UNIVERSITI SAINS MALAYSIA

Second Semester Examination
2011/2012 Academic Session

June 2012

MSG 367 – Time Series Analysis
[Analisis Siri Masa]

Duration : 3 hours
[Masa : 3 jam]

Please check that this examination paper consists of SIXTEEN pages of printed material before you begin the examination.

[Sila pastikan bahawa kertas peperiksaan ini mengandungi ENAM BELAS muka surat yang bercetak sebelum anda memulakan peperiksaan ini.]

Instructions: Answer **all four** [4] questions.

*[**Arahan:** Jawab **semua empat** [4] soalan.]*

In the event of any discrepancies, the English version shall be used.

[Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah diguna pakai].

1. (a) (i) Define stationarity and invertibility conditions for an ARMA model in terms of summability of the polynomial coefficients of the infinite form of the model.

(ii) Explain, why the white noise assumption is important in the model building procedure for a time series data?

(iii) Discuss the characteristics of stationary and non-stationary series with regards to the shape of acf and pacf, forecast values, forecast error variance as well as forecast confidence intervals?

[40 marks]

(b) Consider a process given by:

$$Z_t = X_t + \varepsilon_t - \theta\varepsilon_{t-1} \quad \text{where} \quad X_t = X_{t-1} + \varepsilon_t, \text{ for } t \geq 1$$

such that $|\theta| < 1$ and $\varepsilon_t \sim \text{WN}\left(0, \sigma_\varepsilon^2\right)$.

(i) By finding the mean and autocovariance function, show that Z_t is non-stationary.

(ii) Show that $W_t = Z_t - Z_{t-1}$ is a stationary process.

[35 marks]

(c) Rewrite each of the models below using the backward operator B and state the form of ARIMA(p,d,q) or SARIMA(p,d,q)(P,D,Q). [p, d, q, P, D, and Q are positive finite numbers].

(i) $Y_t = \left(1 - \phi_1 - \phi_3\right)\mu + \phi_1 Y_{t-1} + \phi_3 Y_{t-3} + \varepsilon_t - \theta_1\varepsilon_{t-1} - \theta_2\varepsilon_{t-2}$

(ii) $Y_t = \left(1 - \phi\right)Y_{t-1} + \phi Y_{t-2} + \varepsilon_t - \theta\varepsilon_{t-2}$

(iii) $Y_t = \left(\theta - 0.6\right)Y_{t-1} - \theta\left(\theta - 0.6\right)Y_{t-2} + \theta^2\left(\theta - 0.6\right)Y_{t-3} - \theta^3\left(\theta - 0.6\right)Y_{t-4} + \ldots + \varepsilon_t$

(iv) $Y_t = \left(1 + \phi\right)Y_{t-12} + \phi Y_{t-24} + \varepsilon_t - \theta\varepsilon_{t-1} + \lambda\varepsilon_{t-12} - \theta\lambda\varepsilon_{t-13}$

[25 marks]

1. (a) (i) *Definisikan syarat kepegunan dan syarat ketersongsangan bagi suatu model ARPB dalam sebutan boleh jumlah bagi koefisien polinomial bagi bentuk tak terhingga model tersebut.*

(ii) *Terangkan mengapa andaian hingar putih adalah penting dalam prosedur membangunkan model bagi data siri masa?*

(iii) *Bincangkan sifat-sifat siri pegun dan tak pegun dalam hal fak dan faks, nilai telahan, varians ralat telahan dan juga selang keyakinan bagi telahan?*

[40 markah]

(b) *Pertimbangkan suatu proses yang dinyatakan sebagai:*

$$Z_t = X_t + \varepsilon_t - \theta\varepsilon_{t-1} \quad \textit{yang mana} \quad X_t = X_{t-1} + \varepsilon_t \quad \textit{untuk } t \geq 1$$

yang mana $|\theta| < 1$ *dan* $\varepsilon_t \sim \mathrm{WN}\left(0, \sigma_\varepsilon^2\right)$.

(i) *Dengan mendapatkan min dan fungsi autokovarians, tunjukkan bahawa* Z_t *adalah tidak pegun.*

(ii) *Tunjukkan bahawa* $W_t = Z_t - Z_{t-1}$ *adalah proses pegun.*

[35 markah]

(c) *Tulis semula setiap model di bawah menggunakan pengoperasi anjak kebelakang B dan nyatakan bentuk ARKPB(p,d,q) atau bermusim ARKPB(p,d,q)(P,D,Q). [p, d, q, P, D dan Q adalah nombor-nombor positif terhingga]*

(i) $Y_t = \left(1-\phi_1-\phi_3\right)\mu + \phi_1 Y_{t-1} + \phi_3 Y_{t-3} + \varepsilon_t - \theta_1\varepsilon_{t-1} - \theta_2\varepsilon_{t-2}$

(ii) $Y_t = \left(1-\phi\right)Y_{t-1} + \phi Y_{t-2} + \varepsilon_t - \theta\varepsilon_{t-2}$

(iii) $Y_t = \left(\theta-0.6\right)Y_{t-1} - \theta\left(\theta-0.6\right)Y_{t-2} + \theta^2\left(\theta-0.6\right)Y_{t-3} - \theta^3\left(\theta-0.6\right)Y_{t-4} + \ldots + \varepsilon_t$

(iii) $Y_t = \left(1+\phi\right)Y_{t-12} + \phi Y_{t-24} + \varepsilon_t - \theta\varepsilon_{t-1} + \lambda\varepsilon_{t-12} - \theta\lambda\varepsilon_{t-13}$

[25 markah]

2. (a) Consider the following process:

$$X_t = \alpha\left(X_{t-1} - X_{t-2}\right) + \varepsilon_t$$

where α is a real constant and ε_t is a white noise process with mean zero and variance σ_ε^2. Determine the range of possible values of α for which the process is weakly stationary.

[20 marks]

(b) Given an ARMA(2,1) process: $\left(1-\phi_2 B^2\right)Y_t = \left(1-\theta_1 B\right)\varepsilon_t$

(i) Show that: $\left(1-\phi_2^2\right)Var\left(Y_t\right) = \left[1+\theta_1^2\right]\sigma_\varepsilon^2$.

Using the above expression, obtain the stationarity condition for the given ARMA(2,1) process.

(ii) A weekly observation of length 250 was collected and an ARMA(2,1) model has been fitted with the following estimates: $\hat{\phi}_2 = 0.64$ and $\hat{\theta}_1 = 0.75$.

Calculate the values of autocorrelation, acf for lag k = 1, 2, 3, 4, 5, and partial autocorrelation, pacf for lag k = 1 and 2. What can you say about the calculated values of acf and pacf and its underlying process? Can you suggest a simpler model for the collected data?

[Given the values of acf for lag 6 through to lag 10 are 0.020, 0.090, -0.158, 0.203 and -0.208 respectively, while pacf for lag 3 through to lag 8 are 0.107, -0.036, 0.050, -0.070, 0.110 and -0.017 respectively].

[50 marks]

(c) Consider the following seasonal model for a bi-monthly data:

$$\left(1-0.6B\right)Y_t = \left(1-0.9B^6\right)\varepsilon_t .$$

Obtain the values of the autocorrelation, acf for lag k = 1, 2, … 15. From the values obtained, explain the characteristics of the autocorrelation function of a seasonal process.

[30 marks]

2. (a) Pertimbangkan proses berikut:

$$X_t = \alpha\left(X_{t-1} - X_{t-2}\right) + \varepsilon_t$$

yang mana α *suatu pemalar nyata dan* ε_t *adalah suatu proses hingar putih dengan min sifar dan varians* σ_ε^2. *Tentukan julat bagi nilai* α *yang mungkin supaya ia adalah proses adalah pegun lemah.*

[20 markah]

(b) *Diberi suatu proses ARPB(2,1):* $\left(1-\phi_2 B^2\right)Y_t = \left(1-\theta_1 B\right)\varepsilon_t$

(i) *Tunjukkan bahawa:* $\left(1-\phi_2^2\right)Var\left(Y_t\right) = \left[1+\theta_1^2\right]\sigma_\varepsilon^2$.

Menggunakan ungkapan di atas, dapatkan syarat kepegunan untuk proses ARPB(2,1) yang diberi.

(ii) *Suatu cerapan mingguan dengan panjang 200 telah dikumpul dan suatu model ARPB(2,1) telah disuaikan dengan anggaran berikut:* $\hat{\phi}_2 = 0.64$ *dan* $\hat{\theta}_1 = 0.75$.

Hitung nilai autokorelasi, fak untuk susulan k = 1, 2, 3, 4, 5, dan autokorelasi separa, faks untuk susulan k = 1 dan 2. Apakah yang boleh anda katakan mengenai nilai fak dan faks yang dihitung dan juga proses yang diwakilkan? Bolehkah anda cadangkan suatu model yang lebih mudah untuk data yang dikumpul?

[Diberi nilai fak bagi susulan 6 hingga susulan 10 masing-masing adalah 0.020, 0.090, -0.158, 0.203 dan -0.208 manakala faks untuk susulan 3 hingga susulan 8 masing-masing adalah 0.107, -0.036, 0.050, -0.070, 0.110 dan -0.017]

[50 markah]

(c) *Pertimbangkan model bermusim berikut bagi data dwi-bulanan:*

$$\left(1-0.6B\right)Y_t = \left(1-0.9B^6\right)\varepsilon_t .$$

Dapatkan nilai autokorelasi, fak bagi susulan k = 1, 2, ..., 15. Daripada nilai yang diperoleh, terangkan sifat-sifat fungsi autokorelasi bagi suatu proses bermusim.

[30 markah]

3. (a) Consider a MA(1) process: $Y_t = \varepsilon_t - \theta\varepsilon_{t-1}$.

(i) By considering the expression for ρ_1, show that $|\rho_k| \le 0.5$.

(ii) Show that an invertible moment estimator for θ is given by:

$$\hat{\theta} = \frac{-1+\sqrt{1-4\hat{\rho}_1^2}}{2\hat{\rho}_1}.$$

(iii) Show that the estimate $\hat{\theta}$, has a variance given by:

$$Var\left(\hat{\theta}\right) = \frac{1-\hat{\theta}_1^2}{n}.$$

[30 marks]

(b) A series of 275 observations has a variance of 4.2 and produces estimated acf and pacf as given in Table 1 in Appendix A. In an effort to fit a parsimonious model, a student decided to fit a MA(1) model to the data series. Estimate the coefficient, θ for the MA(1) model, its standard error and the variance of the estimated residuals.

Table 2 in Appendix A shows the acf and pacf of the estimated residuals from the fitted MA(1) model. Briefly explain the adequacy of the fitted model and suggest a possible model that better fit the data series.

[30 marks]

(c) Due to its uncertain fluctuation, many people including Hasiah feels that investment in stocks are very risky. She has been advised to invest in foreign currencies such as the US dollar and is now interested to find a suitable time series model so that she can forecast near future values of the US currency. She managed to collect daily spot value of the currency for the period from January 2010 to March 2012.

Hasiah conducted some time series analysis and modeling of the data and the outputs are given in Appendix B. Explain with reason each of the steps taken by Hasiah. From the model obtained, what can she say about the movement of the US dollar?

[40 marks]

3. (a) *Pertimbangkan proses PB(1):* $Y_t = \varepsilon_t - \theta\varepsilon_{t-1}$.

(i) *Dengan mempertimbangkan ungkapan bagi* ρ_1*, tunjukkan bahawa* $|\rho_k| \le 0.5$.

(ii) *Tunjukkan bahawa penganggar momen tersongsangkan bagi* θ *diberikan oleh:*

$$\hat{\theta} = \frac{-1 + \sqrt{1 - 4\hat{\rho}_1^2}}{2\hat{\rho}_1}.$$

(iii) *Tunjukkan bahawa anggaran* $\hat{\theta}$ *mempunyai varians yang diberikan oleh:*

$$Var\left(\hat{\theta}\right) = \frac{1 - \hat{\theta}_1^2}{n}.$$

[30 markah]

(b) *Suatu siri dengan 250 cerapan telah dikumpul, mempunyai varians 4.2 dan menghasilkan anggaran fak dan faks seperti dalam Jadual 1 di Lampiran A. Dalam usaha untuk mendapatkan model yang parsimoni, seorang pelajar mengambil keputusan untuk menyuaikan model PB(1) bagi siri data tersebut. Anggarkan nilai koefisien* θ *bagi model PB(1), nilai sisihan piawai dan juga nilai varians bagi reja.*

Jadual 2 dalam Lampiran A menunjukkan fak dan faks bagi nilai reja teranggar daripada model PB(1). Terangkan secara ringkas kecukupan model yang disuai dan cadangkan suatu model yang mungkin lebih baik untuk siri data tersebut.

[30 markah]

(c) *Oleh kerana turun naik yang tidak menentu, ramai orang termasuk Hasiah merasakan pelaburan dalam saham adalah terlalu berisiko. Beliau telah dinasihatkan untuk melabur dalam matawang asing seperti dolar US dan beliau berminat untuk mendapatkan suatu model siri masa yang sesuai supaya boleh meramalkan nilai matawang US pada masa terdekat. Beliau telah berjaya mengumpulkan nilai semasa matawang bagi jangkamasa dari Januari 2010 hingga Mac 2012.*

Hasiah telah menjalankan beberapa analisis dan pemodelan siri masa ke atas data tersebut serta outputnya diberikan dalam Lampiran B. Terangkan dengan alasan bagi setiap langkah yang diambil oleh Hasiah. Daripada model yang diperoleh, apa yang boleh beliau perkatakan tentang pergerakan dolar US?

[40 markah]

4. (a) Consider an ARMA(1,3) model for a series with non-zero mean:

$$\left(1-\phi B\right)\left(Y_t-\mu\right)=\left(1-\theta B^3\right)\varepsilon_t$$

(i) Show that the 1-step and *m*-step ahead forecasts made at time *t* = *n* is given by:

$$\hat{Y}_n\left(1\right)=\mu\left(1-\phi\right)+\phi Y_n-\theta\varepsilon_{n-2}$$

$$\hat{Y}_n\left(m\right)=\mu\left(1-\phi\right)+\phi\hat{Y}_n\left(m-1\right)\quad \text{for } m\geq 4$$

What are the expression for $\hat{Y}_n\left(2\right)$ and $\hat{Y}_n\left(3\right)$?

(ii) Show that the MA coefficients are given by:

$$\varphi_j=\phi^{j-3}\left(\phi^3-\theta\right)\quad \text{for } j\geq 3$$

(iii) Show that the variance of forecast error is given by:

$$Var\left[\upsilon_n\left(m\right)\right]=\begin{cases}\left(\dfrac{1-\phi^{2m}}{1-\phi^2}\right)\sigma_\varepsilon^2 & \text{for } m\leq 3\\ \left[1+\phi^2+\phi^4+\left(\phi^3-\theta\right)\left(\dfrac{1-\phi^{2(m-3)}}{1-\phi^2}\right)\right]\sigma_\varepsilon^2 & \text{for } m\geq 4\end{cases}$$

(iv) Consider *n* = 200. If the estimated values of the coefficients are $\hat{\phi}=-0.7$, $\hat{\theta}=0.5$, $\hat{\mu}=50$, $s_\varepsilon^2=9$ with $Y_{200}=66$, $\hat{\varepsilon}_{200}=7$, $\hat{\varepsilon}_{199}=4$ and $\hat{\varepsilon}_{198}=-2$, obtain value of $\hat{Y}_{200}\left(m\right)$ for *m* = 1, 2, …, 6 and the corresponding 95% forecast intervals. What can you say about the suitability of time series ARMA model in making long-term forecast?

(v) At time *t* = 201, a new observation is noted as $Y_{201}=48$. Calculate the updated forecasts for $Y_{202},\ldots Y_{206}$. Compare these new forecasts with those calculated in part (iv) above and discuss.

[65 marks]

(b) Consider the following model for a seasonal time series:

$$\left(1-\phi_4 B^4\right)\left(Y_t-\mu\right)=\varepsilon_t$$

(i) Show that the forecast error variance is given by:

$$Var\left[\upsilon_n(m)\right]=\sigma_\varepsilon^2\left(\frac{1-\phi_4^{2(k+1)}}{1-\phi_4^2}\right)$$

for $m=4k+r+1$, k = 0, 1, …, and $0\le r<4$.

(ii) A quarterly observations of 20 years have been collected, fitted to the above model and produces estimated coefficients: $\hat{\phi}_4=0.8$, $\hat{\mu}=100$, $s_\varepsilon^2=16$, $Y_{80}=106$, $Y_{79}=88$, $Y_{78}=97$, $Y_{77}=91$. Calculate the forecast values for m = 1, 2, …, 16 and the corresponding 95% forecast intervals. What can be said about the forecasts and forecast intervals of a seasonal series?

[35 marks]

4. *(a) Pertimbangkan suatu model ARPB(1,3) bagi siri dengan min bukan sifar:*

$$\left(1-\phi B\right)\left(Y_t-\mu\right)=\left(1-\theta B^3\right)\varepsilon_t$$

(i) Tunjukkan bahawa telahan 1-langkah dan m-langkah kehadapan yang dibuat pada t = n adalah diberikan oleh:

$$\hat{Y}_n(1)=\mu(1-\phi)+\phi Y_n-\theta\varepsilon_{n-2}$$

$$\hat{Y}_n(m)=\mu(1-\phi)+\phi\hat{Y}_n(m-1) \quad \text{for } m\ge 4$$

Apakah ungkapan bagi $\hat{Y}_n(2)$ *dan* $\hat{Y}_n(3)$*?*

(ii) Tunjukkan bahawa koefisien bagi PB adalah diberikan oleh:

$$\varphi_j=\phi^{j-3}\left(\phi^3-\theta\right) \quad \text{for } j\ge 3$$

(iii) Tunjukkan bahawa varians bagi ralat telahan adalah diberikan oleh:

$$Var\left[\upsilon_n(m)\right] = \begin{cases} \left(\dfrac{1-\phi^{2m}}{1-\phi^2}\right)\sigma_\varepsilon^2 & \text{for } m \le 3 \\ \left[1+\phi^2+\phi^4+\left(\phi^3-\theta\right)\left(\dfrac{1-\phi^{2(m-3)}}{1-\phi^2}\right)\right]\sigma_\varepsilon^2 & \text{for } m \ge 4 \end{cases}$$

(iv) *Pertimbangkan n = 200. Jika nilai teranggar bagi koefisien adalah* $\hat{\phi} = -0.7$ $\hat{\theta} = 0.5$, $\hat{\mu} = 50$, $s_\varepsilon^2 = 9$ *dengan* $Y_{200} = 66$, $\hat{\varepsilon}_{200} = 7$, $\hat{\varepsilon}_{199} = 4$ *dan* $\hat{\varepsilon}_{198} = -2$, *dapatkan nilai bagi* $\hat{Y}_{200}(m)$ *untuk m = 1, 2, …, 6 dan selang telahan 95% yang sepadan. Apakah yang boleh anda katakan mengenai kesesuaian model siri masa ARMA dalam menghasilkan telahan jangka panjang?*

(v) *Pada waktu t = 201 satu cerapan baru dicatat sebagai* $Y_{201} = 48$. *Hitung telahan kemaskini bagi* $Y_{202}, \ldots Y_{206}$. *Bandingkan nilai telahan terbaru ini dengan telahan yang diperoleh dalam bahagian (iv) di atas dan bincangkan.*

[65 markah]

(b) *Pertimbangkan model siri masa bermusim berikut:*

$$\left(1-\phi_4 B^4\right)\left(Y_t - \mu\right) = \varepsilon_t$$

(i) *Tunjukkan bahawa ralat varians bagi telahan diberikan oleh:*

$$Var\left[\upsilon_n(m)\right] = \sigma_\varepsilon^2 \left(\frac{1-\phi_4^{2(k+1)}}{1-\phi_4^2}\right)$$

untuk $m = 4k + r + 1$, *k = 0, 1, …, dan* $0 \le r < 4$

(ii) *Suatu cerapan suku-tahun selama 20 tahun telah diperoleh, disuaikan dengan model di atas dan menghasilkan koefisien teranggar:* $\hat{\phi}_4 = 0.8$, $\hat{\mu} = 100$, $s_\varepsilon^2 = 16$, $Y_{80} = 106$, $Y_{79} = 88$, $Y_{78} = 97$, $Y_{77} = 91$. *Hitung nilai telahan untuk m = 1, 2, …, 16 dan selang telahan 95% yang sepadan. Apakah yang boleh diperkatakan tentang nilai telahan dan selangan telahan bagi siri bermusim?*

[35 markah]

APPENDIX/LAMPIRAN A

Table 1: Acf and Pacf of Data Series

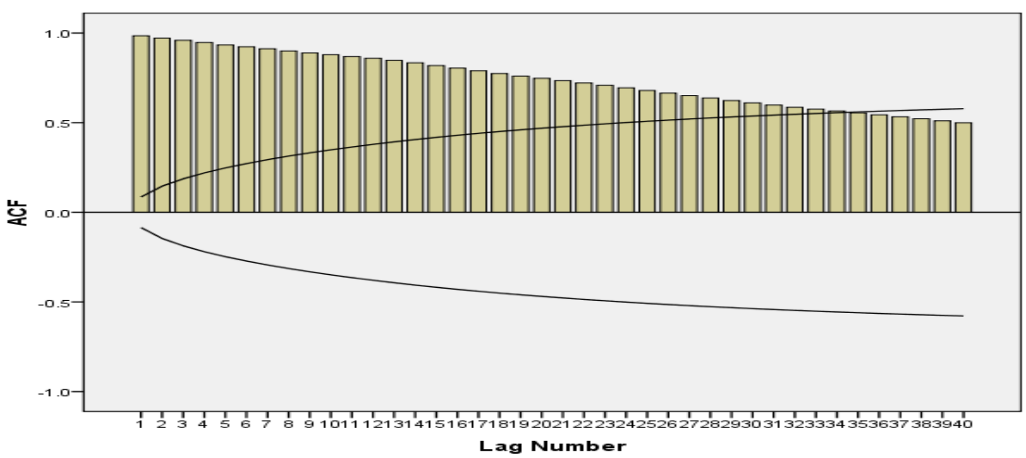
Lag	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Acf	-0.719	0.256	-0.014	-0.067	0.081	-0.025	-0.073	0.095	0.019	-0.121
Pacf	-0.719	-0.540	-0.346	-0.325	-0.254	-0.094	-0.196	-0.288	-0.040	0.015

Table 1: Acf and Pacf of Data Series

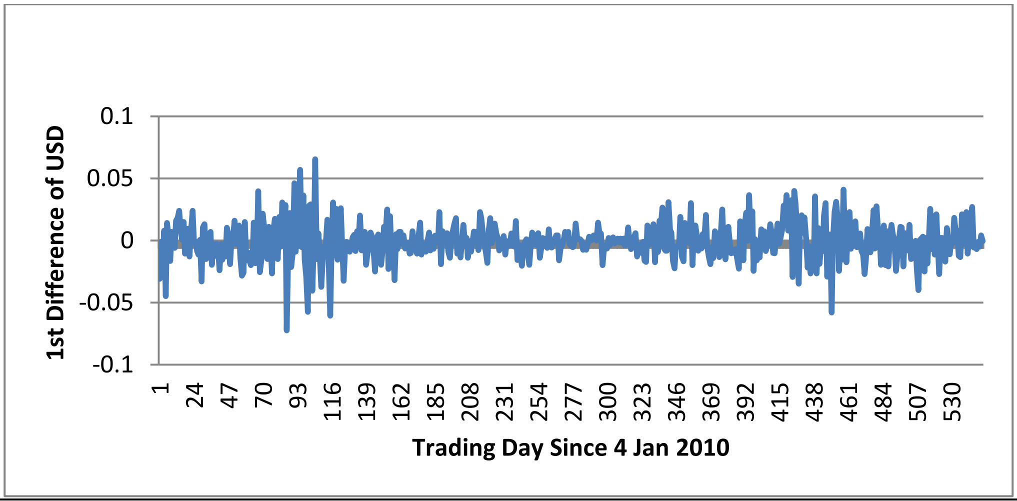
Lag	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Acf	-0.532	0.149	0.024	-0.033	0.094	-0.006	-0.049	0.149	0.042	-0.102
Pacf	-0.532	-0.186	0.028	0.032	0.126	0.142	0.010	0.141	0.276	0.075

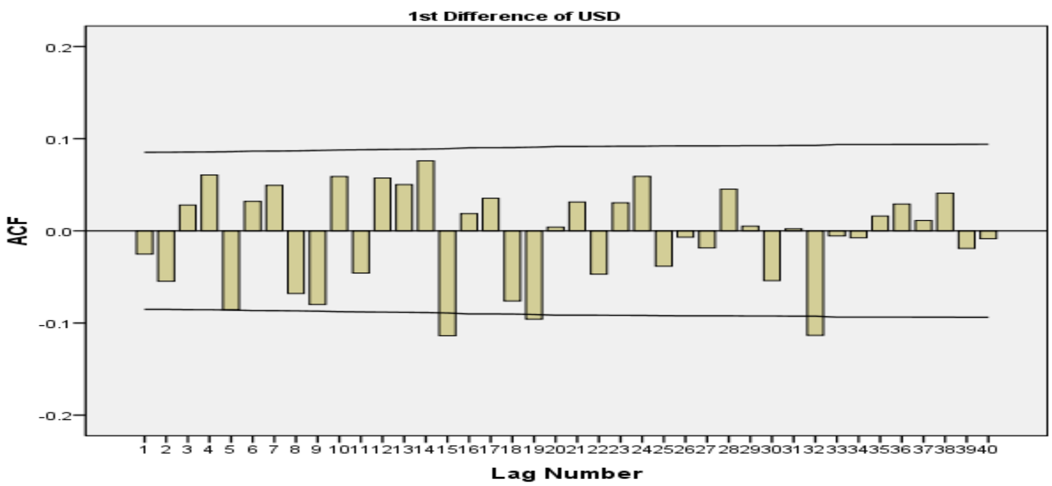
APPENDIX/LAMPIRAN B

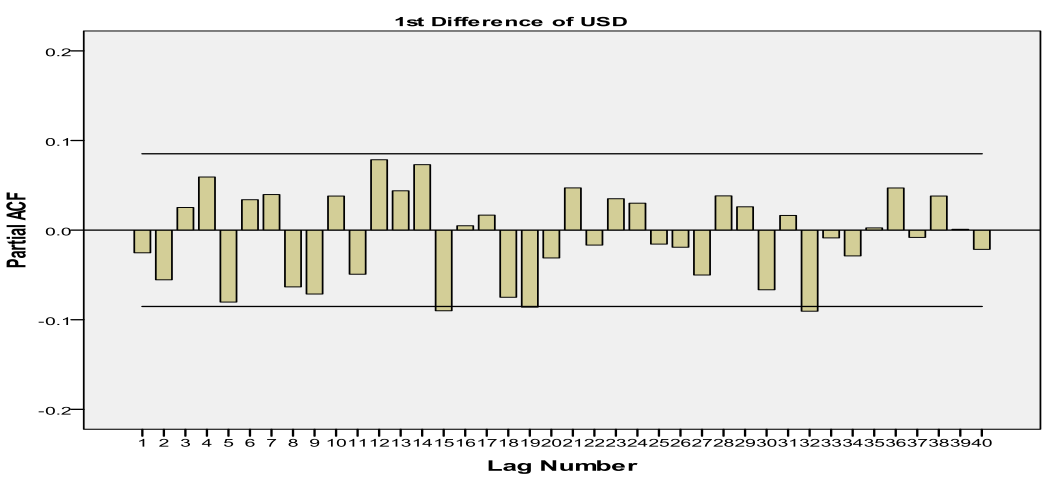
Step 1



Step 2


1st Difference of USD
Trading Day Since 4 Jan 2010
0.1
0.05
0
-0.05
-0.1


1st Difference of USD
ACF
Lag Number


1st Difference of USD
Partial ACF
Lag Number

Step 3a

Dependent Variable: D1USD

	Coefficient	Std. Error	z-Statistic	Prob.
AR(1)	0.004028	0.045745	0.088060	0.9298
		Variance Equation		
C	2.74E-06	1.46E-06	1.874860	0.0608
RESID(-1)^2	0.106801	0.022717	4.701407	0.0000
GARCH(-1)	0.883318	0.024102	36.64850	0.0000
Schwarz criterion	-5.698542	Akaike info criterion		-5.729887

Step 3b

Dependent Variable: D1USD

	Coefficient	Std. Error	z-Statistic	Prob.
MA(1)	0.004374	0.046074	0.094940	0.9244
		Variance Equation		
C	3.06E-06	1.54E-06	1.986718	0.0470
RESID(-1)^2	0.112430	0.023473	4.789817	0.0000
GARCH(-1)	0.876044	0.024723	35.43401	0.0000
Schwarz criterion	-5.695410	Akaike info criterion		-5.726711

Step 3c

Dependent Variable: D1USD

	Coefficient	Std. Error	z-Statistic	Prob.
AR(1)	-0.890413	0.046367	-19.20342	0.0000
MA(1)	0.896123	0.038195	23.46200	0.0000
		Variance Equation		
C	2.71E-06	1.53E-06	1.770748	0.0766
RESID(-1)^2	0.106315	0.022978	4.626785	0.0000
GARCH(-1)	0.884183	0.023993	36.85177	0.0000
Schwarz criterion	-5.688653	Akaike info criterion		-5.727889
Inverted AR Roots	-.89			
Inverted MA Roots	-.90			

Step 4a

ACF & PACF from fitted ARMA(1,1)

	AC	PAC	Q-Stat	Prob
1	0.010	0.010	0.0565	
2	0.009	0.009	0.1020	
3	-0.001	-0.002	0.1032	0.748
4	0.033	0.033	0.6923	0.707
5	-0.012	-0.013	0.7741	0.856
6	0.002	0.002	0.7765	0.942
12	0.043	0.047	8.8481	0.547
18	-0.025	-0.031	16.497	0.419

Step 4b

ARCH Test: Lag 3

Obs*R-squared	0.490372	Probability	0.921002

ARCH Test: Lag 6

Obs*R-squared	3.668497	Probability	0.721433

Step 5a

Dependent Variable: D1USD

	Coefficient	Std. Error	z-Statistic	Prob.
AR(1)	0.726694	0.541453	1.342120	0.1796
AR(2)	-0.014491	0.049251	-0.294223	0.7686
MA(1)	-0.725694	0.540927	-1.341576	0.1797
Variance Equation				
C	2.86E-06	1.50E-06	1.906544	0.0566
RESID(-1)^2	0.109727	0.023421	4.685001	0.0000
GARCH(-1)	0.880132	0.024689	35.64932	0.0000
Schwarz criterion	-5.675819	Akaike info criterion		-5.722968
Inverted AR Roots	.71	.02		
Inverted MA Roots	.73			

Step 5b

Dependent Variable: D1USD

	Coefficient	Std. Error	z-Statistic	Prob.
AR(1)	0.712687	0.301610	2.362939	0.0181
MA(1)	-0.712409	0.307630	-2.315799	0.0206
MA(2)	-0.013369	0.048634	-0.274884	0.7834
		Variance Equation		
C	2.79E-06	1.49E-06	1.878485	0.0603
RESID(-1)^2	0.108876	0.023312	4.670448	0.0000
GARCH(-1)	0.881488	0.024583	35.85769	0.0000
Schwarz criterion	-5.675940	Akaike info criterion		-5.723023

Step 5c

Dependent Variable: D1USD

	Coefficient	Std. Error	z-Statistic	Prob.
AR(1)	0.719102	0.311096	2.311513	0.0208
MA(1)	-0.727230	0.307871	-2.362128	0.0182
		Variance Equation		
C	2.53E-06	1.65E-06	1.527580	0.1266
RESID(-1)^2	0.094635	0.044877	2.108776	0.0350
GARCH(-1)	1.042620	0.469064	2.222769	0.0262
GARCH(-2)	-0.146102	0.423696	-0.344827	0.7302
Schwarz criterion	-5.675885	Akaike info criterion		-5.722968

Step 6

Dependent Variable: D1USD

	Coefficient	Std. Error	z-Statistic	Prob.
		Variance Equation		
C	3.03E-06	1.51E-06	2.003504	0.0451
RESID(-1)^2	0.111674	0.023084	4.837767	0.0000
GARCH(-1)	0.877112	0.024147	36.32408	0.0000
Schwarz criterion	-5.704315	Akaike info criterion		-5.727823

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Step 7a

Dependent Variable: D1USD

	Coefficient	Std. Error	z-Statistic	Prob.
GARCH	-2.928523	2.615615	-1.119630	0.2629
AR(1)	0.661414	0.104347	6.338615	0.0000
MA(1)	-0.677671	0.104041	-6.513477	0.0000
		Variance Equation		
C	2.85E-06	1.50E-06	1.899516	0.0575
RESID(-1)^2	0.108636	0.023144	4.694022	0.0000
GARCH(-1)	0.881525	0.024386	36.14831	0.0000
Schwarz criterion	-5.676877	Akaike info criterion		-5.723960

Step 7b

Dependent Variable: D1USD
LOG(GARCH) = C(3) + C(4)*ABS(RESID(-1)/@SQRT(GARCH(-1))) +
C(5)*RESID(-1)/@SQRT(GARCH(-1)) + C(6)*LOG(GARCH(-1))

	Coefficient	Std. Error	z-Statistic	Prob.
AR(1)	-0.795845	0.187282	-4.249444	0.0000
MA(1)	0.801666	0.187239	4.281518	0.0000
		Variance Equation		
C(3)	-0.355182	0.097478	-3.643703	0.0003
C(4)	0.203356	0.040904	4.971513	0.0000
C(5)	0.050443	0.024826	2.031849	0.0422
C(6)	0.976963	0.009096	107.4046	0.0000
Schwarz criterion	-5.695623	Akaike info criterion		-5.742706

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