A4

Zoe Zhou

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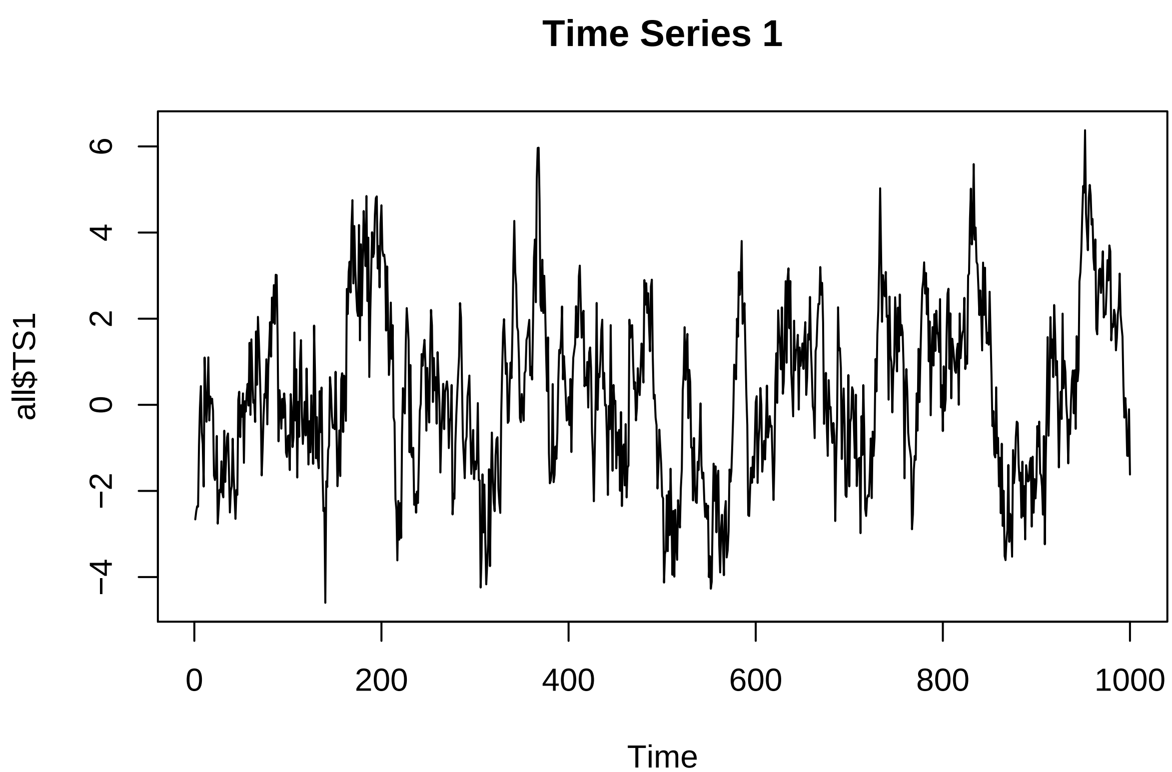
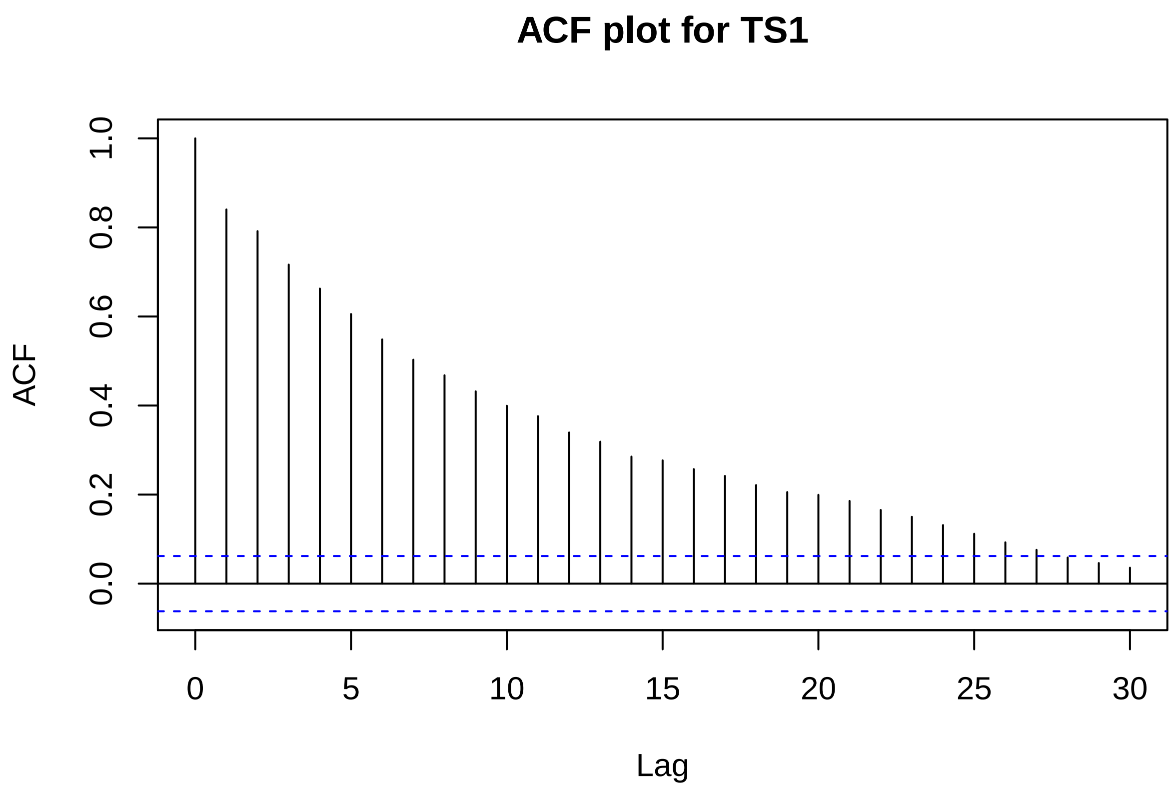
TS1:

(i)

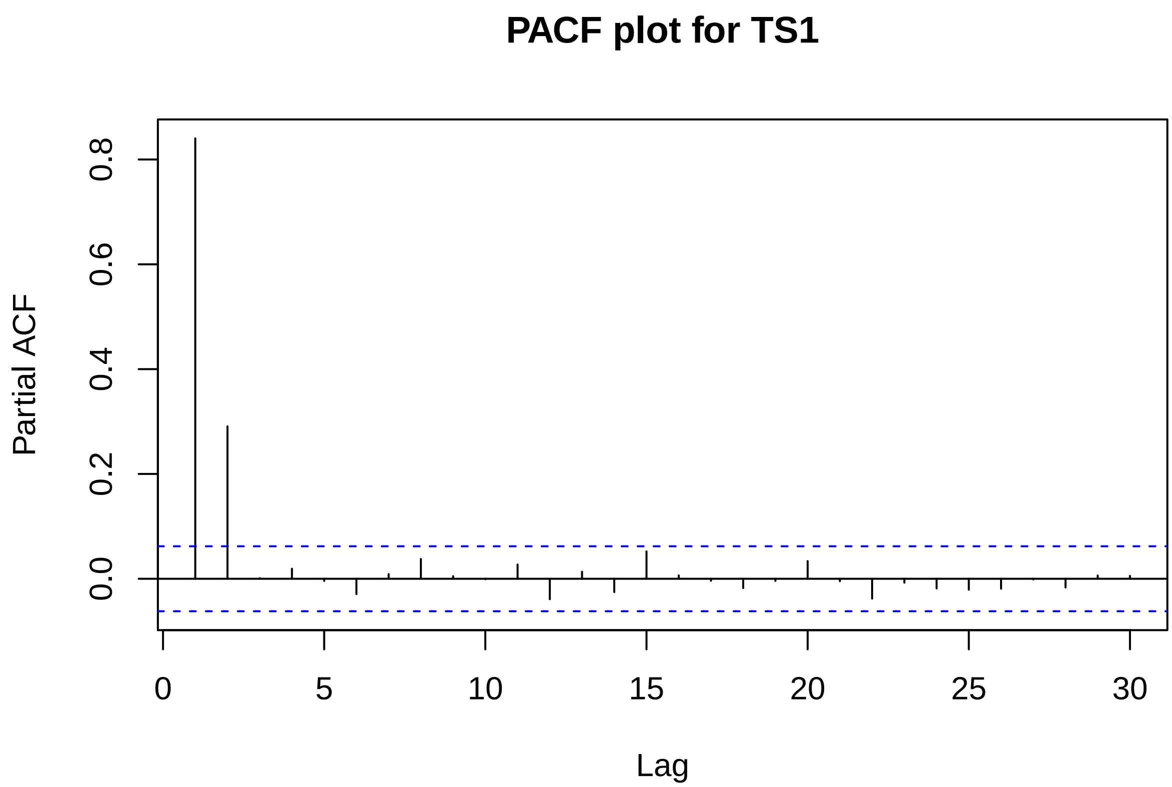
```
plot.ts(all$TS1, main = "Time Series 1")
```




```
acf(all$TS1, main = "ACF plot for TS1")
```




```
pacf(all$TS1, main = "PACF plot for TS1")
```



(ii)

$y_t = \rho_1 y_{t-1} + \rho_2 y_{t-2} + \epsilon_t$

The most appropriate model will be a AR(2). From the series we can see strong clustering pattern which means we have positive autocorrelation in the series. The plot of ACF showed decay and PACF showed a cutoff at 2 lags.

(iii)

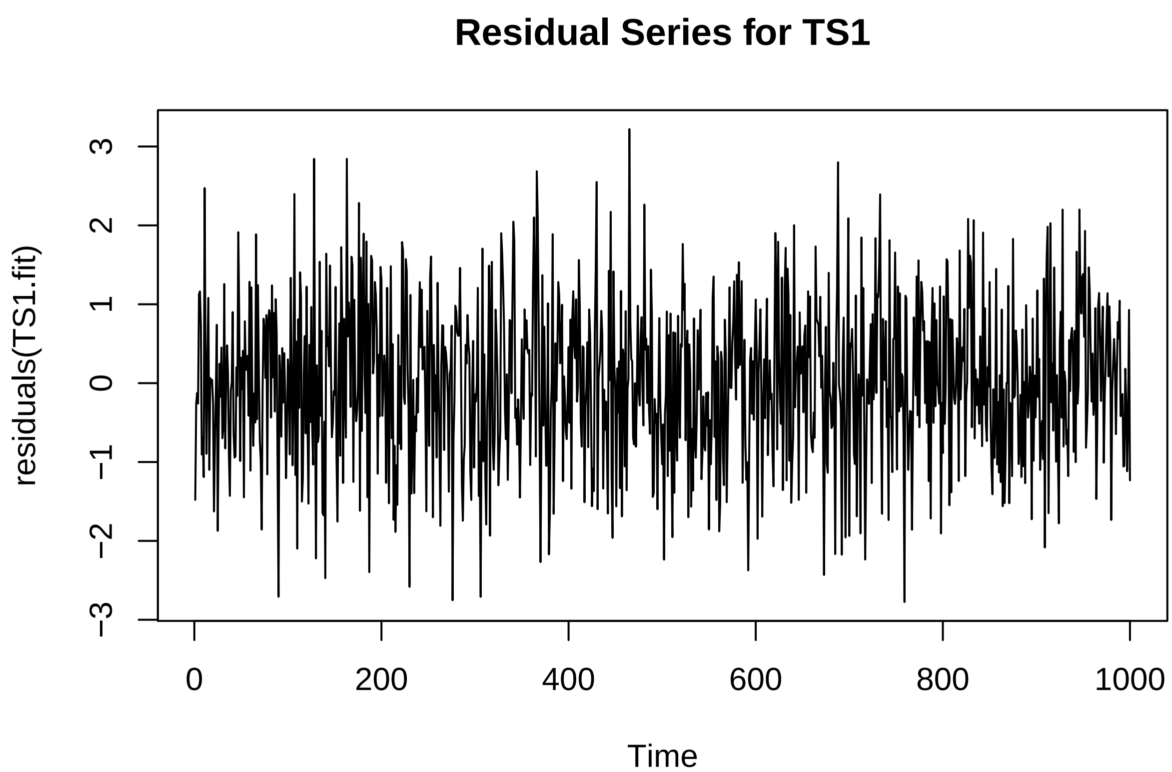
```
TS1.fit = arima(all$TS1, order = c(2, 0, 0))
TS1.fit
```

```
##
## Call:
## arima(x = all$TS1, order = c(2, 0, 0))
##
## Coefficients:
##          ar1     ar2  intercept
##       0.5958  0.2928     0.2106
## s.e.  0.0302  0.0303     0.2821
##
## sigma^2 estimated as 1.008:  log likelihood = -1423.72,  aic = 2855.44
```

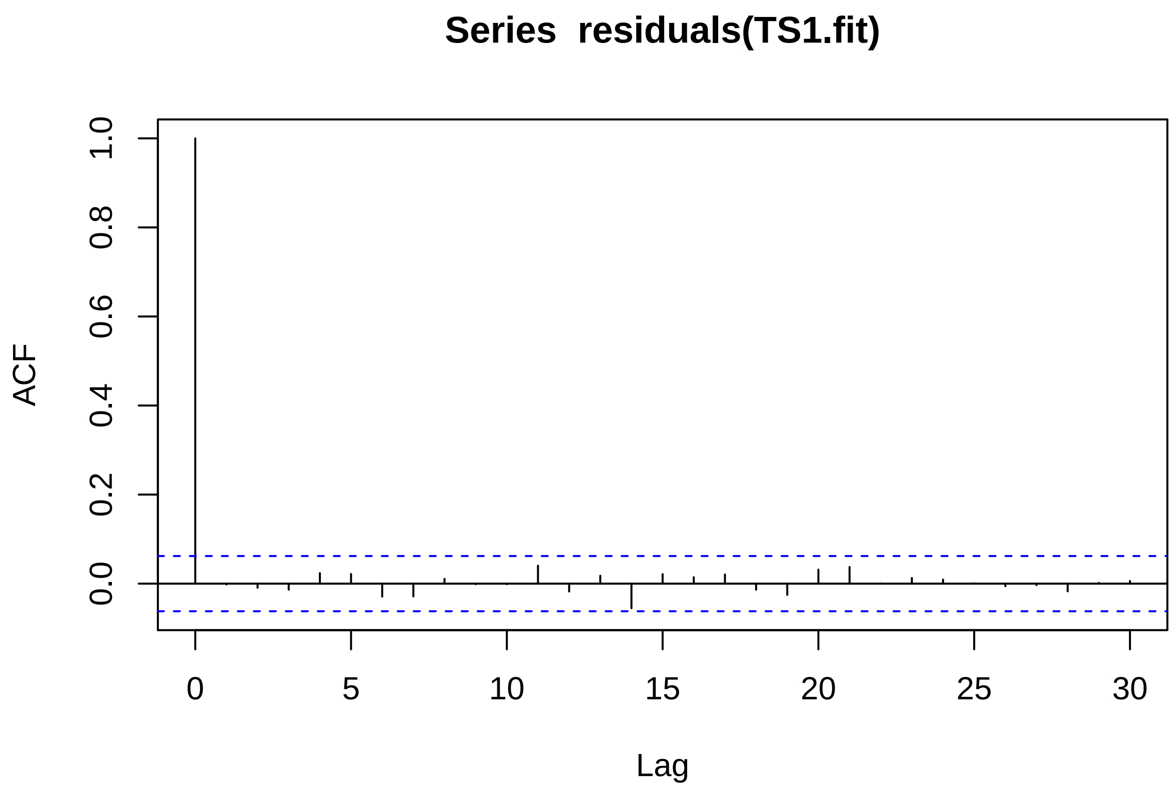
$y_t = 0.5958 y_{t-1} + 0.2928 y_{t-2} + \epsilon_t$

(iv)

```
plot.ts(residuals(TS1.fit), main = "Residual Series for TS1")
```




```
acf(residuals(TS1.fit))
```



Comments:

The residual series seemed to follow a normal distribution with a mean around 0. The variance are reasonably constant. The plot of ACF of the residuals showed no problems. All autocorrelation had been modeled.

(v)

Other models: ARMA(1, 1) AIC = 2863.19

AR(3) AIC = 2857.43, the 3rd AR term is not significant.

ARMA(1, 2) AIC = 2858.79

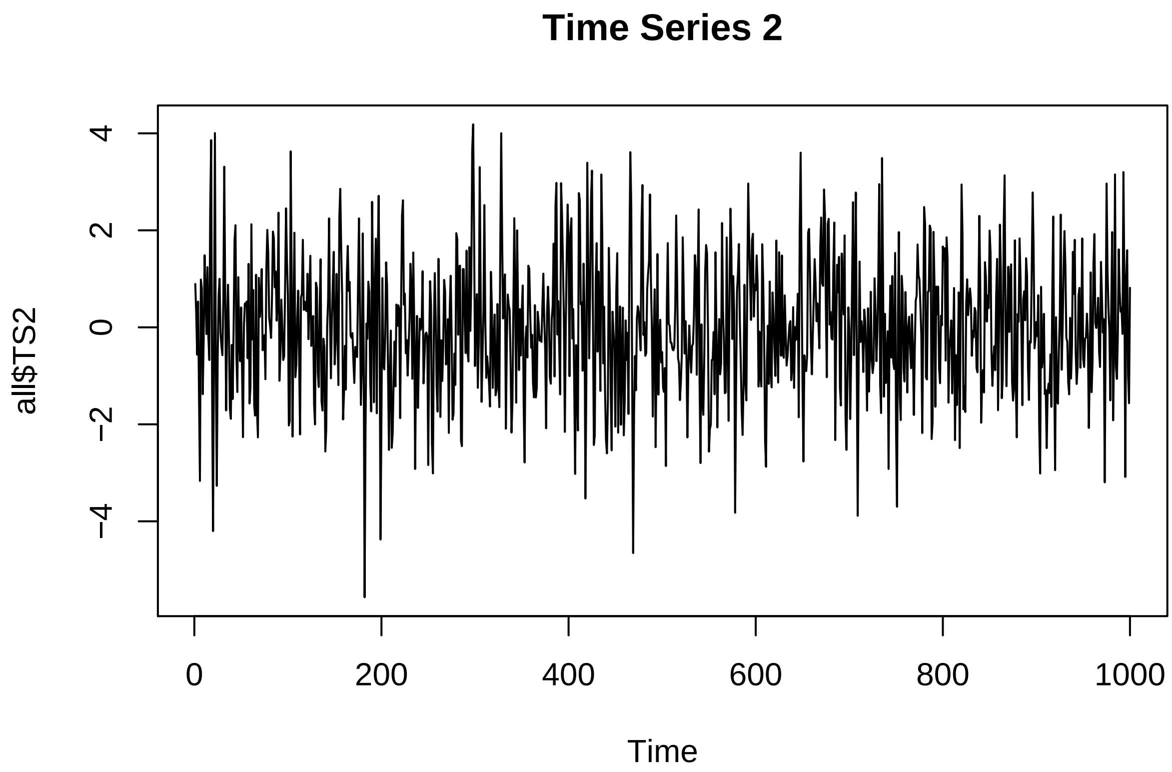
ARMA(2, 1) AIC = 2857.43, the 1st MA term is not significant

The AR(2) model had the smallest AIC (2855.44) and all terms are significant.

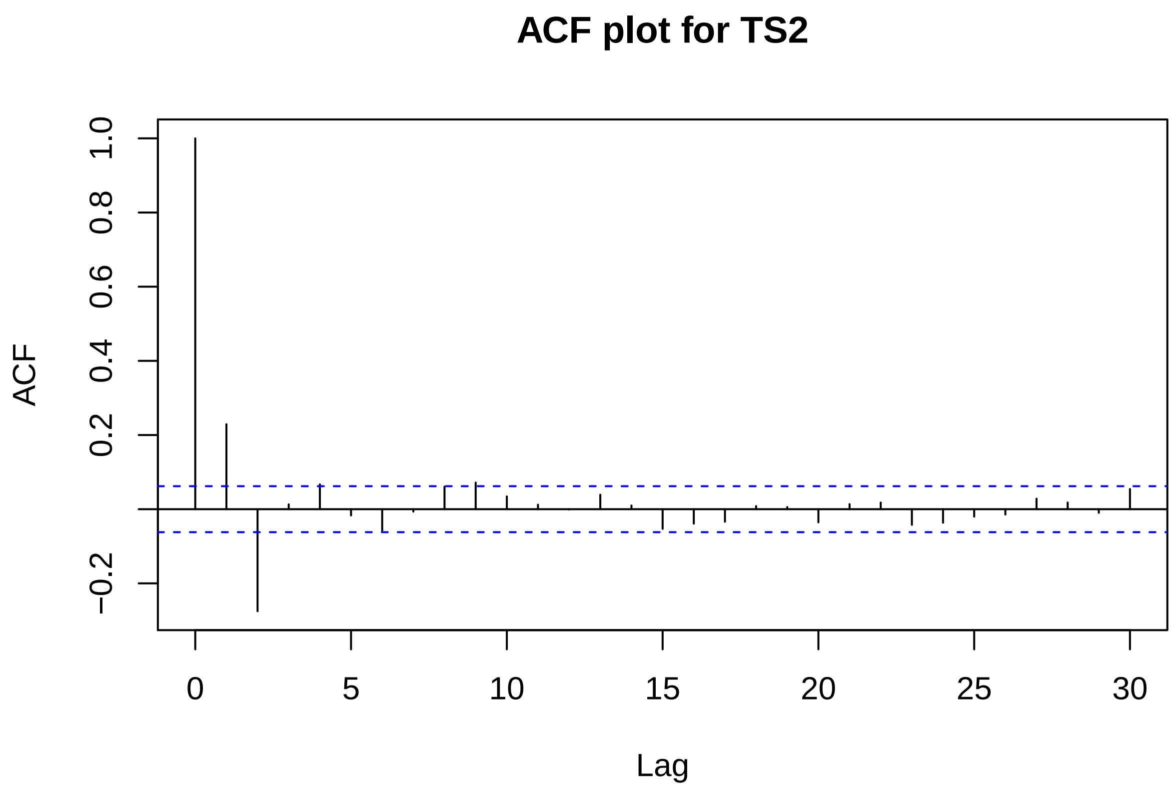
TS2:

(i)

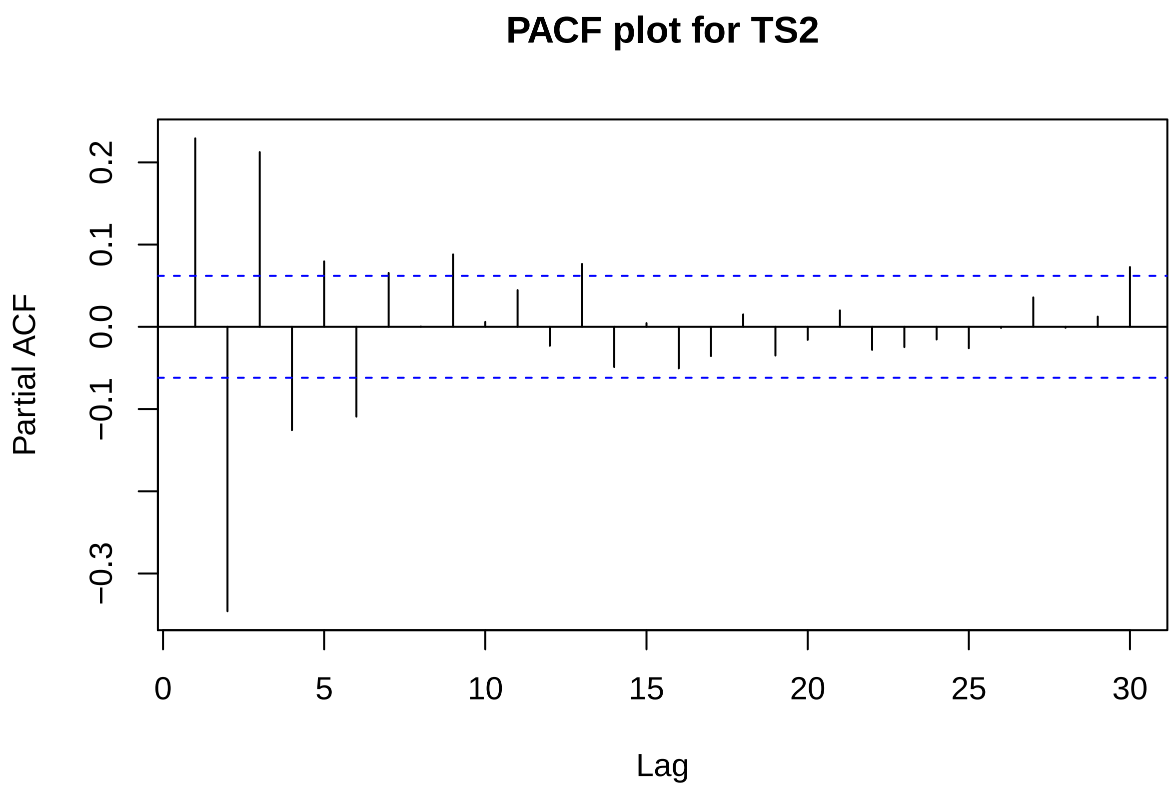
```
plot.ts(all$TS2, main = "Time Series 2")
```




```r
acf(all$TS2, main = "ACF plot for TS2")
```




```
pacf(all$TS2, main = "PACF plot for TS2")
```



(ii)

$y_t = \rho_1 y_{t-1} + \epsilon_t + \alpha_1 \epsilon_{t-1}$

The most appropriate model will be ARMA(1,1). From the series we can see strong clustering pattern which means we have autocorrelation in the series. The plot of ACF showed decay and PACF also showed decay or some persistence. Since we don't know the order for the model we can start trying with ARMA(1,1).

(iii)

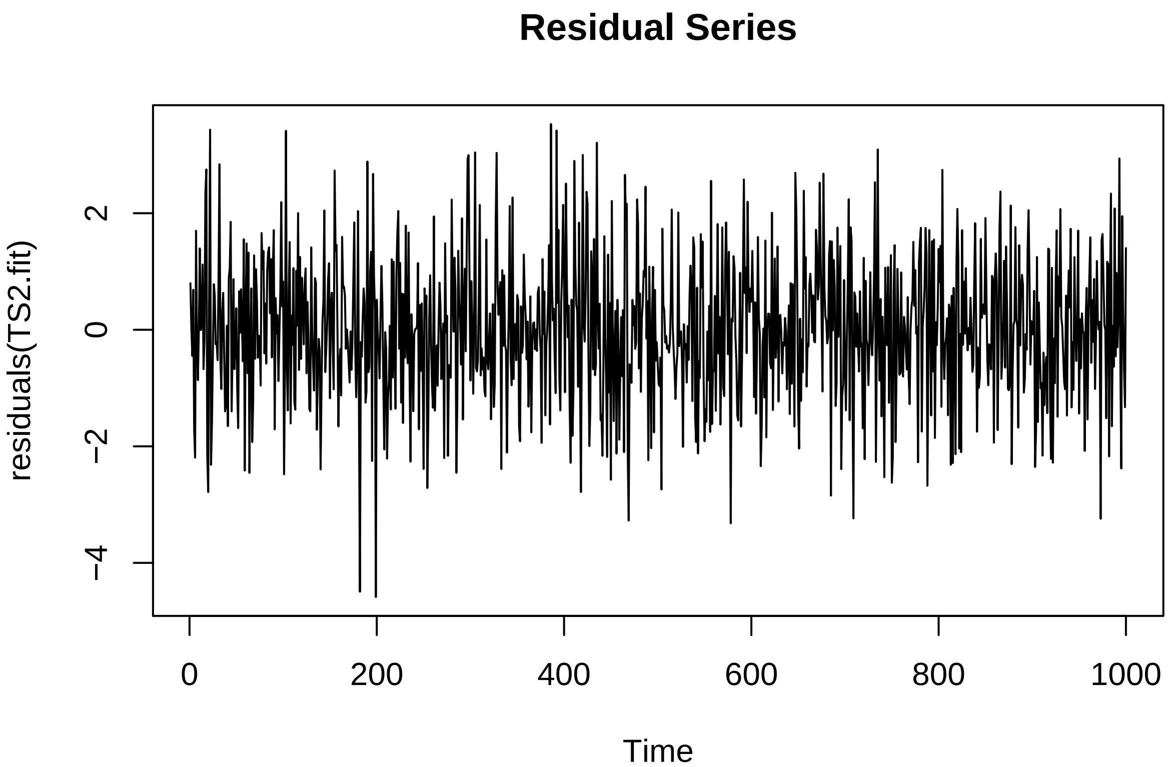
```
TS2.fit = arima(all$TS2, order = c(1, 0, 1))
TS2.fit
```

```
##
## Call:
## arima(x = all$TS2, order = c(1, 0, 1))
##
## Coefficients:
##           ar1     ma1  intercept
##       -0.3504  0.8459    -0.0084
## s.e.   0.0403  0.0219     0.0531
##
## sigma^2 estimated as 1.509:  log likelihood = -1624.86,  aic = 3257.73
```

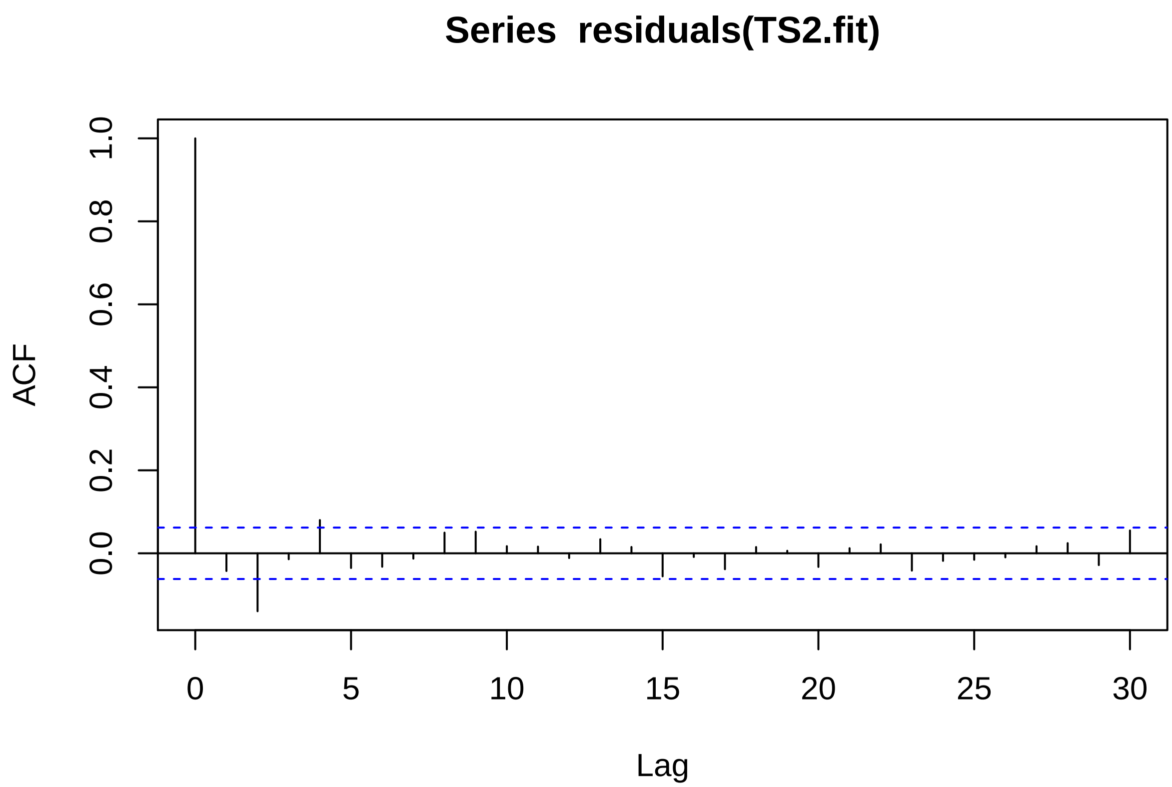
$y_t = -0.3504 y_{t-1} + \epsilon_t + 0.8459 \epsilon_{t-1}$

(iv)

```r
plot.ts(residuals(TS2.fit), main = "Residual Series")
```




```r
acf(residuals(TS2.fit))
```



Comments:

The residual series seemed to follow a normal distribution with a mean around 0. The variance are reasonably constant. The plot of ACF of the residuals showed we still have 2 significant lags at lag(2) and lag(4).

(v)

Better model:

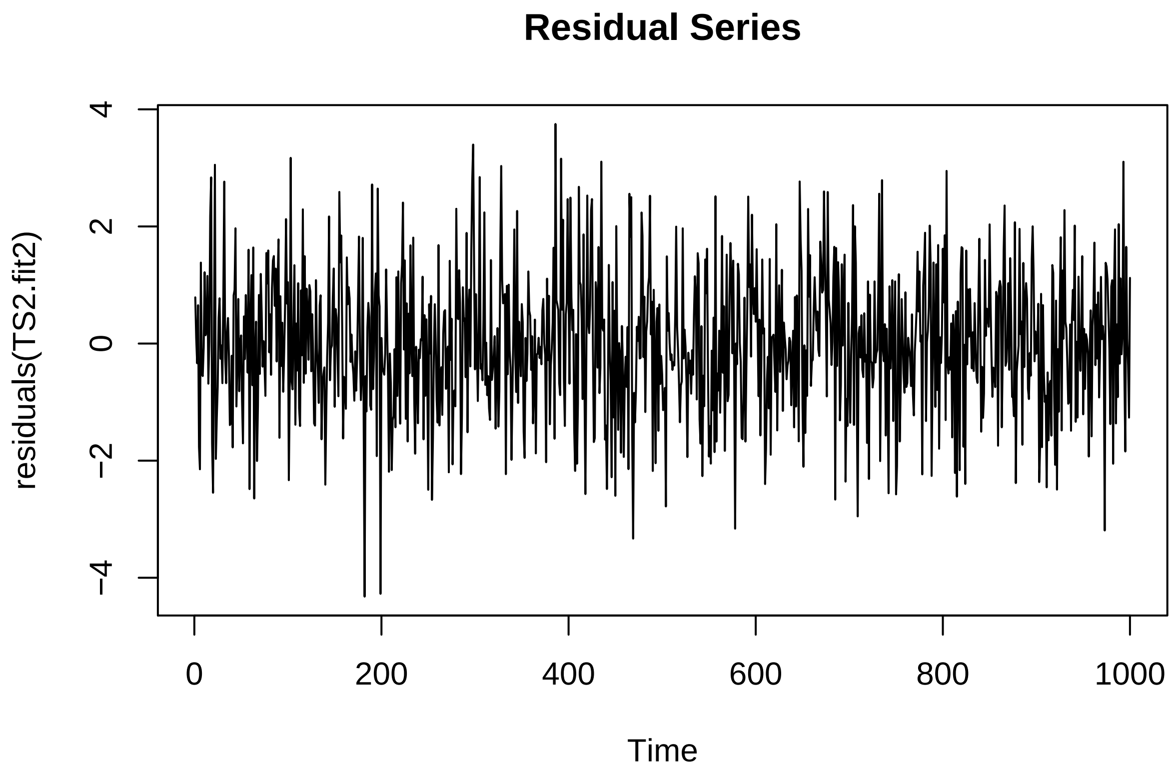
```
# ARMA(2, 1)
TS2.fit2 = arima(all$TS2, order = c(2, 0, 1))
TS2.fit2
```

```
##
## Call:
## arima(x = all$TS2, order = c(2, 0, 1))
##
## Coefficients:
##           ar1      ar2     ma1  intercept
##       -0.2975  -0.1888  0.7471    -0.0088
## s.e.   0.0490   0.0387  0.0427     0.0451
##
## sigma^2 estimated as 1.474:  log likelihood = -1613.16,  aic = 3236.32
```

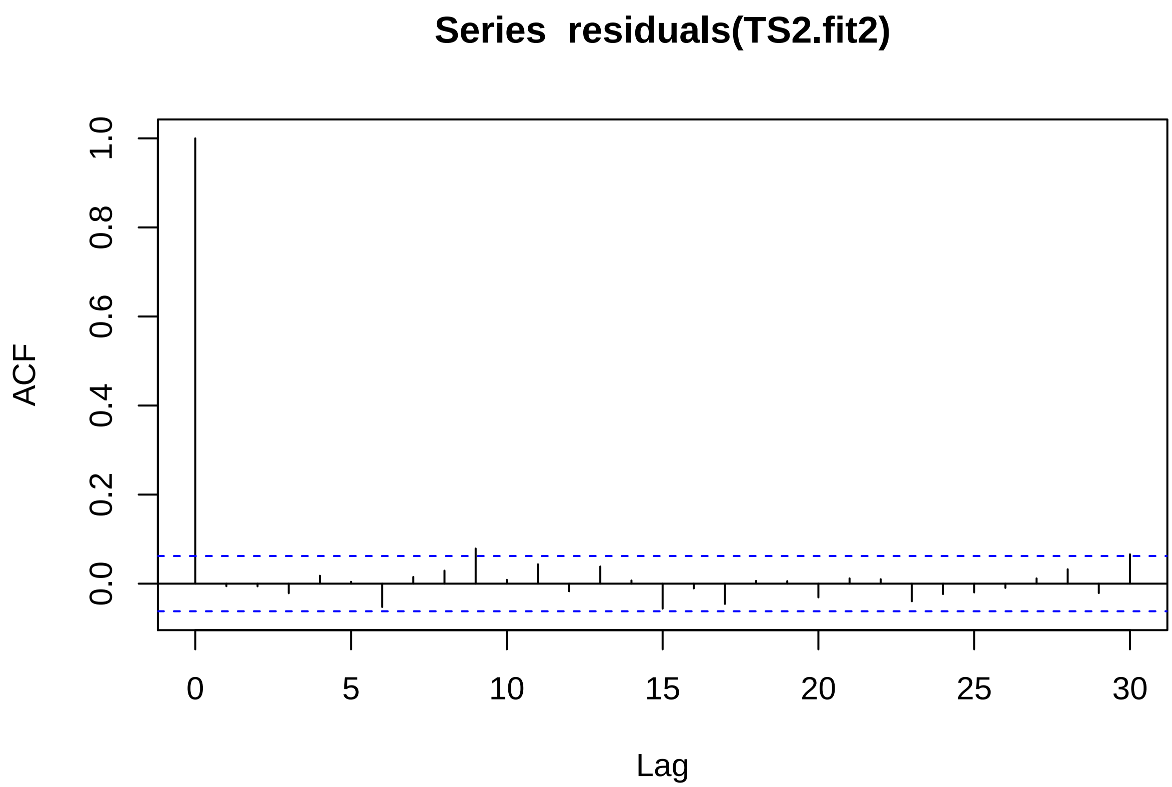
ARMA(2, 1) AIC = 3236.32 $y_t = -0.2975 y_{t-1} + -0.1888 y_{t-1} + \epsilon_t + 0.7471 \epsilon_{t-1}$

The ARMA(2, 1) model has the smallest AIC (3236.32) and all terms are significant.

```r
plot.ts(residuals(TS2.fit2), main="Residual Series")
```




```r
acf(residuals(TS2.fit2))
```

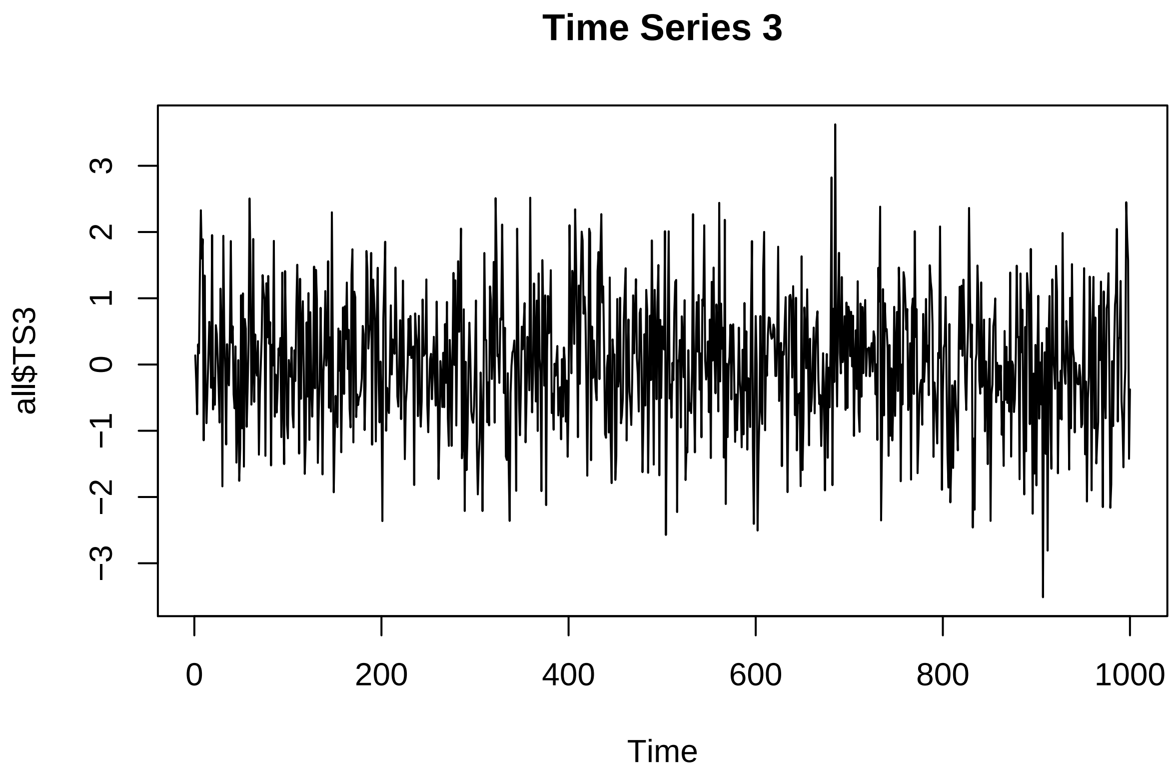


Comments: The residual series seemed to follow a normal distribution with a mean around 0. The variance are reasonably constant. The plot of ACF of the residuals showed lag(9) is slightly significant but it is very weak and not of concern.

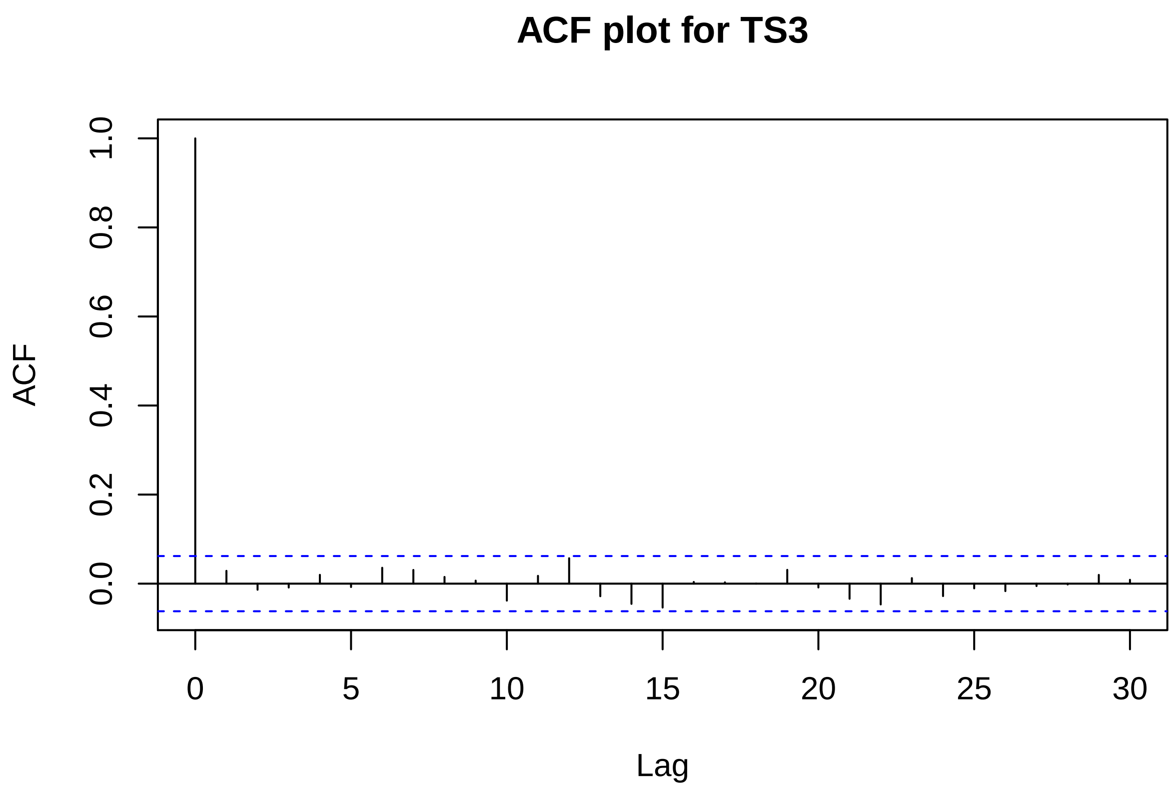
TS3:

(i)

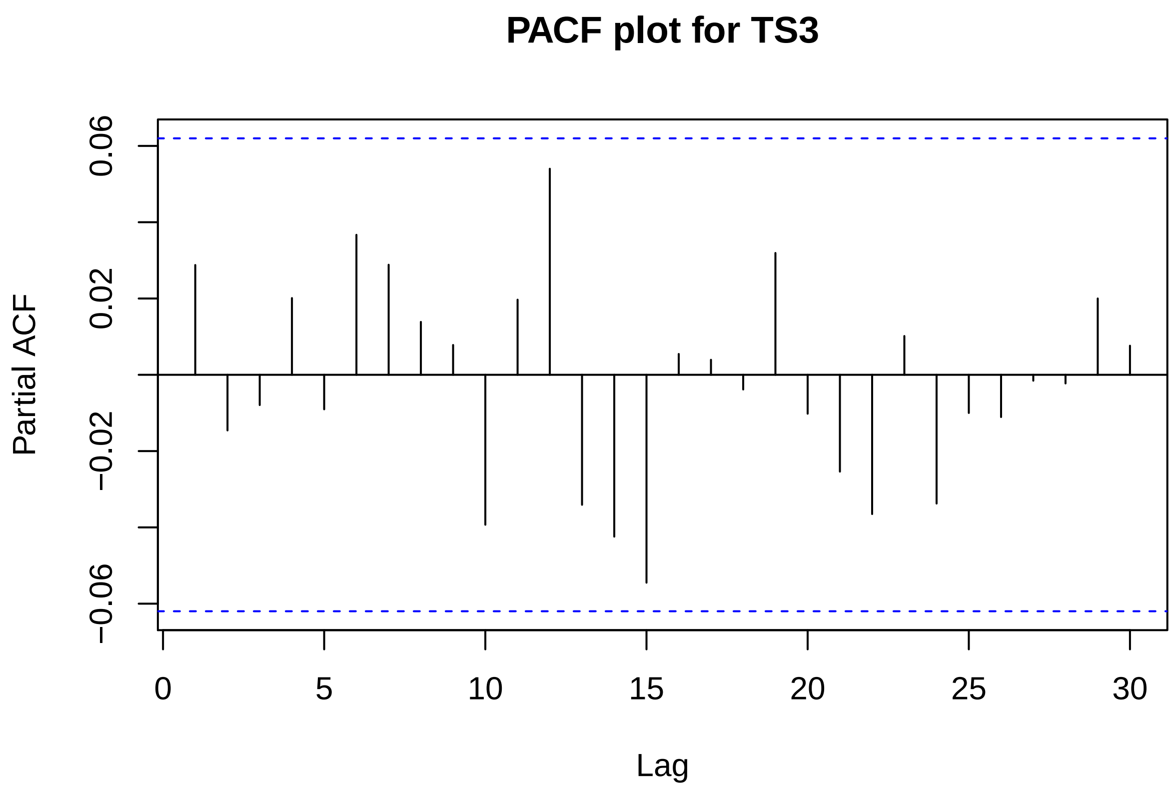
```
plot.ts(all$TS3, main = "Time Series 3")
```




```
acf(all$TS3, main = "ACF plot for TS3")
```




```
pacf(all$TS3, main = "PACF plot for TS3")
```



(ii)

$y_t = \epsilon_t$

The most appropriate model will be a White noise. From the series we cannot really see much pattern happening. The variance seemed very constant and the series has an overall mean around 0. The plot of ACF showed no significant lags and the plot of PACF showed no significant lags as well. This series should be a white noise.

(iii)

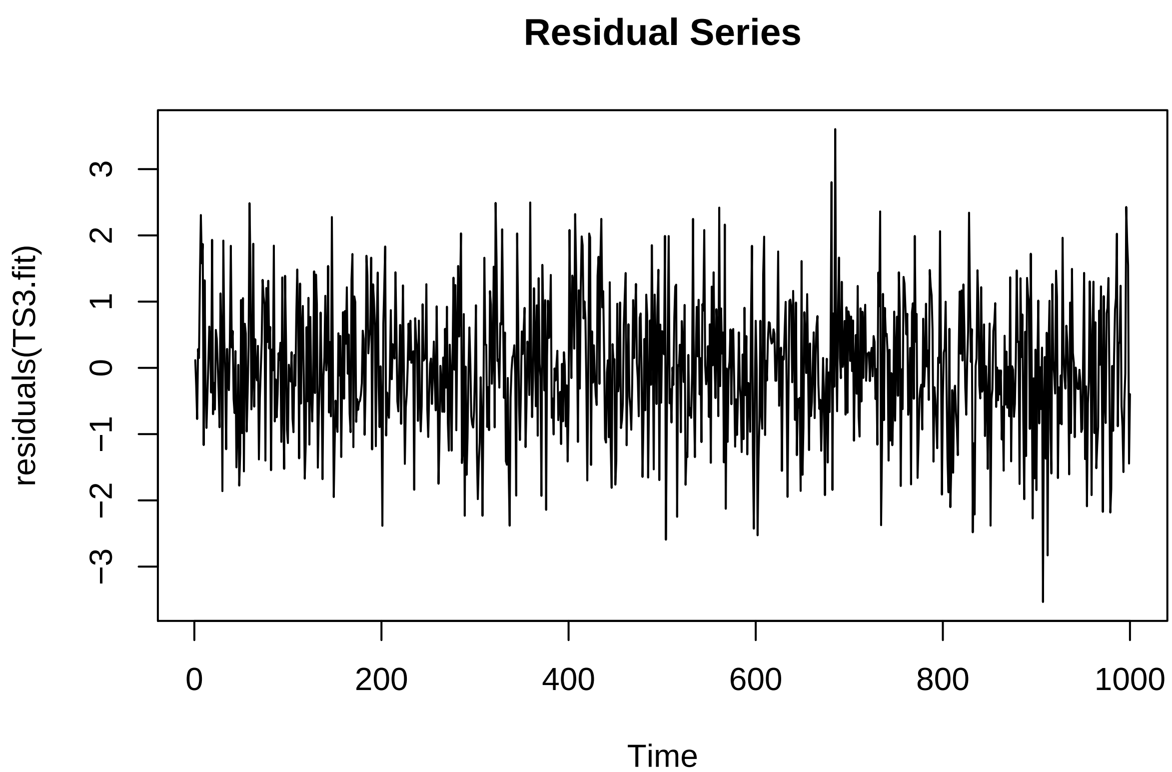
```
TS3.fit = arima(all$TS3, order = c(0, 0, 0))
TS3.fit
```

```
##
## Call:
## arima(x = all$TS3, order = c(0, 0, 0))
##
## Coefficients:
##       intercept
##          0.0211
## s.e.     0.0316
##
## sigma^2 estimated as 0.9961:  log likelihood = -1417,  aic = 2838
```

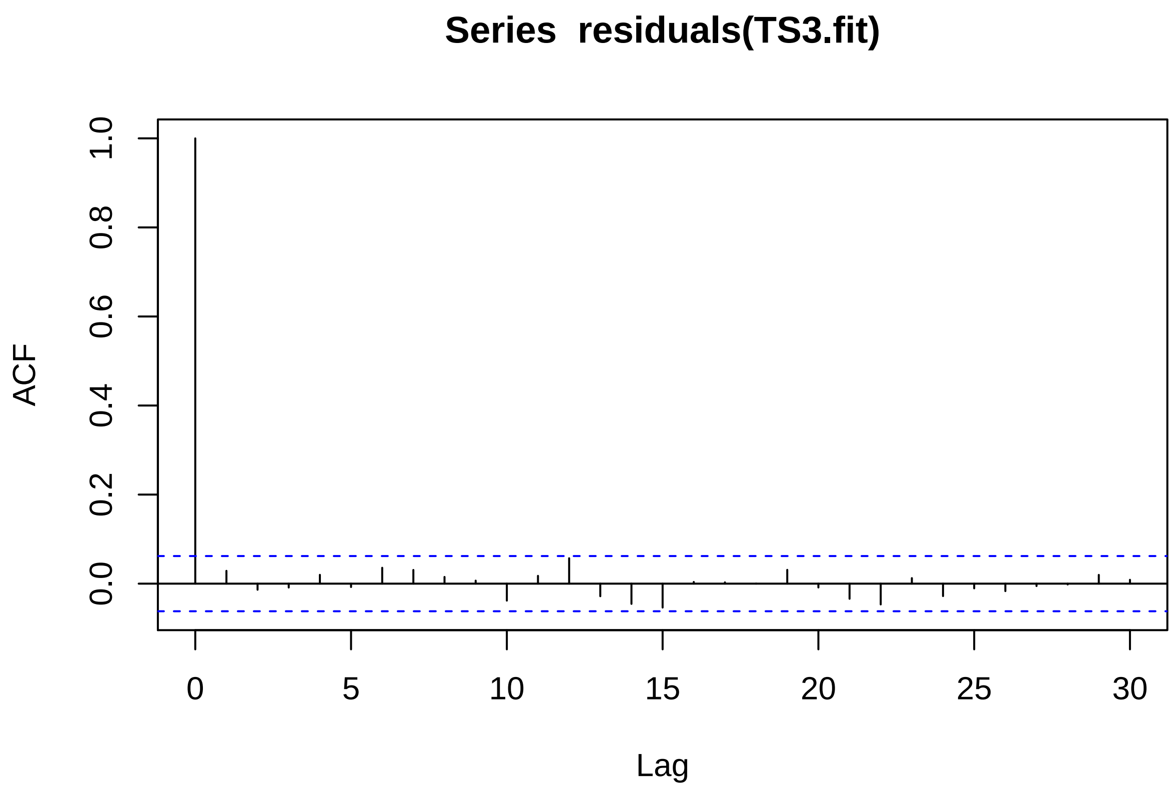
$y_t = \epsilon_t$

(iv)

```r
plot.ts(residuals(TS3.fit), main = "Residual Series")
```




```r
acf(residuals(TS3.fit))
```



Comments:

The residual series seemed to follow a normal distribution with a mean around 0. The variance are reasonably constant. The plot of ACF of the residuals showed no problems. All autocorrelation had been modeled.

(v)

Other models:

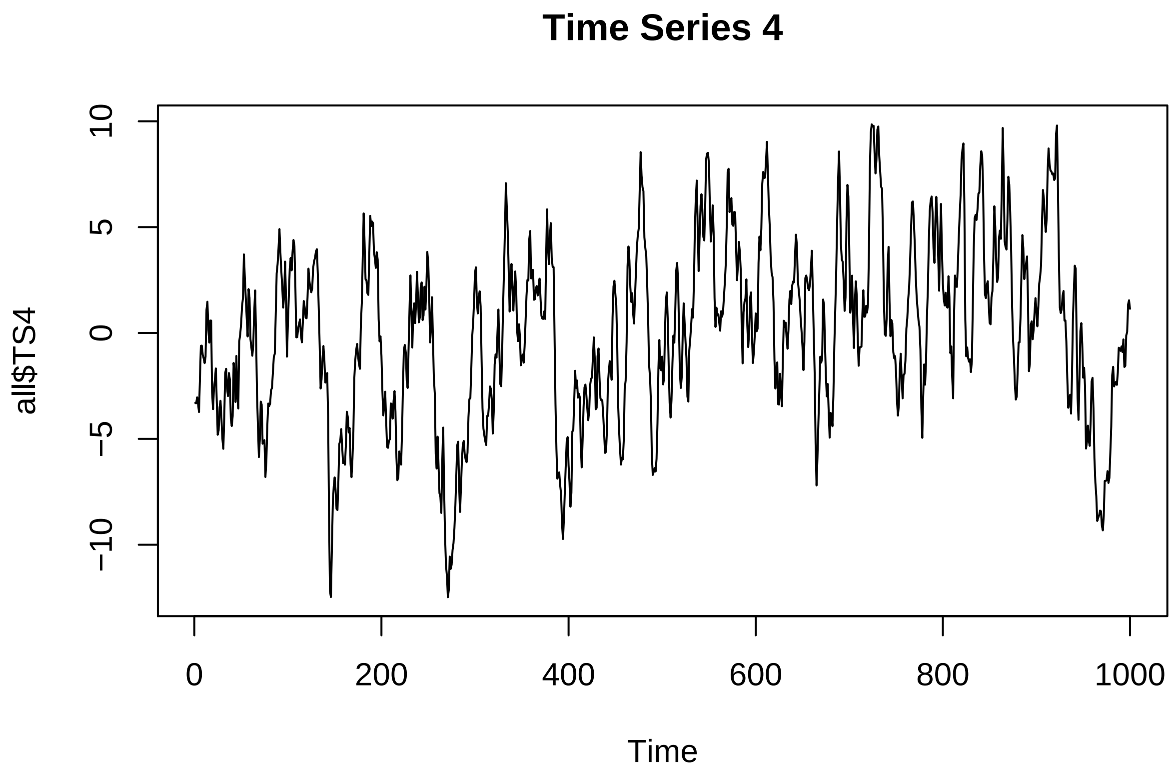
AR(1) AIC = 2839.17, the AR term is not significant MA(1) AIC = 2839.14, the MA term is not significant

The White Noise model has the smallest AIC (2838).

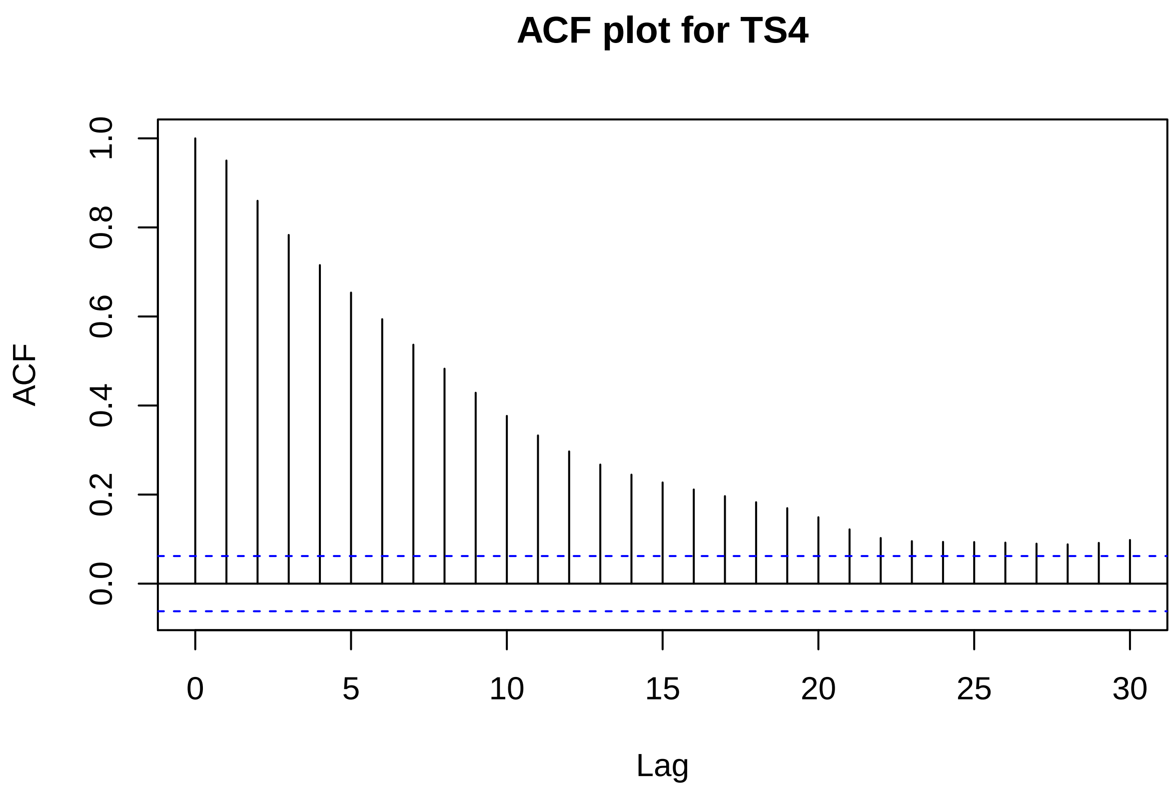
TS4:

(i)

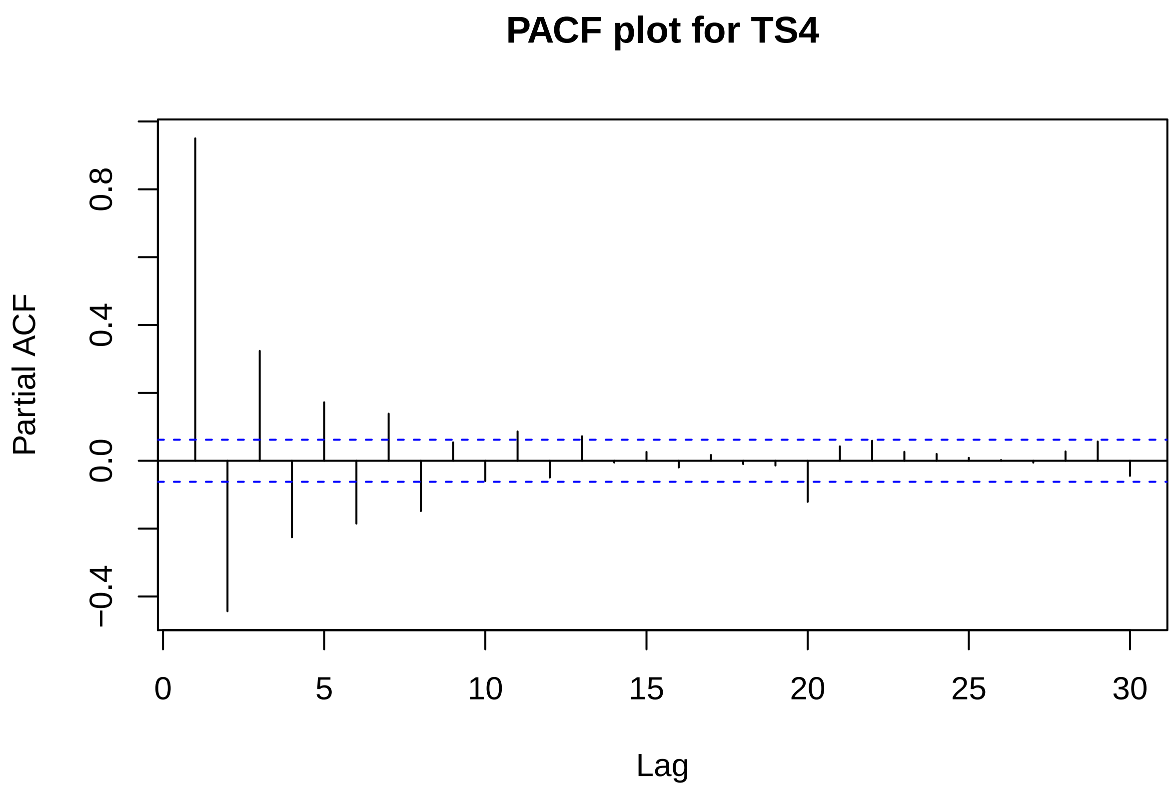
```
plot.ts(all$TS4, main = "Time Series 4")
```




```r
acf(all$TS4, main = "ACF plot for TS4")
```




```r
pacf(all$TS4, main = "PACF plot for TS4")
```



(ii)

$y_t = \rho_1 y_{t-1} + \epsilon_t + \alpha_1 \epsilon_{t-1}$

The most appropriate model will be ARMA(1, 1). From the series we can see some clustering and oscillation The plot of ACF showed decay and PACF also showed decay or some persistence. Since we don't know the order for the model we can start trying with ARMA(1,1).

(iii)

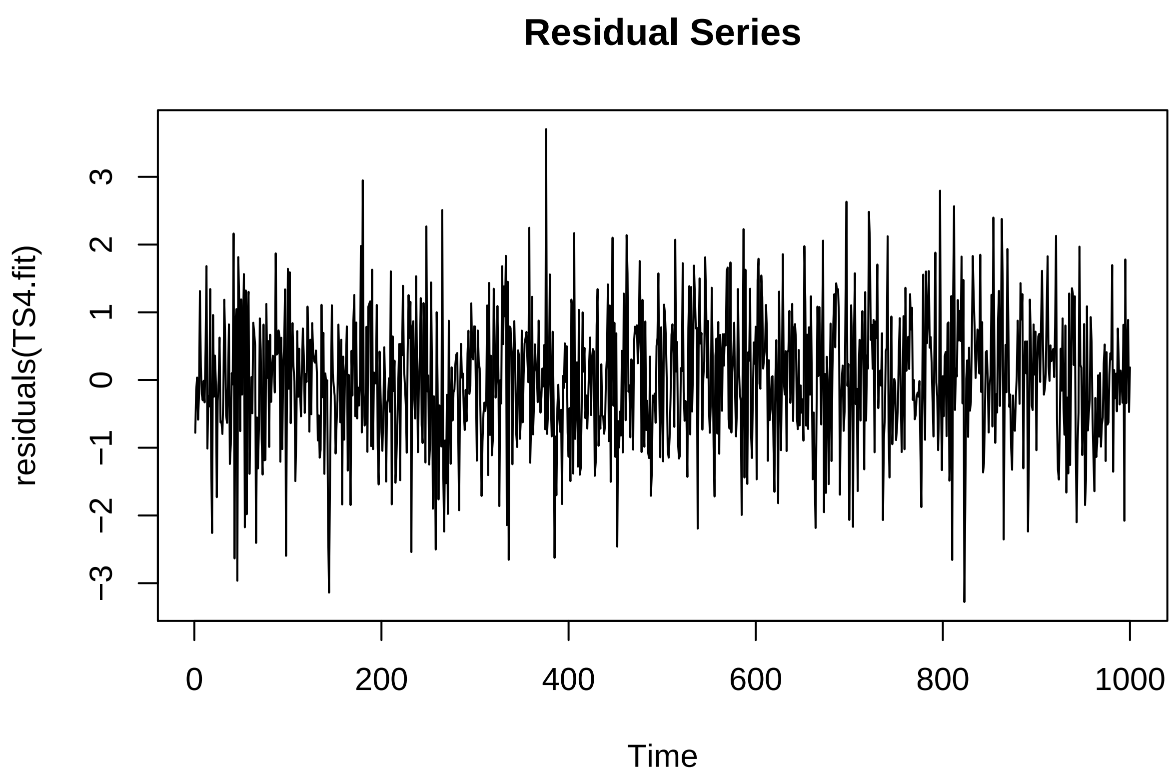
```r
TS4.fit = arima(all$TS4, order = c(1, 0, 1))
TS4.fit
```

```
##
## Call:
## arima(x = all$TS4, order = c(1, 0, 1))
##
## Coefficients:
##          ar1     ma1  intercept
##       0.8974  0.9121    -0.0147
## s.e.  0.0139  0.0128     0.5786
##
## sigma^2 estimated as 0.9828:  log likelihood = -1412.55,  aic = 2833.11
```

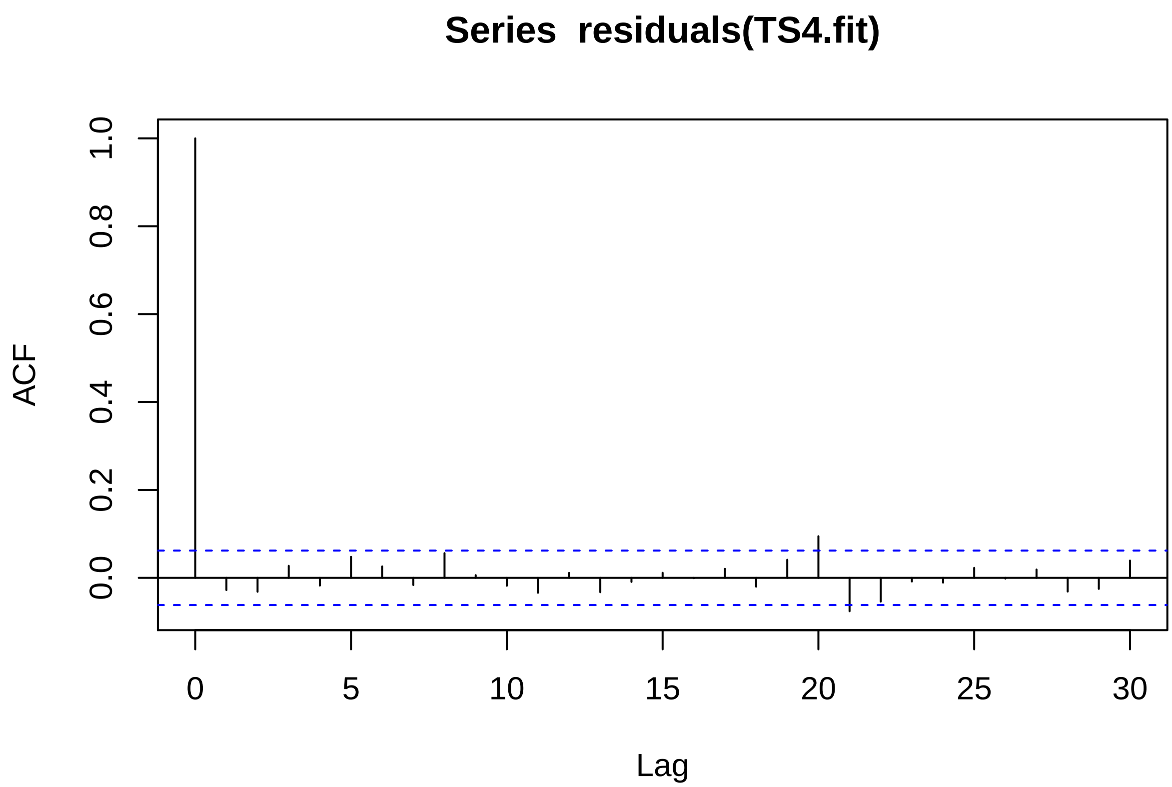
$y_t = 0.8974 y_{t-1} + \epsilon_t + 0.9121 \epsilon_{t-1}$

(iv)

```r
plot.ts(residuals(TS4.fit), main = "Residual Series")
```




```r
acf(residuals(TS4.fit))
```



Comments:

The residual series seemed to follow a normal distribution with a mean around 0. The variance are reasonably constant. The plot of ACF of the residuals showed at lag(20) and lag(21) they are slightly significant but it is not a big problem we can ignore.

(v)

Other models:

ARMA(2, 1) AIC = 2833.86, The 2nd AR term is not significant.

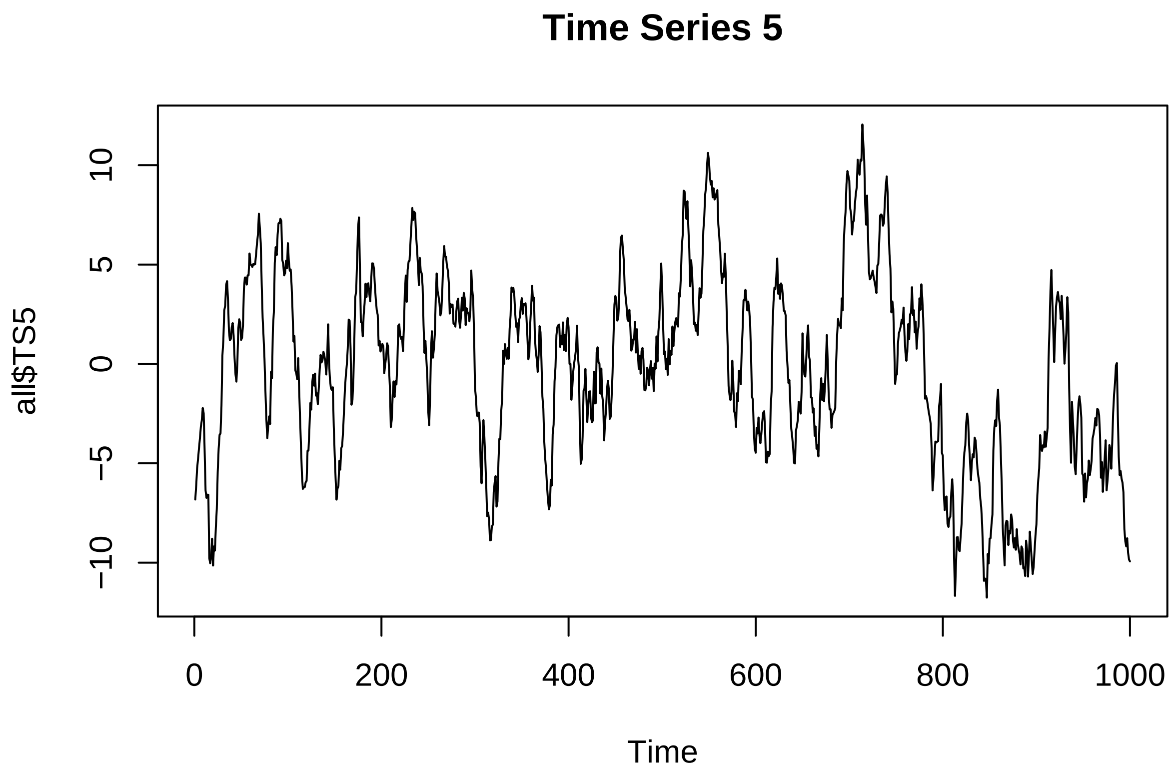
ARMA(1, 2) AIC = 2833.73, The 2nd MA term is not significant.

The ARMA(1, 1) model has the smallest AIC and all terms are significant.

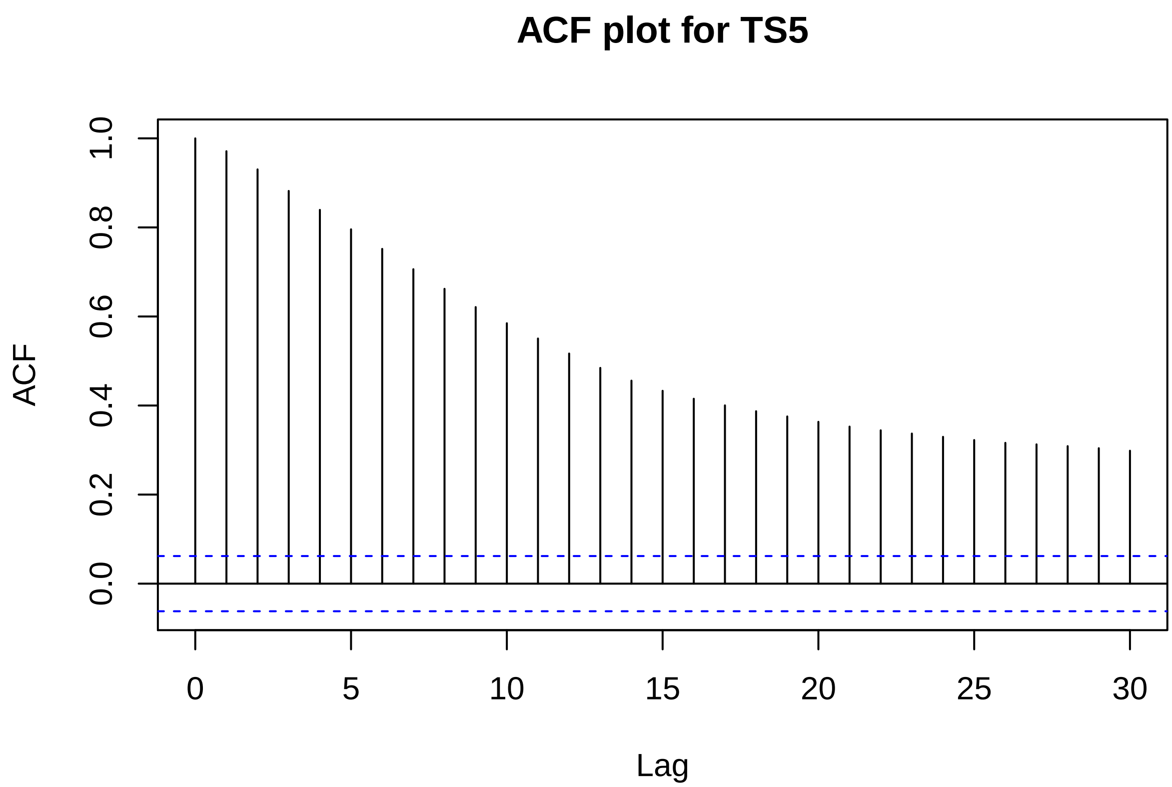
TS5:

(i)

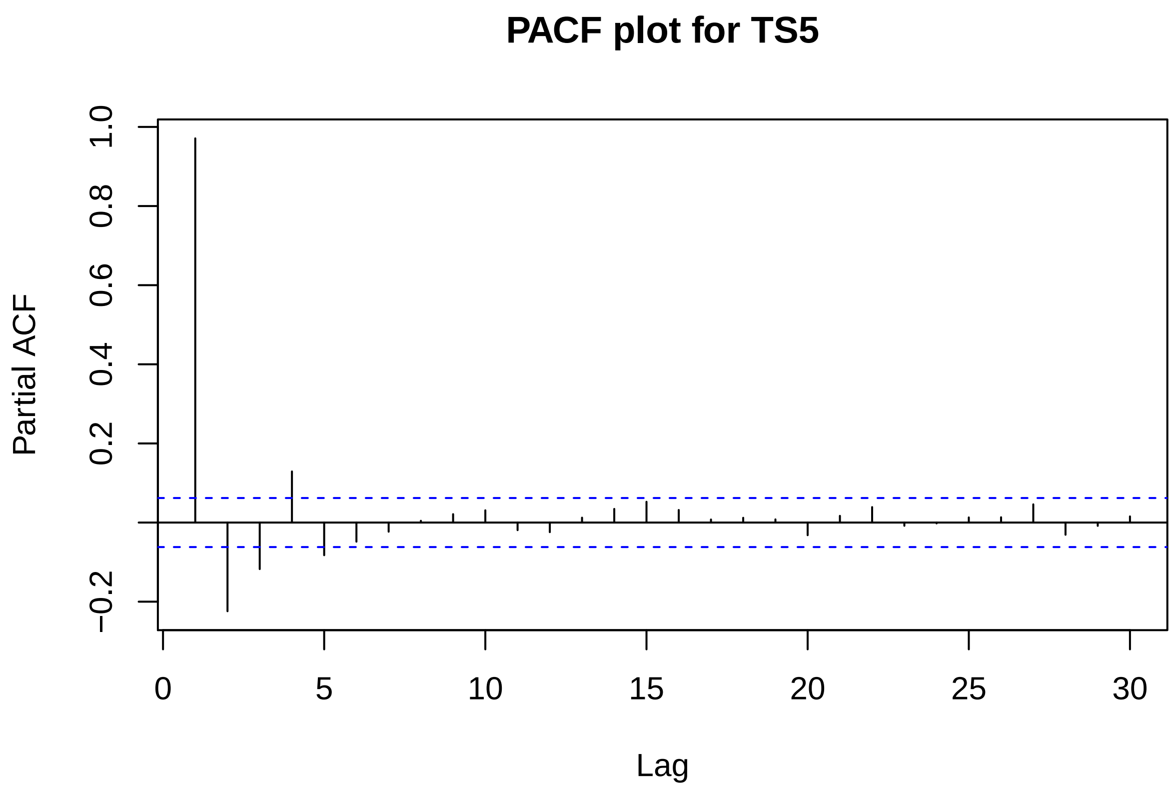
```r
plot.ts(all$TS5, main = "Time Series 5")
```




```r
acf(all$TS5, main = "ACF plot for TS5")
```




```
pacf(all$TS5, main = "PACF plot for TS5")
```



(ii)

$y_t = \rho_1 y_{t-1} + \epsilon_t + \alpha_1 \epsilon_{t-1}$

The most appropriate model will be ARMA(1, 1). From the series we can see strong clustering and some oscillation. The plot of ACF showed decay and PACF also showed decay. Since we don't know the order for the model we can start trying with ARMA(1,1).

(iii)

```r
TS5.fit = arima(all$TS5, order = c(1, 0, 1))
```

```
## Warning in arima(all$TS5, order = c(1, 0, 1)): possible convergence
## problem: optim gave code = 1
```

```r
TS5.fit
```

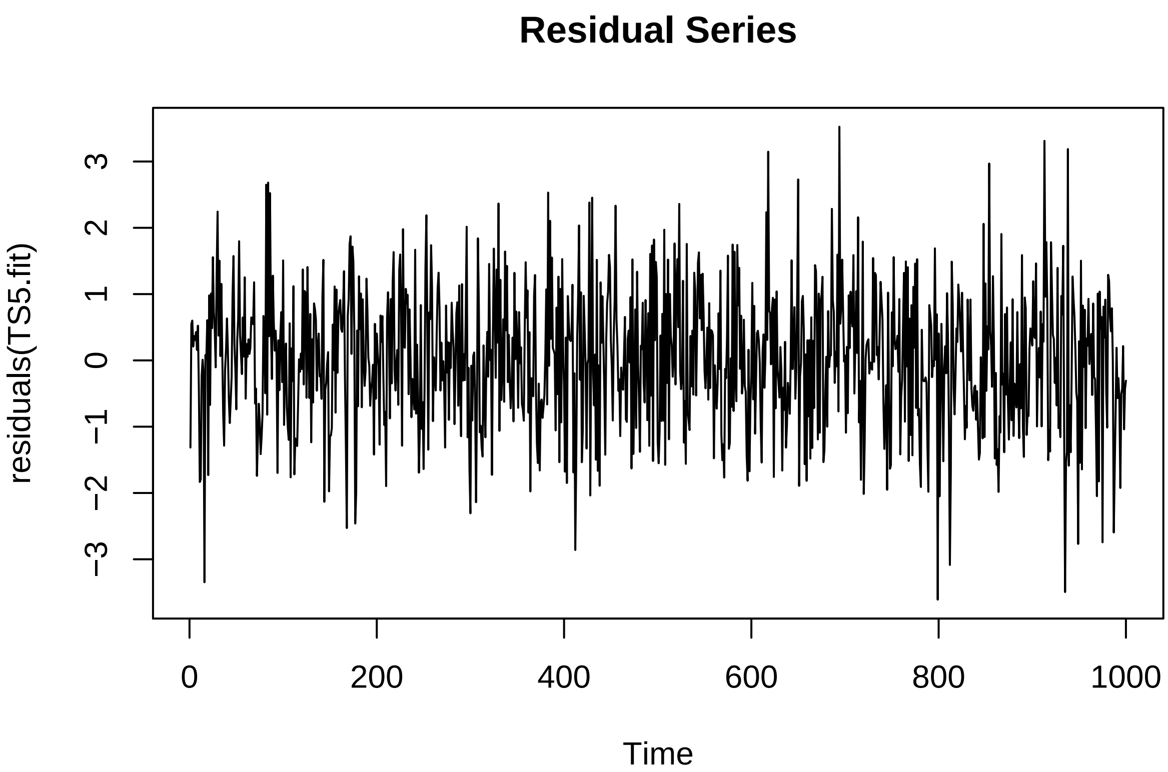
```
##
## Call:
## arima(x = all$TS5, order = c(1, 0, 1))
##
## Coefficients:
##          ar1     ma1  intercept
##       0.9674  0.1876    -0.6895
```

```
## s.e.   0.0082  0.0260     1.1571
##
## sigma^2 estimated as 1.063:  log likelihood = -1450.83,  aic = 2909.67
```

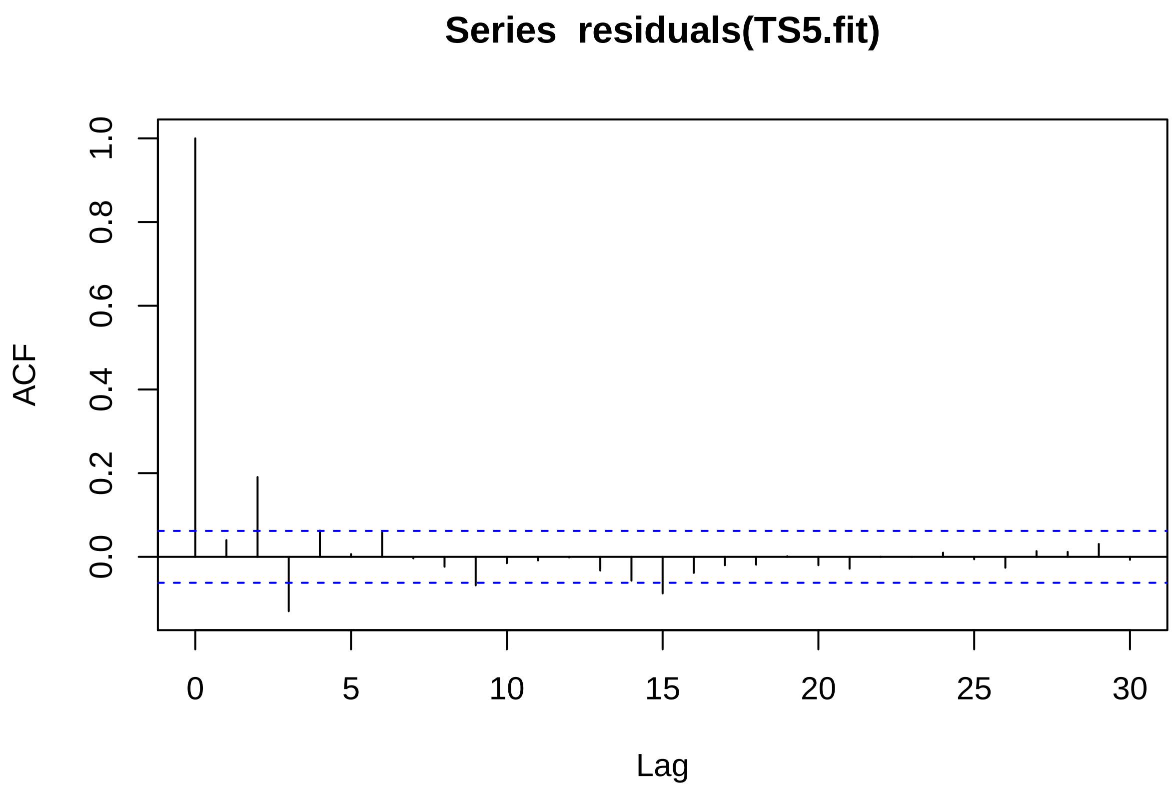
$y_t = 0.9674y_{t-1} + \epsilon_t + 0.1876\epsilon_{t-1}$

(iv)

```
plot.ts(residuals(TS5.fit), main = "Residual Series")
```




```
acf(residuals(TS5.fit))
```



Comments:

The residual series seemed to follow a normal distribution with a mean around 0. The variance are reasonably constant. But the plot of ACF of the residuals showed at lag(2) and lag(3) are significant.

(v)

Better model:

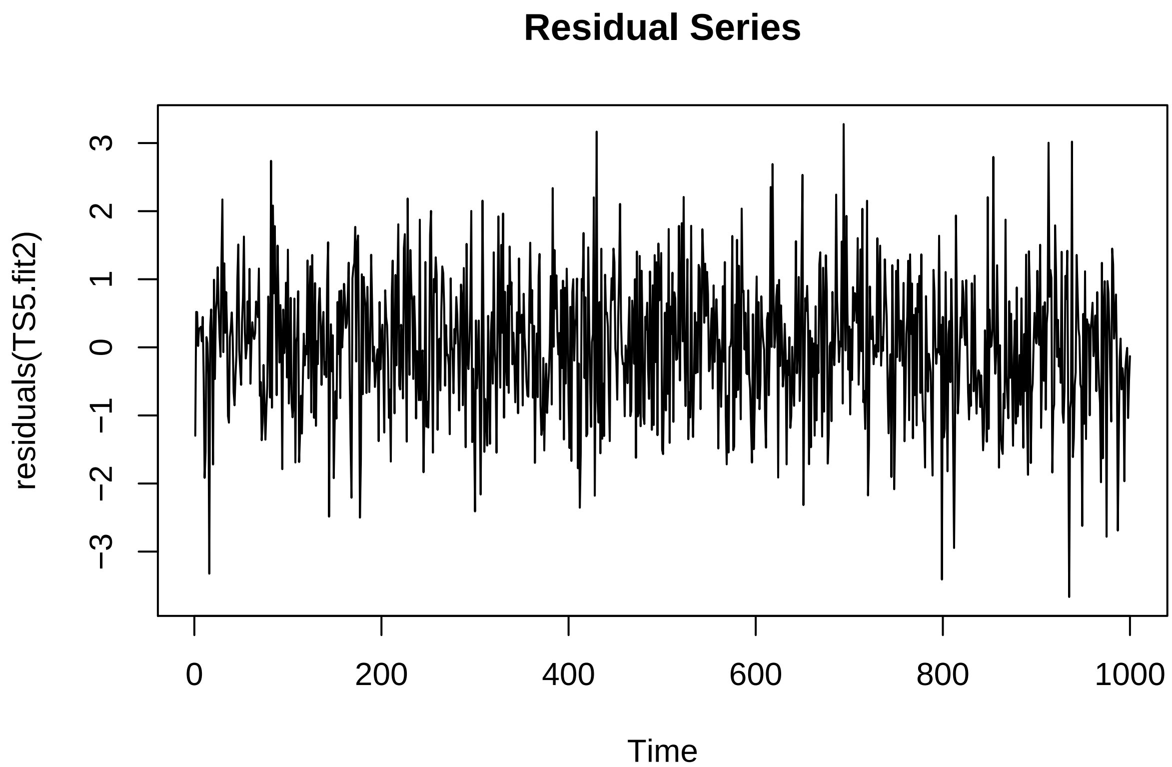
```r
# ARMA(2, 2)
TS5.fit2 = arima(all$TS5, order = c(2, 0, 2))
TS5.fit2
```

```
##
## Call:
## arima(x = all$TS5, order = c(2, 0, 2))
##
## Coefficients:
##          ar1     ar2     ma1     ma2  intercept
##       0.5840  0.3552  0.6361  0.3235    -0.5989
## s.e.  0.1063  0.1040  0.1014  0.0325     0.9989
##
## sigma^2 estimated as 0.9954:  log likelihood = -1418.31,  aic = 2848.63
```

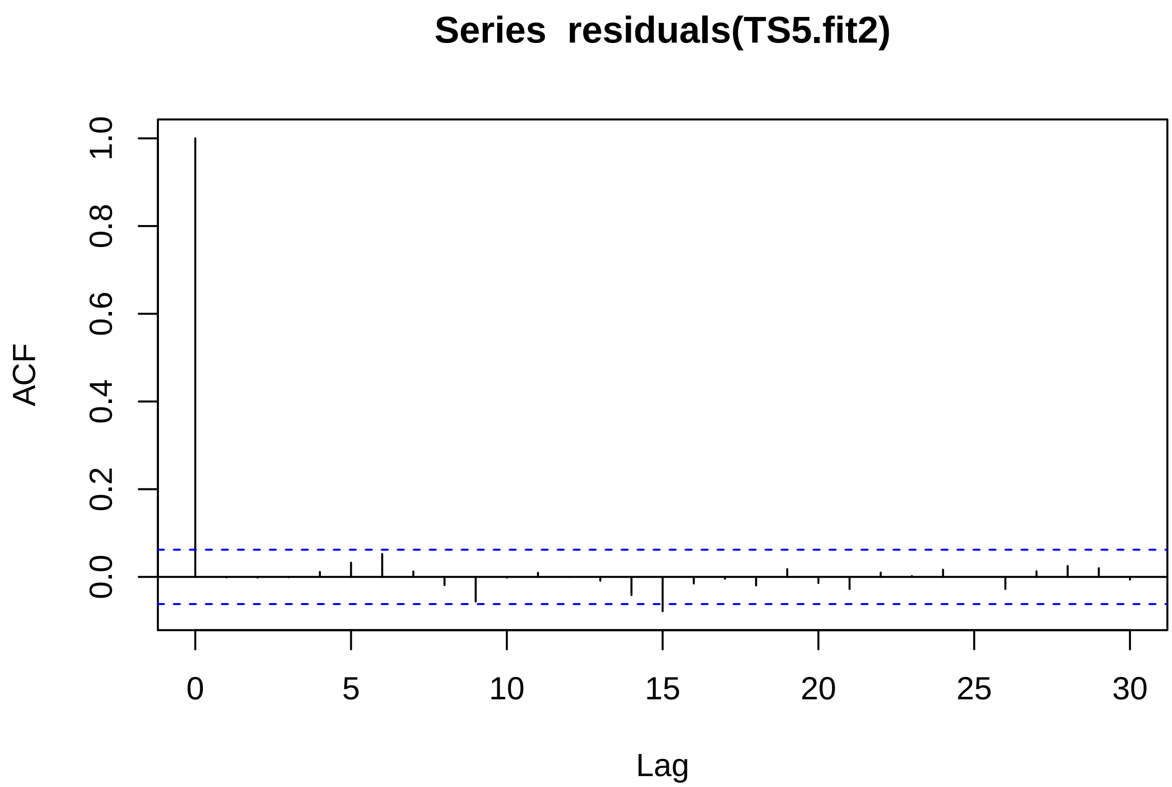
$y_t = 0.5840y_{t-1} + 0.3552y_{t-2} + \epsilon_t + 0.6361\epsilon_{t-1} + 0.3235\epsilon_{t-2}$

ARMA(2, 2) AIC = 2848.63

```r
plot.ts(residuals(TS5.fit2), main = "Residual Series")
```




```r
acf(residuals(TS5.fit2))
```



Comments:

The residual series seemed to follow a normal distribution with a mean around 0. The variance are reasonably constant. The plot of ACF of the residuals showed at lag(15) is slightly significant, but it is very weak so we can ignore it.