Forecasting Time Series – Homework 1

Group D

January 20, 2020

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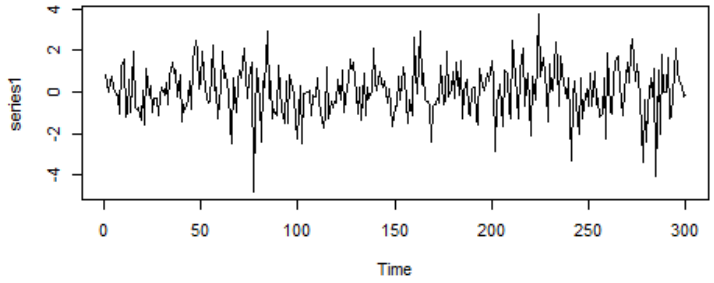
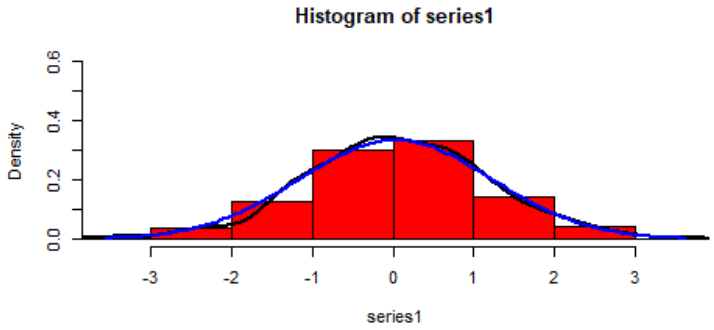
Executive Summary

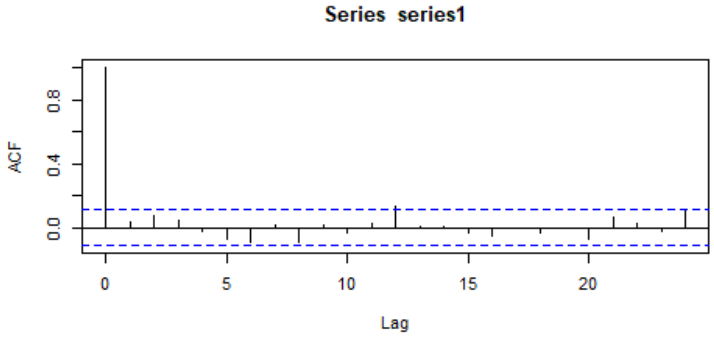
	Series 1	Series 2	Series 2b	Series 3	Series 3b	Series 4	Series 4b	Series 5	Series 6	Series 7	Series 7b
Stationarity	Yes	No	Yes	No	Yes	No	Yes	yes	Yes	No	Yes
Normal Distribution	No	No	Yes	No	Yes	No	No	no	No	No	No
White Noise	Yes	No	Yes	No	No	No	No	yes	No	No	No
Strict White Noise	?	No	Yes	No	No	No	No	no	No	No	No
Gaussian White Noise	No	No	Yes	No	No	No	No	no	No	No	No
Linear Model?	No	Yes	No	yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Non-Linear Model?	No	?	No	?	?	?	?	?	?	?	?
Transformations	0	1	0	1	0	2	0	0	0	1	0

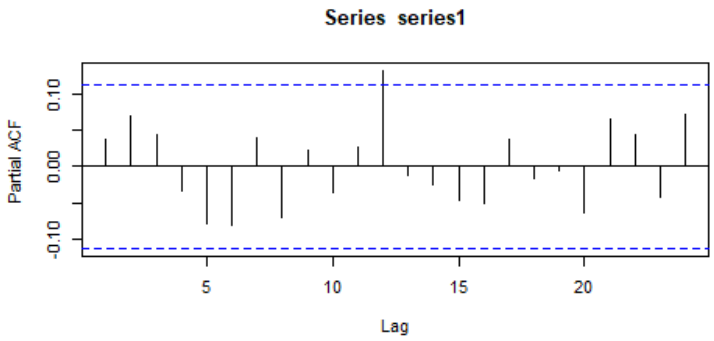
1. Series 1

1.1 Correlogram, Histogram, ACF and PACF Plot









1.2 Analysis

Using the information in the previous plots, discuss whether:

- **Stationarity** – It appears that Series 1 is indeed stationary in both the mean and the variance. Stationarity in the mean is confirmed by the results of the Dickey Fuller test below.

```
ndiffs(series1, alpha=0.05, test=c("adf"))

## [1] 0
```

- **Marginal Normal Distribution** – Though it appears from the histogram in section 1.1 that Series 1 is normally distributed, a formal Shapiro Test, which is conducted below, results in a p-value of 0.02, allowing us to reject the null hypothesis (at 95% confidence level) that the series is normally distributed. Thus, we can conclude that the series is **not normally distributed**.

```
# Ho: the data is normally distributed
# H1: the data is not normally distributed

shapiro.test(series1)

##
##  Shapiro-Wilk normality test
##
## data:  series1
## W = 0.98868, p-value = 0.01941
```

- **White Noise** – The box test, which is conducted below, formally checks Series 1 to determine if it's correlated. Correlated data would suggest that it is not white noise. In this case, the p-value of the test is 0.53. Therefore, we can accept the null hypothesis that the data is uncorrelated at a 95% confidence level. Before being able to conclude that the data is indeed white noise, we perform a t.test to check if the mean is different from 0. The test offers a p-value of 0.94, preventing us from rejecting the null hypothesis that the mean is 0. Thus, it can be **assumed to be white noise**.

```
# Ho: uncorrelated data
# H1: correlated data

Box.test (series1, lag = 20, type="Ljung")

##
##  Box-Ljung test
##
```

```
## data:  series1
## X-squared = 18.804, df = 20, p-value = 0.5346
```

```
t.test(series1, mu = 0)
```

```
##
##  One Sample t-test
##
## data:  series1
## t = 0.46504, df = 299, p-value = 0.6422
## alternative hypothesis: true mean is not equal to 0
## 95 percent confidence interval:
##  -0.1035777  0.1676777
## sample estimates:
## mean of x
##   0.03205
```

```
Box.test(series1^2,lag=20, type="Ljung")
```

```
##
##  Box-Ljung test
##
## data:  series1^2
## X-squared = 14.168, df = 20, p-value = 0.8219
```

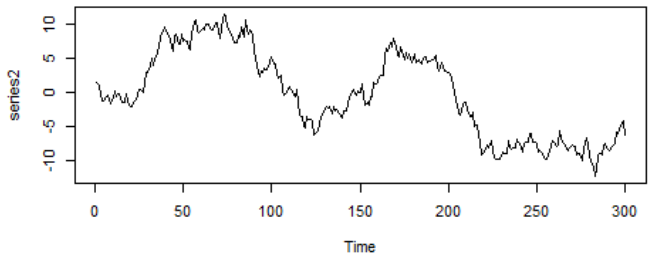
- **Strict White Noise** – Though we can't conclude that the data does not depict strict white noise, we conduct a box test using the square of the Series 1 to determine if the variance is correlated. The p-value of the test is 0.8, preventing us from rejecting the null hypothesis that the data is uncorrelated.
- **Gaussian White Noise** – Using the Shapiro Test results from above; we can conclude that the **data does not depict Gaussian white noise.**
- **Linear Model Representing Dynamic Dependence** – Given that the data depicts white noise, no linear model can represent the data.
- **Potential Non-linear Dependences** – The results of the box test conducted on the square of Series 1 indicated that the variance is uncorrelated. Thus, no non-linear dependences exist.

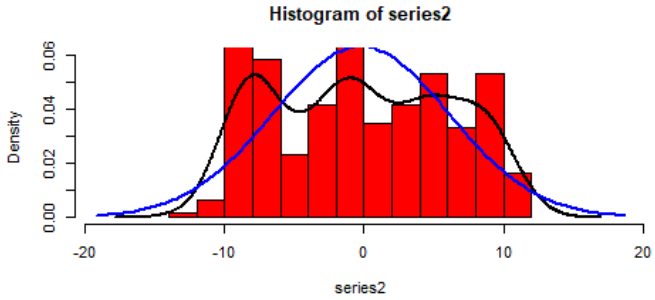
1.3 Results

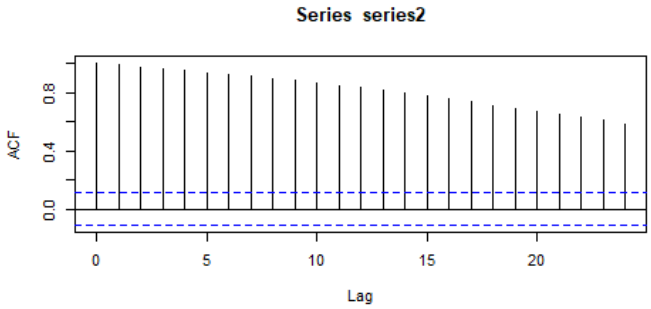
	Series 1
Stationarity	Yes
Normal Distribution	No
White Noise	Yes
Strict White Noise	?
Gaussian White Noise	No
Linear Model?	No
Non-Linear Model?	No
Transformations	0

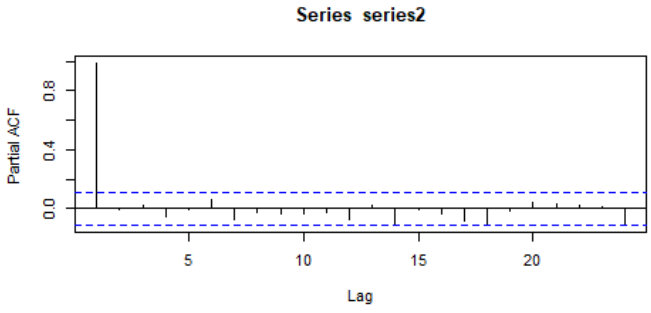
2. Series 2

2.1 Correlogram, Histogram, ACF and PACF Plot









2.2 Analysis

Using the information in the previous plots, discuss whether:

- **Stationarity** – It appears that Series 2 is not stationary in the mean. This is confirmed by the Dickey Fuller test, which indicates that one difference must be taken to make the data stationary in the mean.

```
ndiffs(series2, alpha=0.05, test=c("adf"))
```

```
## [1] 1
```

- **Marginal Normal Distribution** – The series is not normally distributed. This can be seen visually with the histogram in section 2.1. It is also shown using the formal Shapiro Test, which outputs a p-value of 1.133e-08, allowing us to reject the null hypothesis that the data is normally distributed.

```
# Ho: the data is normally distributed
# H1: the data is not normally distributed

shapiro.test(series2)
```

```
##
##  Shapiro-Wilk normality test
##
## data:  series2
## W = 0.94921, p-value = 1.133e-08
```

- **White Noise, Strict White Noise or Gaussian white noise** – The ACF and PACF plot depict that the data does not appear to be white noise. This is confirmed by the box test conducted below, which outputs a p-value of less than 2.2e-16, allowing us to reject the null hypothesis that the data is uncorrelated. Thus, we can conclude that **the data is not white noise, strict noise, nor Gaussian white noise**.

```
# Ho: uncorrelated data
# H1: correlated data

Box.test (series2, lag = 20, type="Ljung")
```

```
##
##  Box-Ljung test
##
## data:  series2
## X-squared = 4509.5, df = 20, p-value < 2.2e-16
```

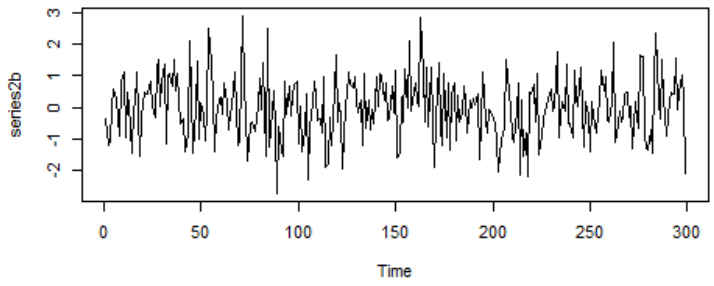
- **Linear Model Representing Dynamic Dependence** – The box test indicates that the data is correlated. Therefore, it can be represented using a linear model.
- **Potential Non-linear Dependences** – We are unable to determine if any non-linear dependences exist, as it would depend on the errors of the linear model.

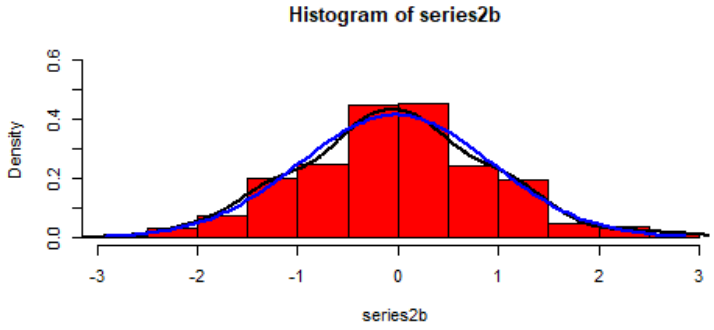
2.3 Results

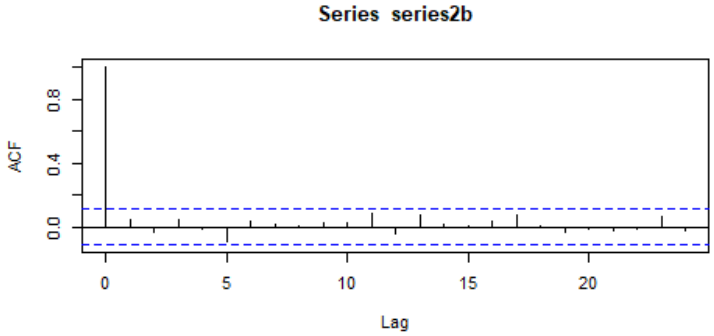
	Series 2
Stationarity	No
Normal Distribution	No
White Noise	No
Strict White Noise	No
Gaussian White Noise	No
Linear Model?	Yes
Non-Linear Model?	?
Transformations	1

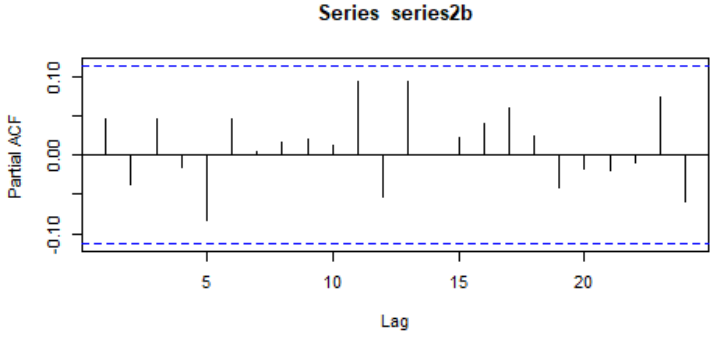
3. Series 2b

3.1 Correlogram, Histogram, ACF and PACF Plot









3.2 Analysis

Using the information in the previous plots, discuss whether:

- **Stationarity** – The newly transformed data, which took the difference of one value and the previous in Series 2, is stationary in both the mean and the variance. The Dickey Fuller test below confirms the stationarity in the mean.

```
ndiffs(series2b, alpha=0.05, test=c("adf"))
```

```
## [1] 0
```

- **Marginal Normal Distribution** – The histogram above and the Shapiro test below both suggest that the transformed series is normally distributed. The Shapiro test outputs a p-value of 0.69, preventing us from rejecting the null hypothesis that the data is normally distributed.

```
# Ho: the data is normally distributed
# H1: the data is not normally distributed

shapiro.test(series2b)
```

```
##
##  Shapiro-Wilk normality test
##
## data:  series2b
## W = 0.99619, p-value = 0.69
```

- **White Noise** – the transformed data appears to be uncorrelated with a mean of "0". This is confirmed by the box and t tests below. Thus, **we can conclude that the data is white noise**.
- **Strict White Noise, Gaussian White Noise** – The Shapiro Test above indicates that the data is normally distributed, therefore, **Gaussian white noise and strict white noise can be assumed.**

```
# Ho: uncorrelated data
# H1: correlated data
Box.test (series2b, lag = 20, type="Ljung")
```

```
##
##  Box-Ljung test
##
## data:  series2b
## X-squared = 12.452, df = 20, p-value = 0.8996
```

```r
t.test(series2b, mu = 0)
```

```
##
##  One Sample t-test
##
## data:  series2b
## t = -0.46706, df = 298, p-value = 0.6408
## alternative hypothesis: true mean is not equal to 0
## 95 percent confidence interval:
##  -0.13548212  0.08350888
## sample estimates:
##   mean of x
## -0.02598662
```

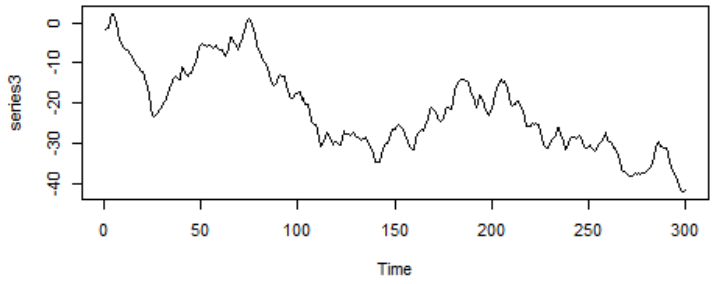
- **Linear Model Representing Dynamic Dependence** – Given that we have white noise, no linear model can be created to represent that data.
- **Potential Non-linear Dependences** – Given that we have strict white noise, no non-linear dependences can be assumed.

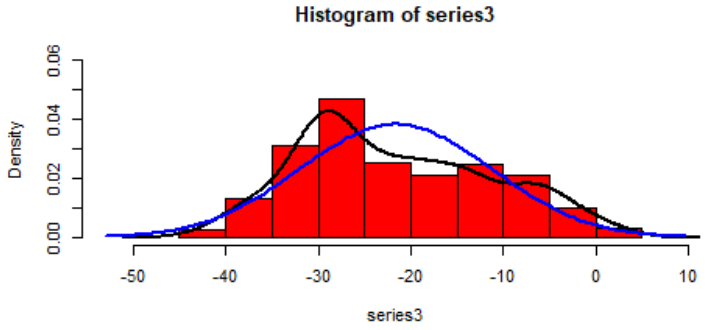
3.3 Results

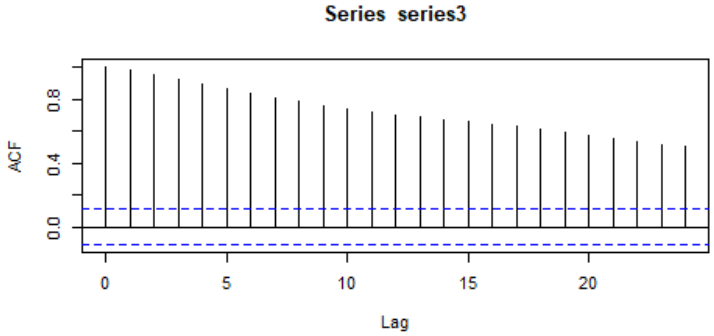
	Series 2b
Stationarity	Yes
Normal Distribution	Yes
White Noise	Yes
Strict White Noise	Yes
Gaussian White Noise	Yes
Linear Model?	No
Non-Linear Model?	No
Transformations	0

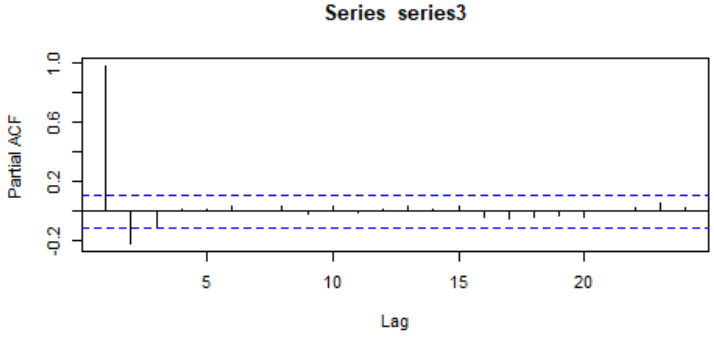
4. Series 3

4.1 Correlogram, Histogram, ACF and PACF Plot









4.2 Analysis

Using the information in the previous plots, discuss whether:

- **Stationarity** – It appears that Series 3 is not stationary in the mean. This is confirmed by the Dickey Fuller test, which indicates that one difference must be taken to make the data stationary in the mean.

```
ndiffs(series3, alpha=0.05, test=c("adf"))
```

```
## [1] 1
```

- **Marginal Normal Distribution** – The histogram above and the Shapiro Test below both suggest that the series is not normally distributed. The Shapiro Test outputs a p-value of 1.019e-06, confirming this and allowing us from rejecting the null hypothesis that the data is normally distributed.

```
# Ho: the data is normally distributed
# H1: the data is not normally distributed

shapiro.test(series3)
```

```
##
##  Shapiro-Wilk normality test
##
## data:  series3
## W = 0.9645, p-value = 1.019e-06
```

- **White Noise, Strict White Noise or Gaussian White Noise** – The data appears to be autocorrelated on the ACF and PACF. This is confirmed by the box test below, which outputs a p-value below 2.2e-16, allowing us to reject the null hypothesis that the data is uncorrelated. Therefore, the data is **not white noise, strict white noise, nor Gaussian white noise**.

```
# Ho: uncorrelated data
# H1: correlated data
Box.test (series3, lag = 20, type="Ljung")
```

```
##
##  Box-Ljung test
##
## data:  series3
## X-squared = 3598.9, df = 20, p-value < 2.2e-16
```

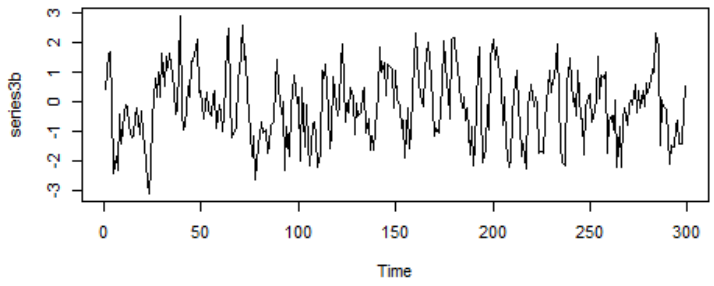
- **Linear Model Representing Dynamic Dependence** – The box test indicates that the data is correlated. Therefore, it can be represented using a linear model.
- **Potential Non-linear Dependences** – We are unable to determine if any non-linear dependences exist, as it would depend on the errors of the linear model.

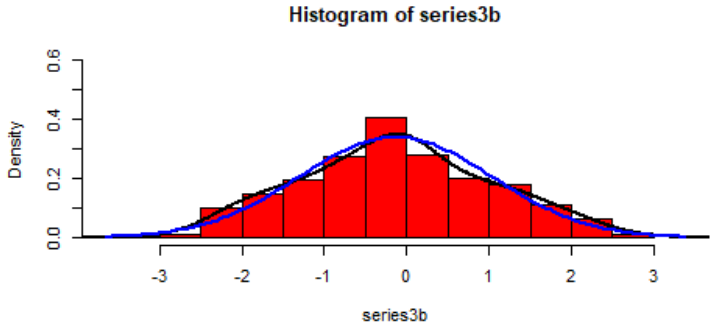
4.3 Results

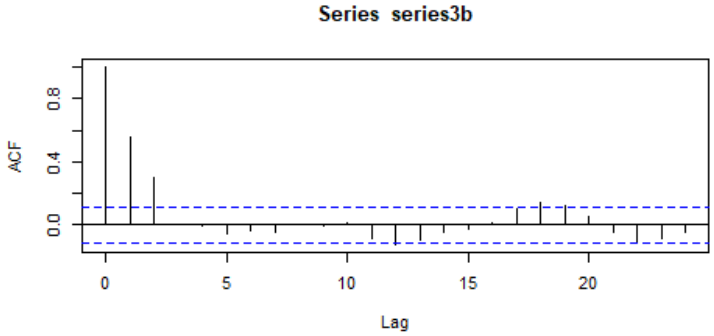
	Series 3
Stationarity	No
Normal Distribution	No
White Noise	No
Strict White Noise	No
Gaussian White Noise	No
Linear Model?	Yes
Non-Linear Model?	?
Transformations	1

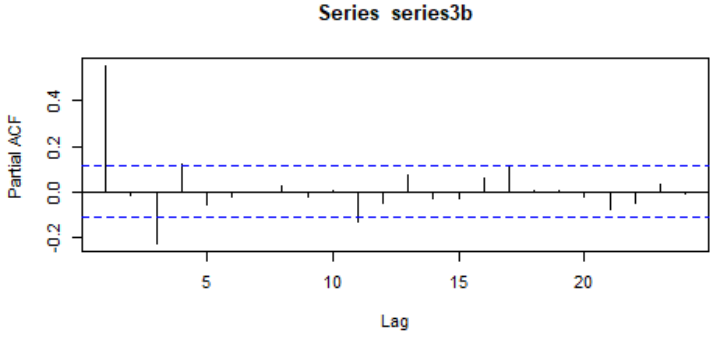
5. Series 3b

5.1 Correlogram, Histogram, ACF and PACF Plot









5.2 Analysis

Using the information in the previous plots, discuss whether:

- **Stationarity** – The newly transformed data, which took the difference of one value and the previous in Series 3, is stationary in both the mean and the variance. The Dickey Fuller test below confirms the stationarity in the mean.

```
ndiffs(series3b, alpha=0.05, test=c("adf"))

## [1] 0
```

- **Marginal Normal Distribution** – The histogram above and the Shapiro Test below both suggest that the transformed series is normally distributed. The Shapiro Test outputs a p-value of 0.2, preventing us from rejecting the null hypothesis that the data is normally distributed.

```
# Ho: the data is normally distributed
# H1: the data is not normally distributed
shapiro.test(series3b)

##
##  Shapiro-Wilk normality test
##
## data:  series3b
## W = 0.99344, p-value = 0.2178
```

- **White Noise, Strict White Noise, Gaussian White Noise** – The transformed data appears to be correlated and the box test confirms this with low p-value. Thus, **we can conclude that the data is not white noise, strict white noise or Gaussian white noise**.

```
# Ho: uncorrelated data
# H1: correlated data
Box.test (series3b, lag = 20, type="Ljung")

##
##  Box-Ljung test
##
## data:  series3b
## X-squared = 148.71, df = 20, p-value < 2.2e-16

t.test(series3b, mu = 0)

##
##  One Sample t-test
##
## data:  series3b
```

```
## t = -1.9742, df = 298, p-value = 0.04928
## alternative hypothesis: true mean is not equal to 0
## 95 percent confidence interval:
##  -0.2672765629 -0.0004224338
## sample estimates:
##  mean of x
## -0.1338495
```

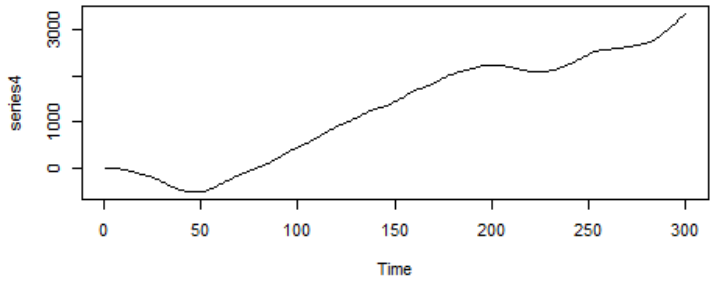
- **Linear Model Representing Dynamic Dependence** – Given that we have no white noise, linear model can be created to represent the data.
- **Potential Non-linear Dependencies** – Given that we might have linear model to represent the data, we cannot know yet if there are non-linear dependences can be assumed.

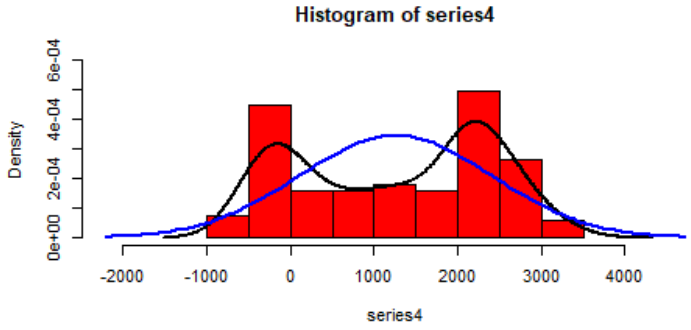
5.3 Results

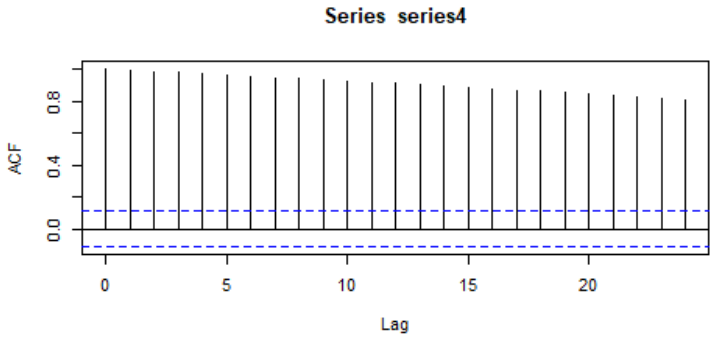
	Series 3b
Stationarity	Yes
Normal Distribution	Yes
White Noise	No
Strict White Noise	No
Gaussian White Noise	No
Linear Model?	Yes
Non-Linear Model?	?
Transformations	0

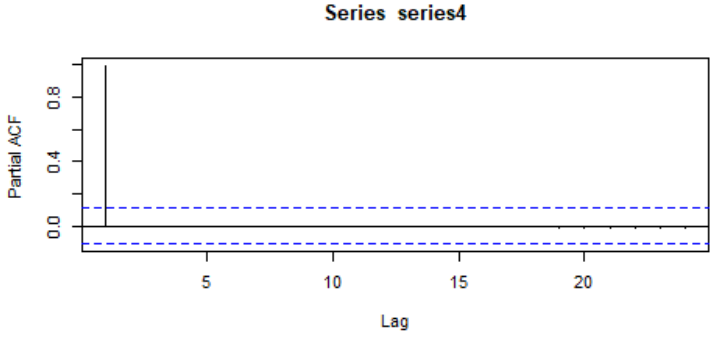
6. Series 4

6.1 Correlogram, Histogram, ACF and PACF Plot









6.2 Analysis

Using the information in the previous plots, discuss whether:

- **Stationarity** – It is clear that Series 4 is not stationary in the mean and the variance. There is a clear initial trend downwards, followed by an upward trend. The Dickey Fuller test suggests taking two differences to make the data stationary.

```
ndiffs(series4, alpha=0.05, test=c("adf"))
```

```
## [1] 2
```

- **Marginal Normal Distribution** – The histogram above and the Shapiro Test below both suggest that the series is not normally distributed. The Shapiro Test outputs a p-value of 2.779e-12, confirming this and allowing us from rejecting the null hypothesis that the data is normally distributed.

```
# Ho: the data is normally distributed
# H1: the data is not normally distributed

shapiro.test(series4)
```

```
##
##  Shapiro-Wilk normality test
##
## data:  series4
## W = 0.91161, p-value = 2.779e-12
```

- **White Noise, Strict White Noise or Gaussian White Noise** – the data appears to be autocorrelated. This is confirmed by the box test below, which outputs a p-value below 2.2e-16, allowing us to reject the null hypothesis that the data is uncorrelated. Therefore, the data is **not white noise, strict white noise, nor Gaussian white noise**.

```
# Ho: uncorrelated data
# H1: correlated data
Box.test (series4, lag = 20, type="Ljung")
```

```
##
##  Box-Ljung test
##
## data:  series4
## X-squared = 5290.9, df = 20, p-value < 2.2e-16
```

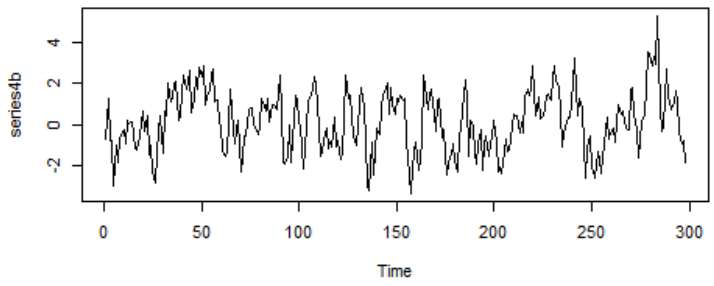
- **Linear Model Representing Dynamic Dependence** – The box test indicates that the data is correlated. Therefore, it can be represented using a linear model.
- **Potential Non-linear Dependences** – We are unable to determine if any non-linear dependences exist, as it would depend on the errors of the linear model.

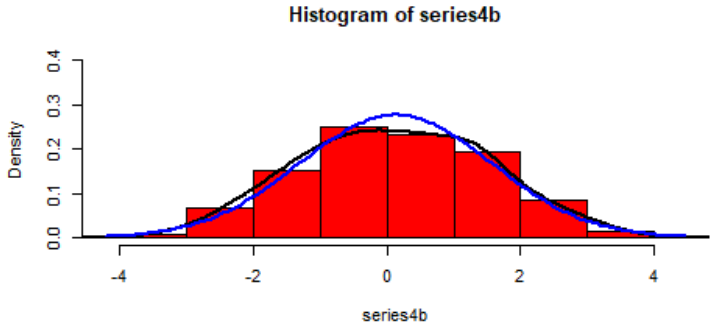
6.3 Results

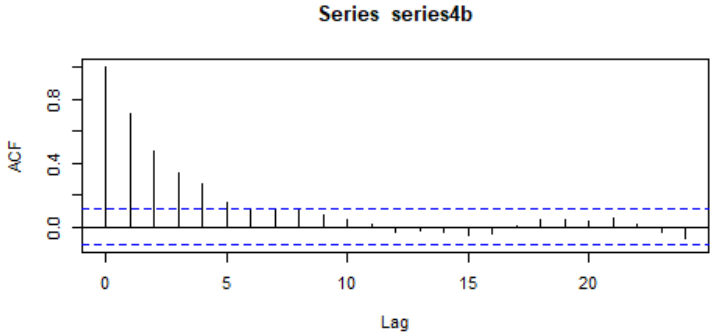
	Series 4
Stationarity	No
Normal Distribution	No
White Noise	No
Strict White Noise	No
Gaussian White Noise	No
Linear Model?	Yes
Non-Linear Model?	?
Transformations	2

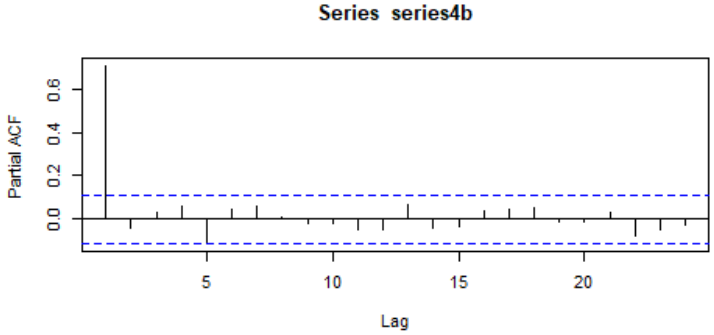
7. Series 4b

7.1 Correlogram and Histogram









7.2 Analysis

Using the information in the previous plots, discuss whether:

- **Stationarity** – Having taken two differences from series 4, is clear that Series 4b is stationary in the mean. The Dickey Fuller test suggests taking no more differences to make and so the data stationary.

```
ndiffs(series4b, alpha=0.05, test=c("adf"))

## [1] 0
```

- **Marginal Normal Distribution** – The histogram above shows a somewhat normal distribution and the Shapiro Test below both suggest that the series is normally distributed. The Shapiro Test outputs a p-value of 0.3416, allowing us to accept the null hypothesis and conclude that the data **is normally distributed.**

```
# Ho: the data is normally distributed
# H1: the data is not normally distributed

shapiro.test(series4b)

##
##  Shapiro-Wilk normality test
##
## data:  series4b
## W = 0.99438, p-value = 0.3416
```

- **White Noise, Strict White Noise or Gaussian White Noise** – The ACF indicates that the data appears to be autocorrelated with couple of point out of limit. This is confirmed by the box test below, which outputs a p-value below 2.2e-16, allowing us to reject the null hypothesis that the data is uncorrelated. Therefore, the data is **not white noise, strict white noise, nor Gaussian white noise**.

```
# Ho: uncorrelated data
# H1: correlated data
Box.test (series4, lag = 20, type="Ljung")

##
##  Box-Ljung test
##
## data:  series4
## X-squared = 5290.9, df = 20, p-value < 2.2e-16
```

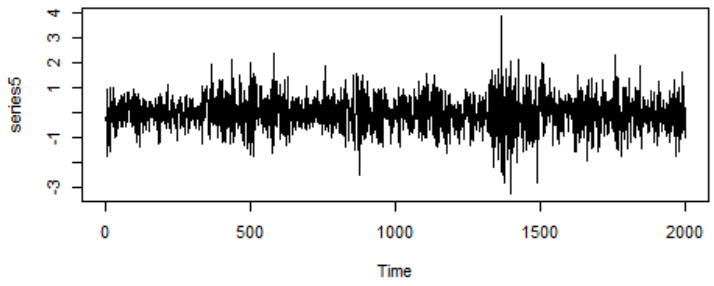
- **The dynamic dependence of the series can be represented by a linear model** – The box test indicates that the data is correlated. Therefore, it can be represented using a linear model.
- **There are potential non-linear dependences** – We are unable to determine if any non-linear dependences exist, as it would depend on the errors of the linear model.

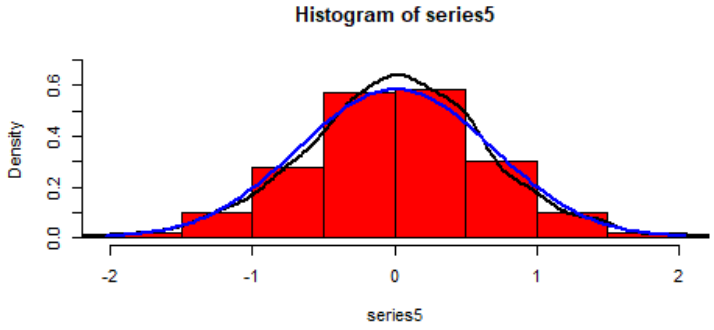
7.3 Results

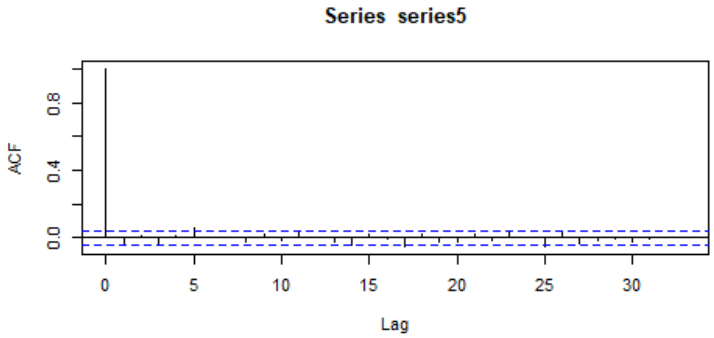
	Series 4b
Stationarity	Yes
Normal Distribution	Yes
White Noise	No
Strict White Noise	No
Gaussian White Noise	No
Linear Model?	Yes
Non-Linear Model?	?
Transformations	0

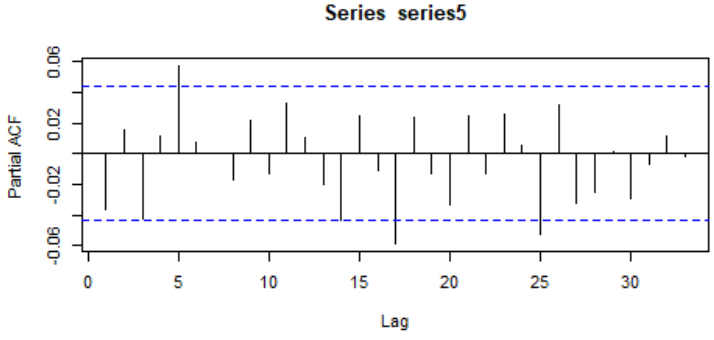
8. Series 5

8.1 Correlogram and Histogram









8.2 Analysis

Using the information in the previous plots, discuss whether:

- **The series is stationary** – Series 5 appears to be stationary in both the mean and variance. The Dickey Fuller does not propose any differences be taken.

```
ndiffs(series5, alpha=0.05, test=c("adf"))

## [1] 0
```

- **Marginal Normal Distribution** – Though the histogram above appears to depict normally distributed data, the Shapiro test below provides a p-value of 3.456e-10, allowing us to reject the null hypothesis that the data is indeed normally distributed. Therefore, **the data is not normally distributed**.

```
# Ho: the data is normally distributed
# H1: the data is not normally distributed

shapiro.test(series5)

##
##  Shapiro-Wilk normality test
##
## data:  series5
## W = 0.99047, p-value = 3.456e-10
```

- **White Noise, Strict White Noise or Gaussian White Noise** – The data appears to be a not white noise from the ACF and PACF. This is confirmed by the box test which resulted in p-value of 0.032. Therefore, the data **is white noise**. Thus, also **not strict white noise or Gaussian white noise**.

```
# Ho: uncorrelated data
# H1: correlated data
Box.test (series5, lag = 20, type="Ljung")

##
##  Box-Ljung test
##
## data:  series5
## X-squared = 33.151, df = 20, p-value = 0.03248

t.test(series5, mu = 0)

##
##  One Sample t-test
##
## data:  series5
## t = 0.47206, df = 1999, p-value = 0.6369
## alternative hypothesis: true mean is not equal to 0
```

```
## 95 percent confidence interval:
##  -0.02263509  0.03698609
## sample estimates:
## mean of x
## 0.0071755
```

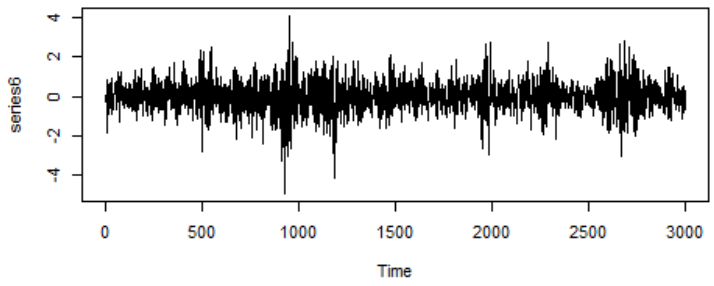
- **Linear Model Representing Dynamic Dependence** – Since the data suggests that there is correlation, it can be represented by a linear model.
- **Potential Non-linear Dependences** – We are unable to determine if any non-linear dependences exist, as it would depend on the errors of the linear model.

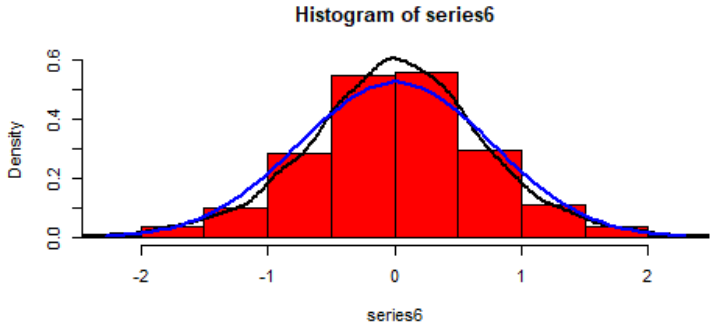
8.3 Results

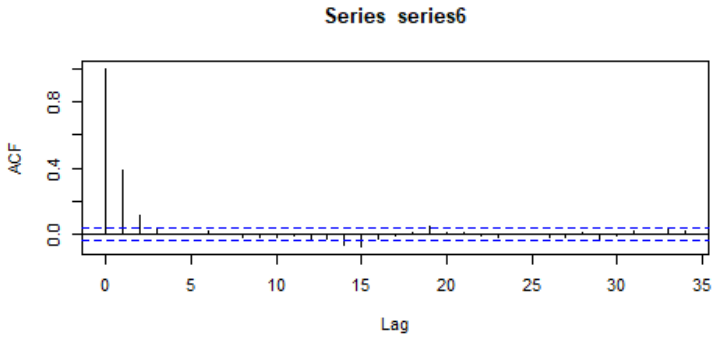
	Series 5
Stationarity	Yes
Normal Distribution	No
White Noise	No
Strict White Noise	No
Gaussian White Noise	No
Linear Model?	Yes
Non-Linear Model?	?
Transformations	0

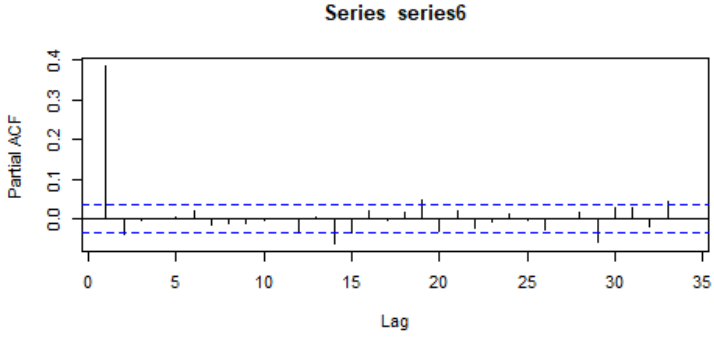
9. Series 6

9.1 Correlogram, Histogram, ACF and PACF Plot









9.2 Analysis

Using the information in the previous plots, discuss whether:

- **Stationarity** – It appears that Series 6 is indeed stationary in both the mean and the variance. Stationarity in the mean is confirmed by the results of the Dickey Fuller test below.

```
ndiffs(series6, alpha=0.05, test=c("adf"))
```

```
## [1] 0
```

- **Marginal Normal Distribution** – It appears from the histogram in section 9.1 that Series 6 is normally distributed. However, a formal Shapiro Test results in a very small p-value, allowing us to reject the null hypothesis (at 95% confidence level) that the series is normally distributed. Thus, we can conclude that the series is **not normally distributed**.

```
# Ho: the data is normally distributed
# H1: the data is not normally distributed

shapiro.test(series6)
```

```
##
##  Shapiro-Wilk normality test
##
## data:  series6
## W = 0.98338, p-value < 2.2e-16
```

- **White Noise, Strict White Noise or Gaussian White Noise** – The ACF and PACF plot indicate a few points out of limit. The box test below indicates a very small p-value and thus we can reject that the data is uncorrelated at a 95% confidence level. Thus, we can conclude that the data is **not white noise**. Thus, **also not strict white noise, nor Gaussian white noise.**

```
# Ho: uncorrelated data
# H1: correlated data

Box.test (series6, lag = 20, type="Ljung")
```

```
##
##  Box-Ljung test
##
## data:  series6
## X-squared = 537.69, df = 20, p-value < 2.2e-16
```

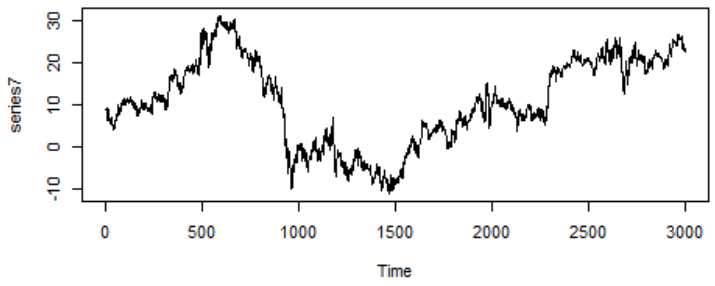
- **Linear Model Representing Dynamic Dependence** – Given that the data depicts no white noise, linear model can represent the data.
- **Potential Non-linear Dependences** – We are unable to determine if any non-linear dependences exist, as it would depend on the errors of the linear model.

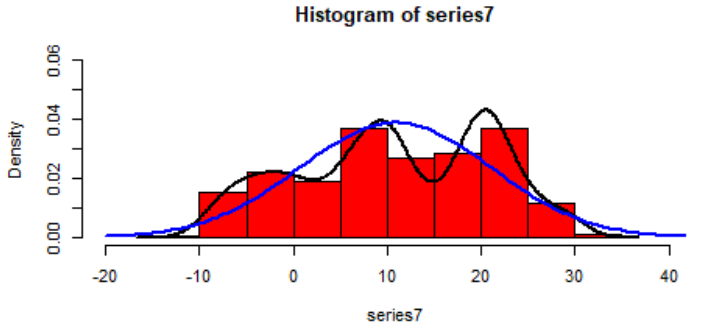
9.3 Results

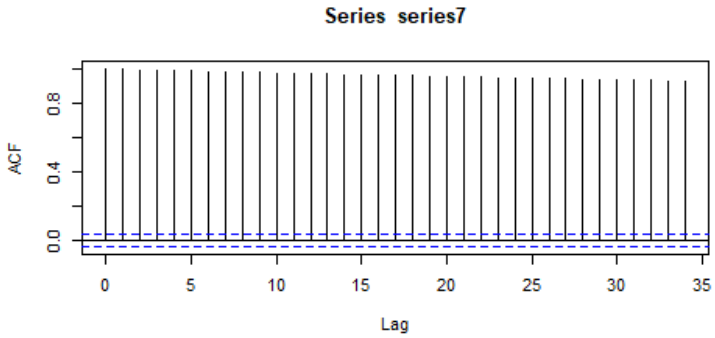
	Series 6
Stationarity	Yes
Normal Distribution	No
White Noise	Yes
Strict White Noise	No
Gaussian White Noise	No
Linear Model?	Yes
Non-Linear Model?	?
Transformations	0

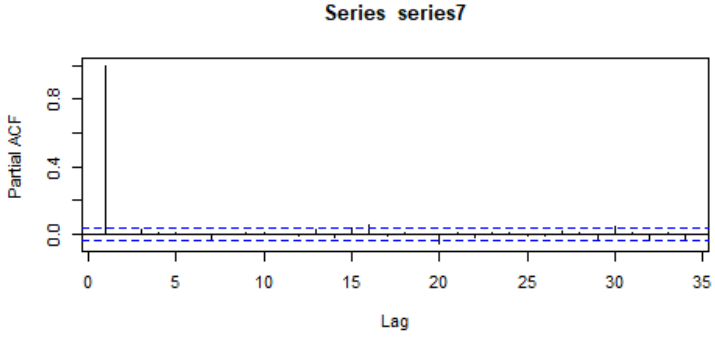
10. Series 7

10.1 Correlogram, Histogram, ACF and PACF Plot









10.2 Analysis

Using the information in the previous plots, discuss whether:

- **Stationarity** – It appears that Series 7 is not stationary in the mean. The Dickey Fuller test below also indicates that one difference of transformation needs to be done to make the data stationary.

```
ndiffs(series7, alpha=0.05, test=c("adf"))
```

```
## [1] 1
```

- **Marginal Normal Distribution** – It appears from the histogram in section 10.1 that Series 7 is not normally distributed. The Shapiro Test results also confirms this with very small p-value, allowing us to reject the null hypothesis (at 95% confidence level) that the series is normally distributed. Thus, we can conclude that the series is **not normally distributed**.

```
# Ho: the data is normally distributed
# H1: the data is not normally distributed

shapiro.test(series7)
```

```
##
##  Shapiro-Wilk normality test
##
## data:  series7
## W = 0.96711, p-value < 2.2e-16
```

- **White Noise, Strict White Noise and Gaussian White Noise** – The ACF indicates that all points are out of limit. The box test below indicates a very small p-value and thus we can reject that the data is uncorrelated at a 95% confidence level. Thus, it can be concluded to be **no white noise**. **Thus, not strict white noise or Gaussian white noise.**

```
# Ho: uncorrelated data
# H1: correlated data

Box.test (series7, lag = 20, type="Ljung")
```

```
##
##  Box-Ljung test
##
## data:  series7
## X-squared = 57372, df = 20, p-value < 2.2e-16
```

```r
t.test(series7, mu = 0)
```

```
##
##  One Sample t-test
##
## data:  series7
## t = 57.946, df = 2999, p-value < 2.2e-16
## alternative hypothesis: true mean is not equal to 0
## 95 percent confidence interval:
##  10.51375 11.25018
## sample estimates:
## mean of x
##  10.88196
```

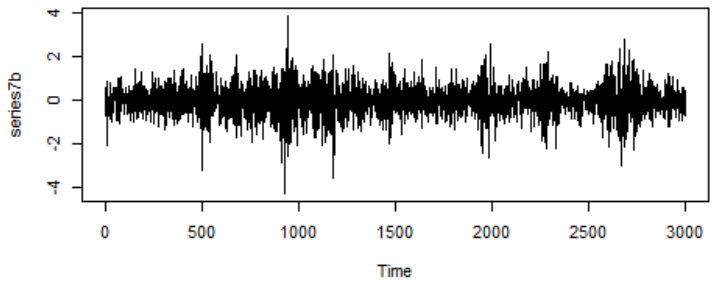
- **Linear Model Representing Dynamic Dependence** – Given that the data depicts no white noise and correlation, linear model can represent the data.
- **Potential Non-linear Dependences** – Since there is a possibility of linear model we cannot determine if there for non-linear dependency until the linear model has been extracted.

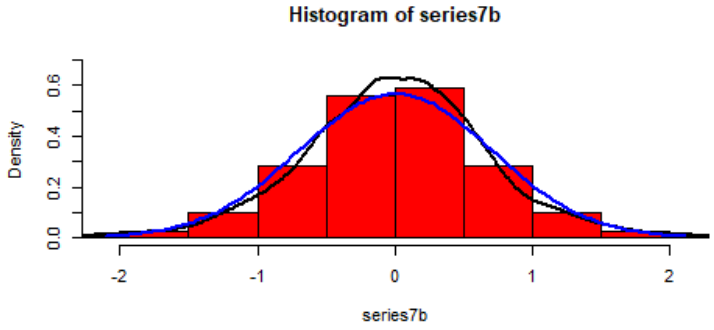
10.3 Results

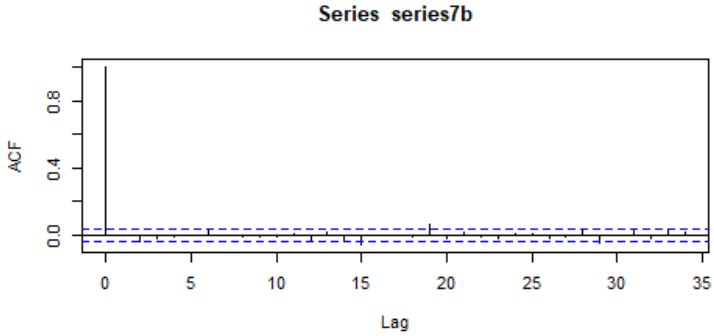
	Series 6
Stationarity	Yes
Normal Distribution	No
White Noise	Yes
Strict White Noise	No
Gaussian White Noise	No
Linear Model?	Yes
Non-Linear Model?	?
Transformations	0

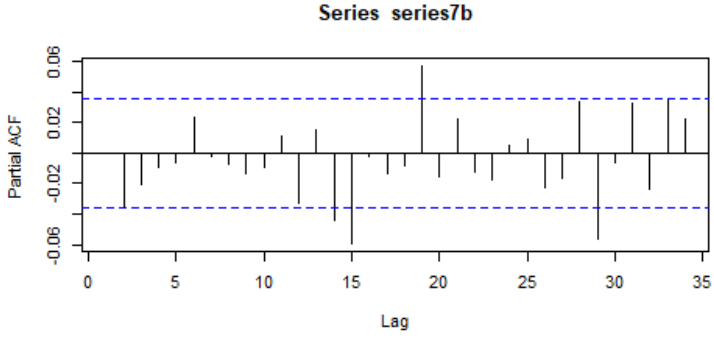
11. Series 7b

11.1 Correlogram, Histogram, ACF and PACF Plot









11.2 Analysis

Using the information in the previous plots, discuss whether:

- **Stationarity** – It appears that Series 7b is stationary in the mean and The Dickey Fuller test below also indicates that no more difference of transformation needs to be done to make the data stationary.

```
ndiffs(series7b, alpha=0.05, test=c("adf"))

## [1] 0
```

- **Marginal Normal Distribution** – The histogram in section 11.1 depicts a somewhat normal distribution for series 7b, however, the Shapiro Test results show a very small p-values; prompting us to reject the null hypothesis (at 95% confidence level) that the series is normally distributed. Thus, we can conclude that the series is **not normally distributed**.

```
# Ho: the data is normally distributed
# H1: the data is not normally distributed

shapiro.test(series7b)

##
##  Shapiro-Wilk normality test
##
## data:  series7b
## W = 0.98584, p-value < 2.2e-16
```

- **White Noise, Strict White Noise and Gaussian White Noise** – The ACF and PACF shows that there are a few points are out of limit. The box test below indicates a very small p-value and thus we can reject that the data is uncorrelated at a 95% confidence level, with t-test confirming the mean is not zero. Thus, it can be concluded to be **no white noise**. **Thus, not strict white noise or Gaussian white noise.**

```
# Ho: uncorrelated data
# H1: correlated data

Box.test (series7, lag = 20, type="Ljung")

##
##  Box-Ljung test
##
```

```
## data:  series7
## X-squared = 57372, df = 20, p-value < 2.2e-16
```

```
t.test(series7, mu = 0)
```

```
##
##  One Sample t-test
##
## data:  series7
## t = 57.946, df = 2999, p-value < 2.2e-16
## alternative hypothesis: true mean is not equal to 0
## 95 percent confidence interval:
##  10.51375 11.25018
## sample estimates:
## mean of x
##  10.88196
```

- **Linear Model Representing Dynamic Dependence** – Given that the data depicts no white noise and correlation, linear model can represent the data.
- **Potential Non-linear Dependences** – Since there is a linear model can represent the data we cannot check if there for non-linear dependency.

11.3 Results

	Series 7b
Stationarity	Yes
Normal Distribution	No
White Noise	No
Strict White Noise	No
Gaussian White Noise	No
Linear Model?	Yes
Non-Linear Model?	?
Transformations	0