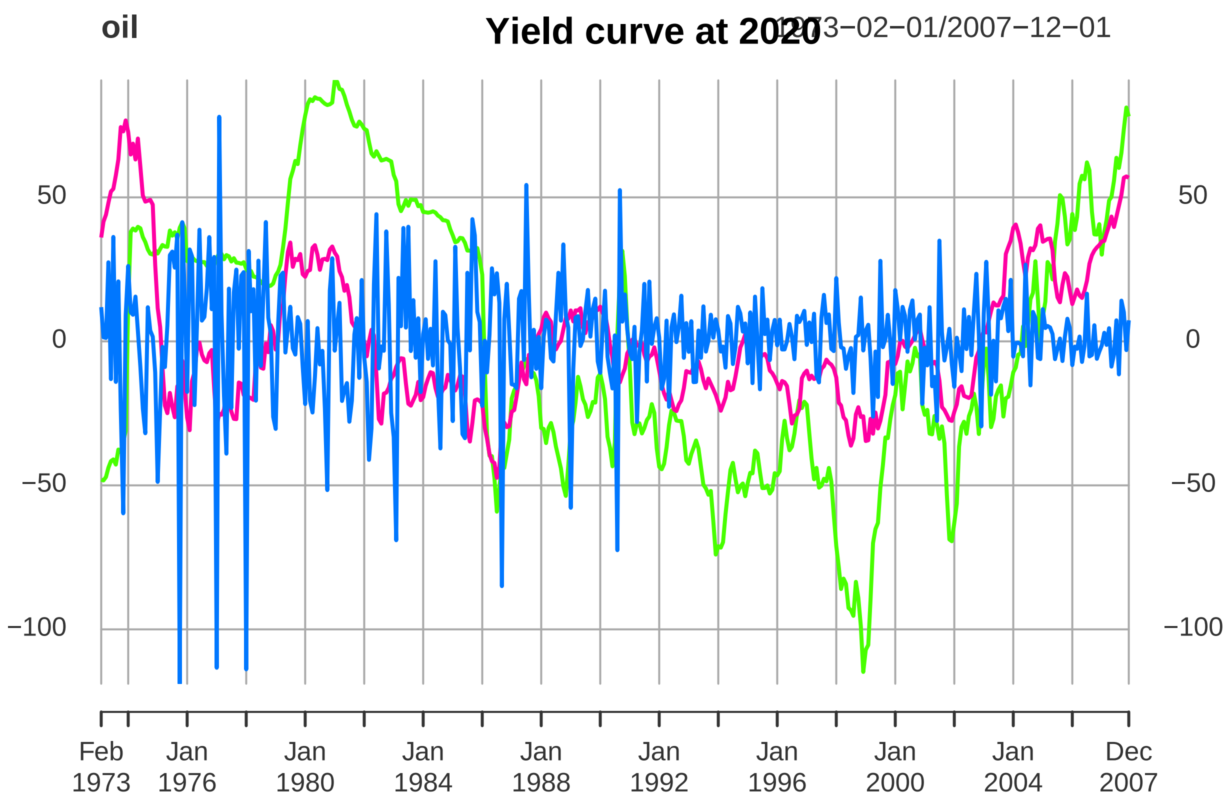
Assignement

Point 1

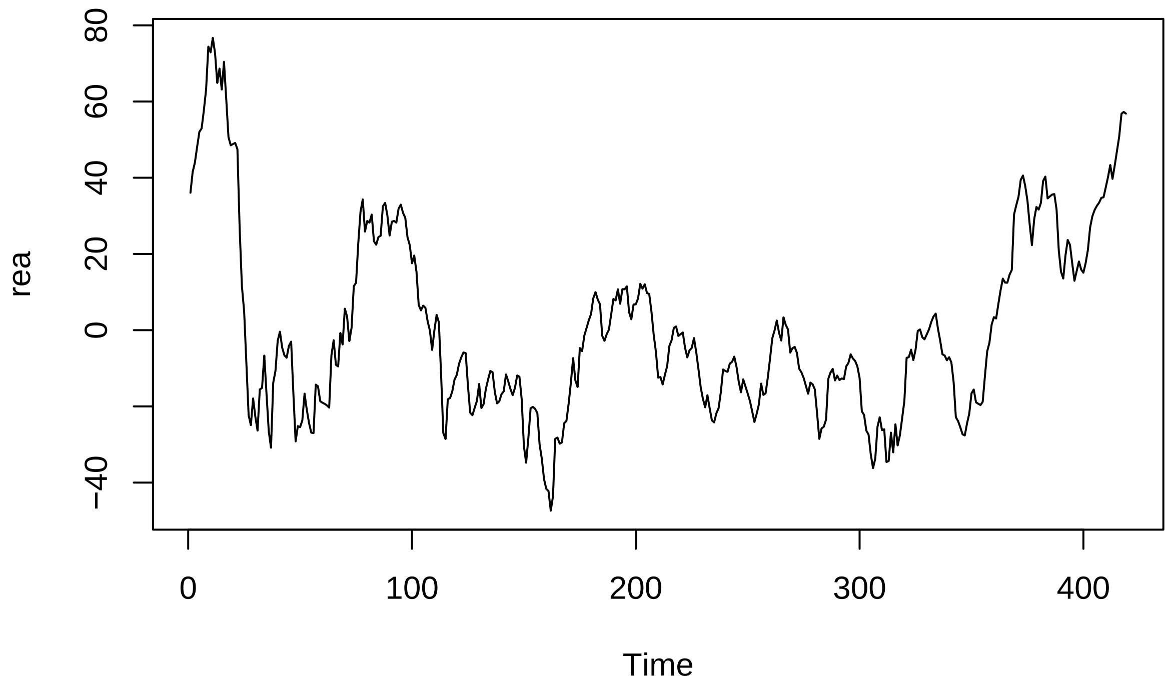
The time series below represents the monthly time series of: 1. % change in global crude oil production 2. the real price of oil 3. the real economy activity From 1973:1 to 2007:12.

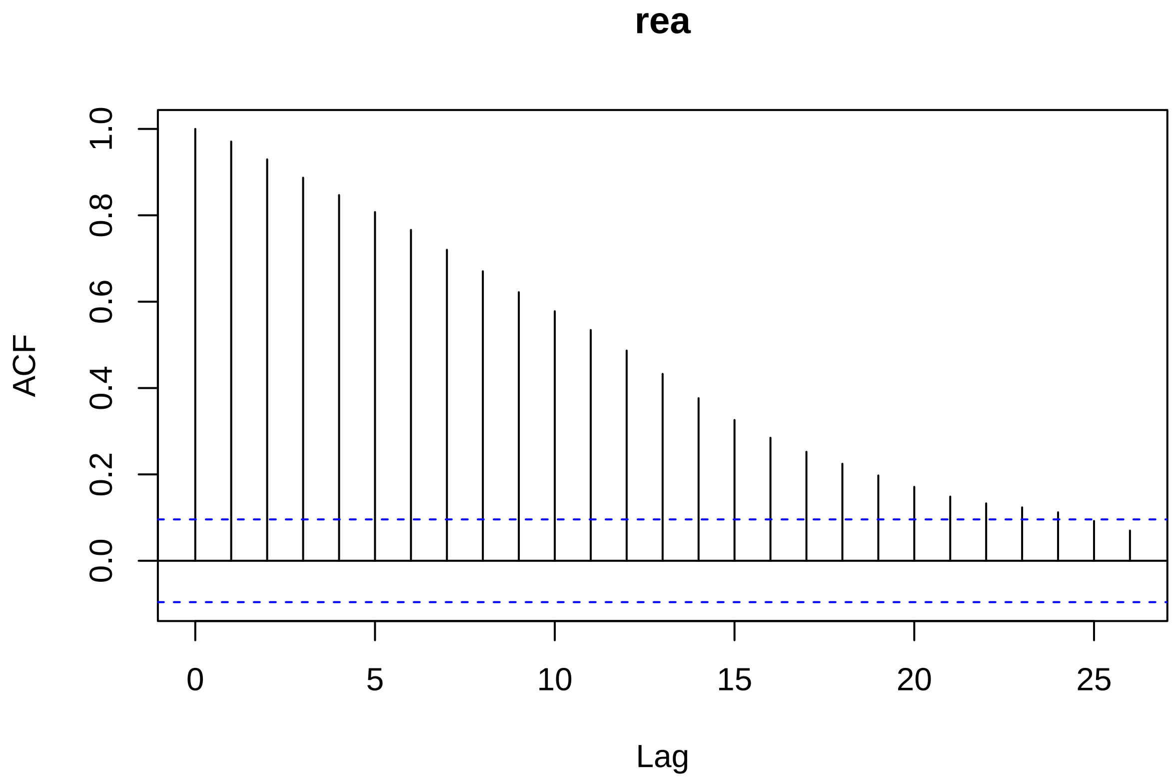


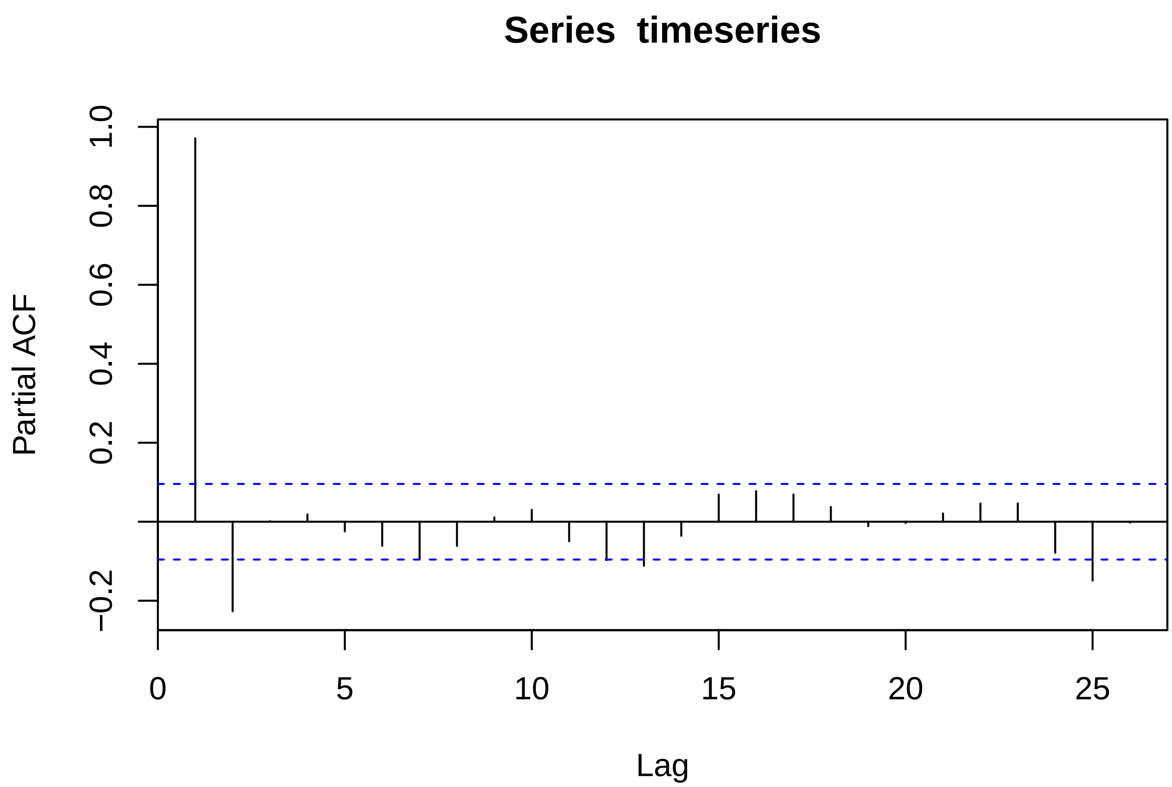
As we can see the acf its clear signaling the presence of an autcorrelation process. In order to test if the rea is an $I(1)$, we will use an ADF test with a minimun lag =1. We will perform the test specifing four different type of the process: 1. No consant, no trend 2. Constant 4. Costant with trend First, we print the first times series graph. We perform the different type of the test with a maximun lag order of 12:

$$rea_t = \alpha + \sigma_1 reat_(t-1) + ... + \sigma_1 2\delta reat_(t-13)$$

The criteria for selection of the lag order is the one which has lower BIC:


rea
80
60
40
20
0
−40
0
100
200
300
400
Time


rea
ACF
1.0
0.8
0.6
0.4
0.2
0.0
0
5
10
15
20
25
Lag




```
## [1] "Without constant and without time trend"
```

```
##
## === Test statistics =========
##                tau1
## statistic -3.056092
##
## === Test critical values ====
##       1pct  5pct 10pct
## tau1 -2.58 -1.95 -1.62
##
## === Combined output =========
## [1] "-3.06 [1]***"
```

```
## [1] "With constant and without time trend"
```

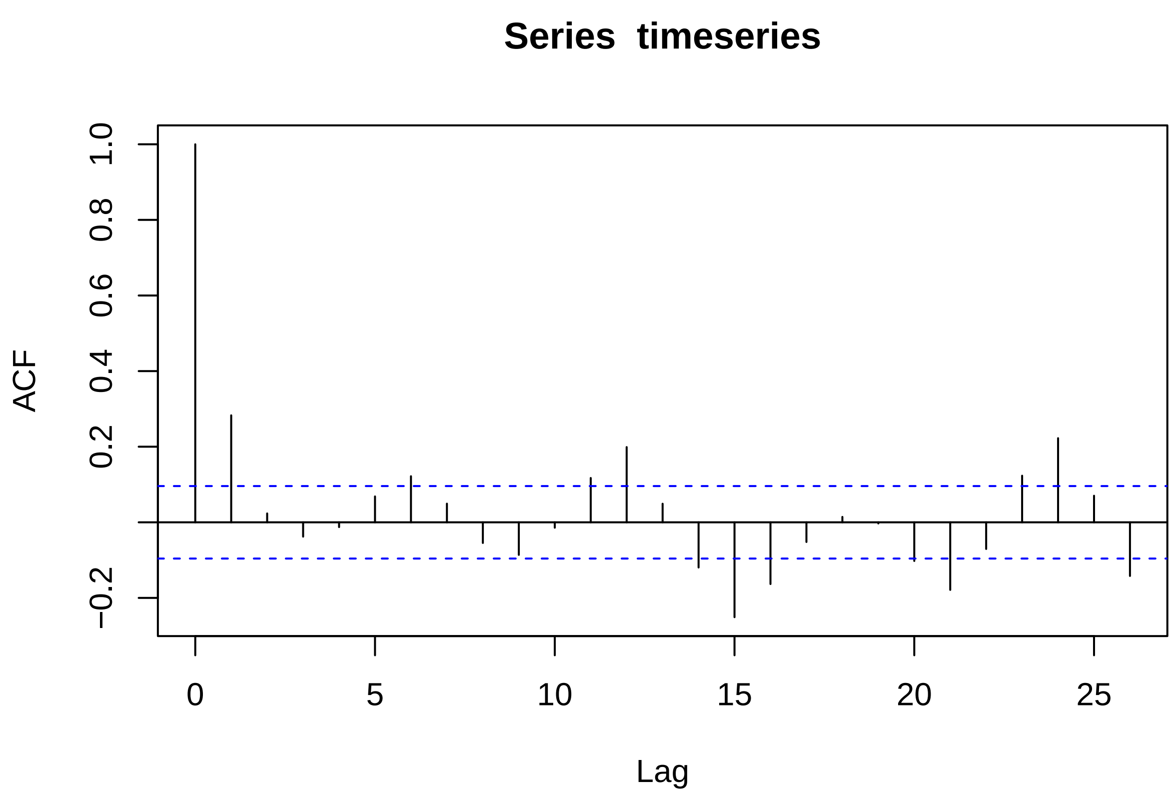
```
##
## === Test statistics =========
##                tau2     phi1
## statistic -3.064165 4.695391
##
## === Test critical values ====
##       1pct  5pct 10pct
## tau2 -3.44 -2.87 -2.57
## phi1  6.47  4.61  3.79
##
## === Combined output =========
## [1] "-3.06 [1]**"
```

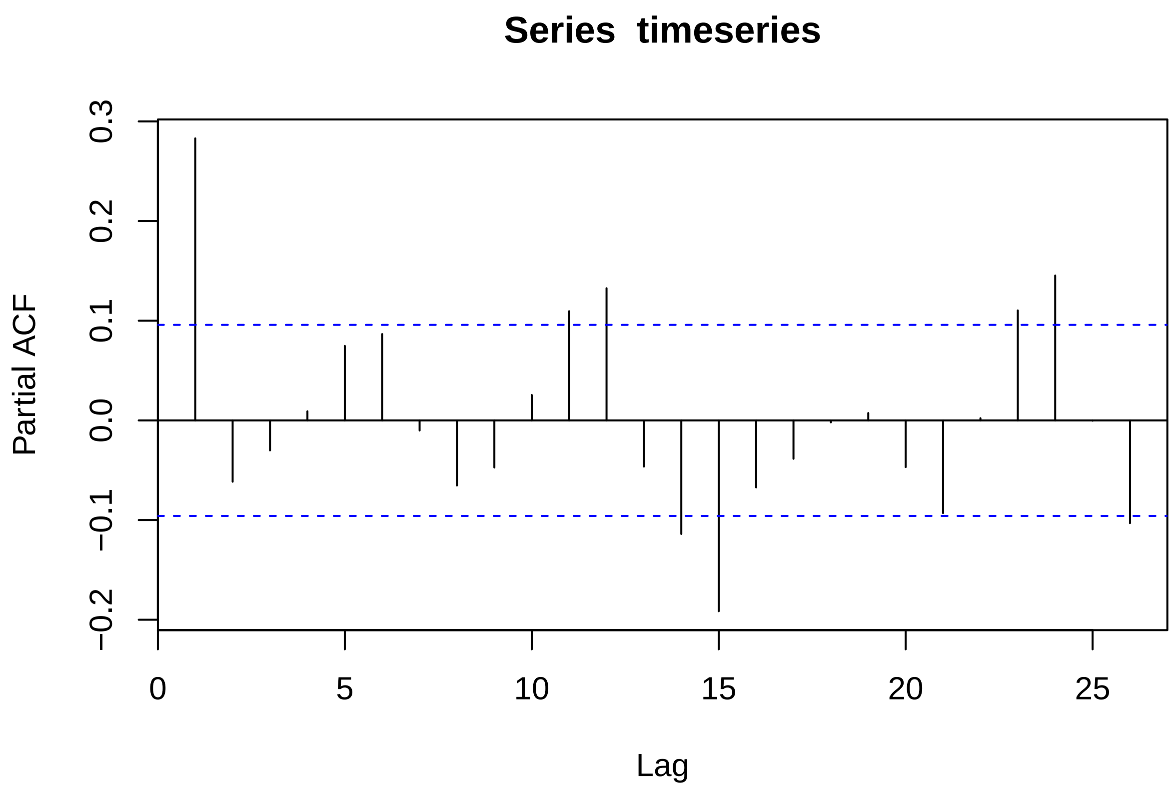
```
## [1] "With constant and with time trend"
##
## === Test statistics =========
##                 tau3     phi2     phi3
## statistic -3.283632 4.530211 6.794472
##
## === Test critical values ====
##       1pct  5pct 10pct
## tau3 -3.98 -3.42 -3.13
## phi2  6.15  4.71  4.05
## phi3  8.34  6.30  5.36
##
## === Combined output =========
## [1] "-3.28 [1]*"
```

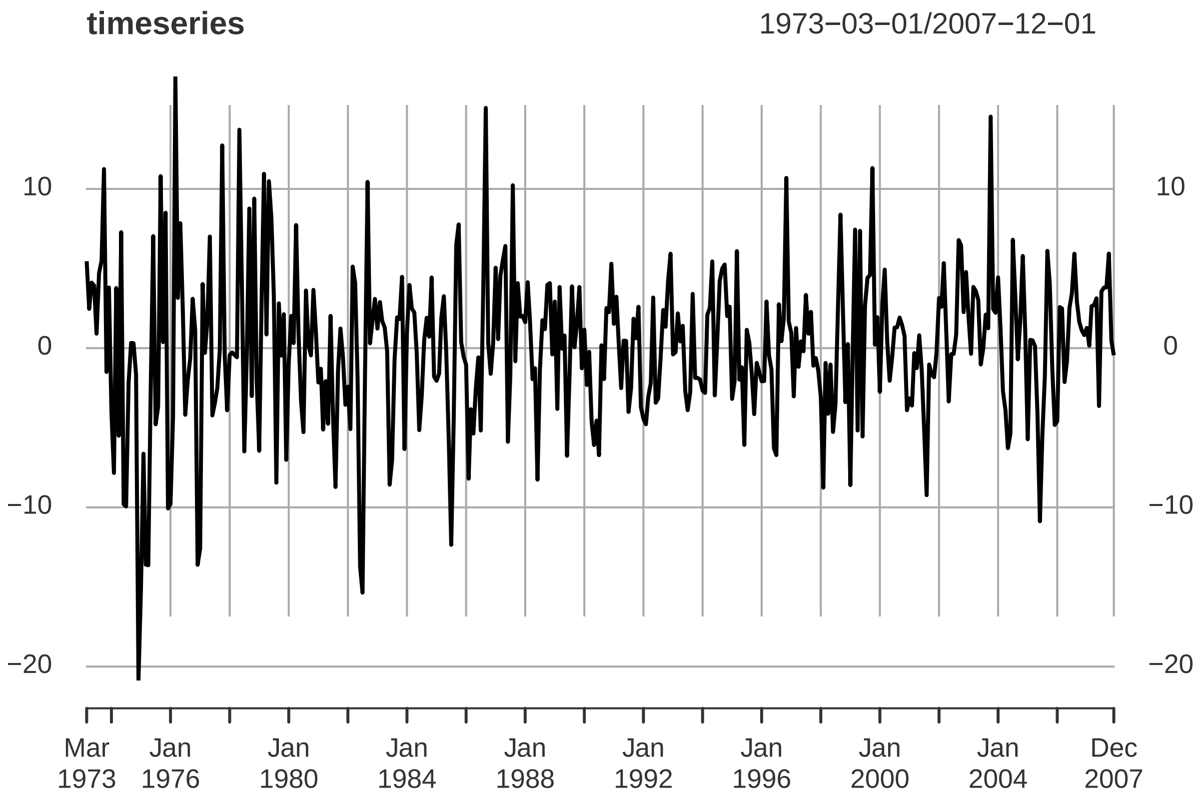
The results of the ADF tests show the process is not stationary with a $alpha < 10$, so there are no sufficent empirical evidence to reject the null. Thus the *rea* time series is not a covariance-stationary process with a minium lag of order 1.

Point 2

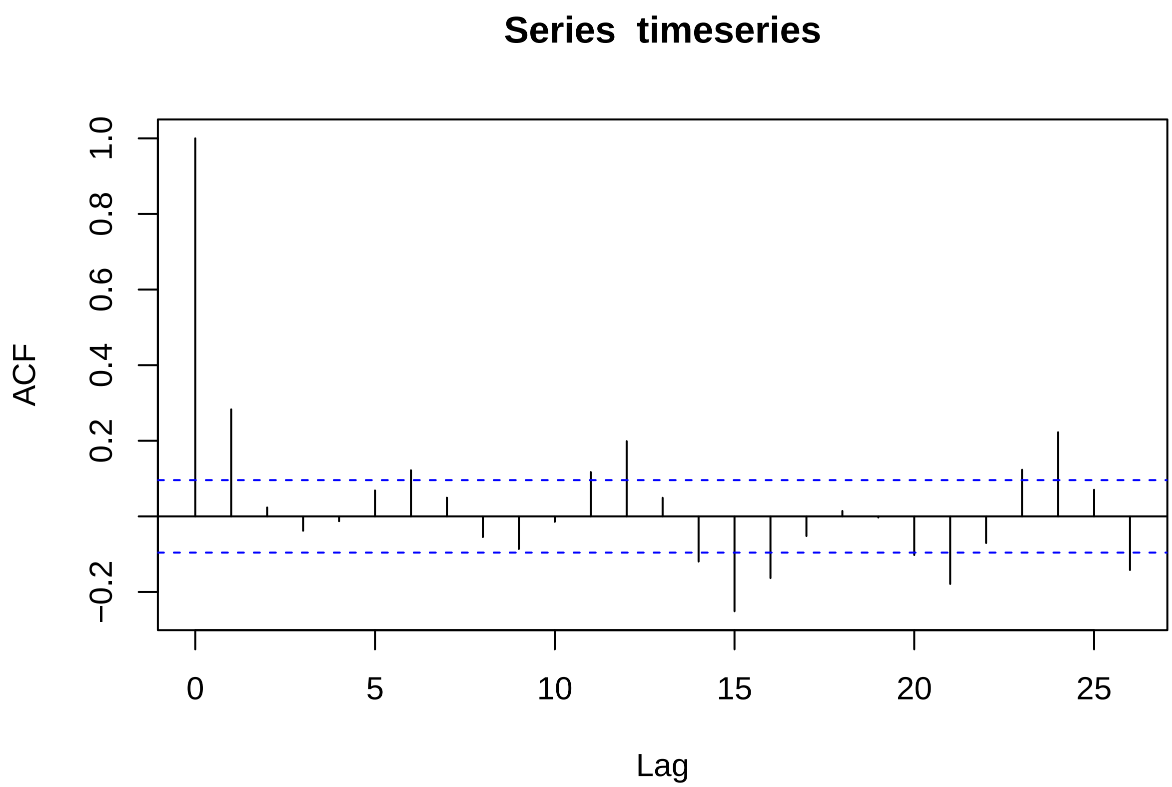
We take the first difference of the timeseries *rea* and check if it is stationary with an adf test. Before that we print the time series of the first differences, the acf, and the pacf to understand the correct specification for the ADF test.

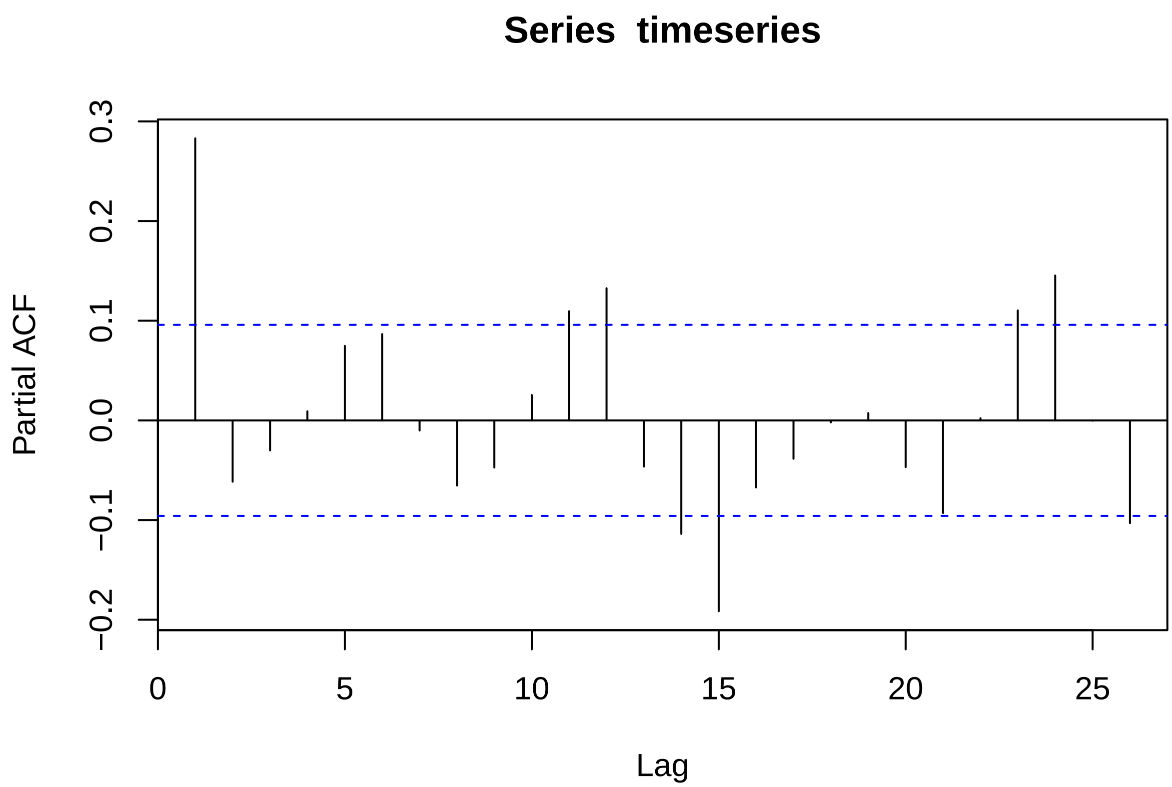



Series timeseries
Partial ACF
Lag
0.3
0.2
0.1
0.0
−0.1
−0.2
0
5
10
15
20
25



timeseries
1973−03−01/2007−12−01
10
0
−10
−20
Mar 1973
Jan 1976
Jan 1980
Jan 1984
Jan 1988
Jan 1992
Jan 1996
Jan 2000
Jan 2004
Dec 2007


Series timeseries
ACF
−0.2
0.2
0.4
0.6
0.8
1.0
0
5
10
15
20
25
Lag



The above graphs clearly underline the stationarity of the process, indeed the acf for the $lag > 2$ the partial autcorrelation is not statisticaly different from 0. As for the partial autcorrelation that is statistically different only for some lag>10. From the plot of the time series we can see a mean reverting process, and so I will opt for the specifications with constant and time trend, becouse it is less restricitve. So the test will have the following specifications:

$$\delta rea_t = \sigma_1 \delta reat_(t-1) + ... + \sigma_1 2 \delta reat_(t-13)$$

$$\delta rea_t = \alpha + \sigma_1 \delta reat_(t-1) + ... + \sigma_1 2 \delta reat_(t-13)$$

$$\delta rea_t = \alpha + \beta * t + \sigma_1 \delta reat_(t-1) + ... + \sigma_1 2 \delta reat_(t-13)$$

The test will be performed with all passible four specification, and will be selected the specification with lower adf value.

```
## [1] "Without constant and without time trend"
```

```
##
## === Test statistics =========
##                 tau1
## statistic -12.92825
##
## === Test critical values ====
##       1pct  5pct 10pct
## tau1 -2.58 -1.95 -1.62
##
## === Combined output =========
## [1] "-12.93 [1]***"
```

```
## [1] "With constant and without time trend"
```

```
##
## === Test statistics =========
##                 tau2     phi1
## statistic -12.91292 83.37187
##
## === Test critical values ====
##       1pct  5pct 10pct
## tau2 -3.44 -2.87 -2.57
## phi1  6.47  4.61  3.79
##
## === Combined output =========
## [1] "-12.91 [1]***"
```

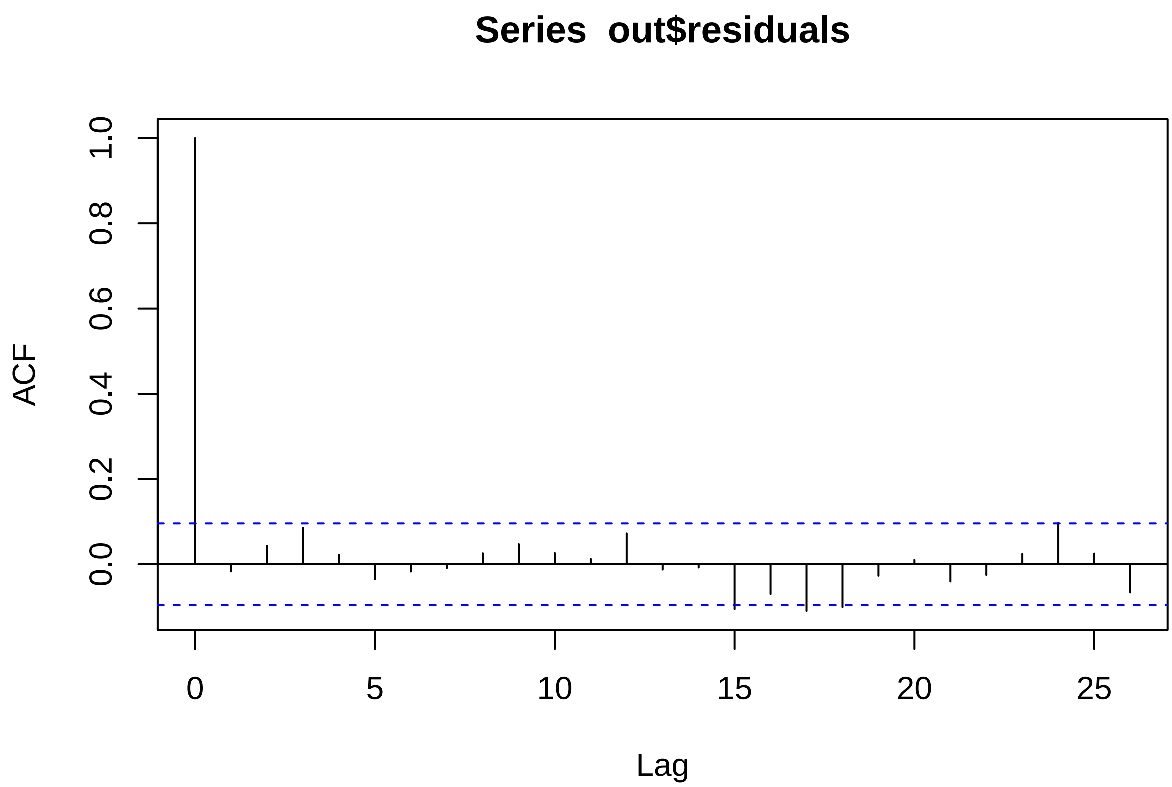
```
## [1] "With constant and with time trend"
```

```
##
## === Test statistics =========
##                 tau3     phi2     phi3
## statistic -13.09473 57.15755 85.73616
##
## === Test critical values ====
##       1pct  5pct 10pct
## tau3 -3.98 -3.42 -3.13
## phi2  6.15  4.71  4.05
## phi3  8.34  6.30  5.36
##
## === Combined output =========
## [1] "-13.09 [1]***"
```

The test above shows the stationarity of the process with an $\alpha >= 1$, (indipendetemente dalla specificazione)

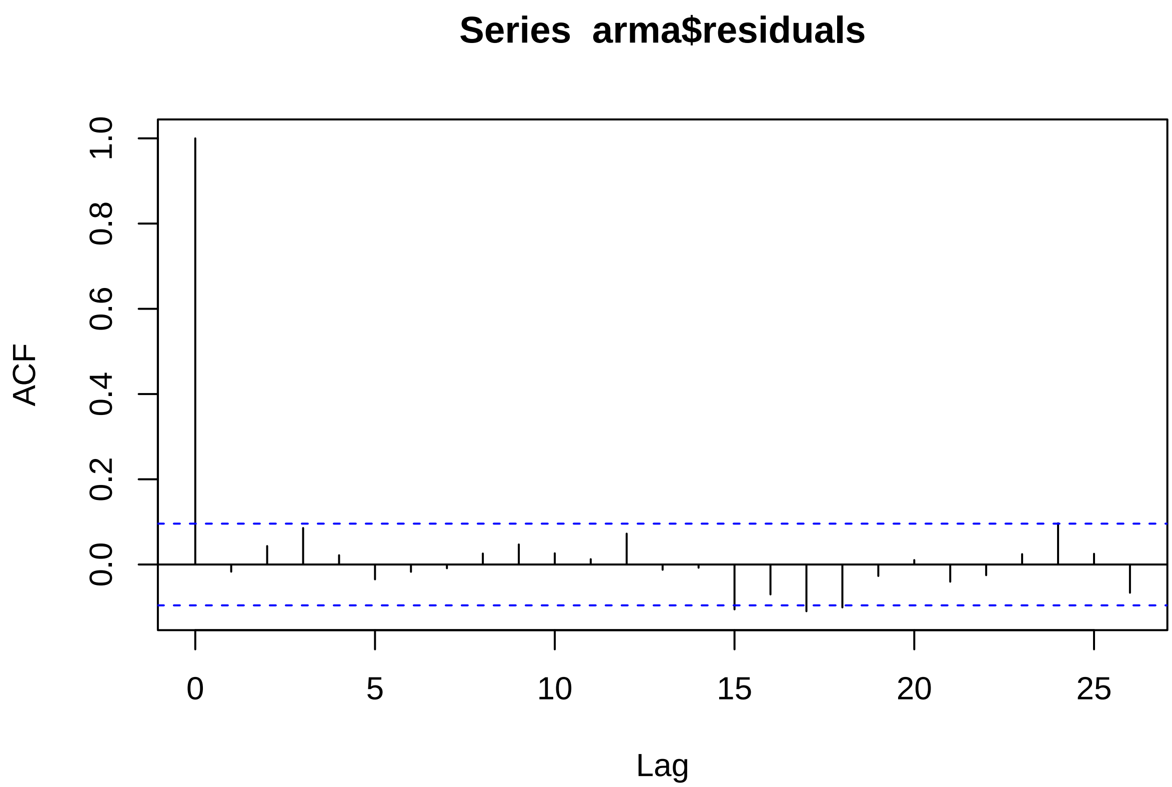
Point 3

We select the best arma model setting the iper-paramenters (p,q), using the BIC criteria:




```
## p   q
## 3 0 2
```

```
##
## Call:
## arima(x = timeseries, order = best_arima, method = "ML")
##
## Coefficients:
##          ar1      ar2     ar3      ma1     ma2  intercept
##       1.2744  -1.2749  0.2778  -1.0256  0.9999     0.0463
## s.e.  0.0481   0.0476  0.0479   0.0144  0.0206     0.2841
##
## sigma^2 estimated as 18.6:  log likelihood = -1207.93,  aic = 2429.85
##
## Training set error measures:
##                       ME     RMSE      MAE      MPE     MAPE      MASE
## Training set 0.004933059 4.312641 3.282753 65.44706 204.7996 0.7697536
##                     ACF1
## Training set -0.01683306
```



The autcorrelation function of the residuals it is not statistically different from 0, it looks like white noise. So the arma model adopted is one the fit perfectly the time series:

$$y_t = \theta_1 y_(t-1) + \theta_2 y_(t-2) + \theta_3 y_(t-3) + \beta_1 \epsilon_(t-1) + \beta_2 \epsilon_(t-2) + \epsilon_(t)$$

The issue regarding this model is an overfitting one, since all the point in the timeseries has been used to fit the model, as opposite to the usual practice. But the aim of this model is not to provide a prediction for the series, but instead the understading of the process in the specific time span of the series.

Point 4

```
## Augmented Dickey-Fuller Test
## alternative: stationary
##
## Type 1: no drift no trend
##      lag  ADF p.value
## [1,]   0 22.3    0.99
## [2,]   1 32.7    0.99
## [3,]   2 41.8    0.99
## [4,]   3 50.3    0.99
## [5,]   4 59.7    0.99
## [6,]   5 66.9    0.99
## Type 2: with drift no trend
##      lag  ADF p.value
## [1,]   0 22.3    0.99
## [2,]   1 32.7    0.99
```

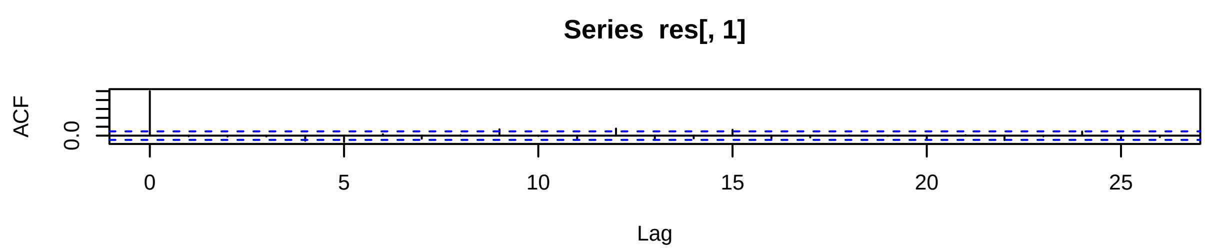
```
## [3,]   2 41.9    0.99
## [4,]   3 50.5    0.99
## [5,]   4 60.1    0.99
## [6,]   5 67.4    0.99
## Type 3: with drift and trend
##      lag  ADF p.value
## [1,]   0 22.3    0.99
## [2,]   1 32.7    0.99
## [3,]   2 41.9    0.99
## [4,]   3 50.5    0.99
## [5,]   4 60.1    0.99
## [6,]   5 67.5    0.99
## ----
## Note: in fact, p.value = 0.01 means p.value <= 0.01
```

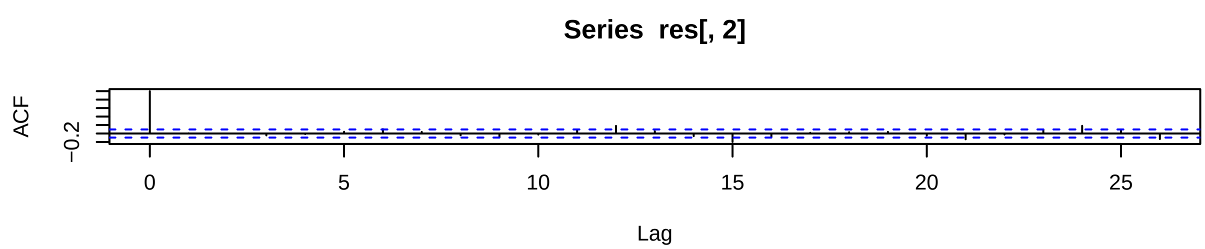
```
## Augmented Dickey-Fuller Test
## alternative: stationary
##
## Type 1: no drift no trend
##      lag  ADF p.value
## [1,]   0 2.47   0.990
## [2,]   1 1.42   0.960
## [3,]   2 1.60   0.973
## [4,]   3 1.63   0.975
## [5,]   4 1.56   0.970
## [6,]   5 1.35   0.955
## Type 2: with drift no trend
##      lag  ADF p.value
## [1,]   0 2.46    0.99
## [2,]   1 1.41    0.99
## [3,]   2 1.60    0.99
## [4,]   3 1.63    0.99
## [5,]   4 1.56    0.99
## [6,]   5 1.35    0.99
## Type 3: with drift and trend
##      lag  ADF p.value
## [1,]   0 2.47    0.99
## [2,]   1 1.42    0.99
## [3,]   2 1.61    0.99
## [4,]   3 1.64    0.99
## [5,]   4 1.57    0.99
## [6,]   5 1.36    0.99
## ----
## Note: in fact, p.value = 0.01 means p.value <= 0.01
```

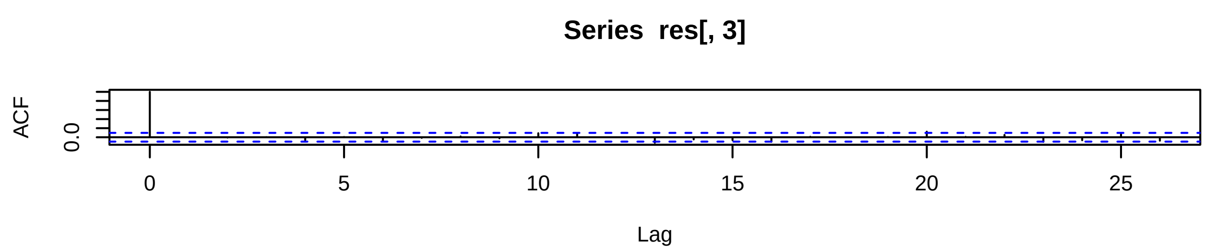
```
## Augmented Dickey-Fuller Test
## alternative: stationary
##
## Type 1: no drift no trend
##      lag   ADF p.value
## [1,]   0 1.852   0.984
## [2,]   1 0.579   0.811
## [3,]   2 0.886   0.899
## [4,]   3 0.933   0.906
## [5,]   4 1.072   0.923
```

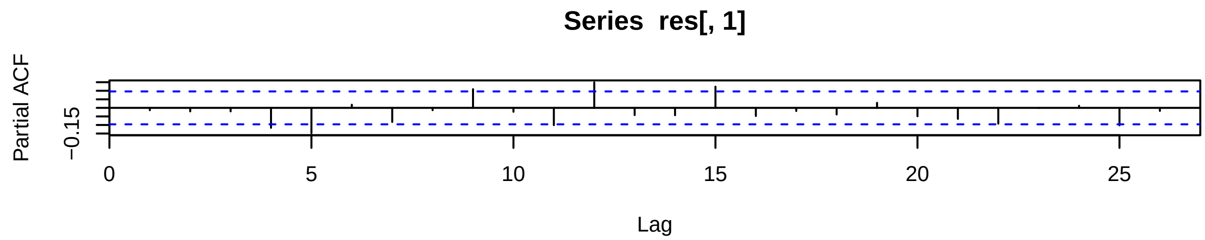
```
## [6,]   5 1.081   0.924
## Type 2: with drift no trend
##      lag   ADF p.value
## [1,]   0 1.847   0.990
## [2,]   1 0.579   0.989
## [3,]   2 0.886   0.990
## [4,]   3 0.933   0.990
## [5,]   4 1.071   0.990
## [6,]   5 1.081   0.990
## Type 3: with drift and trend
##      lag   ADF p.value
## [1,]   0 2.137    0.99
## [2,]   1 0.714    0.99
## [3,]   2 1.070    0.99
## [4,]   3 1.145    0.99
## [5,]   4 1.313    0.99
## [6,]   5 1.332    0.99
## ----
## Note: in fact, p.value = 0.01 means p.value <= 0.01
```

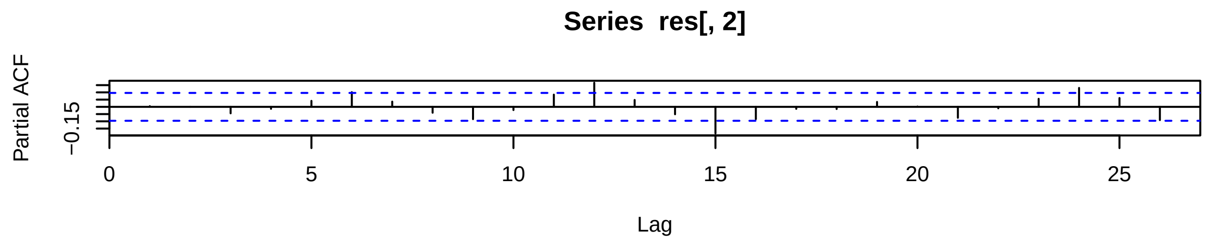
```
## AIC(n)
##      3
```

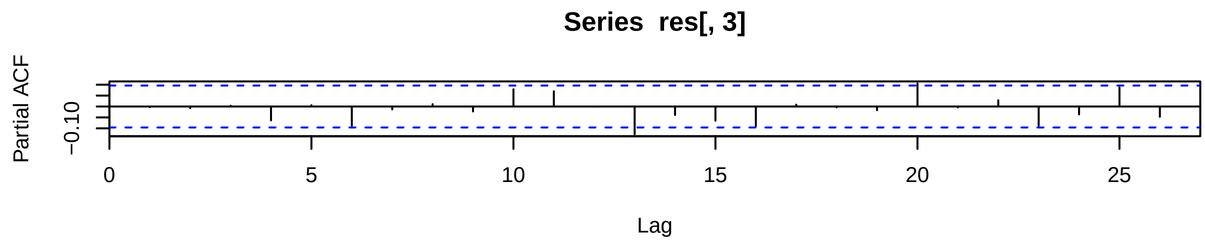










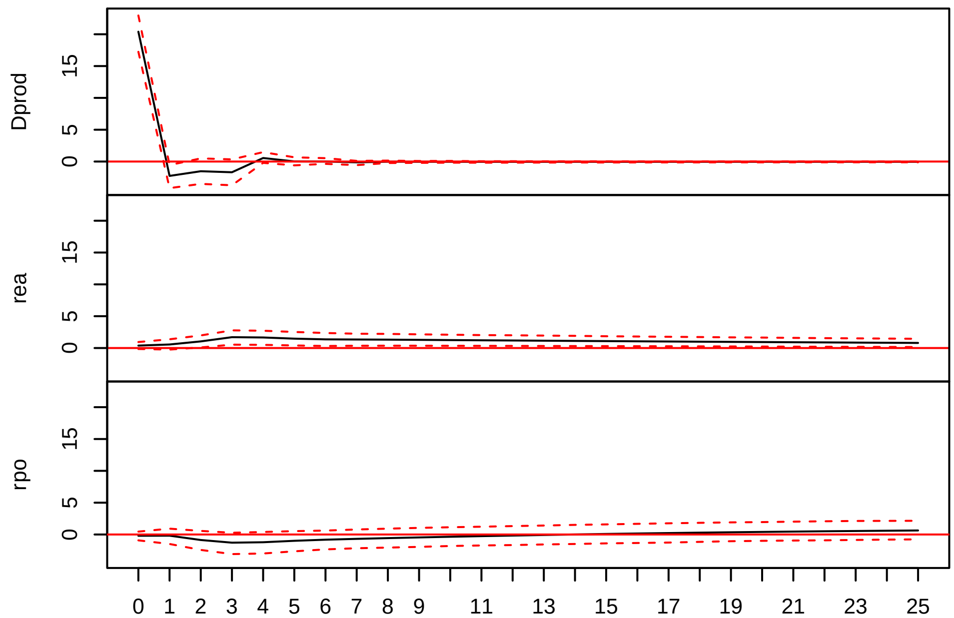



```
##            Dprod       rea       rpo
## Dprod 416.145308  7.824951 -4.099590
## rea     7.824951 20.483391  1.765876
## rpo    -4.099590  1.765876 38.132342
```

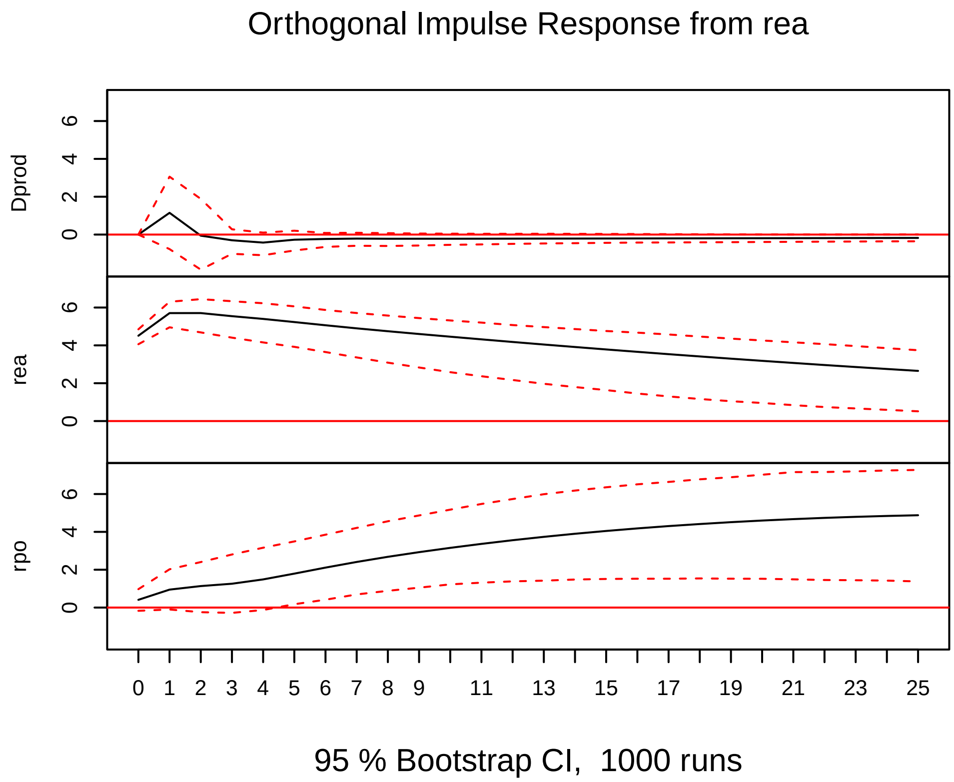
```
##             Dprod        rea         rpo
## Dprod  1.00000000 0.08475361 -0.03254402
## rea    0.08475361 1.00000000  0.06318480
## rpo   -0.03254402 0.06318480  1.00000000
```

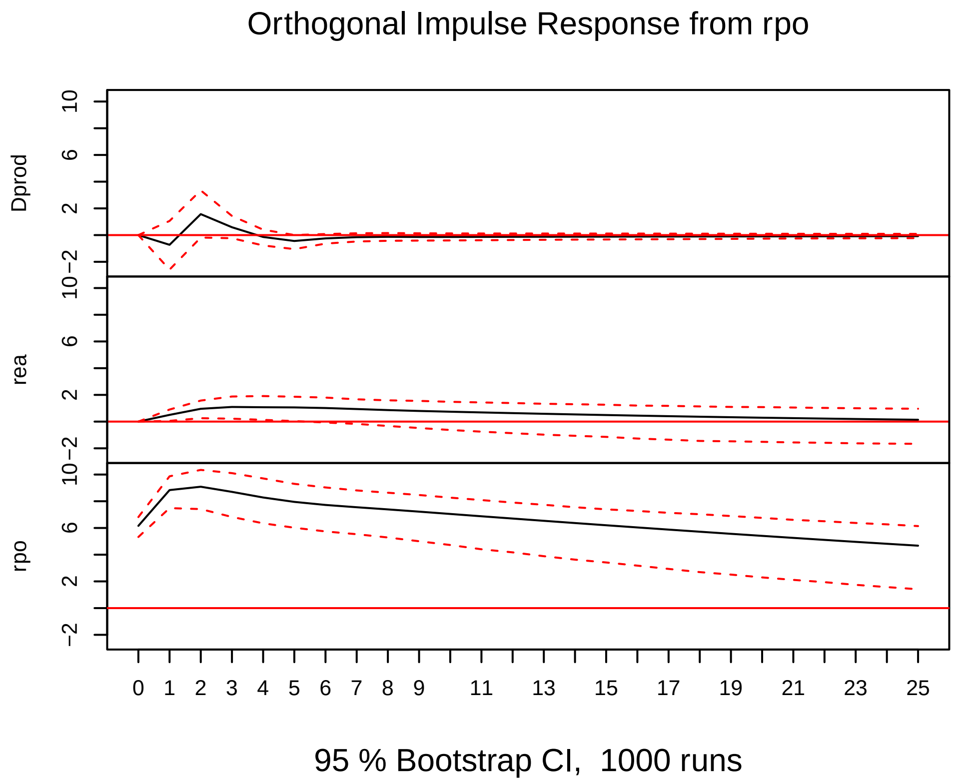
```
## [1] 0.9701644 0.9701644 0.4696721 0.4634054 0.4634054 0.4593787 0.4593787
## [8] 0.2924893 0.2924893
```

Orthogonal Impulse Response from Dprod



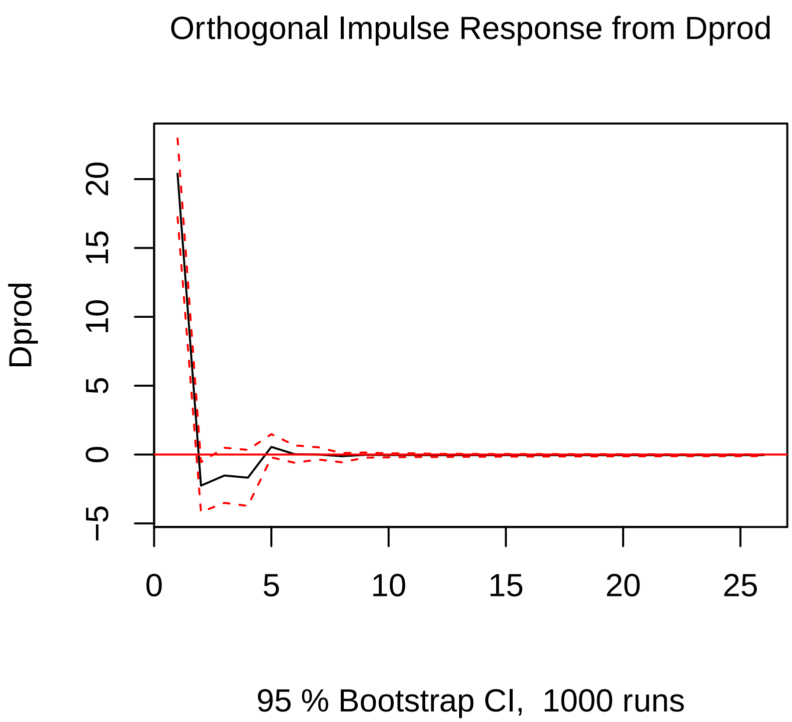
95 % Bootstrap CI, 1000 runs

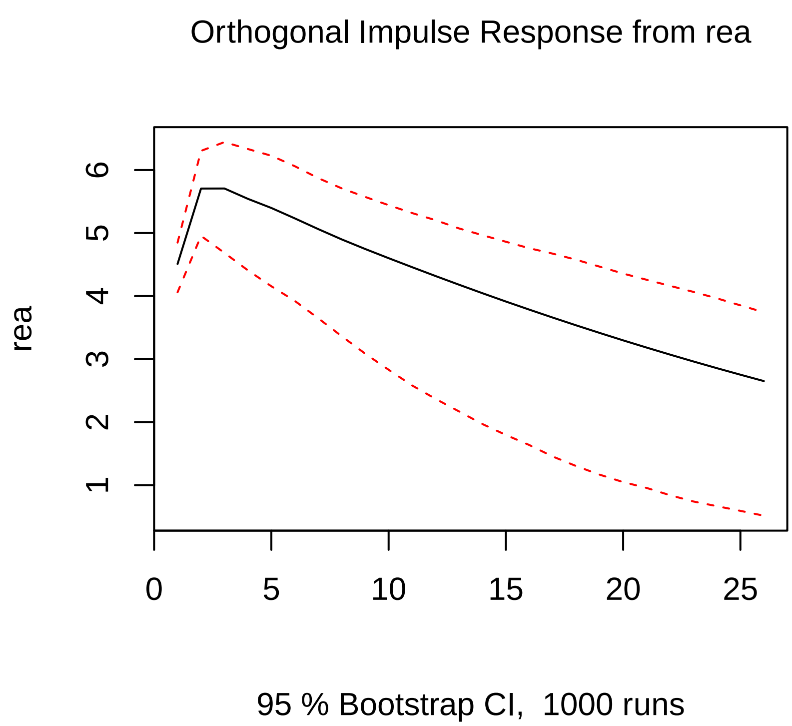

Orthogonal Impulse Response from rea
Dprod
rea
rpo
0
2
4
6
0 1 2 3 4 5 6 7 8 9 11 13 15 17 19 21 23 25
95 % Bootstrap CI, 1000 runs



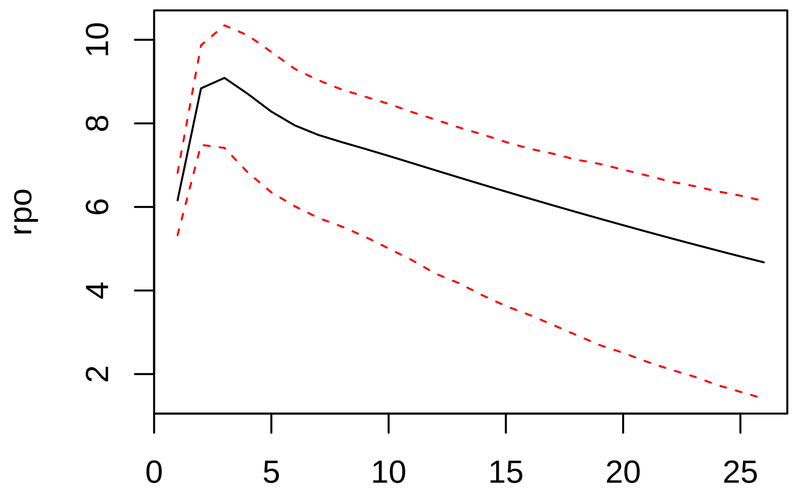
Orthogonal Impulse Response from rpo
Dprod
rea
rpo
10
6
2
−2
0 1 2 3 4 5 6 7 8 9 11 13 15 17 19 21 23 25
95 % Bootstrap CI, 1000 runs

Point 5


Orthogonal Impulse Response from Dprod
Dprod
−5
0
5
10
15
20
0
5
10
15
20
25
95 % Bootstrap CI, 1000 runs


Orthogonal Impulse Response from rea
rea
1
2
3
4
5
6
0
5
10
15
20
25
95 % Bootstrap CI, 1000 runs

Orthogonal Impulse Response from rpo



95 % Bootstrap CI, 1000 runs