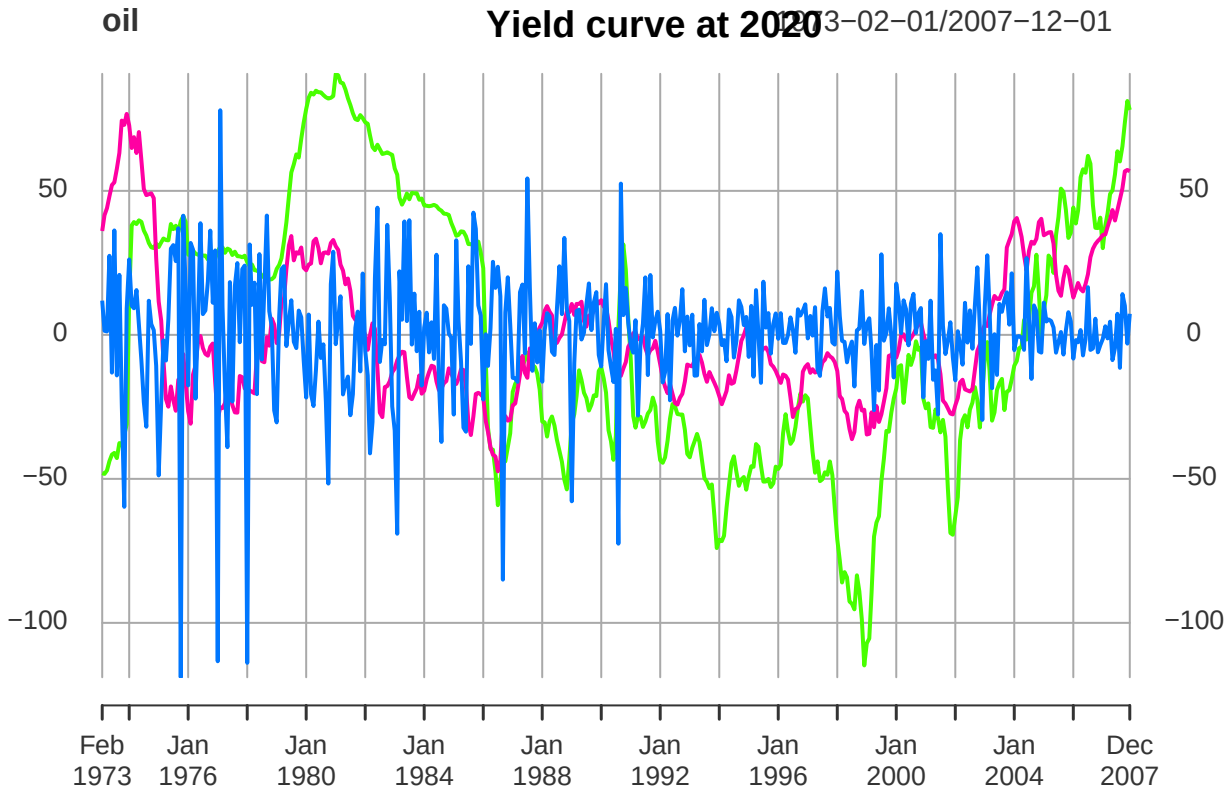
Assignement

Point 1

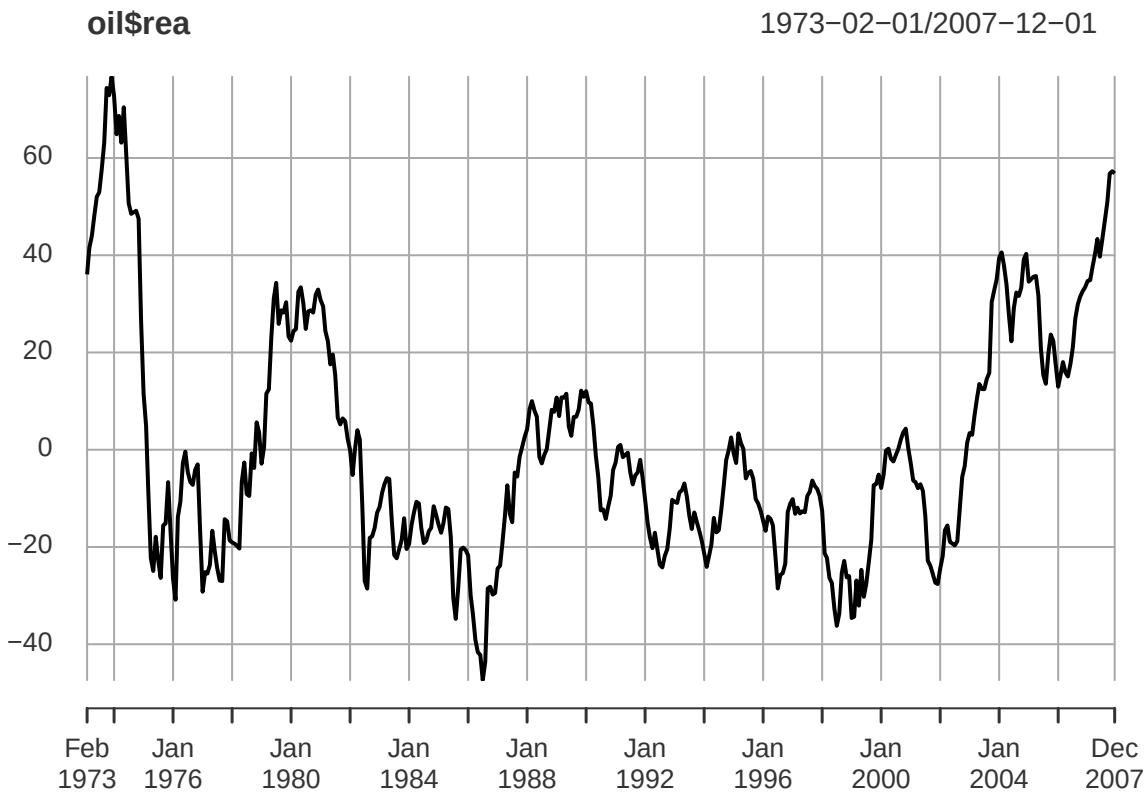
The time series below represents the monthly time series of: 1. % change in global crude oil production 2. the real price of oil 3. the real economy activity From 1973:1 to 2007:12.



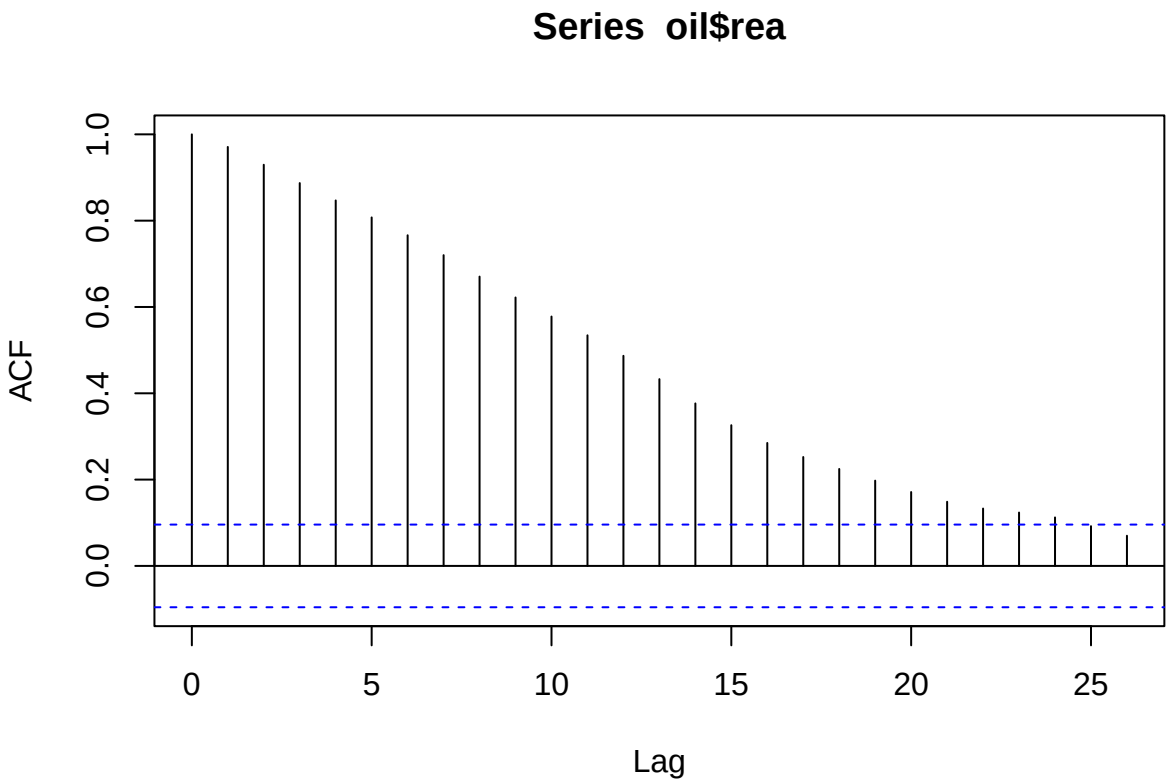
As we can see the acf its clear signaling the presence of an autcorrelation process. In order to test if the rea is an $I(1)$, we will use an ADF test with lag =1. We will perform the test specifing four different type of the process: 1. No consant, no trend 2. Constant 3. Constant with trend 4. No costant 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:

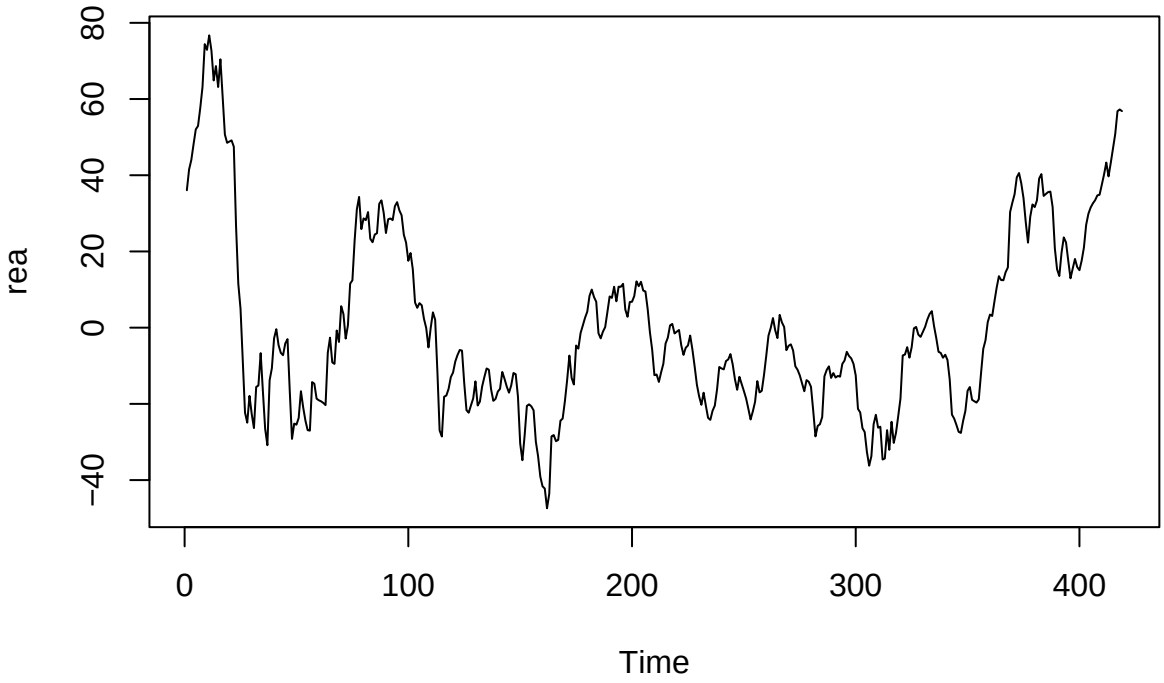
$$rea_t = \alpha + \sigma_1 reat_(t-1) + ... + \sigma_1 2\delta reat_(t-13)$$

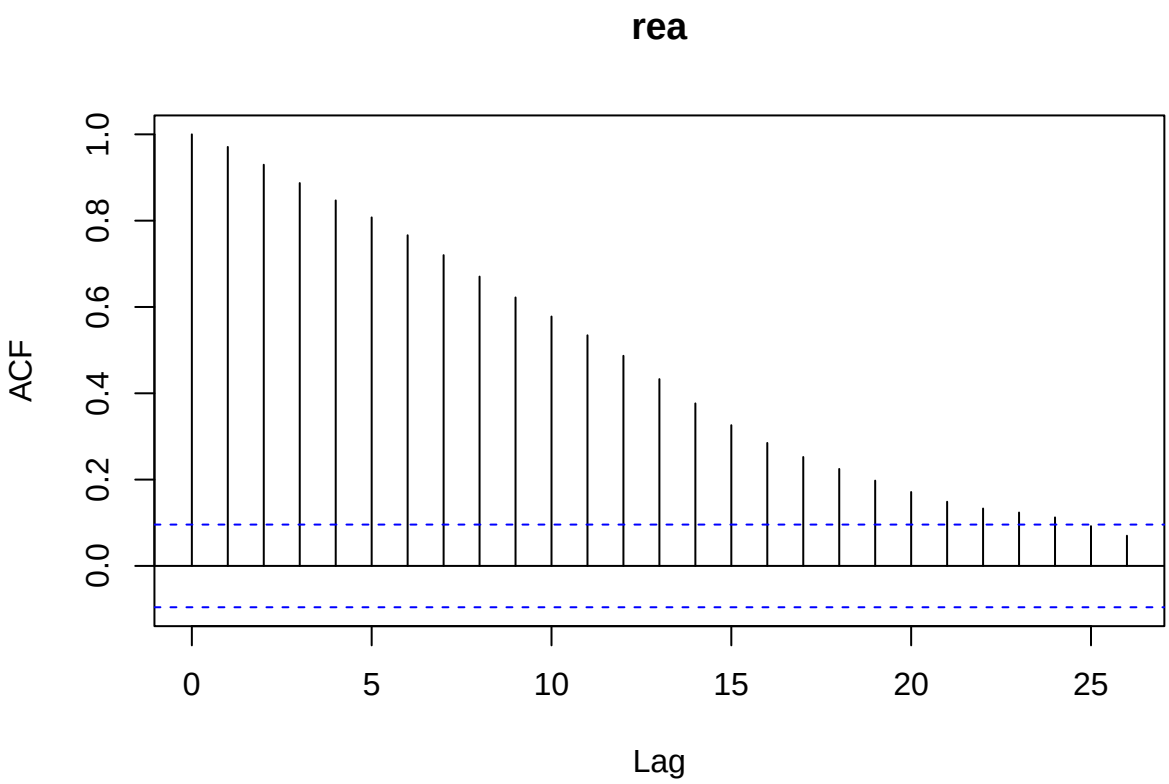
We take the model with constant, otherwise the model will be too restricive, and without time trend, selectin the

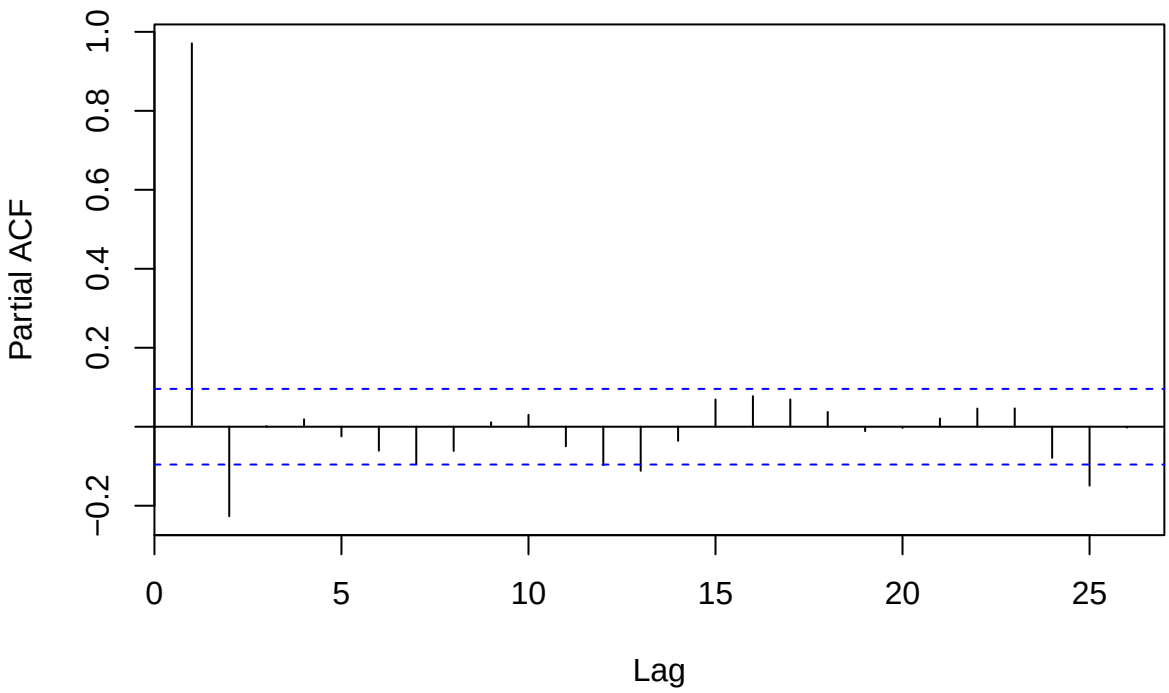


one which as lower BIC:


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


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


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



	N of lags	Type	lag	ADF	p.value	Stationary at 5%	Stationary at 10%
rw	1	no drift no trend	1	-1.6457	0.0961	Stat	Stat
rw	1	with drift no trend	1	-1.6443	0.4692	Stat	Stat
rw	1	with drift and trend	1	-1.6235	0.736	Stat	Stat
rw	2	no drift no trend	1	-1.6457	0.0961	Stat	Stat
rw	2	no drift no trend	2	-2.5702	0.0104	No Stat.	Stat
rw	2	with drift no trend	1	-1.6443	0.4692	Stat	Stat
rw	2	with drift no trend	2	-2.5669	0.1025	Stat	Stat
rw	2	with drift and trend	1	-1.6235	0.736	Stat	Stat
rw	2	with drift and trend	2	-2.5446	0.3465	Stat	Stat
rw	3	no drift no trend	1	-1.6457	0.0961	Stat	Stat
rw	3	no drift no trend	2	-2.5702	0.0104	No Stat.	Stat
rw	3	no drift no trend	3	-2.4271	0.0166	No Stat.	Stat
rw	3	with drift no trend	1	-1.6443	0.4692	Stat	Stat
rw	3	with drift no trend	2	-2.5669	0.1025	Stat	Stat
rw	3	with drift no trend	3	-2.4235	0.1595	Stat	Stat
rw	3	with drift and trend	1	-1.6235	0.736	Stat	Stat
rw	3	with drift and trend	2	-2.5446	0.3465	Stat	Stat
rw	3	with drift and trend	3	-2.3969	0.4087	Stat	Stat
rw	4	no drift no trend	1	-1.6457	0.0961	Stat	Stat
rw	4	no drift no trend	2	-2.5702	0.0104	No Stat.	Stat
rw	4	no drift no trend	3	-2.4271	0.0166	No Stat.	Stat
rw	4	no drift no trend	4	-2.4375	0.0162	No Stat.	Stat
rw	4	with drift no trend	1	-1.6443	0.4692	Stat	Stat
rw	4	with drift no trend	2	-2.5669	0.1025	Stat	Stat

	N of lags	Type	lag	ADF	p.value	Stationary at 5%	Stationary at 10%
rw	4	with drift no trend	3	-2.4235	0.1595	Stat	Stat
rw	4	with drift no trend	4	-2.4339	0.1554	Stat	Stat
rw	4	with drift and trend	1	-1.6235	0.736	Stat	Stat
rw	4	with drift and trend	2	-2.5446	0.3465	Stat	Stat
rw	4	with drift and trend	3	-2.3969	0.4087	Stat	Stat
rw	4	with drift and trend	4	-2.4043	0.4055	Stat	Stat
rw	5	no drift no trend	1	-1.6457	0.0961	Stat	Stat
rw	5	no drift no trend	2	-2.5702	0.0104	No Stat.	Stat
rw	5	no drift no trend	3	-2.4271	0.0166	No Stat.	Stat
rw	5	no drift no trend	4	-2.4375	0.0162	No Stat.	Stat
rw	5	no drift no trend	5	-2.5514	0.0112	No Stat.	Stat
rw	5	with drift no trend	1	-1.6443	0.4692	Stat	Stat
rw	5	with drift no trend	2	-2.5669	0.1025	Stat	Stat
rw	5	with drift no trend	3	-2.4235	0.1595	Stat	Stat
rw	5	with drift no trend	4	-2.4339	0.1554	Stat	Stat
rw	5	with drift no trend	5	-2.5482	0.11	Stat	Stat
rw	5	with drift and trend	1	-1.6235	0.736	Stat	Stat
rw	5	with drift and trend	2	-2.5446	0.3465	Stat	Stat
rw	5	with drift and trend	3	-2.3969	0.4087	Stat	Stat
rw	5	with drift and trend	4	-2.4043	0.4055	Stat	Stat
rw	5	with drift and trend	5	-2.5178	0.3578	Stat	Stat
rw	6	no drift no trend	1	-1.6457	0.0961	Stat	Stat
rw	6	no drift no trend	2	-2.5702	0.0104	No Stat.	Stat
rw	6	no drift no trend	3	-2.4271	0.0166	No Stat.	Stat
rw	6	no drift no trend	4	-2.4375	0.0162	No Stat.	Stat
rw	6	no drift no trend	5	-2.5514	0.0112	No Stat.	Stat
rw	6	no drift no trend	6	-2.801	0.01	No Stat.	No Stat.
rw	6	with drift no trend	1	-1.6443	0.4692	Stat	Stat
rw	6	with drift no trend	2	-2.5669	0.1025	Stat	Stat
rw	6	with drift no trend	3	-2.4235	0.1595	Stat	Stat
rw	6	with drift no trend	4	-2.4339	0.1554	Stat	Stat
rw	6	with drift no trend	5	-2.5482	0.11	Stat	Stat
rw	6	with drift no trend	6	-2.7977	0.0626	Stat	Stat
rw	6	with drift and trend	1	-1.6235	0.736	Stat	Stat
rw	6	with drift and trend	2	-2.5446	0.3465	Stat	Stat
rw	6	with drift and trend	3	-2.3969	0.4087	Stat	Stat
rw	6	with drift and trend	4	-2.4043	0.4055	Stat	Stat
rw	6	with drift and trend	5	-2.5178	0.3578	Stat	Stat
rw	6	with drift and trend	6	-2.7702	0.2515	Stat	Stat
rw	7	no drift no trend	1	-1.6457	0.0961	Stat	Stat
rw	7	no drift no trend	2	-2.5702	0.0104	No Stat.	Stat
rw	7	no drift no trend	3	-2.4271	0.0166	No Stat.	Stat
rw	7	no drift no trend	4	-2.4375	0.0162	No Stat.	Stat
rw	7	no drift no trend	5	-2.5514	0.0112	No Stat.	Stat
rw	7	no drift no trend	6	-2.801	0.01	No Stat.	No Stat.
rw	7	no drift no trend	7	-3.2152	0.01	No Stat.	No Stat.
rw	7	with drift no trend	1	-1.6443	0.4692	Stat	Stat
rw	7	with drift no trend	2	-2.5669	0.1025	Stat	Stat
rw	7	with drift no trend	3	-2.4235	0.1595	Stat	Stat
rw	7	with drift no trend	4	-2.4339	0.1554	Stat	Stat
rw	7	with drift no trend	5	-2.5482	0.11	Stat	Stat
rw	7	with drift no trend	6	-2.7977	0.0626	Stat	Stat

	N of lags	Type	lag	ADF	p.value	Stationary at 5%	Stationary at 10%
rw	7	with drift no trend	7	-3.2132	0.0211	No Stat.	Stat
rw	7	with drift and trend	1	-1.6235	0.736	Stat	Stat
rw	7	with drift and trend	2	-2.5446	0.3465	Stat	Stat
rw	7	with drift and trend	3	-2.3969	0.4087	Stat	Stat
rw	7	with drift and trend	4	-2.4043	0.4055	Stat	Stat
rw	7	with drift and trend	5	-2.5178	0.3578	Stat	Stat
rw	7	with drift and trend	6	-2.7702	0.2515	Stat	Stat
rw	7	with drift and trend	7	-3.1891	0.0898	Stat	Stat
rw	8	no drift no trend	1	-1.6457	0.0961	Stat	Stat
rw	8	no drift no trend	2	-2.5702	0.0104	No Stat.	Stat
rw	8	no drift no trend	3	-2.4271	0.0166	No Stat.	Stat
rw	8	no drift no trend	4	-2.4375	0.0162	No Stat.	Stat
rw	8	no drift no trend	5	-2.5514	0.0112	No Stat.	Stat
rw	8	no drift no trend	6	-2.801	0.01	No Stat.	No Stat.
rw	8	no drift no trend	7	-3.2152	0.01	No Stat.	No Stat.
rw	8	no drift no trend	8	-3.3318	0.01	No Stat.	No Stat.
rw	8	with drift no trend	1	-1.6443	0.4692	Stat	Stat
rw	8	with drift no trend	2	-2.5669	0.1025	Stat	Stat
rw	8	with drift no trend	3	-2.4235	0.1595	Stat	Stat
rw	8	with drift no trend	4	-2.4339	0.1554	Stat	Stat
rw	8	with drift no trend	5	-2.5482	0.11	Stat	Stat
rw	8	with drift no trend	6	-2.7977	0.0626	Stat	Stat
rw	8	with drift no trend	7	-3.2132	0.0211	No Stat.	Stat
rw	8	with drift no trend	8	-3.3321	0.0154	No Stat.	Stat
rw	8	with drift and trend	1	-1.6235	0.736	Stat	Stat
rw	8	with drift and trend	2	-2.5446	0.3465	Stat	Stat
rw	8	with drift and trend	3	-2.3969	0.4087	Stat	Stat
rw	8	with drift and trend	4	-2.4043	0.4055	Stat	Stat
rw	8	with drift and trend	5	-2.5178	0.3578	Stat	Stat
rw	8	with drift and trend	6	-2.7702	0.2515	Stat	Stat
rw	8	with drift and trend	7	-3.1891	0.0898	Stat	Stat
rw	8	with drift and trend	8	-3.3119	0.0686	Stat	Stat
rw	9	no drift no trend	1	-1.6457	0.0961	Stat	Stat
rw	9	no drift no trend	2	-2.5702	0.0104	No Stat.	Stat
rw	9	no drift no trend	3	-2.4271	0.0166	No Stat.	Stat
rw	9	no drift no trend	4	-2.4375	0.0162	No Stat.	Stat
rw	9	no drift no trend	5	-2.5514	0.0112	No Stat.	Stat
rw	9	no drift no trend	6	-2.801	0.01	No Stat.	No Stat.
rw	9	no drift no trend	7	-3.2152	0.01	No Stat.	No Stat.
rw	9	no drift no trend	8	-3.3318	0.01	No Stat.	No Stat.
rw	9	no drift no trend	9	-3.4479	0.01	No Stat.	No Stat.
rw	9	with drift no trend	1	-1.6443	0.4692	Stat	Stat
rw	9	with drift no trend	2	-2.5669	0.1025	Stat	Stat
rw	9	with drift no trend	3	-2.4235	0.1595	Stat	Stat
rw	9	with drift no trend	4	-2.4339	0.1554	Stat	Stat
rw	9	with drift no trend	5	-2.5482	0.11	Stat	Stat
rw	9	with drift no trend	6	-2.7977	0.0626	Stat	Stat
rw	9	with drift no trend	7	-3.2132	0.0211	No Stat.	Stat
rw	9	with drift no trend	8	-3.3321	0.0154	No Stat.	Stat
rw	9	with drift no trend	9	-3.454	0.01	No Stat.	No Stat.
rw	9	with drift and trend	1	-1.6235	0.736	Stat	Stat
rw	9	with drift and trend	2	-2.5446	0.3465	Stat	Stat

	N of lags	Type	lag	ADF	p.value	Stationary at 5%	Stationary at 10%
rw	9	with drift and trend	3	-2.3969	0.4087	Stat	Stat
rw	9	with drift and trend	4	-2.4043	0.4055	Stat	Stat
rw	9	with drift and trend	5	-2.5178	0.3578	Stat	Stat
rw	9	with drift and trend	6	-2.7702	0.2515	Stat	Stat
rw	9	with drift and trend	7	-3.1891	0.0898	Stat	Stat
rw	9	with drift and trend	8	-3.3119	0.0686	Stat	Stat
rw	9	with drift and trend	9	-3.4427	0.0478	No Stat.	Stat
rw	10	no drift no trend	1	-1.6457	0.0961	Stat	Stat
rw	10	no drift no trend	2	-2.5702	0.0104	No Stat.	Stat
rw	10	no drift no trend	3	-2.4271	0.0166	No Stat.	Stat
rw	10	no drift no trend	4	-2.4375	0.0162	No Stat.	Stat
rw	10	no drift no trend	5	-2.5514	0.0112	No Stat.	Stat
rw	10	no drift no trend	6	-2.801	0.01	No Stat.	No Stat.
rw	10	no drift no trend	7	-3.2152	0.01	No Stat.	No Stat.
rw	10	no drift no trend	8	-3.3318	0.01	No Stat.	No Stat.
rw	10	no drift no trend	9	-3.4479	0.01	No Stat.	No Stat.
rw	10	no drift no trend	10	-3.2258	0.01	No Stat.	No Stat.
rw	10	with drift no trend	1	-1.6443	0.4692	Stat	Stat
rw	10	with drift no trend	2	-2.5669	0.1025	Stat	Stat
rw	10	with drift no trend	3	-2.4235	0.1595	Stat	Stat
rw	10	with drift no trend	4	-2.4339	0.1554	Stat	Stat
rw	10	with drift no trend	5	-2.5482	0.11	Stat	Stat
rw	10	with drift no trend	6	-2.7977	0.0626	Stat	Stat
rw	10	with drift no trend	7	-3.2132	0.0211	No Stat.	Stat
rw	10	with drift no trend	8	-3.3321	0.0154	No Stat.	Stat
rw	10	with drift no trend	9	-3.454	0.01	No Stat.	No Stat.
rw	10	with drift no trend	10	-3.2318	0.0202	No Stat.	Stat
rw	10	with drift and trend	1	-1.6235	0.736	Stat	Stat
rw	10	with drift and trend	2	-2.5446	0.3465	Stat	Stat
rw	10	with drift and trend	3	-2.3969	0.4087	Stat	Stat
rw	10	with drift and trend	4	-2.4043	0.4055	Stat	Stat
rw	10	with drift and trend	5	-2.5178	0.3578	Stat	Stat
rw	10	with drift and trend	6	-2.7702	0.2515	Stat	Stat
rw	10	with drift and trend	7	-3.1891	0.0898	Stat	Stat
rw	10	with drift and trend	8	-3.3119	0.0686	Stat	Stat
rw	10	with drift and trend	9	-3.4427	0.0478	No Stat.	Stat
rw	10	with drift and trend	10	-3.2348	0.0819	Stat	Stat
rw	11	no drift no trend	1	-1.6457	0.0961	Stat	Stat
rw	11	no drift no trend	2	-2.5702	0.0104	No Stat.	Stat
rw	11	no drift no trend	3	-2.4271	0.0166	No Stat.	Stat
rw	11	no drift no trend	4	-2.4375	0.0162	No Stat.	Stat
rw	11	no drift no trend	5	-2.5514	0.0112	No Stat.	Stat
rw	11	no drift no trend	6	-2.801	0.01	No Stat.	No Stat.
rw	11	no drift no trend	7	-3.2152	0.01	No Stat.	No Stat.
rw	11	no drift no trend	8	-3.3318	0.01	No Stat.	No Stat.
rw	11	no drift no trend	9	-3.4479	0.01	No Stat.	No Stat.
rw	11	no drift no trend	10	-3.2258	0.01	No Stat.	No Stat.
rw	11	no drift no trend	11	-3.5172	0.01	No Stat.	No Stat.
rw	11	with drift no trend	1	-1.6443	0.4692	Stat	Stat
rw	11	with drift no trend	2	-2.5669	0.1025	Stat	Stat
rw	11	with drift no trend	3	-2.4235	0.1595	Stat	Stat
rw	11	with drift no trend	4	-2.4339	0.1554	Stat	Stat

	N of lags	Type	lag	ADF	p.value	Stationary at 5%	Stationary at 10%
rw	11	with drift no trend	5	-2.5482	0.11	Stat	Stat
rw	11	with drift no trend	6	-2.7977	0.0626	Stat	Stat
rw	11	with drift no trend	7	-3.2132	0.0211	No Stat.	Stat
rw	11	with drift no trend	8	-3.3321	0.0154	No Stat.	Stat
rw	11	with drift no trend	9	-3.454	0.01	No Stat.	No Stat.
rw	11	with drift no trend	10	-3.2318	0.0202	No Stat.	Stat
rw	11	with drift no trend	11	-3.529	0.01	No Stat.	No Stat.
rw	11	with drift and trend	1	-1.6235	0.736	Stat	Stat
rw	11	with drift and trend	2	-2.5446	0.3465	Stat	Stat
rw	11	with drift and trend	3	-2.3969	0.4087	Stat	Stat
rw	11	with drift and trend	4	-2.4043	0.4055	Stat	Stat
rw	11	with drift and trend	5	-2.5178	0.3578	Stat	Stat
rw	11	with drift and trend	6	-2.7702	0.2515	Stat	Stat
rw	11	with drift and trend	7	-3.1891	0.0898	Stat	Stat
rw	11	with drift and trend	8	-3.3119	0.0686	Stat	Stat
rw	11	with drift and trend	9	-3.4427	0.0478	No Stat.	Stat
rw	11	with drift and trend	10	-3.2348	0.0819	Stat	Stat
rw	11	with drift and trend	11	-3.5484	0.0375	No Stat.	Stat
rw	12	no drift no trend	1	-1.6457	0.0961	Stat	Stat
rw	12	no drift no trend	2	-2.5702	0.0104	No Stat.	Stat
rw	12	no drift no trend	3	-2.4271	0.0166	No Stat.	Stat
rw	12	no drift no trend	4	-2.4375	0.0162	No Stat.	Stat
rw	12	no drift no trend	5	-2.5514	0.0112	No Stat.	Stat
rw	12	no drift no trend	6	-2.801	0.01	No Stat.	No Stat.
rw	12	no drift no trend	7	-3.2152	0.01	No Stat.	No Stat.
rw	12	no drift no trend	8	-3.3318	0.01	No Stat.	No Stat.
rw	12	no drift no trend	9	-3.4479	0.01	No Stat.	No Stat.
rw	12	no drift no trend	10	-3.2258	0.01	No Stat.	No Stat.
rw	12	no drift no trend	11	-3.5172	0.01	No Stat.	No Stat.
rw	12	no drift no trend	12	-3.8179	0.01	No Stat.	No Stat.
rw	12	with drift no trend	1	-1.6443	0.4692	Stat	Stat
rw	12	with drift no trend	2	-2.5669	0.1025	Stat	Stat
rw	12	with drift no trend	3	-2.4235	0.1595	Stat	Stat
rw	12	with drift no trend	4	-2.4339	0.1554	Stat	Stat
rw	12	with drift no trend	5	-2.5482	0.11	Stat	Stat
rw	12	with drift no trend	6	-2.7977	0.0626	Stat	Stat
rw	12	with drift no trend	7	-3.2132	0.0211	No Stat.	Stat
rw	12	with drift no trend	8	-3.3321	0.0154	No Stat.	Stat
rw	12	with drift no trend	9	-3.454	0.01	No Stat.	No Stat.
rw	12	with drift no trend	10	-3.2318	0.0202	No Stat.	Stat
rw	12	with drift no trend	11	-3.529	0.01	No Stat.	No Stat.
rw	12	with drift no trend	12	-3.8297	0.01	No Stat.	No Stat.
rw	12	with drift and trend	1	-1.6235	0.736	Stat	Stat
rw	12	with drift and trend	2	-2.5446	0.3465	Stat	Stat
rw	12	with drift and trend	3	-2.3969	0.4087	Stat	Stat
rw	12	with drift and trend	4	-2.4043	0.4055	Stat	Stat
rw	12	with drift and trend	5	-2.5178	0.3578	Stat	Stat
rw	12	with drift and trend	6	-2.7702	0.2515	Stat	Stat
rw	12	with drift and trend	7	-3.1891	0.0898	Stat	Stat
rw	12	with drift and trend	8	-3.3119	0.0686	Stat	Stat
rw	12	with drift and trend	9	-3.4427	0.0478	No Stat.	Stat
rw	12	with drift and trend	10	-3.2348	0.0819	Stat	Stat

	N of lags	Type	lag	ADF	p.value	Stationary at 5%	Stationary at 10%
rw	12	with drift and trend	11	-3.5484	0.0375	No Stat.	Stat
rw	12	with drift and trend	12	-3.863	0.0156	No Stat.	Stat

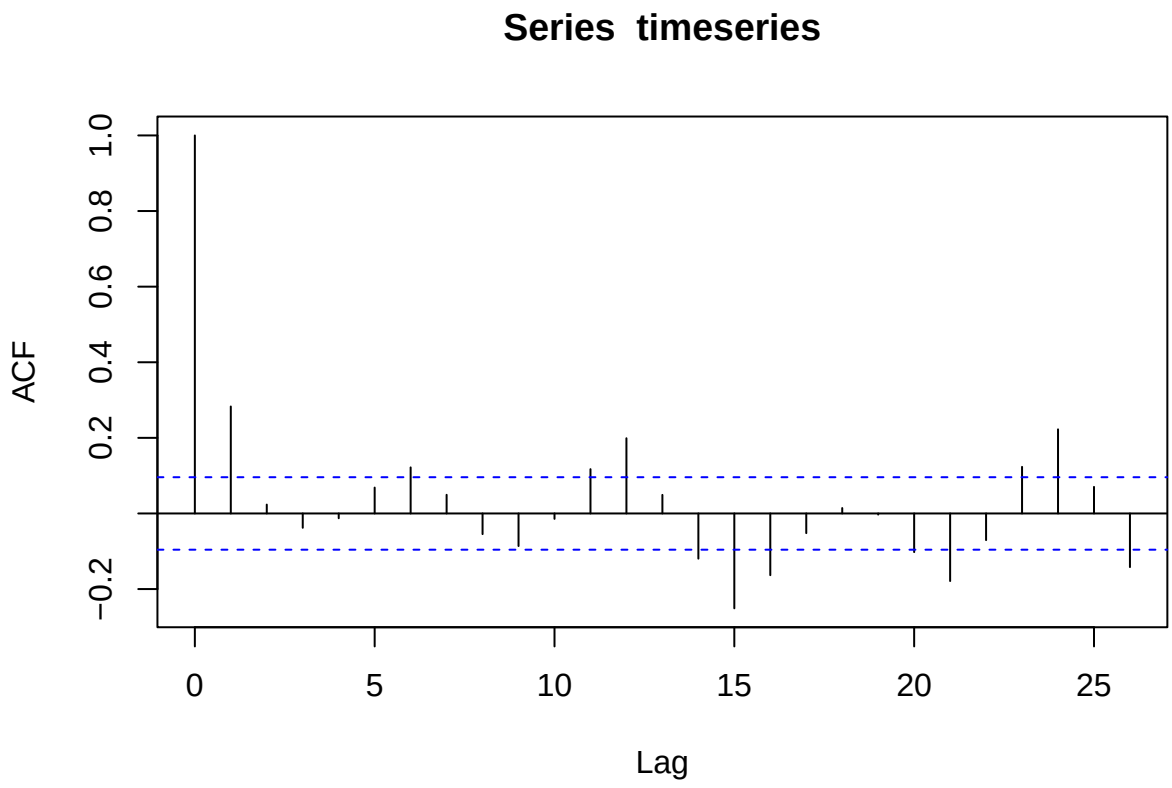
```
## $`ADF Statistic using BIC`
## [1] -4.252854
```

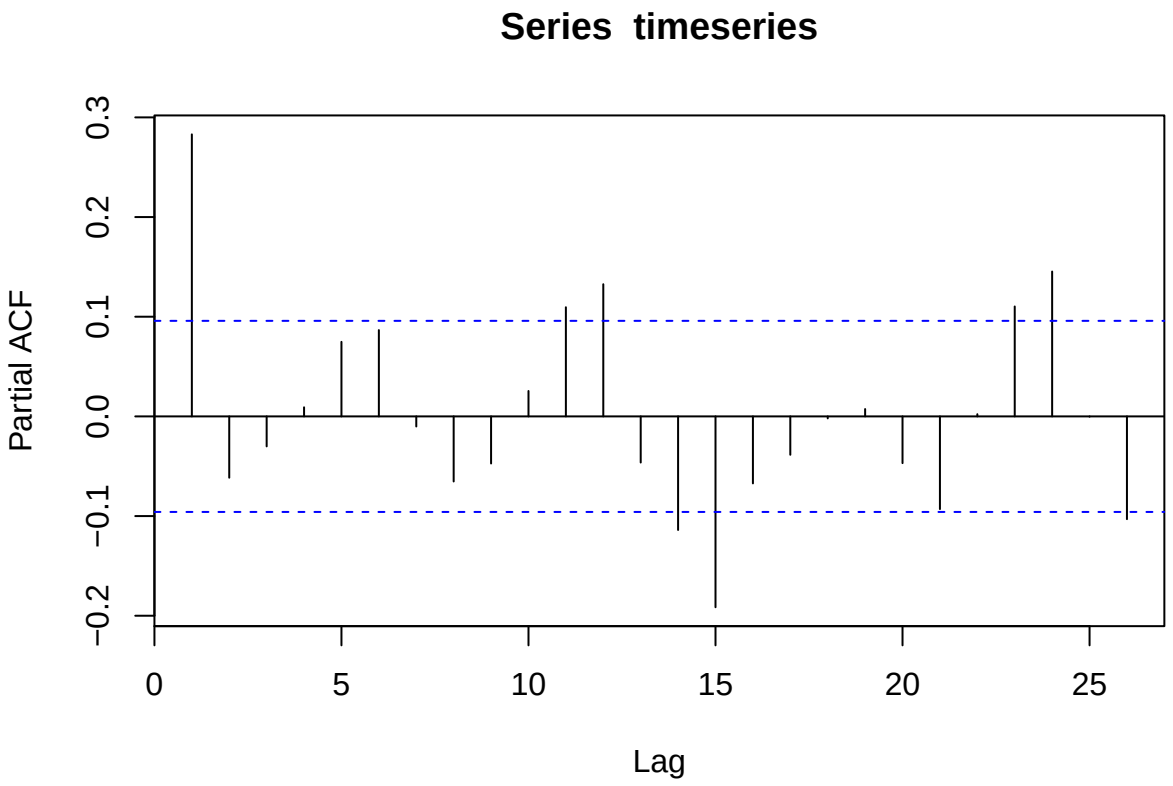
```
##              N of lags                    Type                     lag
##                   "12" "with drift and trend"                   "12"
##                    ADF                 p.value       Stationary at 5%
##                "-3.863"               "0.0156"             "No Stat."
##      Stationary at 10%
##                  "Stat"
```

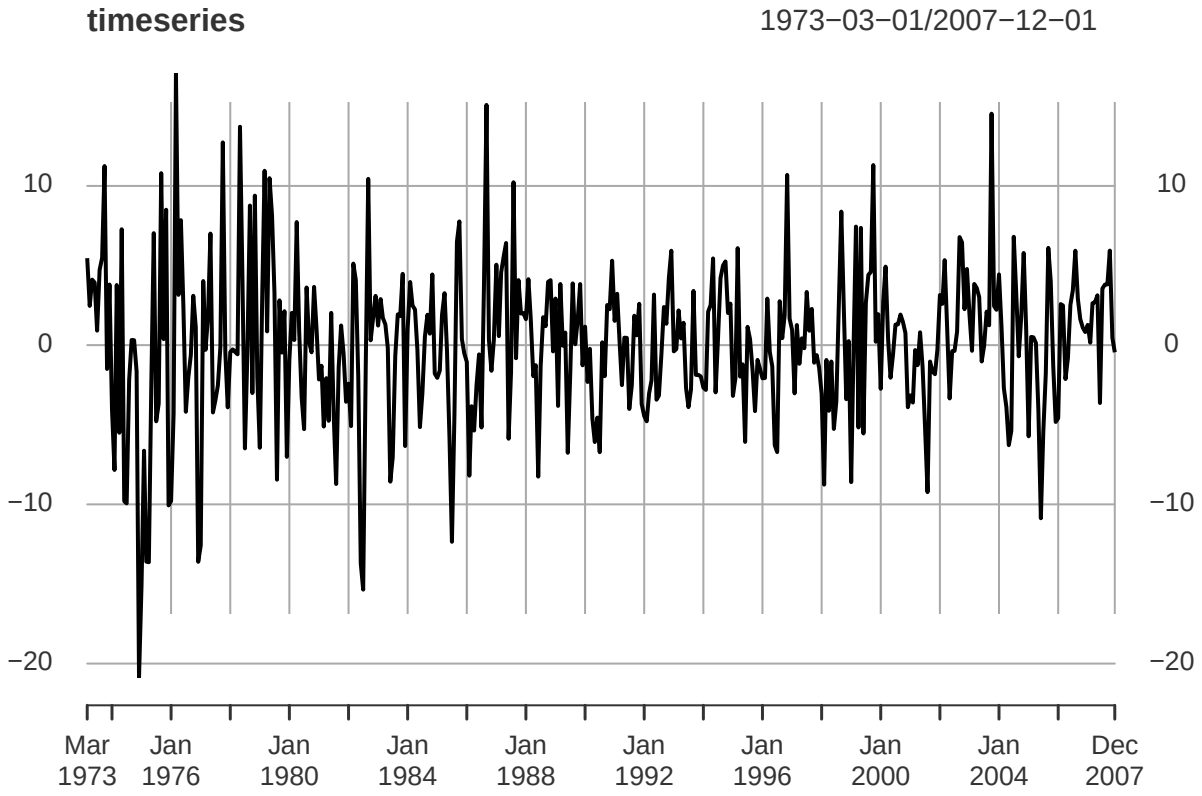
As we can see from the table above which report the result of the ADF tests, it is clear that the process is not stationary with a $alpha < 10$, so there are no sufficent empirical evidence to reject the null. Thus the *rea* time series is not a covariance-stationary process with a minium lag of order 1.

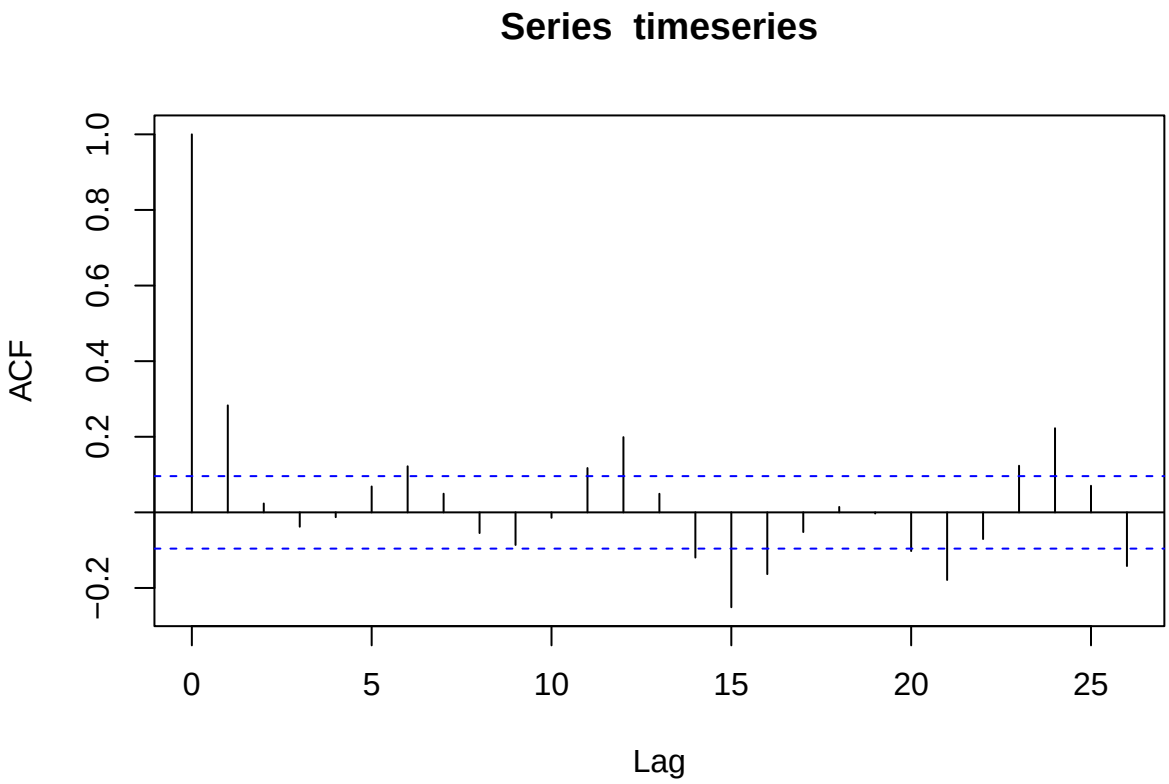
Point 2

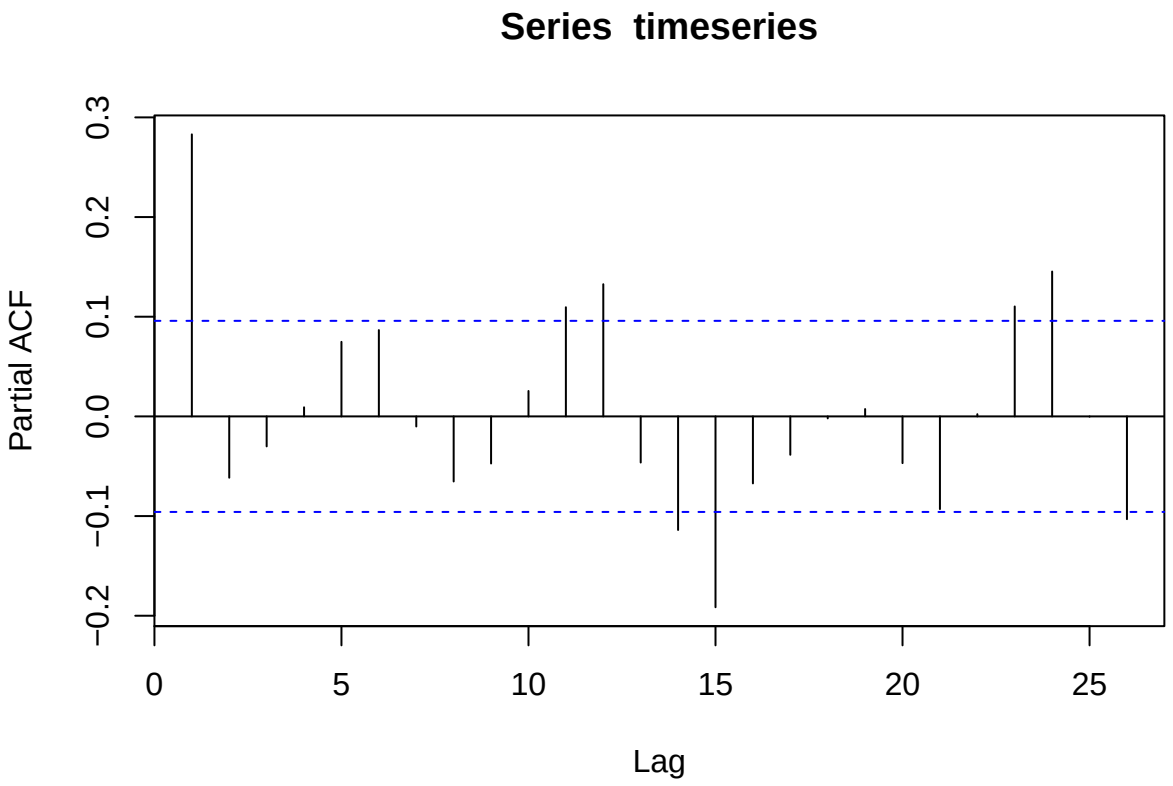
We take the first difference of the timeseries *rea* and check if it is stationary with an adf test. Before that we print the time series of the first differences, the acf, and the pacf to understat the correct specification for the ADF test.




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


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



The above graphs clearly underline 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 specification without time trend and constant. so the test will have the following specification:

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

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

	N of lags	Type	lag	ADF	p.value	Stationary at 5%	Stationary at 10%
rw	1	no drift no trend	1	15.2068	0.99	Stat	Stat
rw	1	with drift no trend	1	15.19	0.99	Stat	Stat
rw	1	with drift and trend	1	15.2459	0.99	Stat	Stat
rw	2	no drift no trend	1	15.2068	0.99	Stat	Stat
rw	2	no drift no trend	2	21.1956	0.99	Stat	Stat
rw	2	with drift no trend	1	15.19	0.99	Stat	Stat
rw	2	with drift no trend	2	21.172	0.99	Stat	Stat
rw	2	with drift and trend	1	15.2459	0.99	Stat	Stat
rw	2	with drift and trend	2	21.306	0.99	Stat	Stat
rw	3	no drift no trend	1	15.2068	0.99	Stat	Stat
rw	3	no drift no trend	2	21.1956	0.99	Stat	Stat
rw	3	no drift no trend	3	26.3129	0.99	Stat	Stat
rw	3	with drift no trend	1	15.19	0.99	Stat	Stat
rw	3	with drift no trend	2	21.172	0.99	Stat	Stat
rw	3	with drift no trend	3	26.2829	0.99	Stat	Stat
rw	3	with drift and trend	1	15.2459	0.99	Stat	Stat

	N of lags	Type	lag	ADF	p.value	Stationary at 5%	Stationary at 10%
rw	3	with drift and trend	2	21.306	0.99	Stat	Stat
rw	3	with drift and trend	3	26.5082	0.99	Stat	Stat
rw	4	no drift no trend	1	15.2068	0.99	Stat	Stat
rw	4	no drift no trend	2	21.1956	0.99	Stat	Stat
rw	4	no drift no trend	3	26.3129	0.99	Stat	Stat
rw	4	no drift no trend	4	30.6551	0.99	Stat	Stat
rw	4	with drift no trend	1	15.19	0.99	Stat	Stat
rw	4	with drift no trend	2	21.172	0.99	Stat	Stat
rw	4	with drift no trend	3	26.2829	0.99	Stat	Stat
rw	4	with drift no trend	4	30.6192	0.99	Stat	Stat
rw	4	with drift and trend	1	15.2459	0.99	Stat	Stat
rw	4	with drift and trend	2	21.306	0.99	Stat	Stat
rw	4	with drift and trend	3	26.5082	0.99	Stat	Stat
rw	4	with drift and trend	4	30.9558	0.99	Stat	Stat
rw	5	no drift no trend	1	15.2068	0.99	Stat	Stat
rw	5	no drift no trend	2	21.1956	0.99	Stat	Stat
rw	5	no drift no trend	3	26.3129	0.99	Stat	Stat
rw	5	no drift no trend	4	30.6551	0.99	Stat	Stat
rw	5	no drift no trend	5	34.0132	0.99	Stat	Stat
rw	5	with drift no trend	1	15.19	0.99	Stat	Stat
rw	5	with drift no trend	2	21.172	0.99	Stat	Stat
rw	5	with drift no trend	3	26.2829	0.99	Stat	Stat
rw	5	with drift no trend	4	30.6192	0.99	Stat	Stat
rw	5	with drift no trend	5	33.9723	0.99	Stat	Stat
rw	5	with drift and trend	1	15.2459	0.99	Stat	Stat
rw	5	with drift and trend	2	21.306	0.99	Stat	Stat
rw	5	with drift and trend	3	26.5082	0.99	Stat	Stat
rw	5	with drift and trend	4	30.9558	0.99	Stat	Stat
rw	5	with drift and trend	5	34.4187	0.99	Stat	Stat
rw	6	no drift no trend	1	15.2068	0.99	Stat	Stat
rw	6	no drift no trend	2	21.1956	0.99	Stat	Stat
rw	6	no drift no trend	3	26.3129	0.99	Stat	Stat
rw	6	no drift no trend	4	30.6551	0.99	Stat	Stat
rw	6	no drift no trend	5	34.0132	0.99	Stat	Stat
rw	6	no drift no trend	6	36.5455	0.99	Stat	Stat
rw	6	with drift no trend	1	15.19	0.99	Stat	Stat
rw	6	with drift no trend	2	21.172	0.99	Stat	Stat
rw	6	with drift no trend	3	26.2829	0.99	Stat	Stat
rw	6	with drift no trend	4	30.6192	0.99	Stat	Stat
rw	6	with drift no trend	5	33.9723	0.99	Stat	Stat
rw	6	with drift no trend	6	36.5007	0.99	Stat	Stat
rw	6	with drift and trend	1	15.2459	0.99	Stat	Stat
rw	6	with drift and trend	2	21.306	0.99	Stat	Stat
rw	6	with drift and trend	3	26.5082	0.99	Stat	Stat
rw	6	with drift and trend	4	30.9558	0.99	Stat	Stat
rw	6	with drift and trend	5	34.4187	0.99	Stat	Stat
rw	6	with drift and trend	6	37.0336	0.99	Stat	Stat
rw	7	no drift no trend	1	15.2068	0.99	Stat	Stat
rw	7	no drift no trend	2	21.1956	0.99	Stat	Stat
rw	7	no drift no trend	3	26.3129	0.99	Stat	Stat
rw	7	no drift no trend	4	30.6551	0.99	Stat	Stat
rw	7	no drift no trend	5	34.0132	0.99	Stat	Stat

	N of lags	Type	lag	ADF	p.value	Stationary at 5%	Stationary at 10%
rw	7	no drift no trend	6	36.5455	0.99	Stat	Stat
rw	7	no drift no trend	7	38.861	0.99	Stat	Stat
rw	7	with drift no trend	1	15.19	0.99	Stat	Stat
rw	7	with drift no trend	2	21.172	0.99	Stat	Stat
rw	7	with drift no trend	3	26.2829	0.99	Stat	Stat
rw	7	with drift no trend	4	30.6192	0.99	Stat	Stat
rw	7	with drift no trend	5	33.9723	0.99	Stat	Stat
rw	7	with drift no trend	6	36.5007	0.99	Stat	Stat
rw	7	with drift no trend	7	38.8127	0.99	Stat	Stat
rw	7	with drift and trend	1	15.2459	0.99	Stat	Stat
rw	7	with drift and trend	2	21.306	0.99	Stat	Stat
rw	7	with drift and trend	3	26.5082	0.99	Stat	Stat
rw	7	with drift and trend	4	30.9558	0.99	Stat	Stat
rw	7	with drift and trend	5	34.4187	0.99	Stat	Stat
rw	7	with drift and trend	6	37.0336	0.99	Stat	Stat
rw	7	with drift and trend	7	39.4714	0.99	Stat	Stat
rw	8	no drift no trend	1	15.2068	0.99	Stat	Stat
rw	8	no drift no trend	2	21.1956	0.99	Stat	Stat
rw	8	no drift no trend	3	26.3129	0.99	Stat	Stat
rw	8	no drift no trend	4	30.6551	0.99	Stat	Stat
rw	8	no drift no trend	5	34.0132	0.99	Stat	Stat
rw	8	no drift no trend	6	36.5455	0.99	Stat	Stat
rw	8	no drift no trend	7	38.861	0.99	Stat	Stat
rw	8	no drift no trend	8	41.0263	0.99	Stat	Stat
rw	8	with drift no trend	1	15.19	0.99	Stat	Stat
rw	8	with drift no trend	2	21.172	0.99	Stat	Stat
rw	8	with drift no trend	3	26.2829	0.99	Stat	Stat
rw	8	with drift no trend	4	30.6192	0.99	Stat	Stat
rw	8	with drift no trend	5	33.9723	0.99	Stat	Stat
rw	8	with drift no trend	6	36.5007	0.99	Stat	Stat
rw	8	with drift no trend	7	38.8127	0.99	Stat	Stat
rw	8	with drift no trend	8	40.9741	0.99	Stat	Stat
rw	8	with drift and trend	1	15.2459	0.99	Stat	Stat
rw	8	with drift and trend	2	21.306	0.99	Stat	Stat
rw	8	with drift and trend	3	26.5082	0.99	Stat	Stat
rw	8	with drift and trend	4	30.9558	0.99	Stat	Stat
rw	8	with drift and trend	5	34.4187	0.99	Stat	Stat
rw	8	with drift and trend	6	37.0336	0.99	Stat	Stat
rw	8	with drift and trend	7	39.4714	0.99	Stat	Stat
rw	8	with drift and trend	8	41.7807	0.99	Stat	Stat
rw	9	no drift no trend	1	15.2068	0.99	Stat	Stat
rw	9	no drift no trend	2	21.1956	0.99	Stat	Stat
rw	9	no drift no trend	3	26.3129	0.99	Stat	Stat
rw	9	no drift no trend	4	30.6551	0.99	Stat	Stat
rw	9	no drift no trend	5	34.0132	0.99	Stat	Stat
rw	9	no drift no trend	6	36.5455	0.99	Stat	Stat
rw	9	no drift no trend	7	38.861	0.99	Stat	Stat
rw	9	no drift no trend	8	41.0263	0.99	Stat	Stat
rw	9	no drift no trend	9	43.5492	0.99	Stat	Stat
rw	9	with drift no trend	1	15.19	0.99	Stat	Stat
rw	9	with drift no trend	2	21.172	0.99	Stat	Stat
rw	9	with drift no trend	3	26.2829	0.99	Stat	Stat

	N of lags	Type	lag	ADF	p.value	Stationary at 5%	Stationary at 10%
rw	9	with drift no trend	4	30.6192	0.99	Stat	Stat
rw	9	with drift no trend	5	33.9723	0.99	Stat	Stat
rw	9	with drift no trend	6	36.5007	0.99	Stat	Stat
rw	9	with drift no trend	7	38.8127	0.99	Stat	Stat
rw	9	with drift no trend	8	40.9741	0.99	Stat	Stat
rw	9	with drift no trend	9	43.4959	0.99	Stat	Stat
rw	9	with drift and trend	1	15.2459	0.99	Stat	Stat
rw	9	with drift and trend	2	21.306	0.99	Stat	Stat
rw	9	with drift and trend	3	26.5082	0.99	Stat	Stat
rw	9	with drift and trend	4	30.9558	0.99	Stat	Stat
rw	9	with drift and trend	5	34.4187	0.99	Stat	Stat
rw	9	with drift and trend	6	37.0336	0.99	Stat	Stat
rw	9	with drift and trend	7	39.4714	0.99	Stat	Stat
rw	9	with drift and trend	8	41.7807	0.99	Stat	Stat
rw	9	with drift and trend	9	44.5401	0.99	Stat	Stat
rw	10	no drift no trend	1	15.2068	0.99	Stat	Stat
rw	10	no drift no trend	2	21.1956	0.99	Stat	Stat
rw	10	no drift no trend	3	26.3129	0.99	Stat	Stat
rw	10	no drift no trend	4	30.6551	0.99	Stat	Stat
rw	10	no drift no trend	5	34.0132	0.99	Stat	Stat
rw	10	no drift no trend	6	36.5455	0.99	Stat	Stat
rw	10	no drift no trend	7	38.861	0.99	Stat	Stat
rw	10	no drift no trend	8	41.0263	0.99	Stat	Stat
rw	10	no drift no trend	9	43.5492	0.99	Stat	Stat
rw	10	no drift no trend	10	45.9555	0.99	Stat	Stat
rw	10	with drift no trend	1	15.19	0.99	Stat	Stat
rw	10	with drift no trend	2	21.172	0.99	Stat	Stat
rw	10	with drift no trend	3	26.2829	0.99	Stat	Stat
rw	10	with drift no trend	4	30.6192	0.99	Stat	Stat
rw	10	with drift no trend	5	33.9723	0.99	Stat	Stat
rw	10	with drift no trend	6	36.5007	0.99	Stat	Stat
rw	10	with drift no trend	7	38.8127	0.99	Stat	Stat
rw	10	with drift no trend	8	40.9741	0.99	Stat	Stat
rw	10	with drift no trend	9	43.4959	0.99	Stat	Stat
rw	10	with drift no trend	10	45.9005	0.99	Stat	Stat
rw	10	with drift and trend	1	15.2459	0.99	Stat	Stat
rw	10	with drift and trend	2	21.306	0.99	Stat	Stat
rw	10	with drift and trend	3	26.5082	0.99	Stat	Stat
rw	10	with drift and trend	4	30.9558	0.99	Stat	Stat
rw	10	with drift and trend	5	34.4187	0.99	Stat	Stat
rw	10	with drift and trend	6	37.0336	0.99	Stat	Stat
rw	10	with drift and trend	7	39.4714	0.99	Stat	Stat
rw	10	with drift and trend	8	41.7807	0.99	Stat	Stat
rw	10	with drift and trend	9	44.5401	0.99	Stat	Stat
rw	10	with drift and trend	10	47.1528	0.99	Stat	Stat
rw	11	no drift no trend	1	15.2068	0.99	Stat	Stat
rw	11	no drift no trend	2	21.1956	0.99	Stat	Stat
rw	11	no drift no trend	3	26.3129	0.99	Stat	Stat
rw	11	no drift no trend	4	30.6551	0.99	Stat	Stat
rw	11	no drift no trend	5	34.0132	0.99	Stat	Stat
rw	11	no drift no trend	6	36.5455	0.99	Stat	Stat
rw	11	no drift no trend	7	38.861	0.99	Stat	Stat

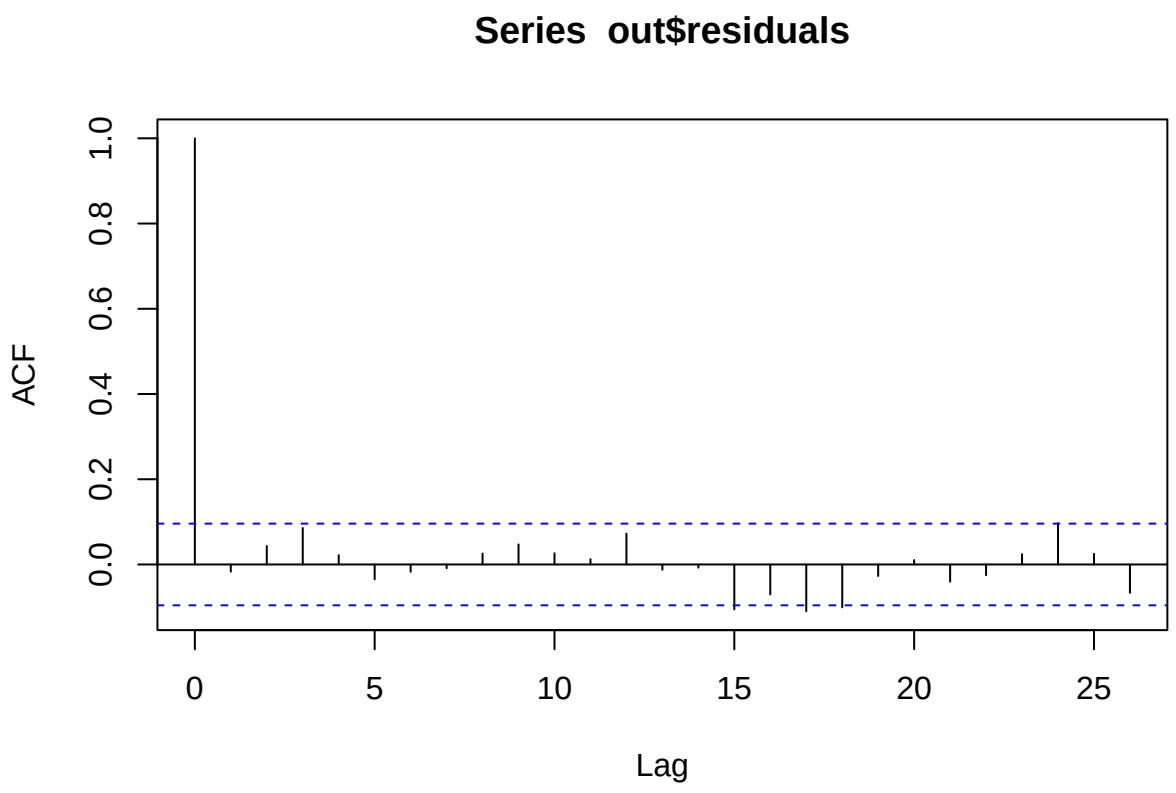
	N of lags	Type	lag	ADF	p.value	Stationary at 5%	Stationary at 10%
rw	11	no drift no trend	8	41.0263	0.99	Stat	Stat
rw	11	no drift no trend	9	43.5492	0.99	Stat	Stat
rw	11	no drift no trend	10	45.9555	0.99	Stat	Stat
rw	11	no drift no trend	11	47.5865	0.99	Stat	Stat
rw	11	with drift no trend	1	15.19	0.99	Stat	Stat
rw	11	with drift no trend	2	21.172	0.99	Stat	Stat
rw	11	with drift no trend	3	26.2829	0.99	Stat	Stat
rw	11	with drift no trend	4	30.6192	0.99	Stat	Stat
rw	11	with drift no trend	5	33.9723	0.99	Stat	Stat
rw	11	with drift no trend	6	36.5007	0.99	Stat	Stat
rw	11	with drift no trend	7	38.8127	0.99	Stat	Stat
rw	11	with drift no trend	8	40.9741	0.99	Stat	Stat
rw	11	with drift no trend	9	43.4959	0.99	Stat	Stat
rw	11	with drift no trend	10	45.9005	0.99	Stat	Stat
rw	11	with drift no trend	11	47.533	0.99	Stat	Stat
rw	11	with drift and trend	1	15.2459	0.99	Stat	Stat
rw	11	with drift and trend	2	21.306	0.99	Stat	Stat
rw	11	with drift and trend	3	26.5082	0.99	Stat	Stat
rw	11	with drift and trend	4	30.9558	0.99	Stat	Stat
rw	11	with drift and trend	5	34.4187	0.99	Stat	Stat
rw	11	with drift and trend	6	37.0336	0.99	Stat	Stat
rw	11	with drift and trend	7	39.4714	0.99	Stat	Stat
rw	11	with drift and trend	8	41.7807	0.99	Stat	Stat
rw	11	with drift and trend	9	44.5401	0.99	Stat	Stat
rw	11	with drift and trend	10	47.1528	0.99	Stat	Stat
rw	11	with drift and trend	11	48.9888	0.99	Stat	Stat
rw	12	no drift no trend	1	15.2068	0.99	Stat	Stat
rw	12	no drift no trend	2	21.1956	0.99	Stat	Stat
rw	12	no drift no trend	3	26.3129	0.99	Stat	Stat
rw	12	no drift no trend	4	30.6551	0.99	Stat	Stat
rw	12	no drift no trend	5	34.0132	0.99	Stat	Stat
rw	12	no drift no trend	6	36.5455	0.99	Stat	Stat
rw	12	no drift no trend	7	38.861	0.99	Stat	Stat
rw	12	no drift no trend	8	41.0263	0.99	Stat	Stat
rw	12	no drift no trend	9	43.5492	0.99	Stat	Stat
rw	12	no drift no trend	10	45.9555	0.99	Stat	Stat
rw	12	no drift no trend	11	47.5865	0.99	Stat	Stat
rw	12	no drift no trend	12	48.4854	0.99	Stat	Stat
rw	12	with drift no trend	1	15.19	0.99	Stat	Stat
rw	12	with drift no trend	2	21.172	0.99	Stat	Stat
rw	12	with drift no trend	3	26.2829	0.99	Stat	Stat
rw	12	with drift no trend	4	30.6192	0.99	Stat	Stat
rw	12	with drift no trend	5	33.9723	0.99	Stat	Stat
rw	12	with drift no trend	6	36.5007	0.99	Stat	Stat
rw	12	with drift no trend	7	38.8127	0.99	Stat	Stat
rw	12	with drift no trend	8	40.9741	0.99	Stat	Stat
rw	12	with drift no trend	9	43.4959	0.99	Stat	Stat
rw	12	with drift no trend	10	45.9005	0.99	Stat	Stat
rw	12	with drift no trend	11	47.533	0.99	Stat	Stat
rw	12	with drift no trend	12	48.4345	0.99	Stat	Stat
rw	12	with drift and trend	1	15.2459	0.99	Stat	Stat
rw	12	with drift and trend	2	21.306	0.99	Stat	Stat

	N of lags	Type	lag	ADF	p.value	Stationary at 5%	Stationary at 10%
rw	12	with drift and trend	3	26.5082	0.99	Stat	Stat
rw	12	with drift and trend	4	30.9558	0.99	Stat	Stat
rw	12	with drift and trend	5	34.4187	0.99	Stat	Stat
rw	12	with drift and trend	6	37.0336	0.99	Stat	Stat
rw	12	with drift and trend	7	39.4714	0.99	Stat	Stat
rw	12	with drift and trend	8	41.7807	0.99	Stat	Stat
rw	12	with drift and trend	9	44.5401	0.99	Stat	Stat
rw	12	with drift and trend	10	47.1528	0.99	Stat	Stat
rw	12	with drift and trend	11	48.9888	0.99	Stat	Stat
rw	12	with drift and trend	12	50.0282	0.99	Stat	Stat

```
##             N of lags                   Type                    lag
##                   "1" "with drift no trend"                    "1"
##                   ADF                p.value      Stationary at 5%
##                "15.19"                 "0.99"                 "Stat"
##     Stationary at 10%
##                 "Stat"
```

```
## $`ADF Statistic using BIC`
## [1] -4.474052
```

Point 3




```
## p q
```

```
## 3 2
```

Point 4

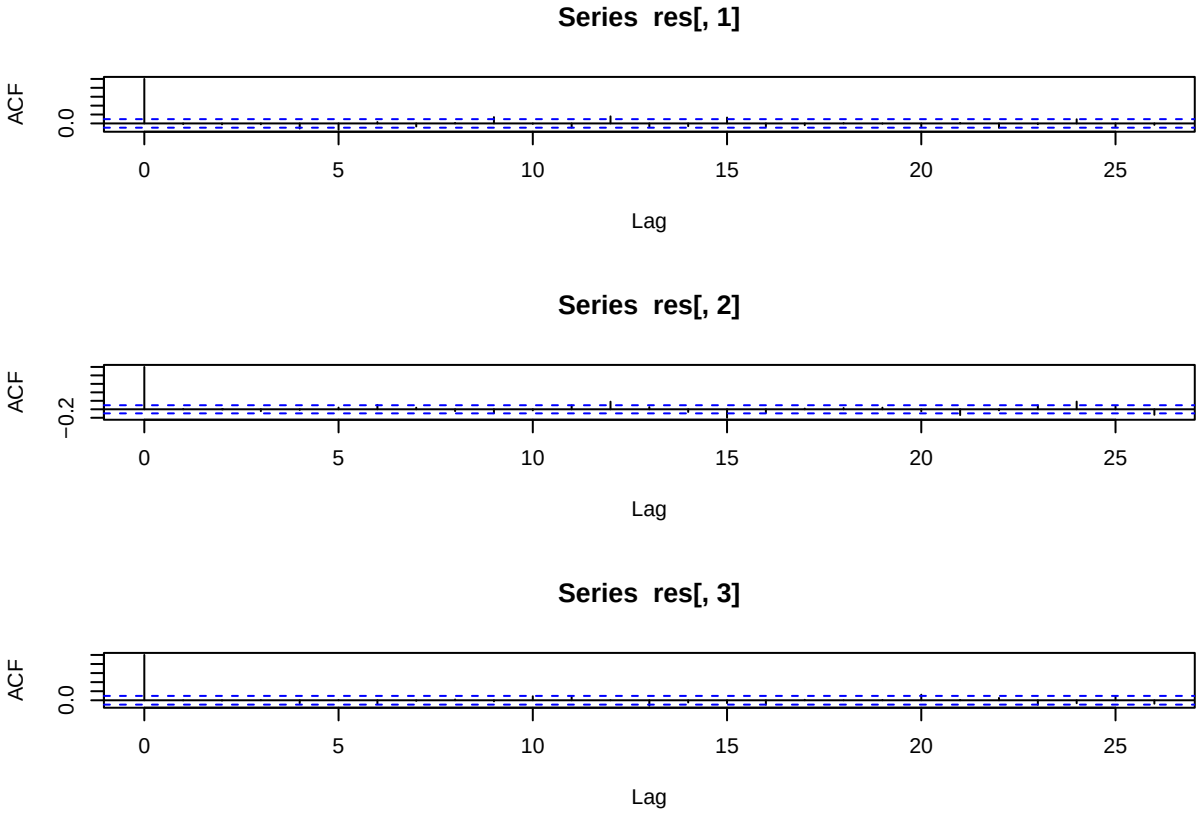
```
## Augmented Dickey-Fuller Test
## alternative: stationary
##
## Type 1: no drift no trend
##      lag  ADF p.value
## [1,]   0 22.3    0.99
## [2,]   1 32.7    0.99
## [3,]   2 41.8    0.99
## [4,]   3 50.3    0.99
## [5,]   4 59.7    0.99
## [6,]   5 66.9    0.99
## Type 2: with drift no trend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

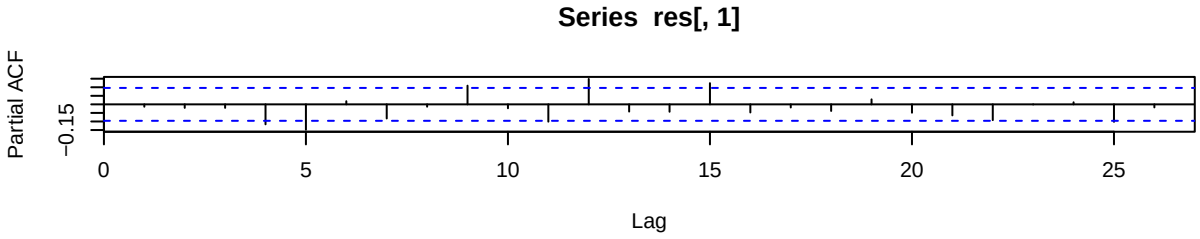
```
## Augmented Dickey-Fuller Test
## alternative: stationary
##
## Type 1: no drift no trend
##      lag  ADF p.value
## [1,]   0 2.47   0.990
## [2,]   1 1.42   0.960
## [3,]   2 1.60   0.973
## [4,]   3 1.63   0.975
## [5,]   4 1.56   0.970
## [6,]   5 1.35   0.955
## Type 2: with drift no trend
##      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
```

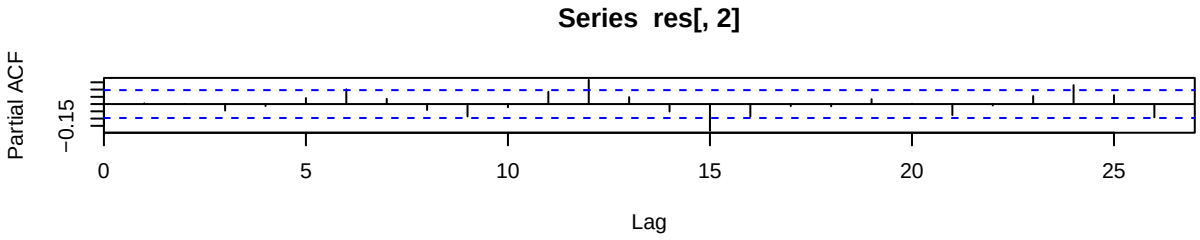
```
##      lag  ADF p.value
## [1,]   0 2.47    0.99
## [2,]   1 1.42    0.99
## [3,]   2 1.61    0.99
## [4,]   3 1.64    0.99
## [5,]   4 1.57    0.99
## [6,]   5 1.36    0.99
## ----
## Note: in fact, p.value = 0.01 means p.value <= 0.01
```

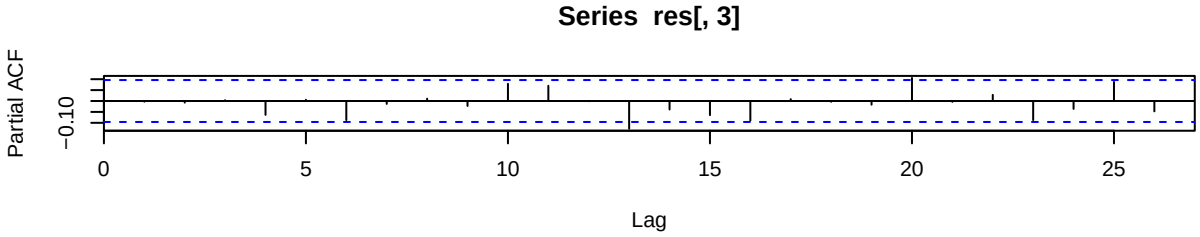
```
## Augmented Dickey-Fuller Test
## alternative: stationary
##
## Type 1: no drift no trend
##      lag   ADF p.value
## [1,]   0 1.852   0.984
## [2,]   1 0.579   0.811
## [3,]   2 0.886   0.899
## [4,]   3 0.933   0.906
## [5,]   4 1.072   0.923
## [6,]   5 1.081   0.924
## Type 2: with drift no 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
```


Series res[, 1]
ACF
0.0
0
5
10
15
20
25
Lag
Series res[, 2]
ACF
−0.2
0
5
10
15
20
25
Lag
Series res[, 3]
ACF
0.0
0
5
10
15
20
25
Lag



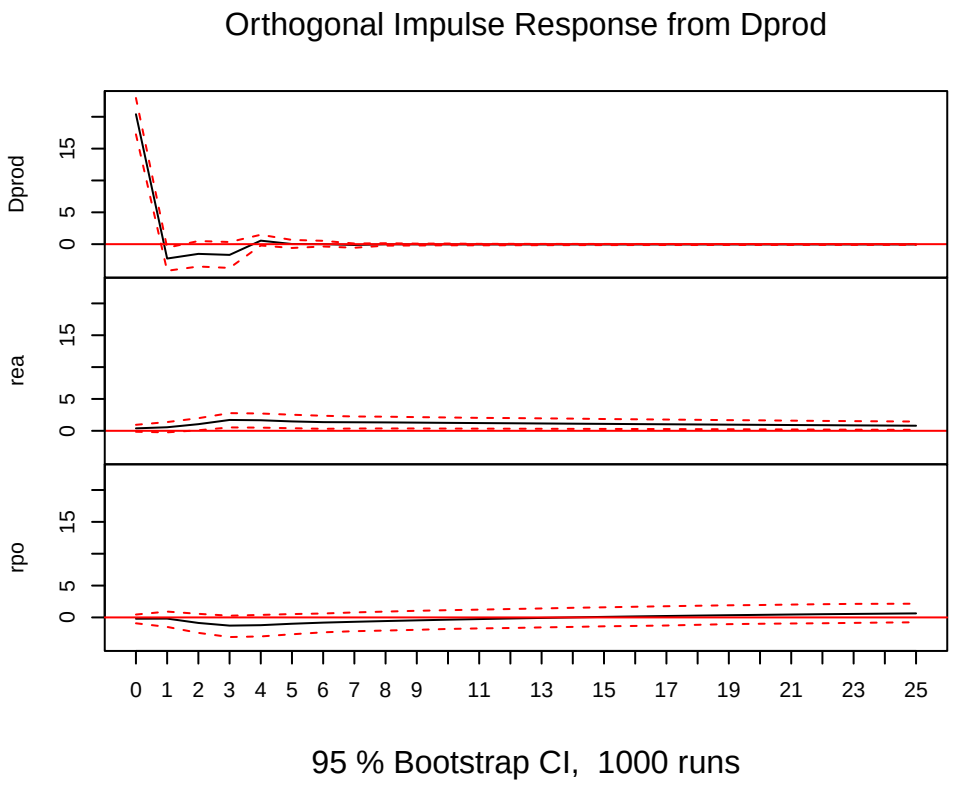


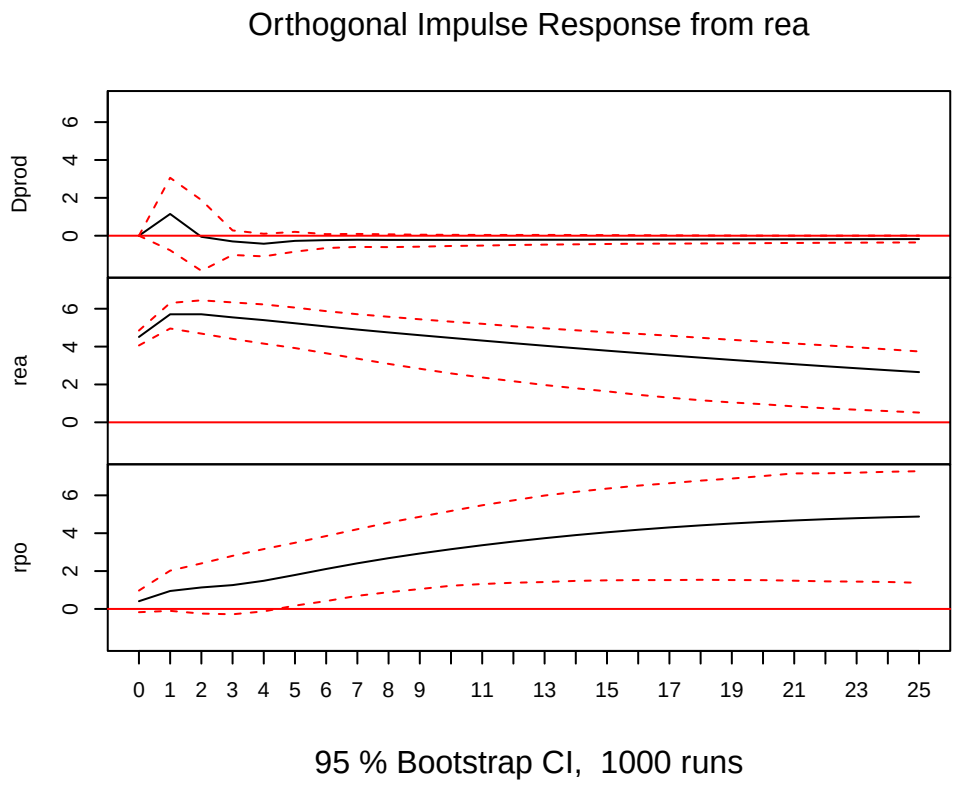


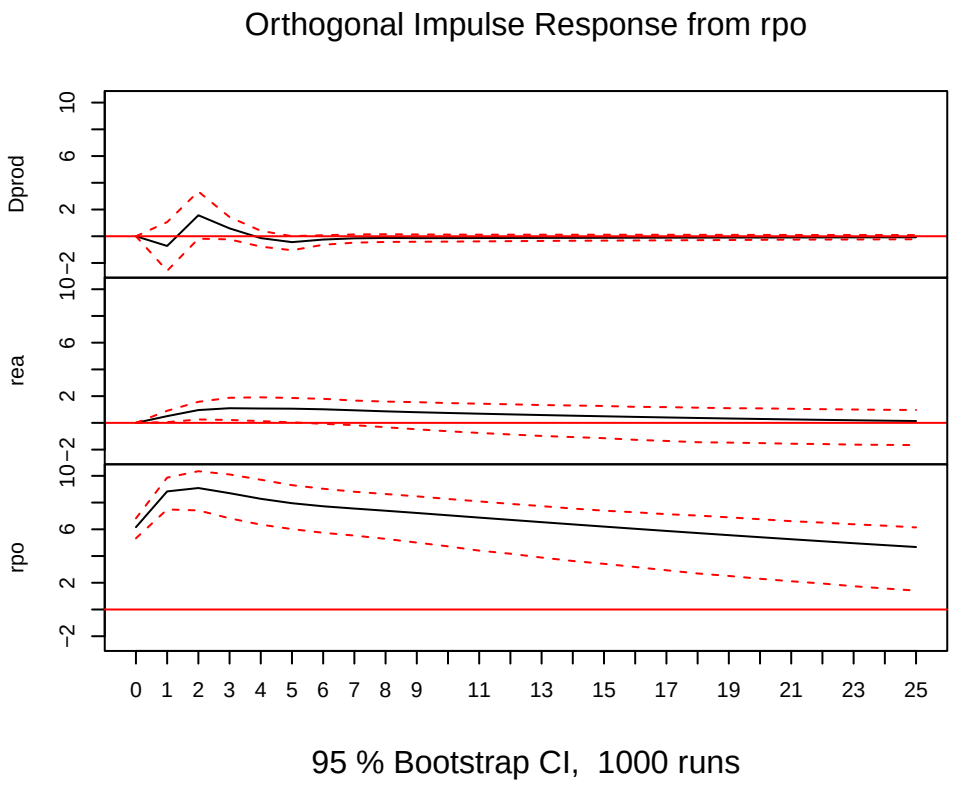

```
##            Dprod       rea       rpo
## Dprod 416.145308  7.824951 -4.099590
## rea     7.824951 20.483391  1.765876
## rpo    -4.099590  1.765876 38.132342
```

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

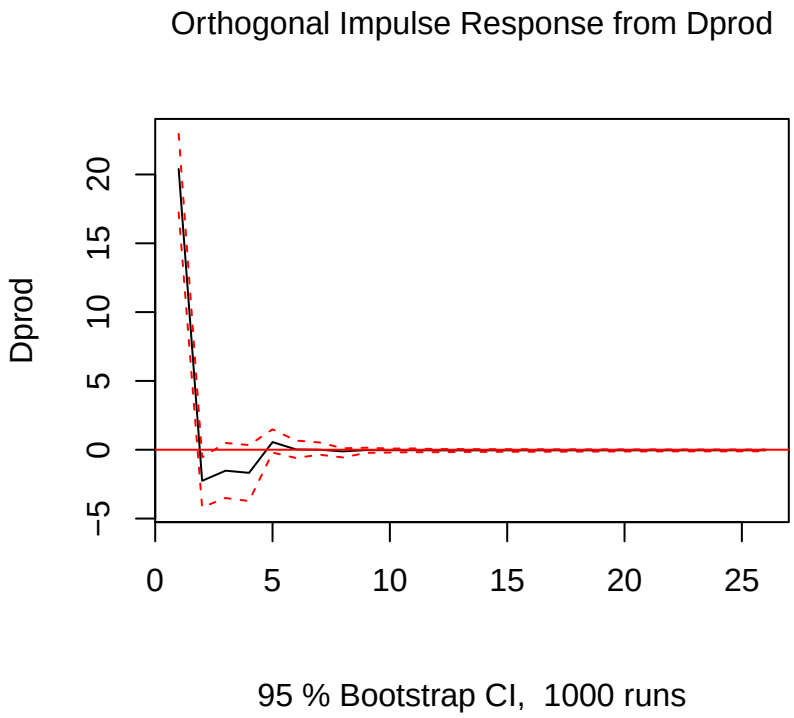
```
## [1] 0.9701644 0.9701644 0.4696721 0.4634054 0.4634054 0.4593787 0.4593787
## [8] 0.2924893 0.2924893
```

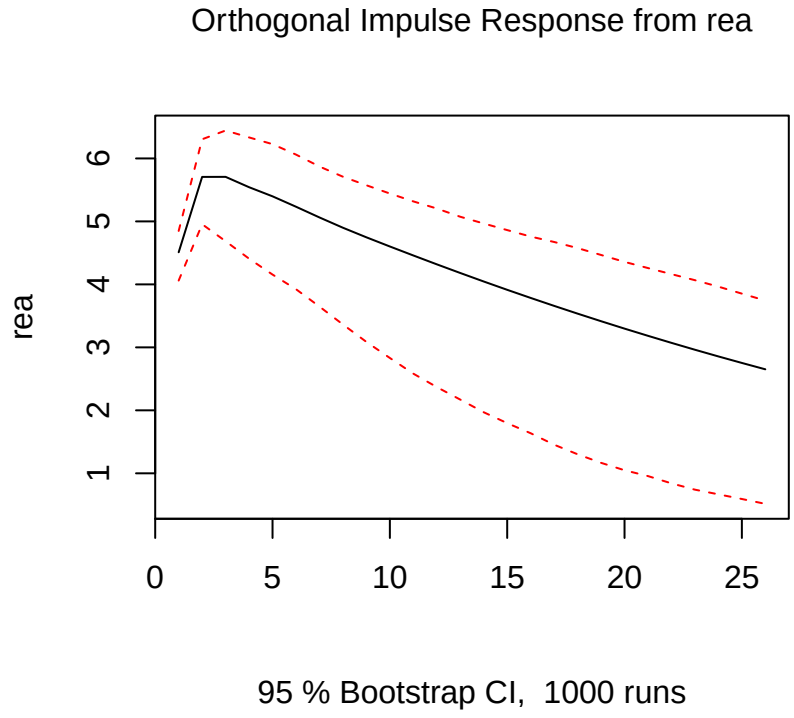

Orthogonal Impulse Response from Dprod
Dprod
rea
rpo
0 5 15
0 1 2 3 4 5 6 7 8 9 11 13 15 17 19 21 23 25
95 % Bootstrap CI, 1000 runs

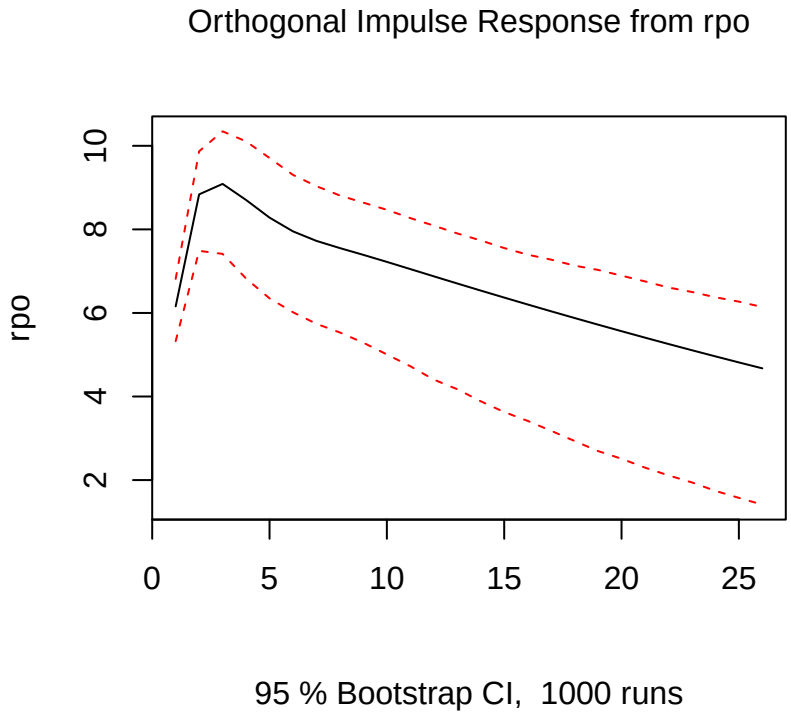

Orthogonal Impulse Response from rea
Dprod
rea
rpo
0 2 4 6
0 1 2 3 4 5 6 7 8 9 11 13 15 17 19 21 23 25
95 % Bootstrap CI, 1000 runs


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
rpo
2
4
6
8
10
0
5
10
15
20
25
95 % Bootstrap CI, 1000 runs