R_p) + \frac{B^2}{C} - A}{C}}$$

and E(Rp)+:

$$E(R_p) = \frac{B}{C} + \sqrt{\frac{D \cdot Var(R_p) + \frac{B^2}{C} - A}{C}}$$

E(Rp)-	E(Rp)+	Var(Rp)^0.5
0.008443	0.008443	0.041707
0.007532	0.00935431	0.042
0.006518	0.01036771	0.043
0.005865	0.01102101	0.044
0.005336	0.01155031	0.045
0.004875	0.01201123	0.046
0.004458	0.01242757	0.047
0.004074	0.01281208	0.048
0.003713	0.01317255	0.049
0.003372	0.0135141	0.05
0.003046	0.01384032	0.051
0.002732	0.01415384	0.052
0.002429	0.01445664	0.053
0.002136	0.01475028	0.054
0.00185	0.01503597	0.055
0.001571	0.01531471	0.056
0.001299	0.01558731	0.057
0.001032	0.01585444	0.058
0.000769	0.01611669	0.059



Since the graph has the standard deviation as the x-axis, the label on the graph to the left is in the order of (σ(Rp), E(Rp)). In this way, I hope the label on the graph that says (0.04170657, 0.008442998) suffices for the prompt in ii b) to show the global minimum variance portfolio expected return and standard deviation on the graph in (a). Just to make sure, the variance is 0.041707^2, which is equal to 0.001739.

Question 2 iii a

Revisiting Question 1, the Capital Market Line for the market portfolio is given by

$$E(R_p) = E(R_p^Z) + \frac{D \sigma_{R_{pM}}}{C E(R_{pM}) - B} \times \sigma_{R_p}$$

where $E(R_p^Z) = 0.004$ (given) and R_{p^*} refers to the tangency portfolio $\begin{bmatrix} \sigma_{R_p} \\ E(R_p) \end{bmatrix}$.

The part ii) covers the 6 countries portfolio combined, so the values of A, B, C and D below are equal to those in part ii. $E(R_p^Z)$ is found to be 0.003 from the Excel data. Solving for the tangency portfolio,

$$E(R_p^Z) = \frac{B E(R_{pM}) - A}{C E(R_{pM}) - B}$$

$$0.002955 = \frac{4.85386548 \cdot E(R_{pM}) - 0.07479308}{574.898349 \cdot E(R_{pM}) - 4.85386548}$$

$$E(R_{pM}) = 0.019159786$$

$$\sigma_{R_{pM}} = \sqrt{\frac{574.898349 \cdot \{E(R_{pM})\}^2 - 2 \cdot 4.85386548 \cdot E(R_{pM}) + 0.07479308}{19.438409}} = 0.07166699$$

The Capital Allocation Line is now

$$E(R_p) = 0.002955 + \frac{19.438409 \cdot 0.07166699}{574.898349 \cdot 0.019159786 - 4.85386548} \times \sigma_{R_p} = 0.002955 + 0.226112281 \cdot \sigma_{R_p}$$

1	Tangency portfolio equation:		Capital Market Line	
2				
3	$E(R_p^Z) = \frac{B E(R_{pM}) - A}{C E(R_{pM}) - B}$		$E(R_p) = E(R_p^Z) + \frac{D \sigma_{R_{pM}}}{C E(R_{pM}) - B} \times \sigma_{R_p}$	
4				
5				
6				
7				
8	Solving for E(RpM):		risk-free rate:	0.002955
9				
10	$E(R_{pM}) = \frac{E(R_p^Z) \cdot B - A}{E(R_p^Z) \cdot C - B}$			
11				
12				
13	A	0.074793082	E(RpM):	0.019159786
14	B	4.853865484	SD(RpM):	0.07166699
15	C	574.8983488	Slope:	0.226112281
16	D	19.43840905		
17				
18				
19	E(Rp)-	E(Rp)+	Var(Rp)^0 CML	
20			0	0.002955
21			0.001	0.003181112
22			0.002	0.003407225
23			0.003	0.003633337
24			0.004	0.003859449
25			0.005	0.004085561
26			0.006	0.004311674
27			0.007	0.004537786
28			0.008	0.004763898
29			0.009	0.004990011
30			0.01	0.005216123
31			0.011	0.005442235
32			0.012	0.005668347
33			0.013	0.00589446
34			0.014	0.006120572
35			0.015	0.006346684
36			0.016	0.006572796
37			0.017	0.006798909
38			0.018	0.007025021
39			0.019	0.007251133
40			0.02	0.007477246

The efficient frontier & CML

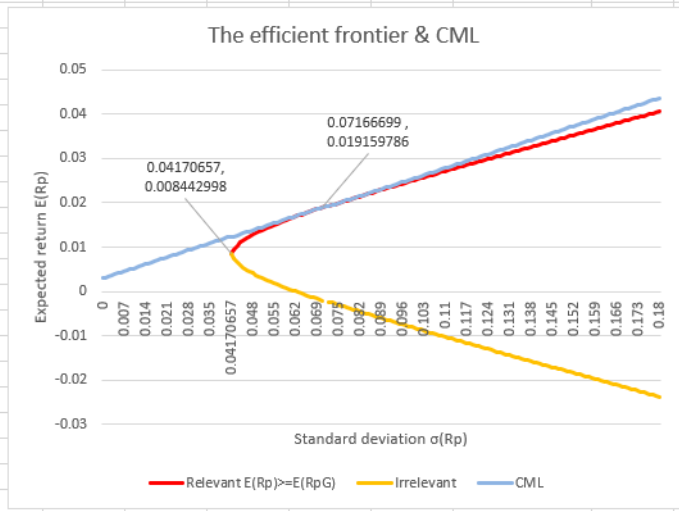
Expected return $E(R_p)$

Standard deviation $\sigma(R_p)$

0.04170657, 0.008442998

0.07166699, 0.019159786

Relevant $E(R_p) \geq E(R_{pG})$ Irrelevant CML



Question 2 iii b

The market price of risk is the ratio $\left(\frac{E[R_{p_M} - R_p^Z]}{\sigma_{p_M}}\right)$. As the name suggests, it is the measure of the investors' opinion on how much worth there is in taking the risk and investing in the asset. Mathematically speaking, the excess return $E(R_{p_M} - R_p^Z)$ divided by σ_{p_M} is the excess return you receive 'per risk'. It is also known as the Sharpe ratio.

$$\begin{aligned} \frac{E[R_{p_M} - R_p^Z]}{\sigma_{p_M}} &= \frac{E(R_{p_M}) - E(R_p^Z)}{\sigma_{p_M}} \\ &= \frac{0.019159786 - 0.002955}{0.07166699} = 0.226112281 \end{aligned}$$

Question 2 iii c

From lecture notes, $W = \begin{bmatrix} w_1 \\ w_2 \\ w_3 \\ w_4 \\ w_5 \\ w_6 \end{bmatrix} = V^{-1} [E(\mathbf{R}), \mathbf{1}] K^{-1} \begin{bmatrix} E(R_p) \\ 1 \end{bmatrix}$.

$$V^{-1} = \begin{bmatrix} 1081.705507 & -144.3777141 & -72.11590133 & -219.0229114 & -210.612872 & -266.1512403 \\ -144.3777141 & 301.6613409 & 55.25862767 & -45.06811878 & -31.7798752 & -190.4611488 \\ -72.11590133 & 55.25862767 & 455.2117242 & 61.51499813 & -119.7185491 & -315.125691 \\ -219.0229114 & -45.06811878 & 61.51499813 & 450.3450969 & -19.67645873 & -98.47205015 \\ -210.612872 & -31.7798752 & -119.7185491 & -19.67645873 & 457.2963775 & -120.6656782 \\ -266.1512403 & -190.4611488 & -315.125691 & -98.47205015 & -120.6656782 & 1301.627469 \end{bmatrix}$$

$$[E(\mathbf{R}), \mathbf{1}] = \begin{bmatrix} 0.011499167 & 1 \\ 0.007920833 & 1 \\ 0.01362 & 1 \\ 0.004193333 & 1 \\ 0.013995 & 1 \\ 0.008180833 & 1 \end{bmatrix}$$

$$K^{-1} = \begin{bmatrix} 29.57538075 & -0.249704874 \\ -0.249704874 & 0.003847696 \end{bmatrix}$$

$$\begin{bmatrix} E(R_p) \\ 1 \end{bmatrix} = \begin{bmatrix} 0.0191597864624464 \\ 1 \end{bmatrix}$$

Skipping detailed calculation process (you can see from the Excel screenshot that I used Excel to multiply the matrices. I used MMULT(), MINVERSE(), TRANSPOSE() functions),

$$W = \begin{bmatrix} 1.194580052 \\ -0.173763658 \\ 0.513703915 \\ -0.511328037 \\ 0.367502023 \\ -0.390694295 \end{bmatrix}$$

Equation to find weights:

$$W = V^{-1} \begin{bmatrix} E(R), & 1 \end{bmatrix} \begin{bmatrix} \lambda_1 \\ \lambda_2 \end{bmatrix}$$

$$= V^{-1} \begin{bmatrix} E(R), & 1 \end{bmatrix} K^{-1} \begin{bmatrix} E(R_p) \\ 1 \end{bmatrix}$$

[E(R),1]	0.011499167	1	V^-1	1081.706	-144.377714	-72.1159	-219.023	-210.613	-266.151
	0.007920833	1		-144.378	301.661341	55.25863	-45.0681	-31.7799	-190.461
	0.01362	1		-72.1159	55.2586277	455.2117	61.515	-119.719	-315.126
	0.004193333	1		-219.023	-45.0681188	61.515	450.3451	-19.6765	-98.4721
	0.013995	1		-210.613	-31.7798752	-119.719	-19.6765	457.2964	-120.666
	0.008180833	1		-266.151	-190.461149	-315.126	-98.4721	-120.666	1301.627
K	0.074793082	4.853865	[E(Rp),1]'	0.01916					
	4.853865484	574.8983		1					
K^-1	29.57538075	-0.2497							
	-0.24970487	0.003848							

Calculation:

1 V^-1[E(Rp),1]'	4.269599364	169.4249
	-0.7100676	-54.7669
	1.812906336	65.02521
	-1.23023211	129.6206
	1.0260448	-45.1571
	-0.31438531	310.7517
2 V^-1[E(Rp),1]'K^-1	83.96881157	-0.41424
	-7.32496059	-0.03342
	37.38028361	-0.20249
	-68.7514676	0.805935
	41.62160253	-0.42996
	-86.8942695	1.274181
3 W	1.194580052	
	-0.17376366	
	0.513703915	
	-0.51132804	
	0.367502023	
	-0.3906943	

Question 2 iii d

1

The mean return rate of the risk-free asset is 0.002955 per month. Therefore, the amount of money expected to remain at the end of the month is $500,000 \times (1 + 0.002955) = 501,477.50$. (\$501,477.50)

2

It is found that $E(R_{p_M}) = 0.019159786$. So the result must be

$$\begin{aligned} & 200,000 \cdot (1 + 0.002955) + 300,000 \cdot (1 + 0.019159786) \\ &= 200,591 + 305,747.90 = 506,338.94 \end{aligned}$$

3

If all of \$500,000 was invested in the market portfolio,

$$500,000 \cdot (1 + 0.019159786) = 509579.89$$

4

The sensible assumption is that $Cov(R_{p_M}, R_p^Z) = 0$, but I wanted to acknowledge the risk-free monthly returns were also a sampled real-life data. It should still be negligibly small, but I did not just let it be zero. I re-mapped the market portfolio by ‘weight-averaging’ the data sample of the 6 countries monthly returns. Then the COVARIANCE.S function was used on the market portfolio versus the risk-free month returns. Please refer to the worksheet ‘iii d 4’. I also outlined the scenario of assuming 0 variance and covariance for the risk-free asset. The difference was, as expected, negligible.

$$\sigma_1 = 0.001460451, \sigma_2 = 0.042931968, \sigma_3 = 0.07166699$$

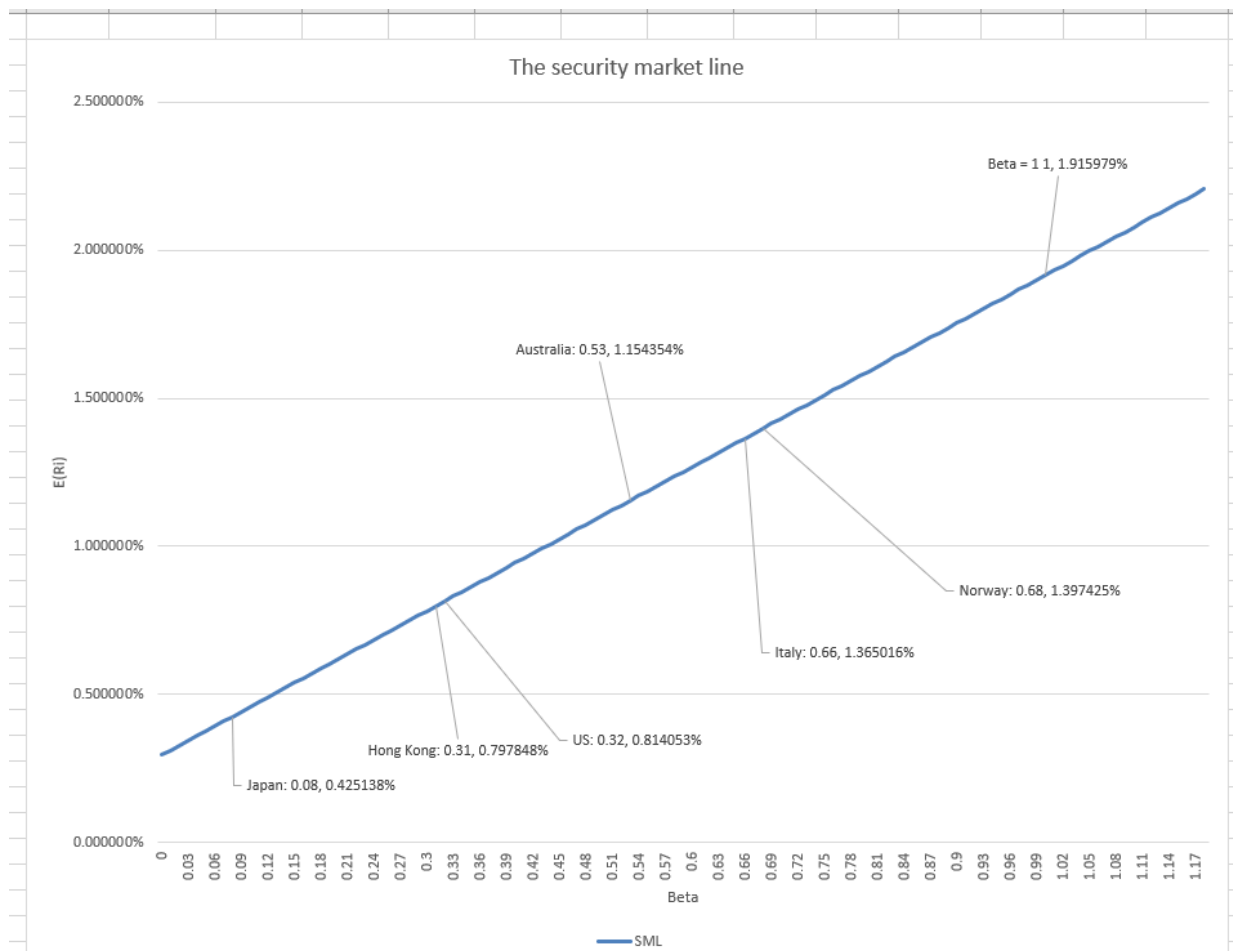
[illegible]

	ORIGINAL							WEIGHTED						PORTFOLIO RETURN	US Riskfree
	Returns Month	Country Port Australia	Country Port Hong Kong	Country Port Italy	Country Port Japan	Country Port Norway	Country Port US	1.194580052	-0.17376	0.513704	-0.51133	0.367502	-0.39069		
								Country Port	Country Port	Country Port	Country Port	Country Port	Country Port		
								Australia	Hong Kong	Italy	Japan	Norway	US		
15	Dec 2006	3.59%	6.23%	2.72%	2.40%	5.39%	1.08%	4.29%	-1.08%	1.40%	-1.23%	1.98%	-0.42%	4.93%	0.40%
16	Nov 2006	3.38%	6.04%	5.74%	0.45%	8.90%	2.37%	4.04%	-1.05%	2.95%	-0.23%	3.27%	-0.93%	8.05%	0.42%
17	Oct 2006	8.65%	1.10%	4.27%	1.94%	8.84%	3.71%	10.33%	-0.19%	2.19%	-0.99%	3.25%	-1.45%	13.14%	0.41%
18	Sep 2006	-1.53%	0.79%	0.67%	-1.88%	-7.52%	1.95%	-1.83%	-0.14%	0.34%	0.96%	-2.76%	-0.76%	-4.18%	0.41%
19	Aug 2006	2.23%	2.71%	3.98%	1.68%	-3.98%	2.51%	2.66%	-0.47%	2.04%	-0.86%	-1.46%	-0.98%	0.94%	0.42%
20	Jul 2006	1.74%	2.44%	1.03%	-0.83%	4.06%	-0.18%	2.08%	-0.42%	0.53%	0.42%	1.49%	0.07%	4.17%	0.40%
21	Jun 2006	0.71%	0.73%	-0.20%	-1.10%	-2.90%	-0.04%	0.85%	-0.13%	-0.10%	0.56%	-1.07%	0.02%	0.13%	0.40%
22	May 2006	-5.49%	-6.27%	-2.14%	-6.28%	-7.52%	-3.10%	-6.56%	1.09%	-1.10%	3.21%	-2.76%	1.21%	-4.91%	0.43%
23	Apr 2006	9.33%	5.08%	4.15%	2.75%	9.82%	1.30%	11.15%	-0.88%	2.13%	-1.41%	3.61%	-0.51%	14.09%	0.36%
24	Mar 2006	0.43%	1.19%	3.08%	2.27%	11.77%	1.91%	0.51%	-0.21%	1.58%	-1.16%	4.33%	-0.75%	4.31%	0.37%
25	Feb 2006	-2.05%	0.69%	1.52%	-1.02%	-0.81%	-0.16%	-2.45%	-0.12%	0.78%	0.52%	-0.30%	0.06%	-1.50%	0.34%
26	Jan 2006	7.49%	5.80%	6.14%	4.34%	12.09%	4.01%	8.95%	-1.01%	3.15%	-2.22%	4.44%	-1.57%	11.75%	0.35%
27	Dec 2005	2.47%	1.20%	4.39%	8.91%	4.59%	0.35%	2.95%	-0.21%	2.26%	-4.56%	1.69%	-0.14%	1.99%	0.32%
28	Nov 2005	2.64%	3.30%	1.86%	3.64%	-0.04%	0.40%	3.15%	-0.57%	0.96%	-1.86%	-0.01%	-1.58%	0.08%	0.31%
29	Oct 2005	-5.19%	-6.91%	-6.41%	-0.74%	-7.15%	-2.08%	-6.20%	1.20%	-3.29%	0.38%	-2.63%	0.81%	-9.73%	0.27%
30	Sep 2005	5.35%	2.39%	1.46%	8.99%	1.80%	1.06%	6.39%	-0.42%	0.75%	-4.60%	0.66%	-0.41%	2.38%	0.29%
31	Aug 2005	0.95%	-0.99%	1.82%	7.46%	8.38%	-0.59%	1.13%	0.17%	0.93%	-3.81%	3.08%	0.23%	1.74%	0.30%
32	Jul 2005	2.42%	6.19%	4.62%	1.02%	6.49%	4.33%	2.89%	-1.08%	2.37%	-0.52%	2.39%	-1.69%	4.36%	0.24%
33	Jun 2005	5.26%	3.70%	0.79%	0.70%	10.71%	1.15%	6.28%	-0.64%	0.41%	-0.36%	3.94%	-0.45%	9.18%	0.23%
34	May 2005	-0.10%	-0.39%	-1.79%	-1.93%	1.15%	3.79%	-0.12%	0.07%	-0.92%	0.99%	0.42%	-1.48%	-1.04%	0.24%
35	Apr 2005	-1.44%	3.73%	-4.89%	-2.15%	-3.52%	-2.52%	-1.72%	-0.65%	-2.51%	1.10%	-1.29%	0.98%	-4.09%	0.21%
36	Mar 2005	-3.87%	-3.42%	-0.62%	-2.24%	-3.36%	-1.69%	-4.62%	0.59%	-0.32%	1.15%	-1.23%	0.66%	-3.78%	0.21%
37	Feb 2005	4.90%	3.72%	2.92%	1.62%	12.62%	2.27%	5.85%	-0.65%	1.50%	-0.83%	4.64%	-0.89%	9.63%	0.16%
38	Jan 2005	0.74%	-3.62%	-1.70%	-1.67%	-2.12%	-2.66%	0.88%	0.63%	-0.87%	0.85%	-0.78%	1.04%	1.75%	0.16%
39	Dec 2004	4.35%	2.13%	8.06%	5.29%	0.20%	3.52%	5.20%	-0.37%	4.14%	-2.70%	0.07%	-1.38%	4.96%	0.16%
40	Nov 2004	8.33%	9.70%	7.85%	4.80%	12.62%	4.82%	9.95%	-1.69%	4.03%	-2.45%	4.64%	-1.88%	12.60%	0.15%
41	Oct 2004	6.13%	-0.65%	5.91%	2.41%	2.48%	1.78%	7.32%	0.11%	3.04%	-1.23%	0.91%	-0.70%	9.46%	0.11%
42	Sep 2004	5.89%	1.41%	5.95%	-2.80%	11.37%	2.06%	7.04%	-0.25%	3.06%	1.43%	4.18%	-0.80%	14.65%	0.11%
43	Aug 2004	1.20%	6.34%	-0.55%	0.67%	2.73%	0.27%	1.43%	-1.10%	-0.28%	-0.34%	1.00%	-0.11%	0.60%	0.11%
44	Jul 2004	0.43%	1.76%	-2.35%	-6.10%	-1.47%	-3.77%	0.51%	-0.31%	-1.21%	3.12%	-0.54%	1.47%	3.05%	0.10%
45	Jun 2004	-0.18%	0.31%	2.88%	4.50%	3.24%	2.16%	-0.22%	-0.05%	1.48%	-2.30%	1.19%	-0.84%	-0.74%	0.08%
46	May 2004	0.86%	-0.69%	-0.54%	-2.90%	3.60%	1.41%	1.03%	0.12%	-0.28%	1.48%	1.32%	-0.55%	3.12%	0.06%
47	Apr 2004	-4.91%	-5.04%	1.35%	-4.96%	-2.60%	-2.42%	-5.87%	0.88%	0.69%	2.54%	-0.96%	0.95%	-1.77%	0.08%
48	Mar 2004	0.41%	-6.05%	-2.78%	14.24%	-0.09%	-1.07%	0.49%	1.05%	-1.43%	-7.28%	-0.03%	0.42%	-6.78%	0.09%
49	Feb 2004	4.26%	3.16%	1.64%	0.06%	8.81%	1.55%	5.09%	-0.55%	0.84%	-0.03%	3.24%	-0.61%	7.98%	0.06%
50	Jan 2004	0.49%	9.62%	2.02%	1.69%	0.96%	2.31%	0.59%	-1.67%	1.04%	-0.86%	0.35%	-0.90%	-1.46%	0.07%
51	Dec 2003	7.91%	2.26%	5.00%	6.73%	9.40%	4.55%	9.45%	-0.39%	2.57%	-3.44%	3.45%	-1.78%	9.86%	0.08%
52	Nov 2003	-0.38%	-0.19%	8.08%	-3.23%	5.36%	1.66%	-0.45%	0.03%	4.15%	1.65%	1.97%	-0.65%	6.70%	0.07%
53	Oct 2003	8.60%	4.79%	5.09%	4.16%	11.93%	6.03%	10.27%	-0.83%	2.61%	-2.13%	4.38%	-2.36%	11.96%	0.07%
54	Sep 2003	3.26%	5.94%	4.25%	6.14%	-0.20%	-0.91%	3.89%	-1.03%	2.18%	-3.14%	-0.07%	0.36%	2.19%	0.08%
55	Aug 2003	3.11%	11.32%	-2.38%	10.47%	0.80%	2.49%	3.72%	-1.97%	-1.22%	-5.35%	0.29%	-0.97%	-5.51%	0.07%
56	Jul 2003	0.27%	6.50%	-0.03%	4.06%	6.38%	2.31%	0.32%	-1.13%	-0.02%	-2.08%	2.34%	-0.90%	-1.46%	0.07%
57	Jun 2003	3.48%	1.18%	-2.77%	7.86%	3.91%	1.63%	4.16%	-0.21%	-1.42%	-4.02%	1.44%	-0.64%	-0.69%	0.10%
58	May 2003	4.82%	8.64%	10.57%	4.68%	4.95%	6.35%	5.76%	-1.50%	5.43%	-2.39%	1.82%	-2.48%	6.63%	0.09%
59	Apr 2003	8.47%	-0.96%	13.73%	0.62%	12.87%	8.28%	10.12%	0.17%	7.05%	-0.32%	4.73%	-3.23%	18.52%	0.10%
60	Mar 2003	2.98%	-5.08%	-5.59%	-4.36%	0.54%	1.03%	3.56%	0.88%	-2.87%	2.23%	0.20%	-0.40%	3.60%	0.10%
61	Feb 2003	-2.38%	-1.04%	1.98%	1.05%	-7.30%	-1.54%	-2.84%	0.18%	1.02%	-0.54%	-2.68%	0.60%	-4.26%	0.09%

Question 2 iii e

Please refer to the Excel screenshot for the SML line, beta values, etc.

The country portfolio Australia has the beta value 0.52726191. This means for every 1% increase/decrease in the market return, Australia portfolio return should increase/decrease by 0.52726191%, hence less risky than the market portfolio. This is a direct relationship between the country portfolio Australia and the system, which cannot be broken by diversification (systematic risk).



$$\beta_{iM} = \frac{Cov(R_i, R_M)}{\sigma_{R_M}^2}, \quad i = 1, 2,$$

	Market portfolio	US Riskfree
Mean	1.9160%	0.2955%
SD	0.071667	0.00146

 \leq [illegible]

Question 2 iii f

Please refer to the Excel screenshot for the calculation background. The function cell is exposed for an inspection and you are able to check that the covariance of 0.0045 was divided by the square of the market return standard deviation.

The expected return for the portfolio is 0.0171527.

	Market po	US Riskfree
Mean	1.9160%	0.2955%
SD	0.071667	0.00146

△

	Country Port	Country Por	Country Por	Country Por	Country Por	Country Por	Mmy Portfolio	Please note the answer for III f)												
	Australia	Hong Kong	Italy	Japan	Norway	US	iii f)	here!!! :)*****												
E(Ri)	0.0114992	0.0079208	0.0136200	0.0041933	0.0139950	0.0081808	0.0171527													
Beta	0.52726191	0.306442	0.658139	0.076418	0.68128	0.322487	=ISO/S&S0^2													
Cov	0.0027081	0.001574	0.00338	0.000392	0.003499	0.001656	0.0045													
Mean	1.15%	0.79%	1.36%	0.42%	1.40%	0.82%		WEIGHTED						Mean	1.92%	0.2955%				
ORIGINAL								1.19458	-0.17376	0.513704	-0.51133	0.367502	-0.39069							SML
Returns	Country Port	Country Por	Country Por	Country Por	Country Por	Country Por	Country Por	Country Por	Country Por	Country Por	Country Por	Country Por	Country Por	PORTFO LIO	US Riskfree				E(Ri)	Beta
Month	Australia	Hong Kong	Italy	Japan	Norway	US		Australia	Hong Kong	Italy	Japan	Norway	US	RETURN	US Riskfree					
Dec 2006	3.59%	6.23%	2.72%	2.40%	5.39%	1.08%		4.29%	-1.08%	1.40%	-1.23%	1.98%	-0.42%	4.93%	0.40%					
Nov 2006	3.38%	6.04%	5.74%	0.45%	8.90%	2.37%		4.04%	-1.05%	2.95%	-0.23%	3.27%	-0.93%	8.05%	0.42%			0.295500%		
Oct 2006	8.65%	1.10%	4.27%	1.94%	8.84%	3.71%		10.33%	-0.19%	2.19%	-0.99%	3.25%	-1.45%	13.14%	0.41%			0.311705%	0.01	
Sep 2006	-1.53%	0.79%	0.67%	-1.88%	-7.52%	1.95%		-1.83%	-0.14%	0.34%	0.96%	-2.76%	-0.76%	-4.18%	0.41%			0.327910%	0.02	
Aug 2006	2.23%	2.71%	3.98%	1.68%	-3.88%	2.51%		2.66%	-0.47%	2.04%	-0.86%	-1.46%	-0.98%	0.94%	0.42%			0.344114%	0.03	
Jul 2006	1.74%	2.44%	1.03%	-0.83%	4.06%	-0.18%		2.08%	-0.42%	0.53%	0.42%	1.49%	0.07%	4.17%	0.40%			0.360319%	0.04	
Jun 2006	0.71%	0.73%	-0.20%	-1.10%	-2.90%	-0.04%		0.85%	-0.13%	-0.10%	0.56%	-1.07%	0.02%	0.13%	0.40%			0.376524%	0.05	