UNIVERSITI SAINS MALAYSIA

Second Semester Examination
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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) With regards to non-seasonal and seasonal time series, discuss by using example, similarities and differences in the identification process of a model and the characteristic of the forecast values?

(iii) Explain the use of LM test and ARCH-LM test on a fitted ARMA model for the diagnostic checking of a white noise assumption. Also explain how the results from the tests can be used to improve the model.

[40 marks]

(b) Consider a process defined as: $Y_t = 20 - 10t + X_t$ where X_t is a process defined as below:

$$X_t = X_{t-1} + \varepsilon_t - \theta\varepsilon_{t-1} \text{ with } X_1 = \varepsilon_1 \text{ and that } Var(X_1) = \sigma_\varepsilon^2.$$

(i) Give reason why X_t is not stationary.

(ii) Show that $Z_t = Y_t - Y_{t-1}$ is stationary.

(iii) By expressing in $\mathrm{AR}(\infty)$ form, obtain the required invertibility condition for Z_t.

[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) $Y_t = \phi Y_{t-1} + \phi^2 Y_{t-2} + \varepsilon_t - \theta\varepsilon_{t-1} + \theta^3\varepsilon_{t-3}$

(ii) $Y_t = \varepsilon_t + Y_{t-1} + \lambda\varepsilon_{t-1} + \phi_1\left(Y_{t-1} - \varepsilon_{t-1}\right) - \phi_1\left(Y_{t-2} + \lambda\varepsilon_{t-2}\right)$

(iii) $Y_t = (1+\phi)Y_{t-1} - \phi Y_{t-2} + Y_{t-6} - (1+\phi)Y_{t-7} + \phi Y_{t-8} + \varepsilon_t - \theta_6\varepsilon_{t-6} + \theta_6^2\varepsilon_{t-12}$

(iv) $$Y_t = \varepsilon_t + (1-0.4)Y_{t-1} - 0.7\varepsilon_{t-1} + 0.4(1-0.4)Y_{t-2} + 0.7^2\varepsilon_{t-2} + 0.4^2(1-0.4)Y_{t-3} - 0.7^3\varepsilon_{t-3} + 0.4^3(1-0.4)Y_{t-3}\cdots$$

[25 marks]

1. (a) (i) *Definisikan syarat kepegunan dan syarat ketersongsangkan bagi suatu model ARMA dalam sebutan keterhasiltambahan bagi koefisien polinomial bagi bentuk tak terhingga model tersebut.*

(ii) *Merujuk kepada siri tak bermusim dan siri bermusim, bincangkan dengan menggunakan contoh, persamaan dan perbezaan dalam proses mengenalpasti model dan ciri nilai ramalan.*

(iii) *Terangkan penggunaan ujian LM dan ujian ARCH-LM ke atas model ARMA untuk penyemakan diagnostik bagi andaian hingar putih. Juga jelaskan bagaimana keputusan daripada ujian tersebut boleh digunakan untuk memperbaiki model .*

[40 markah]

(b) *Pertimbangkan suatu proses yang ditakrifkan oleh:* $Y_t = 20 - 10t + X_t$ yang mana X_t adalah suatu proses yang ditakrifkankan seperti di bawah:

$X_t = X_{t-1} + \varepsilon_t - \theta\varepsilon_{t-1}$ dengan $X_1 = \varepsilon_1$ dan juga $Var(X_1) = \sigma_\varepsilon^2$.

(i) *Berikan sebab mengapa* X_t *adalah tidak pegun?*

(ii) *Tunjukkan bahawa* $Z_t = Y_t - Y_{t-1}$ *adalah pegun.*

(iii) *Dengan menyatakan dalam bentuk* $\mathrm{AR}(\infty)$ *, dapatkan syarat ketersongsangkan bagi* Z_t .

[35 markah]

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

(i) $Y_t = \phi Y_{t-1} + \phi^2 Y_{t-2} + \varepsilon_t - \theta\varepsilon_{t-1} + \theta^3\varepsilon_{t-3}$

(ii) $Y_t = \varepsilon_t + Y_{t-1} + \lambda\varepsilon_{t-1} + \phi_1(Y_{t-1} - \varepsilon_{t-1}) - \phi_1(Y_{t-2} + \lambda\varepsilon_{t-2})$

(iii) $Y_t = (1+\phi)Y_{t-1} - \phi Y_{t-2} + Y_{t-6} - (1+\phi)Y_{t-7} + \phi Y_{t-8} + \varepsilon_t - \theta_6\varepsilon_{t-6} + \theta_6^2\varepsilon_{t-12}$

(iv) $$\begin{aligned} Y_t = \varepsilon_t &+ (1-0.4)Y_{t-1} - 0.7\varepsilon_{t-1} + 0.4(1-0.4)Y_{t-2} + 0.7^2\varepsilon_{t-2} \\ &+ 0.4^2(1-0.4)Y_{t-3} - 0.7^3\varepsilon_{t-3} + 0.4^3(1-0.4)Y_{t-3}\ldots \end{aligned}$$

[25 markah]

2. (a) Show that the ACF of the *m*-th order MA process given by:

$$Y_t = \sum_{k=0}^{m} \left(\frac{\varepsilon_{t-k}}{m+1} \right)$$

can be written as:

$$\rho_k = \begin{cases} \dfrac{m+1-k}{m+1} & \text{for } k = 0,\ 1,\ \ldots,\ m \\ 0 & \text{for } k > m \end{cases}$$

[25 marks]

(b) Consider an ARMA(2,2) process: $\left(1-\phi_1 B-\phi_2 B^2\right) Y_t = \left(1-\theta_1 B-\theta_2 B^2\right)\varepsilon_t$

(i) Show that:

$$Var\left(Y_t\right) = \phi_1\gamma_1 + \phi_2\gamma_2 + \left[1-\theta_1\left(\phi_1-\theta_1\right)-\theta_2\left(\phi_1^2-\phi_1\theta_1+\phi_2-\theta_2\right)\right]\sigma_\varepsilon^2$$

Find the expression for two other specific autocovariances.

(ii) A weekly observation of 5 years (*n* = 260) was collected and the fitted ARMA(2,2) model can be written as follows:

$$Y_t = 0.7Y_{t-1} + 0.18Y_{t-2} + \varepsilon_t - 1.7\varepsilon_{t-1} + 0.72\varepsilon_{t-2}$$

Estimate the values of autocorrelation, acf for lag *k* = 1, 2, 3, 4, 5, and partial autocorrelation, pacf for lag *k* = 1 and 2.

Draw the sample ACF and PACF, and comment on the features you observed. Is the ARMA(2,2) an appropriate model for the series? Suggest one or two more parsimonious ARMA model that can be fitted to the data series?

[The values of ACF for lag 6 through to lag 10 are -0.080, 0.052, 0.022, -0.061 and 0.065 respectively, while PACF for lag 3 through to lag 8 are -0.246, -0.156, -0.026, -0.077, -0.053, -0.004 respectively].

[50 marks]

(c) Consider the following seasonal process with period four: $Y_t = \phi_4 Y_{t-4} + \varepsilon_t$.

(i) Show that the ACF tails off exponentially seasonally with non-zero values given as:

$$\rho_{4k} = \phi_4^k \quad \text{for } k \geq 1$$

(ii) Show that the PACF cuts off with only one non-zero value of $\rho_{4,4} = \phi_4$

[25 marks]

2. (a) *Tunjukkan bahawa FAK pangkat ke-m proses MA yang diberi oleh:*

$$Y_t = \sum_{k=0}^{m}\left(\frac{\varepsilon_{t-k}}{m+1}\right)$$

boleh tulis sebagai:

$$\rho_k = \begin{cases} \dfrac{m+1-k}{m+1} & \text{untuk } k = 0,\ 1,\ \ldots,\ m \\ 0 & \text{untuk } k > m \end{cases}$$

[25 markah]

(b) *Pertimbangkan proses ARMA(2,2):* $\left(1-\phi_1 B-\phi_2 B^2\right)Y_t = \left(1-\theta_1 B-\theta_2 B^2\right)\varepsilon_t$

(i) *Tunjukkan bahawa*

$$Var\left(Y_t\right) = \phi_1\gamma_1 + \phi_2\gamma_2 + \left[1-\theta_1\left(\phi_1-\theta_1\right)-\theta_2\left(\phi_1^2-\phi_1\theta_1+\phi_2-\theta_2\right)\right]\sigma_\varepsilon^2$$

Dapatkan dua ungkapan khusus yang lain bagi autokovarians.

(ii) *Suatu cerapan mingguan selama 5 tahun (n = 260) telah dikumpul dan model ARMA(2,2) yang disuaikan boleh ditulis seperti di bawah:*

$$Y_t = 0.7Y_{t-1} + 0.18Y_{t-2} + \varepsilon_t - 1.7\varepsilon_{t-1} + 0.72\varepsilon_{t-2}$$

Anggarkan nilai bagi autokorelasi, FAK untuk susulan k = 1, 2, 3, 4, 5, dan autokorelasi separa, FAKS untuk susulan k = 1 dan 2.

Lukiskan sampel FAK dan FAKS, dan beri komen terhadap sifat yang diperhati. Adakah model ARMA(2,2) sesuai untuk siri tersebut? Cadangkan satu atau dua model ARMA yang lebih parsimoni yang boleh disuaikan bagi data siri tersebut?

[Diberi nilai FAK bagi susulan 6 hingga 10 adalah -0.080, 0.052, 0.022, -0.061 dan 0.065 manakala FAKS untuk susulan 3 hingga 8 adalah -0.246, -0.156, -0.026, -0.077, -0.053, -0.004*].*

[50 markah]

(c) *Pertimbangkan proses bermusim dengan tempoh empat yang berikut:* $Y_t = \phi_4 Y_{t-4} + \varepsilon_t$.

(i) *Tunjukkan bahawa FAK menyusut secara bermusim dengan nilai bukan sifar diberikan oleh:*

$$\rho_{4k} = \phi_4^k \quad \text{for } k \geq 1$$

(ii) *Tunjukkan bahawa FAKS terpangkas dengan hanya satu nilai bukan sifar* $\rho_{4,4} = \phi_4$.

[25 markah]

3. (a) Consider an ARMA(1,1) model: $Y_t = \phi Y_{t-1} + \varepsilon_t - \theta\varepsilon_{t-1}$.

(i) Using method of moments, show that the estimate of ϕ is given by $\hat{\phi} = \dfrac{\hat{\rho}_2}{\hat{\rho}_1}$ while the estimate of θ_1 can be obtained by solving the following quadratic equation:

$$\hat{\rho}_1 = \frac{\left(1-\hat{\phi}\theta\right)\left(\hat{\phi}-\theta\right)}{1-2\hat{\phi}\theta+\theta^2}$$

(ii) Show that the standard error of the estimates, SE are given by:

$$\mathrm{SE}\left(\hat{\phi}\right) = \sqrt{\frac{1-\hat{\phi}^2}{n}\left(\frac{1-\hat{\phi}\hat{\theta}}{\hat{\phi}-\hat{\theta}}\right)^2} \quad \text{and} \quad \mathrm{SE}\left(\hat{\theta}\right) = \sqrt{\frac{1-\hat{\theta}^2}{n}\left(\frac{1-\hat{\phi}\hat{\theta}}{\hat{\phi}-\hat{\theta}}\right)^2}$$

[30 marks]

(b) Consider the following seasonal process:

$$S_t = \left(1+\phi_6\right)S_{t-6} - \phi_6 S_{t-12} + \varepsilon_t - \theta_1\varepsilon_{t-1}$$

(i) Show that the process can be represented as SARIMA(0,0,1)(1,1,0)

(ii) Show that $Y_t = S_t - S_{t-6}$ has the variance and autocorrelation functions given by:

$$\gamma_0 = \frac{1+\theta_1^2}{1-\phi_6^2}\sigma_\varepsilon^2, \qquad \rho_{6k} = \phi_6^k \ \text{ for } k = 1,\ 2,\ \ldots$$

$$\rho_{6k-1} = \rho_{6k+1} = -\frac{\theta_1}{1+\theta_1^2}\phi_6^k \ \text{ for } k = 0,\ 1,\ 2,\ \ldots$$

(iii) Table 1 and Table 2 in the Appendix A show the sample acf and sample pacf of $\{S_t\}$ and $\{\nabla_6 S_t\}$. The mean and standard deviation for the original and differenced series are also given.

Discuss the appropriateness of the SARIMA$(0,0,1)(1,1,0)$ model for the series based on the given sample acf and sample pacf. Calculate the estimate for ϕ_6, θ_1 and σ_ε^2.

[40 marks]

(c) Following her promotion to Senior Risk Analyst, Mr. William is responsible to assess the returns and volatility of the Malaysian stock prices. He has conducted the appropriate time series analysis with the output as shown in Appendix B. Unfortunately, he is unwell and is not able to prepare the report to be presented to the Panel of Market Risk.

As an Assistant Risk Analyst, write a short report on the findings. Explain with reason each of the steps that was taken

[30 marks]

3. *(a) Pertimbangkan model ARMA(1,1):* $Y_t = \phi Y_{t-1} + \varepsilon_t - \theta\varepsilon_{t-1}$.

(i) *Menggunakan kaedah momen, tunjukkan bahawa anggaran bagi* ϕ_1 *diberikan oleh* $\hat{\phi}_1 = \dfrac{\hat{\rho}_2}{\hat{\rho}_1}$, sementara anggaran bagi θ_1 boleh diperoleh dengan menyelesaikan persamaan kuadratik yang berikut:

$$\hat{\rho}_1 = \frac{\left(1-\hat{\phi}\theta\right)\left(\hat{\phi}-\theta\right)}{1-2\hat{\phi}\theta+\theta^2}$$

(ii) *Tunjukkan bahawa ralat piawai bagi nilai anggaran diberikan oleh*

$$\mathrm{SE}\left(\hat{\phi}\right) = \sqrt{\frac{1-\hat{\phi}^2}{n}\left(\frac{1-\hat{\phi}\hat{\theta}}{\hat{\phi}-\hat{\theta}}\right)^2} \quad \text{dan} \quad \mathrm{SE}\left(\hat{\theta}\right) = \sqrt{\frac{1-\hat{\theta}^2}{n}\left(\frac{1-\hat{\phi}\hat{\theta}}{\hat{\phi}-\hat{\theta}}\right)^2}$$

[30 markah]

(b) Pertimbangkan proses bermusim yang berikut:

$$S_t = \left(1+\phi_6\right)S_{t-6} - \phi_6 S_{t-12} + \varepsilon_t - \theta_1\varepsilon_{t-1}$$

(i) Tunjukkan bahawa proses ini boleh dikenalpasti sebagai SARIMA(0,0,1)(1,1,0).

(ii) Tunjukkan bahawa $Y_t = S_t - S_{t-6}$ *mempunyai varians dan fungsi autokorelasi yang diberikan oleh:*

$$\gamma_0 = \frac{1+\theta_1^2}{1-\phi_6^2}\sigma_\varepsilon^2, \qquad \rho_{6k} = \phi_6^k \ \text{ untuk } k = 1,\ 2,\ \ldots$$

$$\rho_{6k-1} = \rho_{6k+1} = -\frac{\theta_1}{1+\theta_1^2}\phi_6^k \ \text{ for } k = 0,\ 1,\ 2,\ \ldots$$

(iii) *Jadual 1 dan Jadual 2 di Lampiran A menunjukkan sampel FAK dan sampel FAKS bagi* $\{S_t\}$ *dan* $\{\nabla_6 S_t\}$*. Min serta sisihan piawai bagi siri asal dan siri yang telah dibezakan juga diberikan.*

Bincang kesesuaian bagi model bermusim ARKPB $(0,0,1)(1,1,0)_{12}$ *untuk siri tersebut berdasarkan sampel FAK dan sampel FAKS yang diberi. Hitung anggaran bagi* ϕ_6, θ_1 *dan* σ_ε^2.

[40 markah]

(c) *Berikutan kenaikan pangkat beliau kepada Penganalisa Risiko Kanan, Encik William bertanggungjawab untuk menilai pulangan dan volatiliti harga saham di Malaysia. Beliau telah menjalankan analisis siri masa yang sesuai dan output ditunjukkan dalam Lampiran B. Malangnya beliau tidak sihat dan tidak dapat untuk menyediakan laporan yang akan dibentangkan kepada Panel Risiko Pasaran.*

Sebagai Penolong Penganalisa Risiko, anda dikehendaki untuk menulis satu laporan berhubung penemuan tersebut.Terangkan dengan alasan setiap langkah yang telah diambil.

[30 markah]

4. (a) Consider an ARMA(2,2) model for a series with non-zero mean:

$$\left(1-\phi_2 B^2\right)\left(Y_t-\mu\right)=\left(1-\theta_1 B-\theta_2 B^2\right)\varepsilon_t$$

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

$$\hat{Y}_n(1)=\mu\left(1-\phi_2\right)+\phi Y_{n-1}-\theta_1\varepsilon_n-\theta_3\varepsilon_{n-1}$$

$$\hat{Y}_n(m)=\mu\left(1-\phi_2\right)+\phi\hat{Y}_n(m-2) \quad \text{for } m\geq 3$$

What is the expression for $\hat{Y}_n(2)$?

(ii) Show that the m-step ahead forecasts can be rewritten as:

$$\hat{Y}_n(m)=\mu\left(1-\phi_2^{m/2}\right)+\phi_2^{m/2}Y_n-\phi_2^{(m-2)/2}\theta_2\varepsilon_n \quad \text{when } m \text{ is even}$$

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

$$\phi_k=\begin{cases}-\theta_1\phi_2^{(m-1)/2} & \text{when } k \text{ is odd}\\ \\ \left(\phi_2-\theta_2\right)\phi_2^{(m-2)/2} & \text{when } k \text{ is even}\end{cases}$$

(iv) For n = 300, consider an ARMA(2,2) model with the following values of estimated coefficients: $\hat{\phi}_2 = 0.8$, $\hat{\theta}_1 = -0.30$, $\hat{\theta}_2 = 0.54$, $\hat{\mu} = 100$, $s_\varepsilon^2 = 16$ and latest information $Y_{300} = 132$, $Y_{299} = 124$, $\hat{\varepsilon}_{300} = 7$ and $\hat{\varepsilon}_{299} = 24$.

Obtain value of $\hat{Y}_{200}(m)$ for m = 1, 2, …, 6 and the corresponding 95% forecast intervals. What can be said about the behavior of the forecast values from an ARMA model?

(v) At time t = 301, a new observation is noted as $Y_{301} = 106$. Calculate the updated forecasts for Y_{302}, …, Y_{206}. Compare these new forecasts with those calculated in part (iv) above and discuss.

[70 marks]

(b) Consider the following non-stationary model: $Y_t = \lambda + Y_{t-1} + \varepsilon_t - \theta_2 \varepsilon_{t-2}$

(i) Show that: $\hat{Y}_n(m) = m\lambda + Y_n - \theta_2(\varepsilon_n + \varepsilon_{n-1})$ for $m \geq 2$

(ii) Show that: $Var\left[\upsilon_n(m)\right] = \left\{2 + (m-2)(1-\theta_2)^2\right\}\sigma_\varepsilon^2$

(iii) Consider n = 150. If estimated values for the coefficients are $\hat{\lambda} = 5$, $\hat{\theta}_2 = 0.9$, $s_\varepsilon^2 = 6$ with $Y_{150} = 100$, $\varepsilon_{150} = 4$ and $\varepsilon_{149} = -2$, obtain value of $\hat{Y}_{150}(m)$ for m = 1, 2, …, 6 and the corresponding 95% forecast intervals. What can you say about the forecast values from a series possessing deterministic trend?

[30 marks]

4. *(a)* *Pertimbangkan model ARMA(2,2) bagi suatu siri dengan min bukan sifar:*

$$\left(1-\phi_2 B^2\right)\left(Y_t - \mu\right) = \left(1 - \theta_1 B - \theta_2 B^2\right)\varepsilon_t$$

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

$$\hat{Y}_n(1) = \mu(1-\phi_2) + \phi Y_{n-1} - \theta_1 \varepsilon_n - \theta_3 \varepsilon_{n-1}$$

$$\hat{Y}_n(m) = \mu(1-\phi_2) + \phi \hat{Y}_n(m-2) \quad \text{for } m \geq 3$$

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

(ii) *Tunjukkan bahawa telahan –langkah kehadapan boleh ditulis semula sebagai:*

$$\hat{Y}_n(m) = \mu\left(1-\phi_2^{m/2}\right) + \phi_2^{m/2} Y_n - \phi_2^{(m-2)/2}\theta_2 \varepsilon_n \quad \text{apabila } m \text{ genap}$$

(iii) *Tunjukkan bahawa pekali-pekali bagi MA adalah diberikan oleh:*

$$\phi_k = \begin{cases} -\theta_1\phi_2^{(m-1)/2} & \text{apabila } k \text{ ganjil} \\ \\ (\phi_2 - \theta_2)\,\phi_2^{(m-2)/2} & \text{apabila } k \text{ genap} \end{cases}$$

(iv) *Untuk n = 300, pertimbangkan suatu model ARMA(2,2) dengan nilai-nilai teranggar bagi koefisien seperti berikut* $\hat{\phi}_2 = 0.8$, $\hat{\theta}_1 = -0.30$, $\hat{\theta}_2 = 0.54$, $\hat{\mu} = 100$, $s_\varepsilon^2 = 16$ serta maklumat terkini $Y_{300} = 132$, $Y_{299} = 132$, $\hat{\varepsilon}_{300} = 7$ dan $\hat{\varepsilon}_{299} = 24$.

Dapatkan nilai bagi $\hat{Y}_{300}(m)$ *untuk m = 1, 2, …, 6 dan selang telahan 95% yang sepadan. Apa yang boleh diperkatakan tentang sifat nilai telahan daripada suatu model ARMA?*

(v) *Pada waktu t = 301 satu cerapan baru dicatat sebagai* $Y_{301} = 106$. *Hitung telahan kemaskini bagi* $Y_{302}, \dots Y_{306}$. *Bandingkan nilai telahan terbaru ini dengan telahan yang diperoleh dalam bahagian (iv) di atas dan bincangkan.*

[70 markah]

(b) *Pertimbangkan model tak pegun seperti berikut:* $Y_t = \lambda + Y_{t-1} + \varepsilon_t - \theta_2\varepsilon_{t-2}$

(i) *Tunjukkan bahawa:* $\hat{Y}_n(m) = m\lambda + Y_n - \theta_2(\varepsilon_n + \varepsilon_{n-1})$ untuk $m \geq 2$

(ii) *Tunjukkan bahawa:* $Var\left[\upsilon_n(m)\right] = \left\{2 + (m-2)(1-\theta_2)^2\right\}\sigma_\varepsilon^2$

(iii) *Pertimbangkan n= 150. Sekiranya nilai teranggaran koefisien adalah* $\hat{\lambda} = 5$, $\hat{\theta}_2 = 0.9$, $s_\varepsilon^2 = 6$ dengan $Y_{150} = 100$, $\varepsilon_{150} = 4$ dan $\varepsilon_{149} = -2$, *dapatkan nilai telahan* $\hat{Y}_{150}(m)$ *untuk m = 1, 2, …,6 dan selang telahan 95% yang sepadan. Apa yang boleh diperkatakan tentang telahan dan selang telahan bagi siri yang mempunyai tren deterministik?*

[30 markah]

APPENDIX/LAMPIRAN A

Table 1: Series $\{S_t\}$, std deviation = 58.18

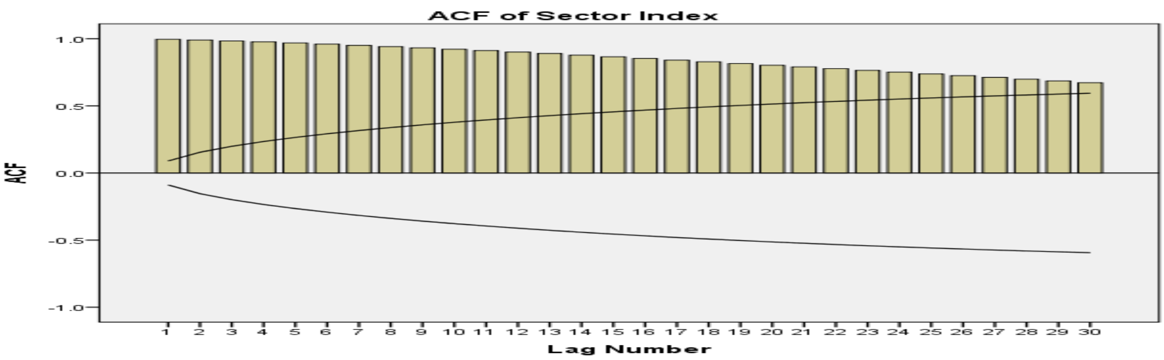
lag	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
ACF	0.446	0.040	0.064	0.034	0.456	0.963	0.404	0.023	0.054	0.033
PACF	0.446	0.199	0.170	-0.090	0.658	0.912	-0.436	-0.139	0.086	0.143
lag	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
ACF	0.452	0.923	0.363	0.009	0.046	0.032	0.447	0.881	0.321	-0.005
PACF	-0.321	0.115	0.084	0.001	-0.155	0.139	-0.027	-0.078	-0.042	0.138
lag	**21**	**22**	**23**	**24**	**25**	**26**	**28**	**29**	**30**	**31**
ACF	0.038	0.030	0.440	0.838	0.279	-0.020	0.026	0.430	0.793	0.237
PACF	-0.082	-0.052	0.030	0.046	-0.111	0.014	-0.026	-0.071	0.033	0.011

Table 2: Series $\{\nabla_6 S_t\}$, std deviation = 3.503

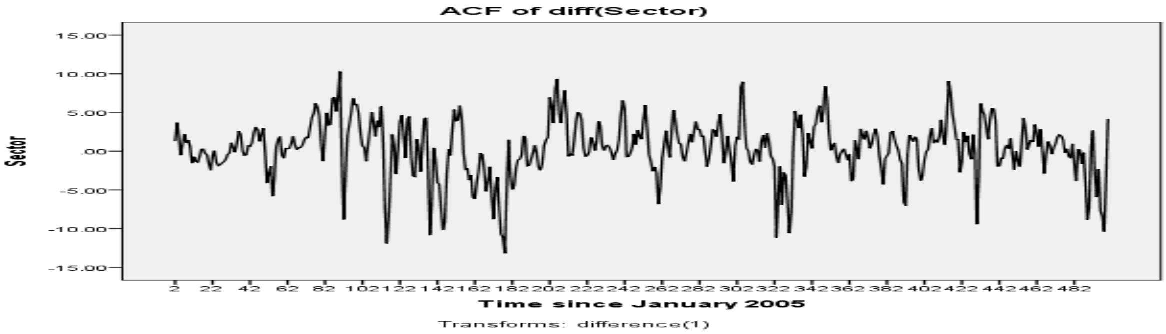
lag	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
ACF	0.446	0.040	0.064	0.034	0.456	0.963	0.404	0.023	0.054	0.033
PACF	0.446	0.199	0.170	-0.090	0.658	0.912	-0.436	-0.139	0.086	0.143
lag	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
ACF	0.452	0.923	0.363	0.009	0.046	0.032	0.447	0.881	0.321	-0.005
PACF	-0.321	0.115	0.084	0.001	-0.155	0.139	-0.027	-0.078	-0.042	0.138
lag	**21**	**22**	**23**	**24**	**25**	**26**	**28**	**29**	**30**	**31**
ACF	0.038	0.030	0.440	0.838	0.279	-0.020	0.026	0.430	0.793	0.237
PACF	-0.082	-0.052	0.030	0.046	-0.111	0.014	-0.026	-0.071	0.033	0.011

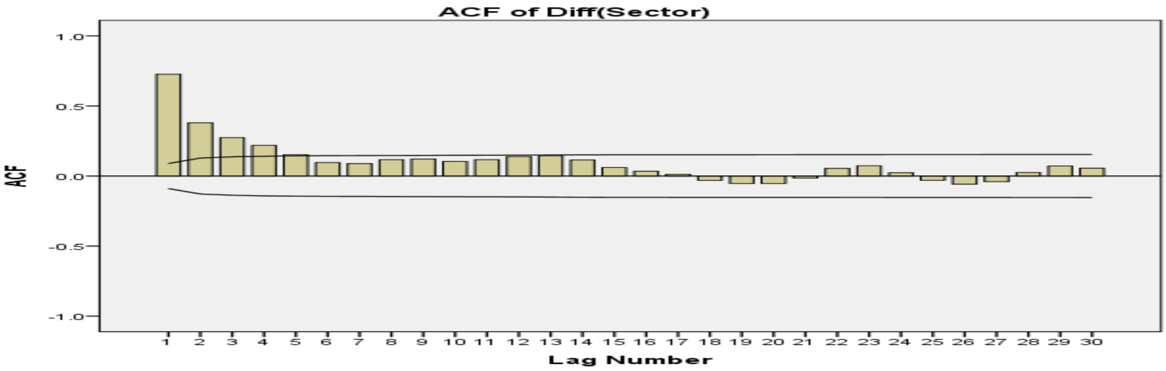
APPENDIX/LAMPIRAN B

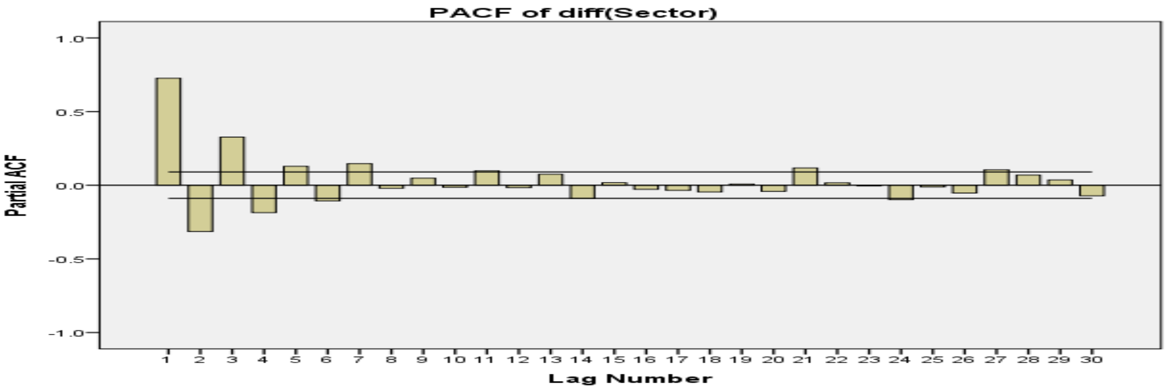
Step 1a



Step 1b







Step 2a

Dependent Variable: DSECTOR

Variable	Coefficient	Std. Error	t-Statistic	Prob.
AR(1)	0.430395	0.044767	9.614155	0.0000
MA(1)	0.808505	0.031137	25.96569	0.0000

Adjusted R-squared	0.649242	S.D. dependent var	3.584174
S.E. of regression	2.122720	Akaike info criterion	4.347282
Log likelihood	-1080.473	Schwarz criterion	4.364192

Inverted AR Roots	.43
Inverted MA Roots	-.81

Serial Correlation LM Test at Lag 3 on ARMA(1,1)

F-statistic	3.004153	Prob. F(3,493)	0.0301
Obs*R-squared	7.599161	Prob. Chi-Square(3)	0.0551

ARCH-LM Test at Lag 3 on ARMA(1,1)

F-statistic	16.94514	Prob. F(3,491)	0.0000
Obs*R-squared	46.44128	Prob. Chi-Square(3)	0.0000

Step 2b

Variable	Coefficient	Std. Error	z-Statistic	Prob.
AR(1)	0.435378	0.042336	10.28391	0.0000
MA(1)	0.869633	0.027846	31.22979	0.0000
		Variance Equation		
C	0.622394	0.187055	3.327332	0.0009
RESID(-1)^2	0.218669	0.052195	4.189426	0.0000
GARCH(-1)	0.657540	0.077328	8.503239	0.0000
Adjusted R-squared	0.646460	S.D. dependent var		3.584174
S.E. of regression	2.131122	Akaike info criterion		4.216295
Log likelihood	-1044.857	Schwarz criterion		4.258570
Inverted AR Roots	.44			
Inverted MA Roots	-.87			

ACF & PACF of Residuals from fitted ARMA(1,1)-G(1,1)

	AC	PAC	Q-Stat	Prob
1	-0.043	-0.043	0.9058	
2	0.057	0.055	2.5309	
3	0.068	0.073	4.8603	0.027
4	0.083	0.086	8.3170	0.016
5	0.020	0.020	8.5116	0.037
6	0.005	-0.008	8.5232	0.074
9	0.087	0.088	12.645	0.081
12	0.019	0.012	15.248	0.123
18	-0.090	-0.098	26.774	0.044
24	-0.023	-0.004	32.354	0.072

ARCH-LM Lag 3 on ARMA(1,1)+G(1,1)

F-statistic	0.111190	Prob. F(3,491)	0.9536
Obs*R-squared	0.336058	Prob. Chi-Square(3)	0.9531

Step 3a

Variable	Coefficient	Std. Error	z-Statistic	Prob.
AR(1)	0.303891	0.052851	5.749903	0.0000
AR(2)	0.167197	0.054622	3.061001	0.0022
MA(1)	0.940316	0.016795	55.98872	0.0000
		Variance Equation		
C	0.570413	0.196090	2.908934	0.0036
RESID(-1)^2	0.219736	0.054810	4.009020	0.0001
GARCH(-1)	0.667921	0.083645	7.985161	0.0000

Adjusted R-squared	0.651626	S.D. dependent var	3.584639
S.E. of regression	2.115770	Akaike info criterion	4.203448
Log likelihood	-1038.557	Schwarz criterion	4.254256

ACF & PACF of Residuals from fitted ARMA(2,1)-G(1,1)

	AC	PAC	Q-Stat	Prob
1	0.004	0.004	0.0091	
2	0.001	0.001	0.0093	
3	0.010	0.010	0.0610	
4	0.103	0.103	5.3894	0.020
5	-0.015	-0.016	5.5058	0.064
6	0.014	0.014	5.6042	0.133
9	0.059	0.063	8.8319	0.183
12	0.042	0.032	10.480	0.313
18	-0.076	-0.089	19.554	0.190
24	-0.021	-0.002	25.484	0.227

Step 3b

Variable	Coefficient	Std. Error	z-Statistic	Prob.
AR(1)	0.695705	0.082961	8.385966	0.0000
MA(1)	0.551919	0.117895	4.681430	0.0000
MA(2)	-0.347992	0.115815	-3.004729	0.0027
		Variance Equation		
C	0.601930	0.192255	3.130890	0.0017
RESID(-1)^2	0.228445	0.056404	4.050178	0.0001
GARCH(-1)	0.653173	0.082408	7.926133	0.0000

Adjusted R-squared	0.651927	S.D. dependent var	3.584174
S.E. of regression	2.114581	Akaike info criterion	4.204425
Log likelihood	-1040.902	Schwarz criterion	4.255155

ACF & PACF of Residuals from fitted ARMA(1,2)-G(1,1)

	AC	PAC	Q-Stat	Prob
1	0.001	0.001	0.0004	
2	0.027	0.027	0.3782	
3	-0.011	-0.011	0.4365	
4	0.078	0.077	3.4645	0.063
5	-0.029	-0.028	3.8784	0.144
6	-0.001	-0.005	3.8788	0.275
9	0.060	0.066	6.6393	0.355
12	0.036	0.032	8.5228	0.482
18	-0.087	-0.093	18.812	0.222
24	-0.022	-0.011	25.466	0.228

Step 4a

Variable	Coefficient	Std. Error	z-Statistic	Prob.
AR(1)	-0.394804	0.043845	-9.004462	0.0000
AR(2)	0.400207	0.045366	8.821686	0.0000
MA(1)	1.681070	0.002374	708.2114	0.0000
MA(2)	0.690069	0.003046	226.5230	0.0000
		Variance Equation		
C	0.651815	0.202318	3.221743	0.0013
RESID(-1)^2	0.226915	0.059227	3.831245	0.0001
GARCH(-1)	0.643987	0.083733	7.690936	0.0000
Adjusted R-squared	0.653049	S.D. dependent var		3.584639
S.E. of regression	2.111444	Akaike info criterion		4.203823
Log likelihood	-1037.650	Schwarz criterion		4.263099
Inverted AR Roots	.47	-.86		
Inverted MA Roots	-.71	-.97		

ACF & PACF of Residuals from fitted ARMA(1,2)-G(1,1)

	AC	PAC	Q-Stat	Prob
1	-0.021	-0.021	0.2171	
2	0.014	0.013	0.3099	
3	0.083	0.084	3.7603	
4	0.075	0.079	6.6263	
5	0.021	0.023	6.8423	0.009
6	0.006	-0.002	6.8602	0.032
9	0.070	0.070	10.325	0.067
12	0.043	0.029	12.134	0.145
18	-0.071	-0.080	21.553	0.088
24	-0.011	0.010	25.694	0.176

Step 4b

Variable	Coefficient	Std. Error	z-Statistic	Prob.
AR(1)	0.681448	0.121679	5.600387	0.0000
MA(1)	0.563790	0.142508	3.956197	0.0001
MA(2)	-0.325814	0.186186	-1.749936	0.0801
MA(3)	0.013212	0.072514	0.182192	0.8554
		Variance Equation		
C	0.606788	0.198442	3.057757	0.0022
RESID(-1)^2	0.229361	0.056938	4.028234	0.0001
GARCH(-1)	0.651056	0.084611	7.694736	0.0000
Adjusted R-squared	0.651205	S.D. dependent var		3.584174
S.E. of regression	2.116772	Akaike info criterion		4.208370
Log likelihood	-1040.884	Schwarz criterion		4.267555

ACF & PACF of Residuals from fitted ARMA(1,3)-G(1,1)

	AC	PAC	Q-Stat	Prob
1	0.003	0.003	0.0033	
2	0.022	0.022	0.2523	
3	-0.011	-0.011	0.3171	
4	0.081	0.081	3.6365	
5	-0.027	-0.027	3.9960	0.046
6	0.002	-0.002	3.9973	0.136
9	0.059	0.065	6.8133	0.235
12	0.037	0.033	8.6394	0.374
18	-0.085	-0.093	18.730	0.176
24	-0.022	-0.010	25.365	0.188

Step 5

Variable	Coefficient	Std. Error	z-Statistic	Prob.
AR(1)	0.679565	0.089015	7.634271	0.0000
MA(1)	0.572683	0.122449	4.676913	0.0000
MA(2)	-0.328066	0.119945	-2.735152	0.0062
		Variance Equation		
C(4)	-0.060271	0.062732	-0.960781	0.3367
C(5)	0.412095	0.077636	5.308029	0.0000
C(6)	-0.099396	0.037313	-2.663811	0.0077
C(7)	0.816657	0.058024	14.07451	0.0000
Adjusted R-squared	0.651664	S.D. dependent var		3.584174
S.E. of regression	2.115380	Akaike info criterion		4.189075
Log likelihood	-1036.080	Schwarz criterion		4.248260

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