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EXAM COVER SHEET

NOTE: DO NOT REMOVE this exam paper from the exam venue

EXAM DETAILS

Course Code: **MATH1318**

Course Description: **Time Series Analysis**

Date of exam: 12/06/2019 **Start time of exam:** 09:15 **Duration of exam:** 2hr 15min

Total number of pages (incl. this cover sheet) 15

ALLOWABLE MATERIALS AND INSTRUCTIONS TO CANDIDATES

1. Write your full name and student number on each exam booklet together with the number of exam books used.
2. You must not write, mark in any way any exam materials, read any other text other than the exam paper or do any calculations during reading time.
3. All mobile phones must be switched off and placed under your desk. You are in breach of exam conditions if it is on your person (ie. pocket).
4. You can be reported for misconduct if you breach exam regulations.
5. This is a **LIMITED TEXT** Exam.

   Students are permitted to bring along one double sided hand written or typed A4 size cheat sheet.
6. Non text storing calculators are allowed.
7. This exam constitutes 40% of the total assessment in this course.
8. Students should answer questions 1 to 40 using the answer sheet.

Created on: 13 May 2019 -- 2-42-55:601 -- 122

This exam is composed of 40 multiple choice questions. Please choose the correct answer for each question by selecting one of* (A), (B), (C), or (D) on THE MCQ ANSWER SHEET*. Answers other than these will be counted incorrect. Each question is 2.5 marks (2.5 x 40 = 100 marks).

1. Which of the following is an example of a time series problem?

1. Forecasting the interest rate for the next 6 weeks.
2. Estimating autocorrelation structure of a sales series of a company.
3. Forecasting the closing stock prices for the next week.

a) 1 and 2
b) 2 and 3
c) 1 and 3
d) 1, 2 and 3

2. When choosing a model, it is desirable to adhere the principle of parsimony; that is,

a) the model with the smallest number of parameters that will adequately represent the time series.
b) the model with the smallest number of observations that will adequately represent the time series.
c) the model with the smallest AIC that will adequately represent the time series.
d) the model with the largest adjusted R-square that will adequately represent the time series.

3. For the random walk series, which one of the following is not true?

a) Variance of the series is decreasing with time.
b) The neighbouring time points are less correlated than those distant from each other.
c) Mean of the series is decreasing with time.
d) All of the above.

4. Which statement is correct about the moving average model?

a) Variance of the series is increasing with time.
b) Moving average models are always considered to be non-stationary.
c) Mean of the series is always non-zero.
d) Values of the series precisely one-time unit apart have exactly the same correlation no matter where they occur in time.

5. Which one of the following is a component that we can observe over a time series plot?

a) Trend
b) Seasonality
c) Changing variance
d) All of the above.

6. Which of the following are used to check the normality of residuals?

1. Normal QQ plot of the residuals.
2. Histogram of observed series.
3. Time series plot of residuals.

a) 1 and 2
b) 1,2 and 3
c) Only 1
d) All of the above.

7. For a constant mean model, the estimator of population mean (μ) is

a) the population mode.
b) the sample mean.
c) the variance of the sample mean.
d) the population mean divided by the square root of the sample size.

8. The ACF plot of standardised residuals of a fitted model is given in Figure 1.

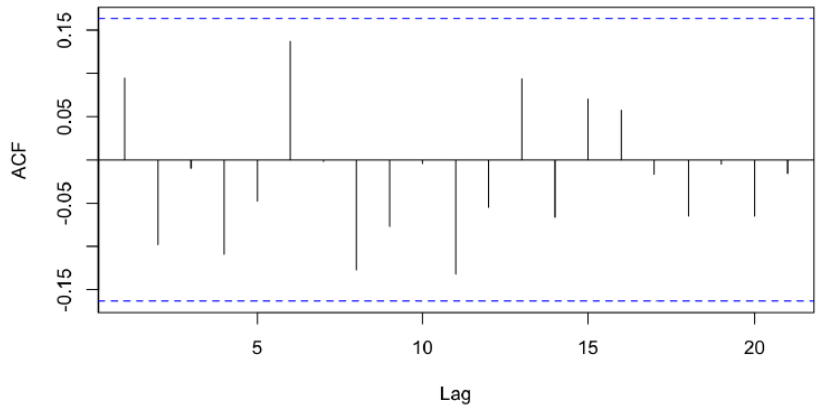


Figure 1: ACF of standardized residuals.

Based on Figure 1, which of the following interpretations is(are) correct?

1. There seems to be more variation in the last third of the series than in the first two-thirds.
2. The standardised residual series is a white noise.
3. There are no significant correlations left in the standardised residuals.

a) 1 and 2
b) 2 and 3
c) Only 3
d) All of the above.

9. Please select the correct interpretation based on the following R output:

```
Call:
lm(formula = rwalk ~ time(rwalk))

Residuals:
     Min       1Q   Median       3Q      Max
-2.70045 -0.79782  0.06391  0.63064  2.22128

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) -1.007888   0.297245  -3.391  0.00126 **
time(rwalk)  0.134087   0.008475  15.822  < 2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1.137 on 58 degrees of freedom
Multiple R-squared:  0.8119, Adjusted R-squared:  0.8086
F-statistic: 250.3 on 1 and 58 DF,  p-value: < 2.2e-16
```

a) The slope is statistically insignificant at a 5% significance level.
b) 80.86% of the variation in the series is explained by the linear time trend model.
c) 0.1341 is point where the fitted line cuts the y-axis.
d) Quadratic time trend is statistically significant at a 5% significance level.

10. Which of the following statement(s) is(are) true about an autoregressive process?

1. This process has no autocorrelation between the successive values.
2. PACF of AR(1) process has a positive or negative spike at lag 1 depending on the sign of coefficient then cuts off.
3. ACF of AR(2) process cuts off after the second seasonal lag.

a) 1 and 2
b) 1,2 and 3
c) Only 2
d) 2 and 3

11. An ARMA(p, 0) model will have

a) an ACF and PACF that both decline geometrically.
b) an ACF that has a pattern and a PACF that is zero after lag p.
c) an ACF that declines geometrically and a PACF that is zero after lag q.
d) an ACF that is zero after lag p and a PACF that is zero after lag q.

12. The ACF and PACF plots of a stationary series are given in Figure 2.1 and 2.2, respectively.

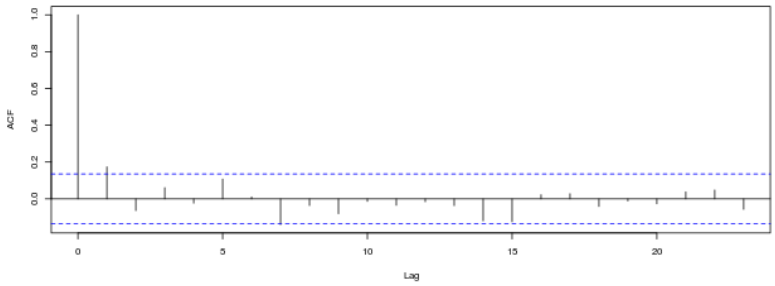


Figure 2.1: ACF plot.

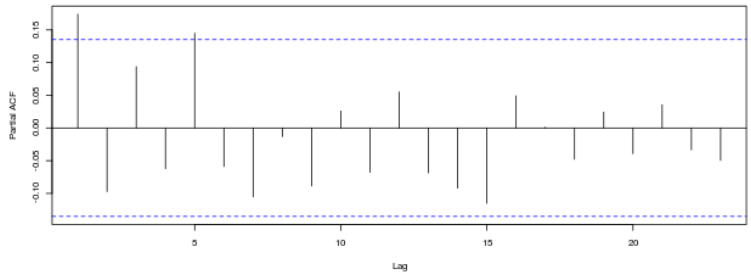


Figure 2.2: PACF plot.

Based on Figure 2.1 and 2.2, please select the set with most possible models.

a) {ARMA(1,1), ARMA(1,2)}
b) {ARMA(1,0), ARMA(0,1)}
c) {ARMA(1,5), ARMA(1,1)}
d) {ARMA(5,1), ARMA(0,1)}

13. If the mean of time series is not constant over time, then it is a

a) non-stationary process.
b) stationary process.
c) stationary and unit root process.
d) ARMA process.

14. In IMA(d , q) process, 'd' represents the

a) order of differencing that makes the series stationary.
b) order of the moving average component of the series.
c) order of the autoregressive component of the series.
d) lambda value from the Box-Cox transformation.

15. Figure 3.1 shows the time series plot of an electricity series and Figure 3.2 represents the log transformation of the series.

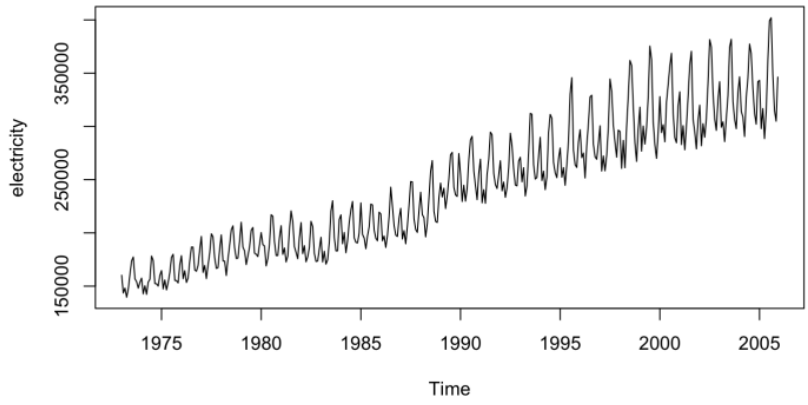


Figure 3.1: Time series plot of raw electricity series.

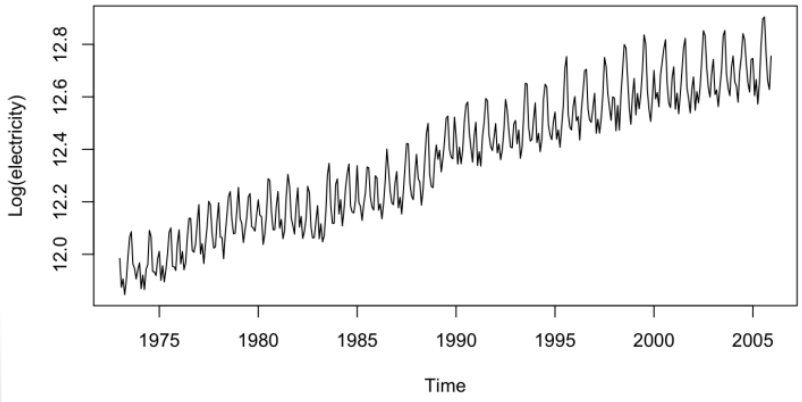


Figure 3.2: Time series plot of log transformed series.

Based on only Figure 3.1 and Figure 3.2, please select the correct interpretation below:

a) Log transformation has made the series stationary.
b) Log transformation has produced a series with approximately constant variance over time.
c) Log transformation has not changed the series significantly.
d) Log transformation has made the series normally distributed.

16. Which of the following statements is(are) true concerning the class of ARIMA(p,d,q) models?

1. It is plausible for a financial time series that the optimal value of "d" could be more than 100.
2. An ARIMA(p,1,q) model estimated on a series of logs of prices is equivalent to an ARIMA(p,0,q) model estimated on the raw price series.
3. ARIMA stands for autoregressive integrated moving average.

a) Only 3
b) Only 2
c) 2 and 3
d) 1, 2 and 3

17. Looking at the Box-Cox plot given in Figure 4, please select the most suitable transformation.

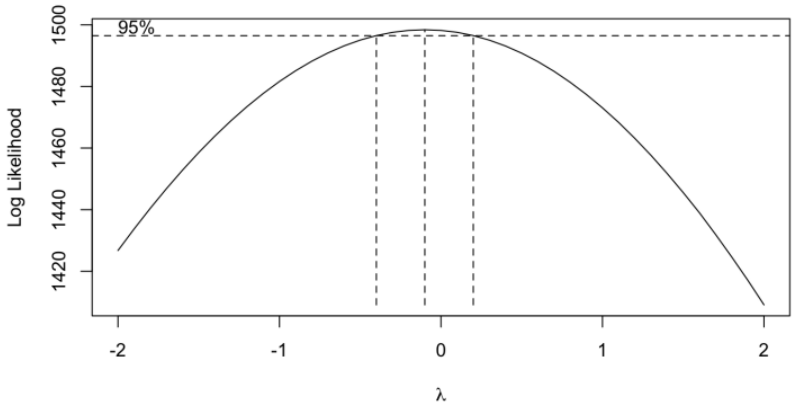


Figure 4: Box-Cox plot.

a) Log transformation.
b) Reciprocal transformation.
c) No transformation needed.
d) Reciprocal square root transformation.

18. Select the correct statement about the sample PACF.

a) In the sample PACF of a white noise series, all partial autocorrelations should be significant at all lags.
b) The sample PACF of an AR(1) series will show significant positive or negative spike at lag 0.
c) In the sample PACF of an AR(2) series, the partial autocorrelations will be significant only at lag 2.
d) In the sample PACF of an AR(p) series, the estimates of partial autocorrelations at the lags 1, 2, …, p will be significant and then they will vanish after lag p.

19. The ACF and PACF plots of a stationary series are given in Figure 5.1 and 5.2, respectively.

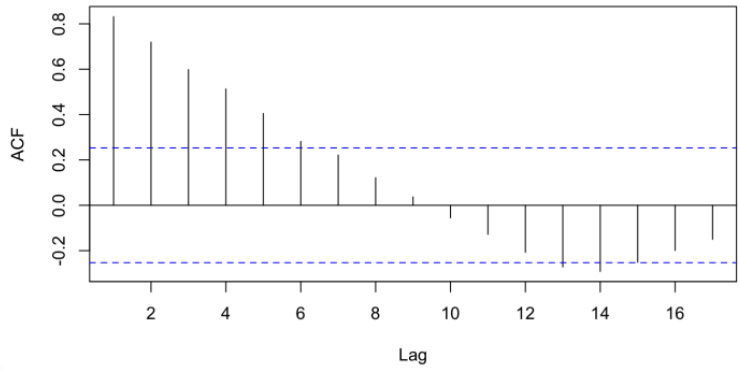


Figure 5.1: ACF plot.

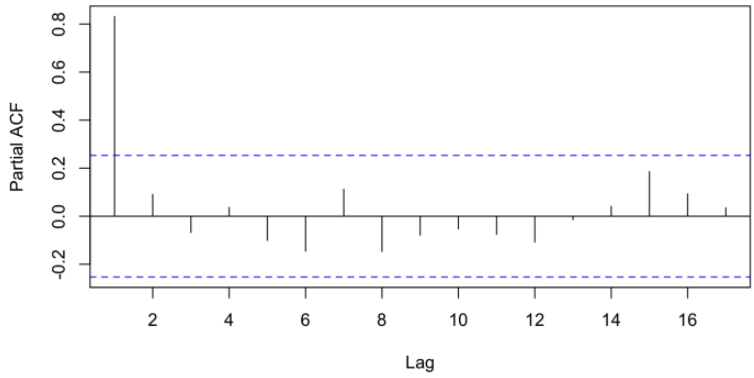


Figure 5.2: PACF plot.

Based on Figure 5.1 and 5.2, please select the most suitable model.

a) ARMA(0,1)
b) ARMA(1,0)
c) ARMA(6,1)
d) ARMA(1,6)

20. What does autocorrelation measure?

a) Linear dependence between multiple points on the different series observed at different times.
b) Quadratic dependence between two points on the same series observed at different times.
c) Linear dependence between two points on different series observed at the same time.
d) Linear dependence between two points on the same series observed at different times.

21. Please select the correct statement about the stochastic trend.

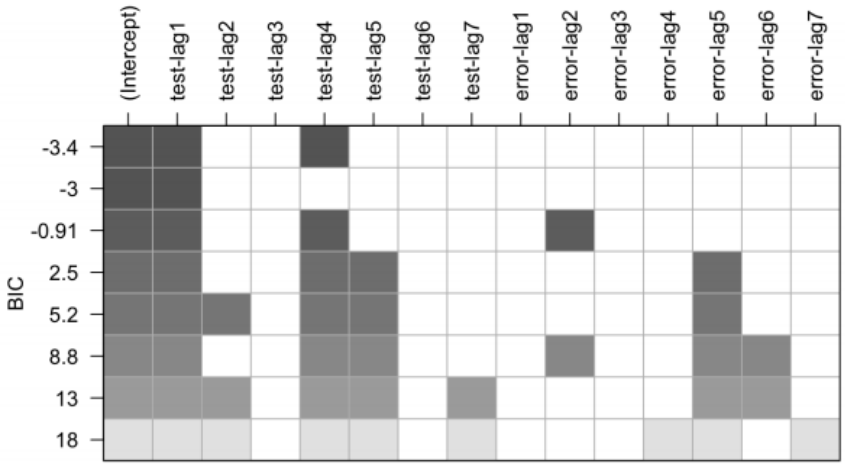
a) Time series with a stochastic trend is deterministic.
b) Stochastic trend can be fitted with a trend model and the residuals will be stationary.
c) Time series with a stochastic trend always revert to the trend in the long run.
d) Time series with a stochastic trend never recover from shocks to the system.

22. Based on the EACF of the first difference of a series given below, please select the set with most possible models.

```
## AR/MA
##   0 1 2 3 4 5 6 7 8 9 10 11 12 13
## 0 x x x x o o o o o o o  o  o  o
## 1 x o o o o o o o o o o  o  o  o
## 2 x o o o o o o o o o o  o  o  o
## 3 x x o o o o o o o o o  o  o  o
## 4 x o x o o o o o o o o  o  o  o
## 5 x o o o o o o o o o o  o  o  o
## 6 x o o o x o o o o o o  o  o  o
## 7 x o o o x o o o o o o  o  o  o
```

a) {ARIMA(0,1,4), ARIMA (0,1,5) , ARIMA (1,1,4) , ARIMA (4,1,1)}
b) {ARIMA (1,1,1), ARIMA (1,1,2) , ARIMA (2,1,1) , ARIMA (2,1,2)}
c) {ARIMA (4,1,1), ARIMA (5,1,1) , ARIMA (5,1,2)}
d) {ARMA (1,1), ARMA (1,2), ARMA (2,1), ARMA (2,2)}

23. Based on the BIC table given below, please select the set of most possible models.



a) {ARMA(0,1), ARMA(0,4)}
b) {ARMA(1,0), ARMA(4,0)}
c) {ARMA(1,4), ARMA(2,0)}
d) {ARMA(0,2), ARMA(0,7)}

24. To check on the independence of the noise terms in the model, we consider the

a) time series plot of the raw series.
b) histogram of the raw series.
c) sample autocorrelation function of the residuals.
d) histogram of residuals.

25. Please select the best model(s) using the AIC and BIC values given in Table 1.

Table 1: AIC and BIC values for candidate models.

Model	ARIMA(0,2,1)	ARIMA(1,2,1)	ARIMA(2,2,1)	ARIMA(3,2,1)	ARIMA(4,2,1)	ARIMA(5,2,1)
AIC	611.0137	612.5445	614.1957	615.9907	612.8191	614.7374
BIC	613.6781	616.5411	619.5245	622.6517	620.8123	624.0628

a) From AIC ARIMA(3,2,1) and from BIC ARIMA(5,2,1).
b) From both AIC and BIC ARIMA(0,2,1).
c) From both AIC and BIC ARIMA(5,2,1).
d) From AIC ARIMA(5,2,1) and from BIC ARIMA(0,2,1).

26. ACF plot of residuals and p-values for Ljung-Box statistics are plotted in Figure 6.1 and 6.2 for a fitted model.

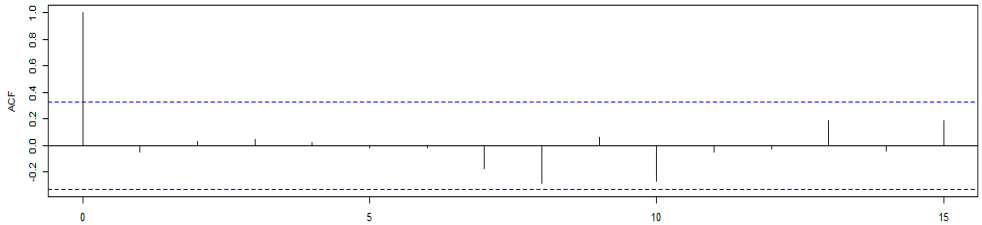


Figure 6.1: ACF plot of residual.

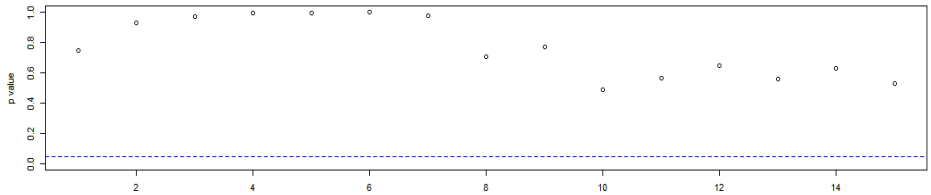


Figure 6.2: p-value for Ljung-Box statistic.

From Figure 6.1 and 6.2, some interpretations are given below:

1. According to both figures, the estimated model seems to be capturing the correlation structure quite well.
2. All the standardised residuals are between -2 and 2.
3. According to Figure 6.1 there is still significant autocorrelations left in residuals.
4. According to Figure 6.2 Ljung-Box suggests that the error terms are correlated.

Based on Figure 6.1 and Figure 6.2, please select the correct interpretations.

a) 1, 3 and 4
b) 2 and 3
c) Only 1
d) 2, 3 and 4

27. If a model is adequate for forecasting, we expect the time series plot of the residuals over time to suggest

a) a triangle scatter around a zero-horizontal level with no trends.
b) a scatter around a zero-horizontal level with increasing or decreasing trend depending on data.
c) a rectangular scatter around a nonzero-horizontal level with no trends.
d) a rectangular scatter around a zero-horizontal level with no trends.

28. A data scientist believes that MA(1) to be an adequate model for her time series data. She uses over parameterisation (overfitting) as another tool to detect anomalies in terms of goodness of fit. Following is the output of her overfitted model.

```
z test of coefficients:

       Estimate  Std. Error    z value  Pr(>|z|)
ar1 -0.24808059  0.00058834 -421.6624 < 2.2e-16 ***
ma1 -0.94516235  0.25010270   -3.7791 0.0001574 ***
ma2 -0.24912523  0.28926628   -0.8612 0.3891106
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Please select the correct statement below:

a) Overfitting should not be used as another tool to detect anomalies in terms of goodness of fit.
b) The data scientist should include ARMA(1,1) into her set of possible models.
c) The data scientist should not increase the orders of both the AR and MA parts of the model simultaneously.
d) The data scientist should include both ARMA(1,1) and ARMA(1,2) into her set of possible models.

29. Suppose you have given an observed time series that has a clear non-constant variance and a sharp upward linear trend over time. What should you do?

a) Display the ACF, PACF, and EACF of the observed time series to look for candidate models.
b) Split the series up into halves and then fit a linear regression model to each part.
c) Try differencing the series first, and then, try a transformation to stabilize the variance.
d) Try a variance-stabilizing transformation first, and then use differencing to remove the trend.

30. If after fitting an MA(1) model, a substantial correlation remains at lag 2 in the ACF of residuals,

a) try fitting an ARMA(1,1) model.
b) try fitting an MA(2) model.
c) try fitting an ARMA(2,1) model.
d) try fitting an AR(2) model.

31. Please select the incorrect statement regarding a time series with only the seasonality component.

a) When there is seasonality, it is hard to explain the behaviour of the series from the time series plot.
b) The autocorrelation function will be nonzero only at the seasonal lags.
c) Seasonal SMA(Q) model can also be viewed as a special case of a non-seasonal MA model of order $q = Qs$, where s denote the known seasonal period.
d) The series is non-stationary.

32. Figure 7 displays the ACF and PACF of residuals of SARIMA$(0,1,0)(0,1,1)_6$ model.

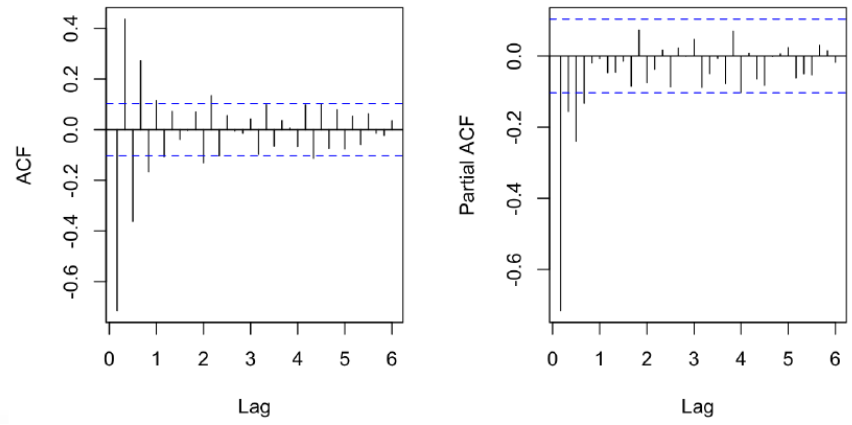


Figure 7: ACF and PACF plot of residuals.

Based on Figure 7, please select the final set of possible models for the original series.

a) {SARIMA$(4,1,0)(0,1,1)_6$, SARIMA$(3,1,1)(0,1,1)_6$, SARIMA$(2,1,9)(0,1,1)_6$}
b) {SARIMA$(4,1,0)(0,1,1)_6$, SARIMA$(3,1,0)(0,1,1)_6$, SARIMA$(2,1,0)(0,1,1)_6$}
c) {ARMA(4,0), ARMA(3,0), ARMA(1,0)}
d) {SARIMA$(0,1,4)(0,1,1)_6$, SARIMA$(0,1,3)(0,1,1)_6$, SARIMA$(0,1,2)(0,1,1)_6$}

33. Volatility in a time series refers to the phenomenon

a) where the conditional variance of the time series varies over time.
b) where the conditional variance of the time series always increases over time.
c) where the conditional variance of the time series always decreases over time.
d) where the conditional variance of the time series is constant over time.

34. GARCH orders can be identified based on the

a) time series of Y_t.
b) squared residuals from the fitted ARMA model.
c) standardised residuals from the fitted ARMA model.
d) studentised residuals from the fitted ARMA model.

35. Figure 8 displays the ACF and PACF of residuals of SARIMA(0,0,0)(1,1,1)$_{12}$ model.

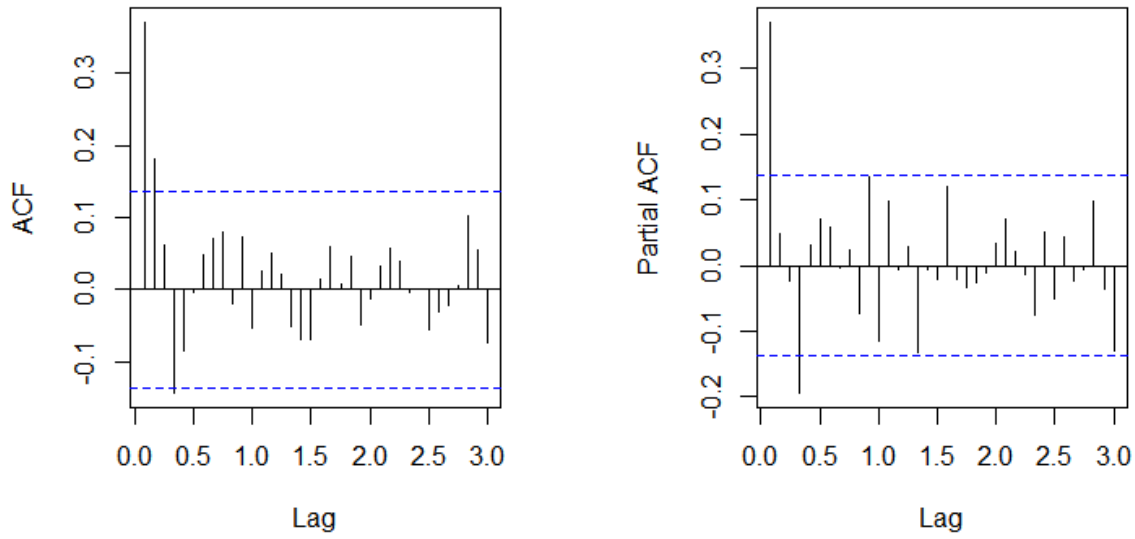


Figure 8: ACF and PACF plot of residuals.

Based on Figure 8, please select the final set of most possible models for the original series.

a) {SARIMA(2,1,1)(1,1,1)$_{12}$, SARIMA(2,1,3)(2,1,1)$_{12}$, SARIMA(1,1,2)(2,1,1)$_{12}$}
b) {SARIMA(2,0,1)(1,1,1)$_{12}$, SARIMA(2,0,2)(1,1,1)$_{12}$, SARIMA(2,0,3)(1,1,1)$_{12}$}
c) {SARIMA(2,1,1)(1,1,1)$_{12}$, SARIMA(2,1,3)(1,1,1)$_{12}$, SARIMA(2,1,3)(1,1,1)$_{12}$}
d) {SARIMA(2,0,2)(1,0,1)$_{12}$, SARIMA(1,0,3)(1,0,1)$_{12}$, SARIMA(2,0,1)(1,0,1)$_{12}$}

36. Following is the EACF of an absolute return series.

AR/MA

	0	1	2	3	4	5	6	7	8	9	10	11	12	13
0	x	x	x	o	o	o	x	o	o	x	o	o	x	x
1	x	o	o	o	o	o	o	o	o	o	o	o	o	x
2	x	x	o	o	o	o	o	o	o	o	o	o	o	x
3	x	x	x	o	o	o	o	o	o	o	o	o	o	x
4	x	o	x	o	o	o	o	o	o	o	o	o	o	o
5	x	o	x	o	x	o	o	o	o	o	o	o	o	o
6	o	x	x	x	x	x	o	o	o	o	o	o	o	o
7	x	o	x	x	x	o	x	o	o	o	o	o	o	o

Based on the given EACF, please find a set of most possible GARCH(p, q) models.

a) {GARCH(1,0), GARCH(1,2), GARCH(2,2)}
b) {GARCH(0,3), GARCH(1,3), GARCH(3,3)}
c) {GARCH(3,0), GARCH(3,1), GARCH(3,3)}
d) {GARCH(1,1), GARCH(2,1), GARCH(2,2)}

37. Figure 9 displays the p values of McLeod-Li test for a time series data.

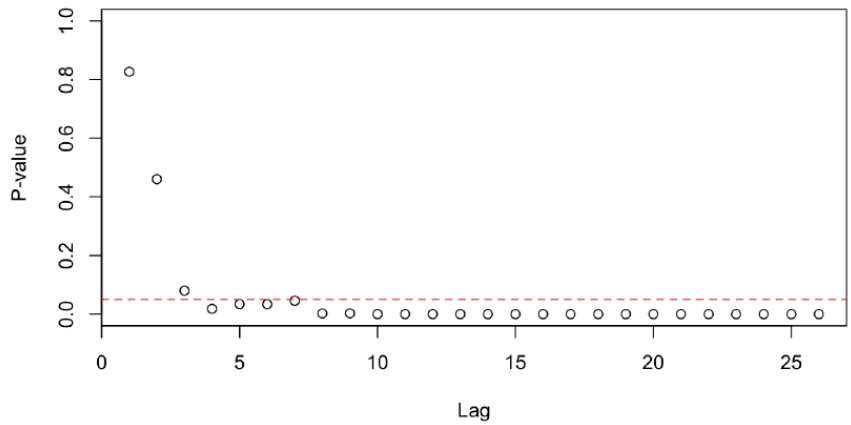


Figure 9: McLeod-Li test statistics

Based on Figure 9, please select the correct statement:

a) The McLeod-Li tests are all significant at the 5% significance level at all lags.
b) There is a strong evidence for ARCH effect in this data.
c) The McLeod-Li tests are all significant at the 5% significance level when the first 3 lags are included in the test.
d) The McLeod-Li tests are all significant at the 5% significance level when the first 3 lags are excluded from the test.

38. Which of the following statements are true concerning the standardised residuals (residuals divided by their respective conditional standard deviations) from an estimated GARCH model?

1. They are assumed to be normally distributed.
2. Their squares will be related to their lagged squared values if the GARCH model is appropriate.
3. In practice, they are likely to have fat tails.
4. If the GARCH model is adequate, the standardised residuals and the raw residuals will be identical.

a) 1 and 3.
b) 2 and 4.
c) 1, 2 and 3.
d) 1, 2, 3 and 4.

39. Which of the following features of financial asset return time series could be captured using a standard GARCH(1, 1) model?

1. Fat tails in the return distribution
2. Leverage effects
3. Volatility clustering
4. Volatility affecting returns

a) 1 and 3.
b) 2 and 4.
c) 1, 2 and 3.
d) 1, 2, 3 and 4.

40. If a series has deterministic seasonality effect, then it can be modelled using

a) GARCH model.
b) Seasonal trend model.
c) ARMA model.
d) ARCH model.