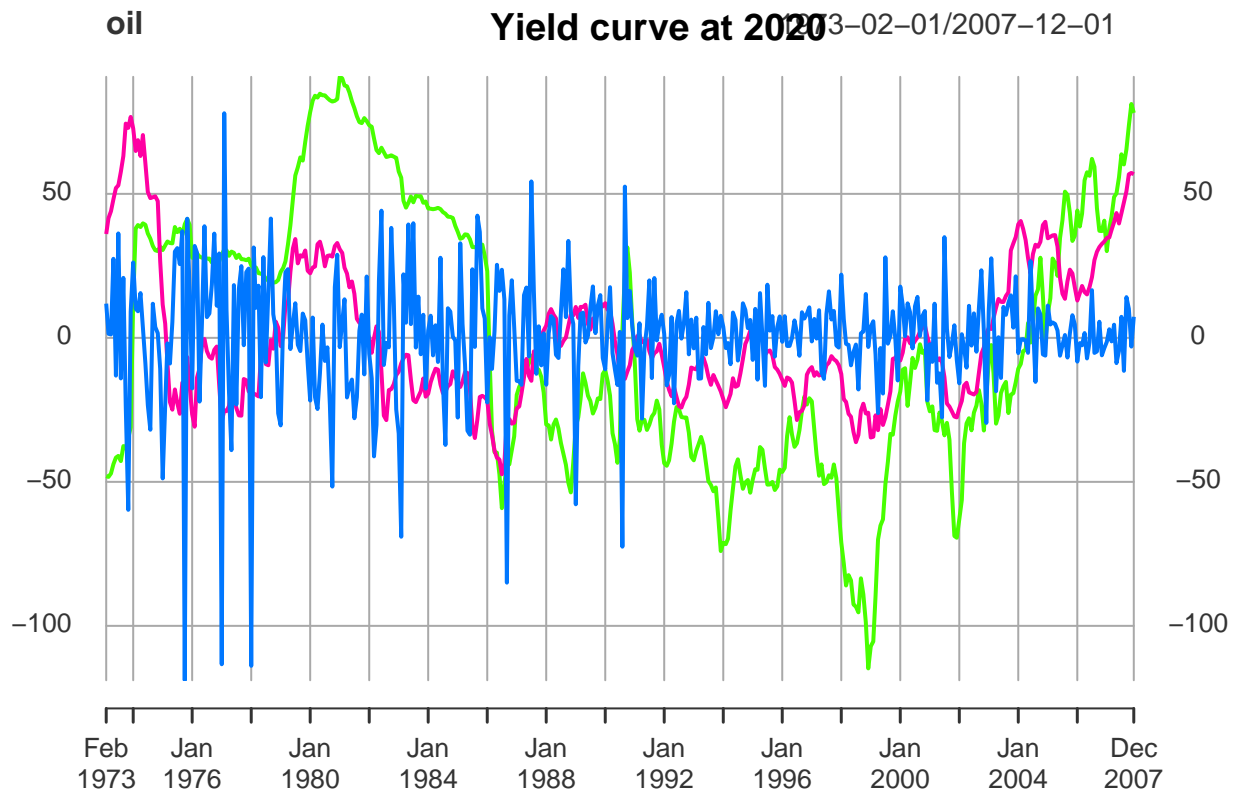


# Assignement

## 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.



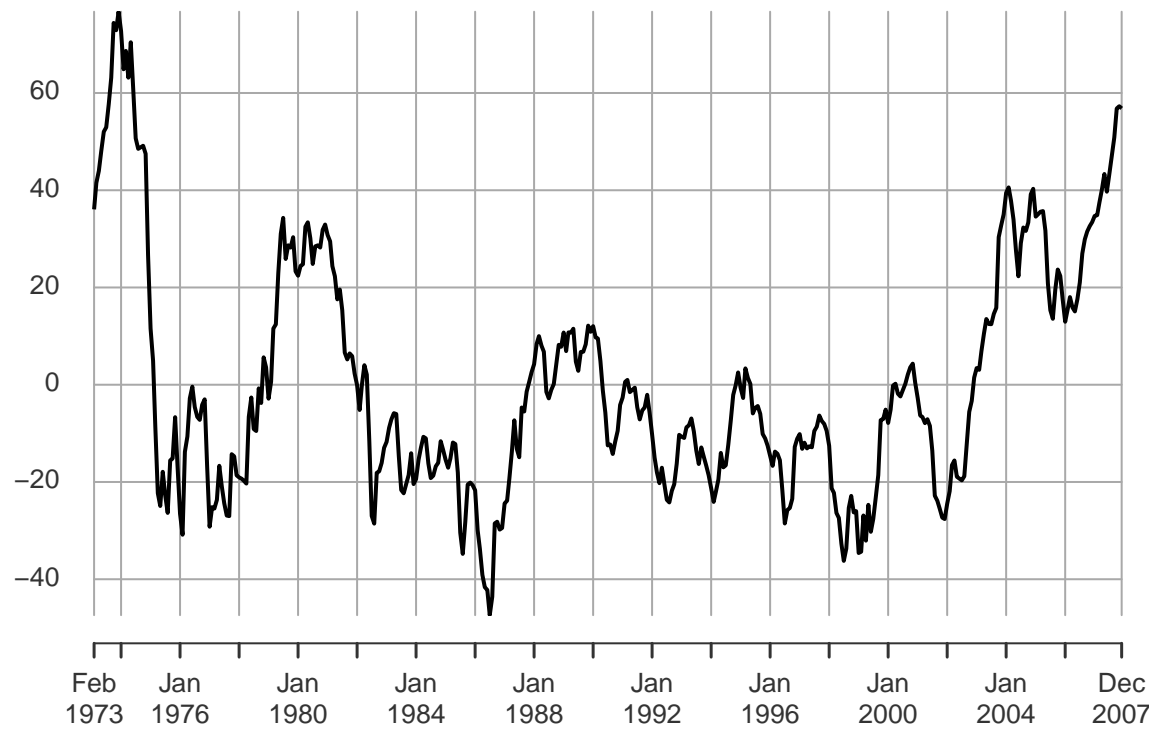
As we can see the acf its clear signaling the presence of an autocorrelation process. In order to test if the *rea* is an  $I(1)$ , we will use an ADF test with lag =1. We will perform the test specifying four different type of the process: 1. No constant, no trend 2. Constant 3. Constant with trend 4. No constant with trend First, we print the first times series graph. We perform the different type of the test with a maximum lag order of 12:

$$rea_t = \alpha + \sigma_1 rea_{t-1} + \dots + \sigma_{12} \delta rea_{t-12}$$

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

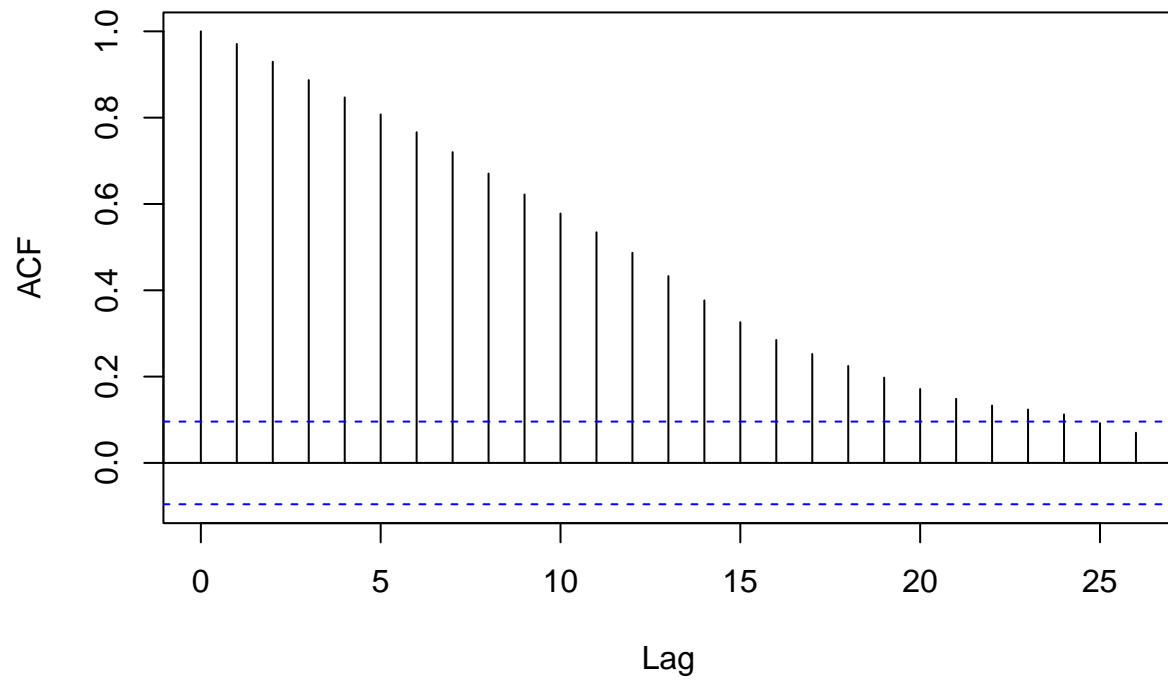
oil\$rea

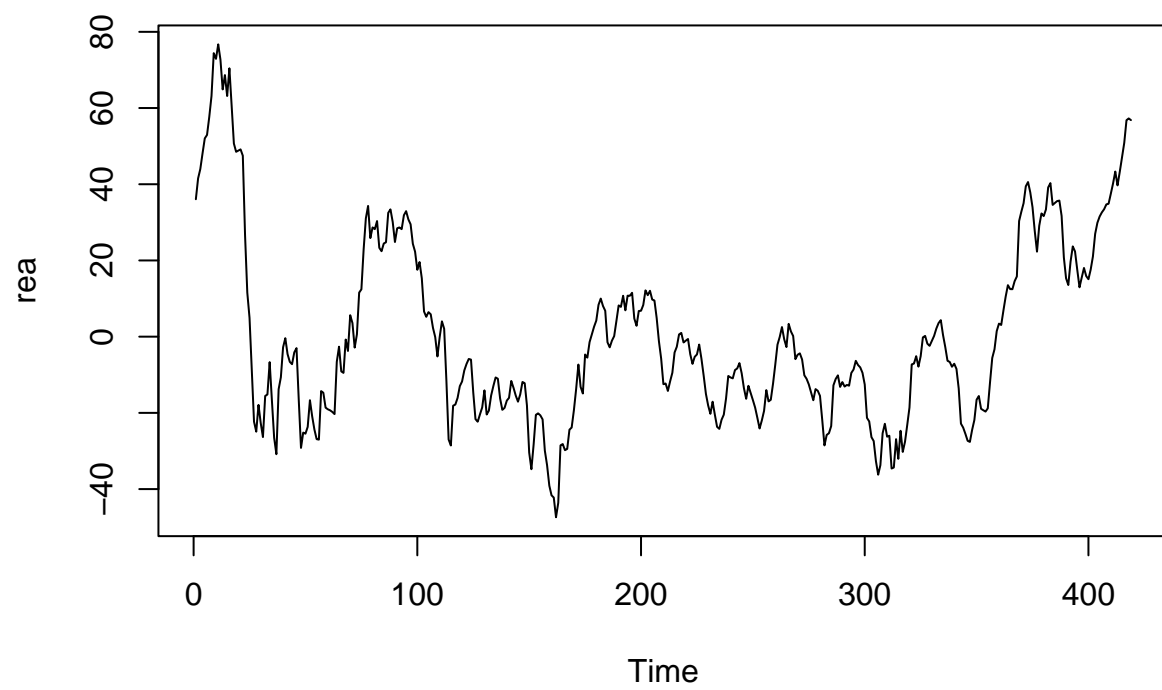
1973-02-01/2007-12-01

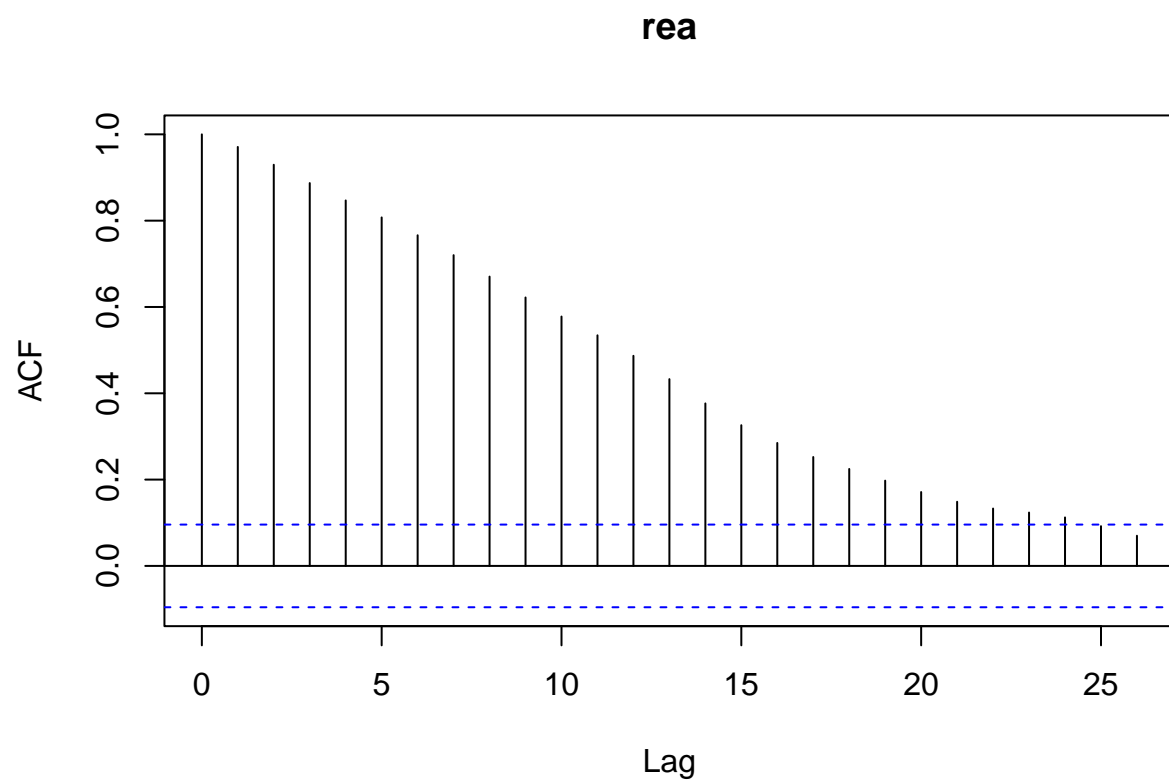


one which as lower BIC:

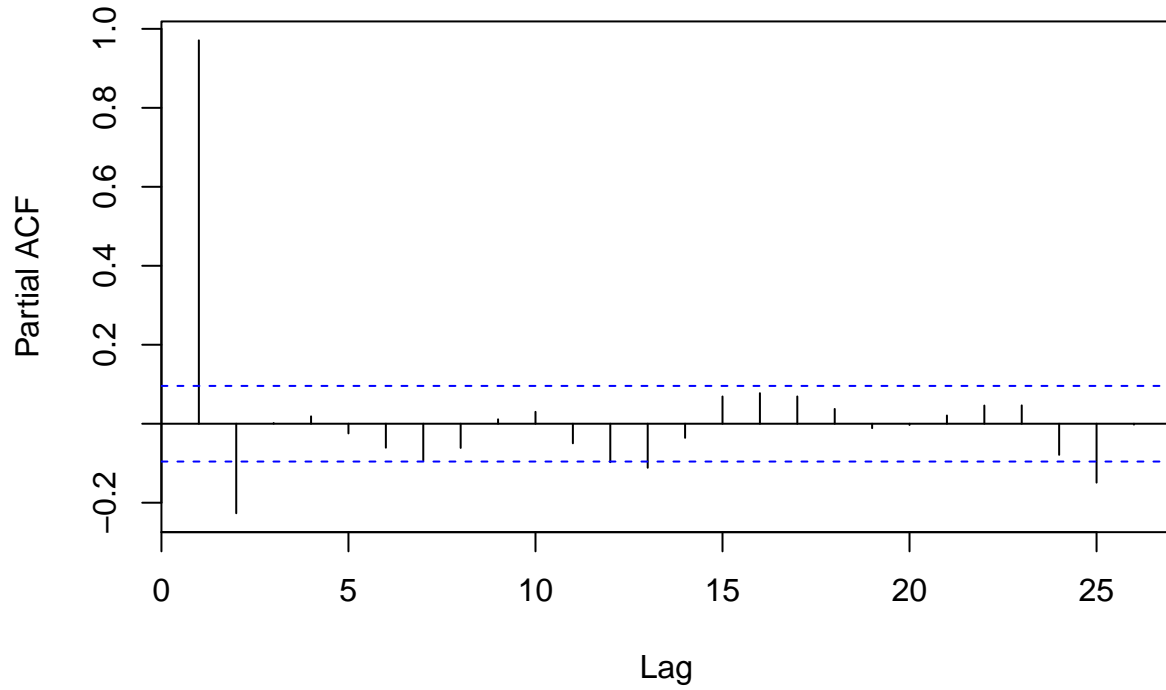
**Series oil\$rea**







## Series timeseries



	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	No Stat.	No Stat.
rw	1	with drift no trend	1	-1.6443	0.4692	No Stat.	No Stat.
rw	1	with drift and trend	1	-1.6235	0.736	No Stat.	No Stat.
rw	2	no drift no trend	1	-1.6457	0.0961	No Stat.	No Stat.
rw	2	no drift no trend	2	-2.5702	0.0104	Stat	No Stat.
rw	2	with drift no trend	1	-1.6443	0.4692	No Stat.	No Stat.
rw	2	with drift no trend	2	-2.5669	0.1025	No Stat.	No Stat.
rw	2	with drift and trend	1	-1.6235	0.736	No Stat.	No Stat.
rw	2	with drift and trend	2	-2.5446	0.3465	No Stat.	No Stat.
rw	3	no drift no trend	1	-1.6457	0.0961	No Stat.	No Stat.
rw	3	no drift no trend	2	-2.5702	0.0104	Stat	No Stat.
rw	3	no drift no trend	3	-2.4271	0.0166	Stat	No Stat.
rw	3	with drift no trend	1	-1.6443	0.4692	No Stat.	No Stat.
rw	3	with drift no trend	2	-2.5669	0.1025	No Stat.	No Stat.
rw	3	with drift no trend	3	-2.4235	0.1595	No Stat.	No Stat.
rw	3	with drift and trend	1	-1.6235	0.736	No Stat.	No Stat.
rw	3	with drift and trend	2	-2.5446	0.3465	No Stat.	No Stat.
rw	3	with drift and trend	3	-2.3969	0.4087	No Stat.	No Stat.
rw	4	no drift no trend	1	-1.6457	0.0961	No Stat.	No Stat.
rw	4	no drift no trend	2	-2.5702	0.0104	Stat	No Stat.
rw	4	no drift no trend	3	-2.4271	0.0166	Stat	No Stat.
rw	4	no drift no trend	4	-2.4375	0.0162	Stat	No Stat.
rw	4	with drift no trend	1	-1.6443	0.4692	No Stat.	No Stat.
rw	4	with drift no trend	2	-2.5669	0.1025	No Stat.	No 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	No Stat.	No Stat.
rw	4	with drift no trend	4	-2.4339	0.1554	No Stat.	No Stat.
rw	4	with drift and trend	1	-1.6235	0.736	No Stat.	No Stat.
rw	4	with drift and trend	2	-2.5446	0.3465	No Stat.	No Stat.
rw	4	with drift and trend	3	-2.3969	0.4087	No Stat.	No Stat.
rw	4	with drift and trend	4	-2.4043	0.4055	No Stat.	No Stat.
rw	5	no drift no trend	1	-1.6457	0.0961	No Stat.	No Stat.
rw	5	no drift no trend	2	-2.5702	0.0104	Stat	No Stat.
rw	5	no drift no trend	3	-2.4271	0.0166	Stat	No Stat.
rw	5	no drift no trend	4	-2.4375	0.0162	Stat	No Stat.
rw	5	no drift no trend	5	-2.5514	0.0112	Stat	No Stat.
rw	5	with drift no trend	1	-1.6443	0.4692	No Stat.	No Stat.
rw	5	with drift no trend	2	-2.5669	0.1025	No Stat.	No Stat.
rw	5	with drift no trend	3	-2.4235	0.1595	No Stat.	No Stat.
rw	5	with drift no trend	4	-2.4339	0.1554	No Stat.	No Stat.
rw	5	with drift no trend	5	-2.5482	0.11	No Stat.	No Stat.
rw	5	with drift and trend	1	-1.6235	0.736	No Stat.	No Stat.
rw	5	with drift and trend	2	-2.5446	0.3465	No Stat.	No Stat.
rw	5	with drift and trend	3	-2.3969	0.4087	No Stat.	No Stat.
rw	5	with drift and trend	4	-2.4043	0.4055	No Stat.	No Stat.
rw	5	with drift and trend	5	-2.5178	0.3578	No Stat.	No Stat.
rw	6	no drift no trend	1	-1.6457	0.0961	No Stat.	No Stat.
rw	6	no drift no trend	2	-2.5702	0.0104	Stat	No Stat.
rw	6	no drift no trend	3	-2.4271	0.0166	Stat	No Stat.
rw	6	no drift no trend	4	-2.4375	0.0162	Stat	No Stat.
rw	6	no drift no trend	5	-2.5514	0.0112	Stat	No Stat.
rw	6	no drift no trend	6	-2.801	0.01	Stat	Stat
rw	6	with drift no trend	1	-1.6443	0.4692	No Stat.	No Stat.
rw	6	with drift no trend	2	-2.5669	0.1025	No Stat.	No Stat.
rw	6	with drift no trend	3	-2.4235	0.1595	No Stat.	No Stat.
rw	6	with drift no trend	4	-2.4339	0.1554	No Stat.	No Stat.
rw	6	with drift no trend	5	-2.5482	0.11	No Stat.	No Stat.
rw	6	with drift no trend	6	-2.7977	0.0626	No Stat.	No Stat.
rw	6	with drift and trend	1	-1.6235	0.736	No Stat.	No Stat.
rw	6	with drift and trend	2	-2.5446	0.3465	No Stat.	No Stat.
rw	6	with drift and trend	3	-2.3969	0.4087	No Stat.	No Stat.
rw	6	with drift and trend	4	-2.4043	0.4055	No Stat.	No Stat.
rw	6	with drift and trend	5	-2.5178	0.3578	No Stat.	No Stat.
rw	6	with drift and trend	6	-2.7702	0.2515	No Stat.	No Stat.
rw	7	no drift no trend	1	-1.6457	0.0961	No Stat.	No Stat.
rw	7	no drift no trend	2	-2.5702	0.0104	Stat	No Stat.
rw	7	no drift no trend	3	-2.4271	0.0166	Stat	No Stat.
rw	7	no drift no trend	4	-2.4375	0.0162	Stat	No Stat.
rw	7	no drift no trend	5	-2.5514	0.0112	Stat	No Stat.
rw	7	no drift no trend	6	-2.801	0.01	Stat	Stat
rw	7	no drift no trend	7	-3.2152	0.01	Stat	Stat
rw	7	with drift no trend	1	-1.6443	0.4692	No Stat.	No Stat.
rw	7	with drift no trend	2	-2.5669	0.1025	No Stat.	No Stat.
rw	7	with drift no trend	3	-2.4235	0.1595	No Stat.	No Stat.
rw	7	with drift no trend	4	-2.4339	0.1554	No Stat.	No Stat.
rw	7	with drift no trend	5	-2.5482	0.11	No Stat.	No Stat.
rw	7	with drift no trend	6	-2.7977	0.0626	No Stat.	No 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	Stat	No Stat.
rw	7	with drift and trend	1	-1.6235	0.736	No Stat.	No Stat.
rw	7	with drift and trend	2	-2.5446	0.3465	No Stat.	No Stat.
rw	7	with drift and trend	3	-2.3969	0.4087	No Stat.	No Stat.
rw	7	with drift and trend	4	-2.4043	0.4055	No Stat.	No Stat.
rw	7	with drift and trend	5	-2.5178	0.3578	No Stat.	No Stat.
rw	7	with drift and trend	6	-2.7702	0.2515	No Stat.	No Stat.
rw	7	with drift and trend	7	-3.1891	0.0898	No Stat.	No Stat.
rw	8	no drift no trend	1	-1.6457	0.0961	No Stat.	No Stat.
rw	8	no drift no trend	2	-2.5702	0.0104	Stat	No Stat.
rw	8	no drift no trend	3	-2.4271	0.0166	Stat	No Stat.
rw	8	no drift no trend	4	-2.4375	0.0162	Stat	No Stat.
rw	8	no drift no trend	5	-2.5514	0.0112	Stat	No Stat.
rw	8	no drift no trend	6	-2.801	0.01	Stat	Stat
rw	8	no drift no trend	7	-3.2152	0.01	Stat	Stat
rw	8	no drift no trend	8	-3.3318	0.01	Stat	Stat
rw	8	with drift no trend	1	-1.6443	0.4692	No Stat.	No Stat.
rw	8	with drift no trend	2	-2.5669	0.1025	No Stat.	No Stat.
rw	8	with drift no trend	3	-2.4235	0.1595	No Stat.	No Stat.
rw	8	with drift no trend	4	-2.4339	0.1554	No Stat.	No Stat.
rw	8	with drift no trend	5	-2.5482	0.11	No Stat.	No Stat.
rw	8	with drift no trend	6	-2.7977	0.0626	No Stat.	No Stat.
rw	8	with drift no trend	7	-3.2132	0.0211	Stat	No Stat.
rw	8	with drift no trend	8	-3.3321	0.0154	Stat	No Stat.
rw	8	with drift and trend	1	-1.6235	0.736	No Stat.	No Stat.
rw	8	with drift and trend	2	-2.5446	0.3465	No Stat.	No Stat.
rw	8	with drift and trend	3	-2.3969	0.4087	No Stat.	No Stat.
rw	8	with drift and trend	4	-2.4043	0.4055	No Stat.	No Stat.
rw	8	with drift and trend	5	-2.5178	0.3578	No Stat.	No Stat.
rw	8	with drift and trend	6	-2.7702	0.2515	No Stat.	No Stat.
rw	8	with drift and trend	7	-3.1891	0.0898	No Stat.	No Stat.
rw	8	with drift and trend	8	-3.3119	0.0686	No Stat.	No Stat.
rw	9	no drift no trend	1	-1.6457	0.0961	No Stat.	No Stat.
rw	9	no drift no trend	2	-2.5702	0.0104	Stat	No Stat.
rw	9	no drift no trend	3	-2.4271	0.0166	Stat	No Stat.
rw	9	no drift no trend	4	-2.4375	0.0162	Stat	No Stat.
rw	9	no drift no trend	5	-2.5514	0.0112	Stat	No Stat.
rw	9	no drift no trend	6	-2.801	0.01	Stat	Stat
rw	9	no drift no trend	7	-3.2152	0.01	Stat	Stat
rw	9	no drift no trend	8	-3.3318	0.01	Stat	Stat
rw	9	no drift no trend	9	-3.4479	0.01	Stat	Stat
rw	9	with drift no trend	1	-1.6443	0.4692	No Stat.	No Stat.
rw	9	with drift no trend	2	-2.5669	0.1025	No Stat.	No Stat.
rw	9	with drift no trend	3	-2.4235	0.1595	No Stat.	No Stat.
rw	9	with drift no trend	4	-2.4339	0.1554	No Stat.	No Stat.
rw	9	with drift no trend	5	-2.5482	0.11	No Stat.	No Stat.
rw	9	with drift no trend	6	-2.7977	0.0626	No Stat.	No Stat.
rw	9	with drift no trend	7	-3.2132	0.0211	Stat	No Stat.
rw	9	with drift no trend	8	-3.3321	0.0154	Stat	No Stat.
rw	9	with drift no trend	9	-3.454	0.01	Stat	Stat
rw	9	with drift and trend	1	-1.6235	0.736	No Stat.	No Stat.
rw	9	with drift and trend	2	-2.5446	0.3465	No Stat.	No 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	No Stat.	No Stat.
rw	9	with drift and trend	4	-2.4043	0.4055	No Stat.	No Stat.
rw	9	with drift and trend	5	-2.5178	0.3578	No Stat.	No Stat.
rw	9	with drift and trend	6	-2.7702	0.2515	No Stat.	No Stat.
rw	9	with drift and trend	7	-3.1891	0.0898	No Stat.	No Stat.
rw	9	with drift and trend	8	-3.3119	0.0686	No Stat.	No Stat.
rw	9	with drift and trend	9	-3.4427	0.0478	Stat	No Stat.
rw	10	no drift no trend	1	-1.6457	0.0961	No Stat.	No Stat.
rw	10	no drift no trend	2	-2.5702	0.0104	Stat	No Stat.
rw	10	no drift no trend	3	-2.4271	0.0166	Stat	No Stat.
rw	10	no drift no trend	4	-2.4375	0.0162	Stat	No Stat.
rw	10	no drift no trend	5	-2.5514	0.0112	Stat	No Stat.
rw	10	no drift no trend	6	-2.801	0.01	Stat	Stat
rw	10	no drift no trend	7	-3.2152	0.01	Stat	Stat
rw	10	no drift no trend	8	-3.3318	0.01	Stat	Stat
rw	10	no drift no trend	9	-3.4479	0.01	Stat	Stat
rw	10	no drift no trend	10	-3.2258	0.01	Stat	Stat
rw	10	with drift no trend	1	-1.6443	0.4692	No Stat.	No Stat.
rw	10	with drift no trend	2	-2.5669	0.1025	No Stat.	No Stat.
rw	10	with drift no trend	3	-2.4235	0.1595	No Stat.	No Stat.
rw	10	with drift no trend	4	-2.4339	0.1554	No Stat.	No Stat.
rw	10	with drift no trend	5	-2.5482	0.11	No Stat.	No Stat.
rw	10	with drift no trend	6	-2.7977	0.0626	No Stat.	No Stat.
rw	10	with drift no trend	7	-3.2132	0.0211	Stat	No Stat.
rw	10	with drift no trend	8	-3.3321	0.0154	Stat	No Stat.
rw	10	with drift no trend	9	-3.454	0.01	Stat	Stat
rw	10	with drift no trend	10	-3.2318	0.0202	Stat	No Stat.
rw	10	with drift and trend	1	-1.6235	0.736	No Stat.	No Stat.
rw	10	with drift and trend	2	-2.5446	0.3465	No Stat.	No Stat.
rw	10	with drift and trend	3	-2.3969	0.4087	No Stat.	No Stat.
rw	10	with drift and trend	4	-2.4043	0.4055	No Stat.	No Stat.
rw	10	with drift and trend	5	-2.5178	0.3578	No Stat.	No Stat.
rw	10	with drift and trend	6	-2.7702	0.2515	No Stat.	No Stat.
rw	10	with drift and trend	7	-3.1891	0.0898	No Stat.	No Stat.
rw	10	with drift and trend	8	-3.3119	0.0686	No Stat.	No Stat.
rw	10	with drift and trend	9	-3.4427	0.0478	Stat	No Stat.
rw	10	with drift and trend	10	-3.2348	0.0819	No Stat.	No Stat.
rw	11	no drift no trend	1	-1.6457	0.0961	No Stat.	No Stat.
rw	11	no drift no trend	2	-2.5702	0.0104	Stat	No Stat.
rw	11	no drift no trend	3	-2.4271	0.0166	Stat	No Stat.
rw	11	no drift no trend	4	-2.4375	0.0162	Stat	No Stat.
rw	11	no drift no trend	5	-2.5514	0.0112	Stat	No Stat.
rw	11	no drift no trend	6	-2.801	0.01	Stat	Stat
rw	11	no drift no trend	7	-3.2152	0.01	Stat	Stat
rw	11	no drift no trend	8	-3.3318	0.01	Stat	Stat
rw	11	no drift no trend	9	-3.4479	0.01	Stat	Stat
rw	11	no drift no trend	10	-3.2258	0.01	Stat	Stat
rw	11	no drift no trend	11	-3.5172	0.01	Stat	Stat
rw	11	with drift no trend	1	-1.6443	0.4692	No Stat.	No Stat.
rw	11	with drift no trend	2	-2.5669	0.1025	No Stat.	No Stat.
rw	11	with drift no trend	3	-2.4235	0.1595	No Stat.	No Stat.
rw	11	with drift no trend	4	-2.4339	0.1554	No Stat.	No 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	No Stat.	No Stat.
rw	11	with drift no trend	6	-2.7977	0.0626	No Stat.	No Stat.
rw	11	with drift no trend	7	-3.2132	0.0211	Stat	No Stat.
rw	11	with drift no trend	8	-3.3321	0.0154	Stat	No Stat.
rw	11	with drift no trend	9	-3.454	0.01	Stat	Stat
rw	11	with drift no trend	10	-3.2318	0.0202	Stat	No Stat.
rw	11	with drift no trend	11	-3.529	0.01	Stat	Stat
rw	11	with drift and trend	1	-1.6235	0.736	No Stat.	No Stat.
rw	11	with drift and trend	2	-2.5446	0.3465	No Stat.	No Stat.
rw	11	with drift and trend	3	-2.3969	0.4087	No Stat.	No Stat.
rw	11	with drift and trend	4	-2.4043	0.4055	No Stat.	No Stat.
rw	11	with drift and trend	5	-2.5178	0.3578	No Stat.	No Stat.
rw	11	with drift and trend	6	-2.7702	0.2515	No Stat.	No Stat.
rw	11	with drift and trend	7	-3.1891	0.0898	No Stat.	No Stat.
rw	11	with drift and trend	8	-3.3119	0.0686	No Stat.	No Stat.
rw	11	with drift and trend	9	-3.4427	0.0478	Stat	No Stat.
rw	11	with drift and trend	10	-3.2348	0.0819	No Stat.	No Stat.
rw	11	with drift and trend	11	-3.5484	0.0375	Stat	No Stat.
rw	12	no drift no trend	1	-1.6457	0.0961	No Stat.	No Stat.
rw	12	no drift no trend	2	-2.5702	0.0104	Stat	No Stat.
rw	12	no drift no trend	3	-2.4271	0.0166	Stat	No Stat.
rw	12	no drift no trend	4	-2.4375	0.0162	Stat	No Stat.
rw	12	no drift no trend	5	-2.5514	0.0112	Stat	No Stat.
rw	12	no drift no trend	6	-2.801	0.01	Stat	Stat
rw	12	no drift no trend	7	-3.2152	0.01	Stat	Stat
rw	12	no drift no trend	8	-3.3318	0.01	Stat	Stat
rw	12	no drift no trend	9	-3.4479	0.01	Stat	Stat
rw	12	no drift no trend	10	-3.2258	0.01	Stat	Stat
rw	12	no drift no trend	11	-3.5172	0.01	Stat	Stat
rw	12	no drift no trend	12	-3.8179	0.01	Stat	Stat
rw	12	with drift no trend	1	-1.6443	0.4692	No Stat.	No Stat.
rw	12	with drift no trend	2	-2.5669	0.1025	No Stat.	No Stat.
rw	12	with drift no trend	3	-2.4235	0.1595	No Stat.	No Stat.
rw	12	with drift no trend	4	-2.4339	0.1554	No Stat.	No Stat.
rw	12	with drift no trend	5	-2.5482	0.11	No Stat.	No Stat.
rw	12	with drift no trend	6	-2.7977	0.0626	No Stat.	No Stat.
rw	12	with drift no trend	7	-3.2132	0.0211	Stat	No Stat.
rw	12	with drift no trend	8	-3.3321	0.0154	Stat	No Stat.
rw	12	with drift no trend	9	-3.454	0.01	Stat	Stat
rw	12	with drift no trend	10	-3.2318	0.0202	Stat	No Stat.
rw	12	with drift no trend	11	-3.529	0.01	Stat	Stat
rw	12	with drift no trend	12	-3.8297	0.01	Stat	Stat
rw	12	with drift and trend	1	-1.6235	0.736	No Stat.	No Stat.
rw	12	with drift and trend	2	-2.5446	0.3465	No Stat.	No Stat.
rw	12	with drift and trend	3	-2.3969	0.4087	No Stat.	No Stat.
rw	12	with drift and trend	4	-2.4043	0.4055	No Stat.	No Stat.
rw	12	with drift and trend	5	-2.5178	0.3578	No Stat.	No Stat.
rw	12	with drift and trend	6	-2.7702	0.2515	No Stat.	No Stat.
rw	12	with drift and trend	7	-3.1891	0.0898	No Stat.	No Stat.
rw	12	with drift and trend	8	-3.3119	0.0686	No Stat.	No Stat.
rw	12	with drift and trend	9	-3.4427	0.0478	Stat	No Stat.
rw	12	with drift and trend	10	-3.2348	0.0819	No Stat.	No 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	Stat	No Stat.
rw	12	with drift and trend	12	-3.863	0.0156	Stat	No Stat.

```
## $`ADF Statistic using BIC`
```

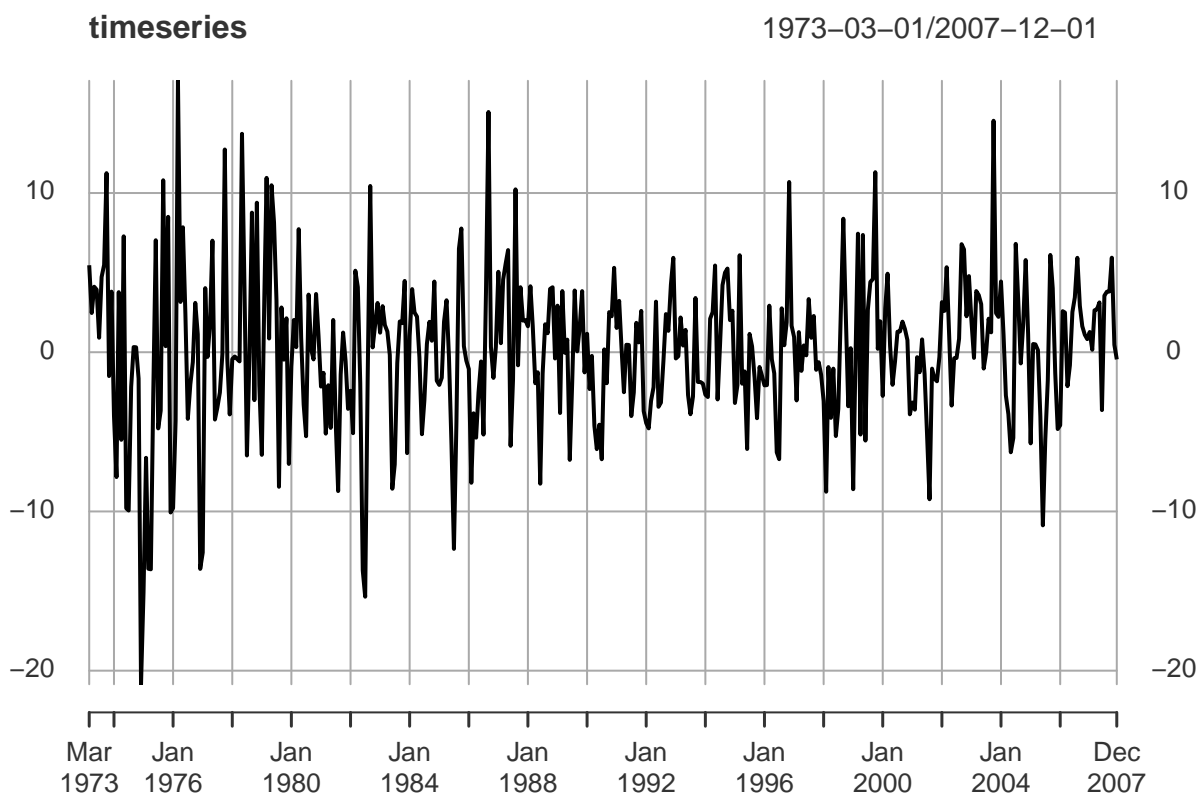
```
## [1] -4.252854
```

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

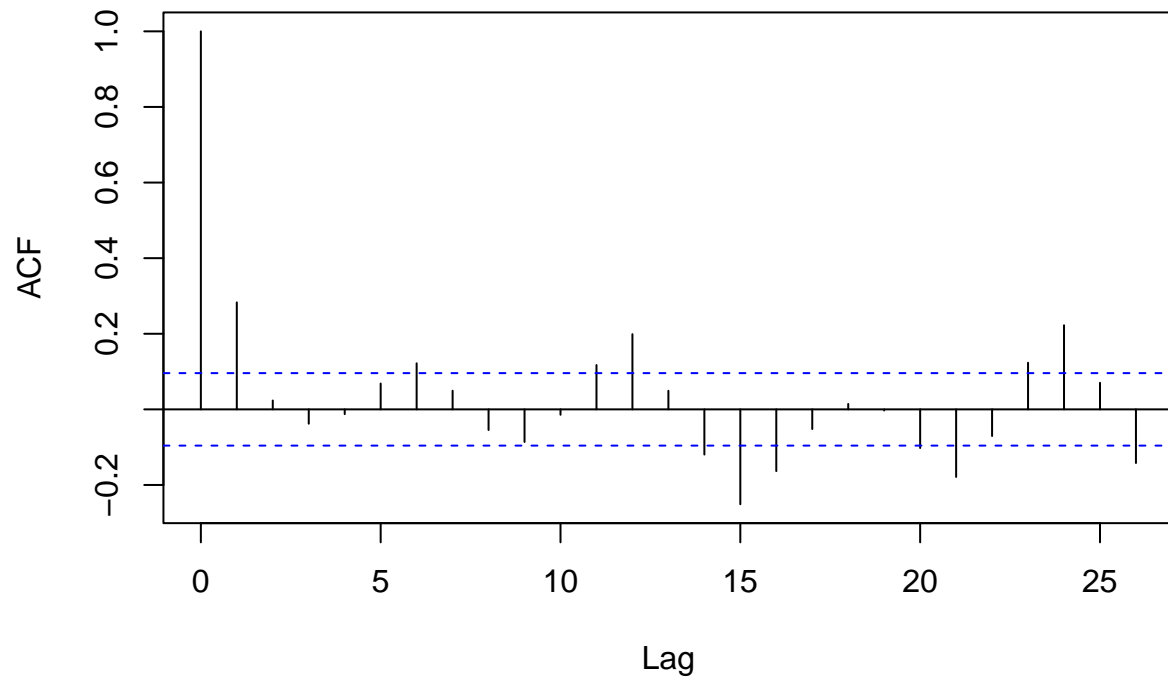
As we can see from the table above which report the result of the ADF tests, it is clear that the process is not stationary with a  $\alpha < 10$ , so there are no sufficient empirical evidence to reject the null. Thus the *rea* time series is not a covariance-stationary process with a minimum lag of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

## Point 2

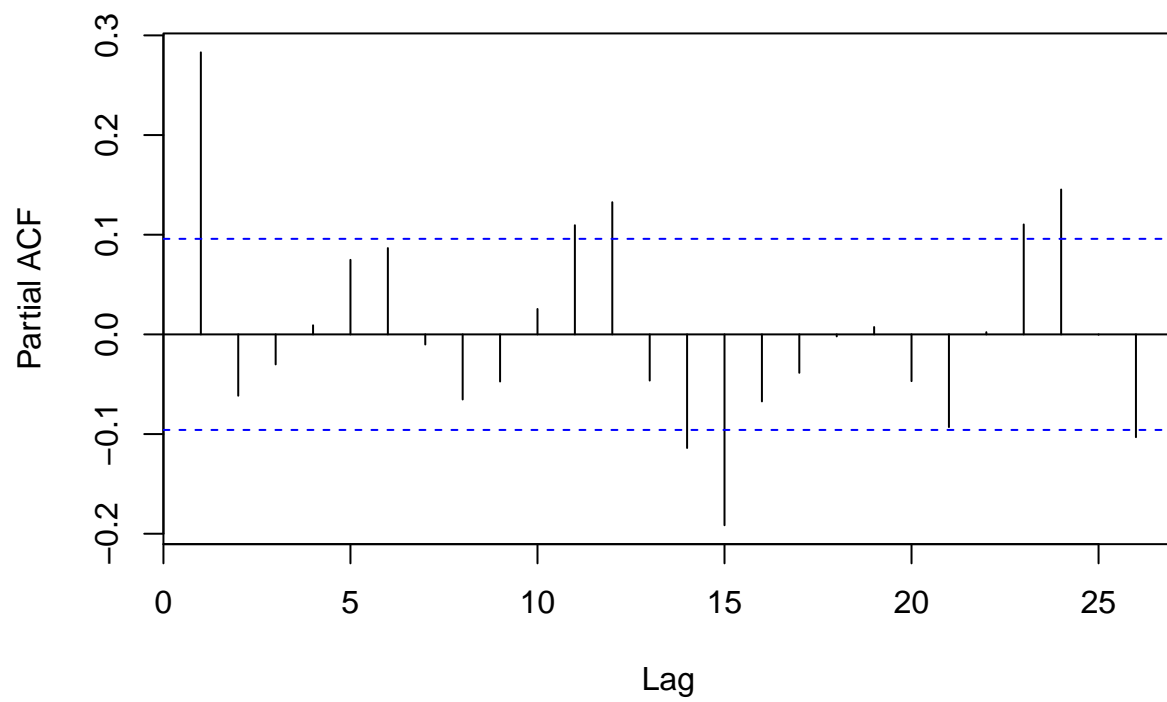
We take the first difference of the timeseries *rea* and check if it is stationary with an adf test. Before that we print the time series of the first differences, the acf, and the pacf to understat the correct specification for the ADF test.

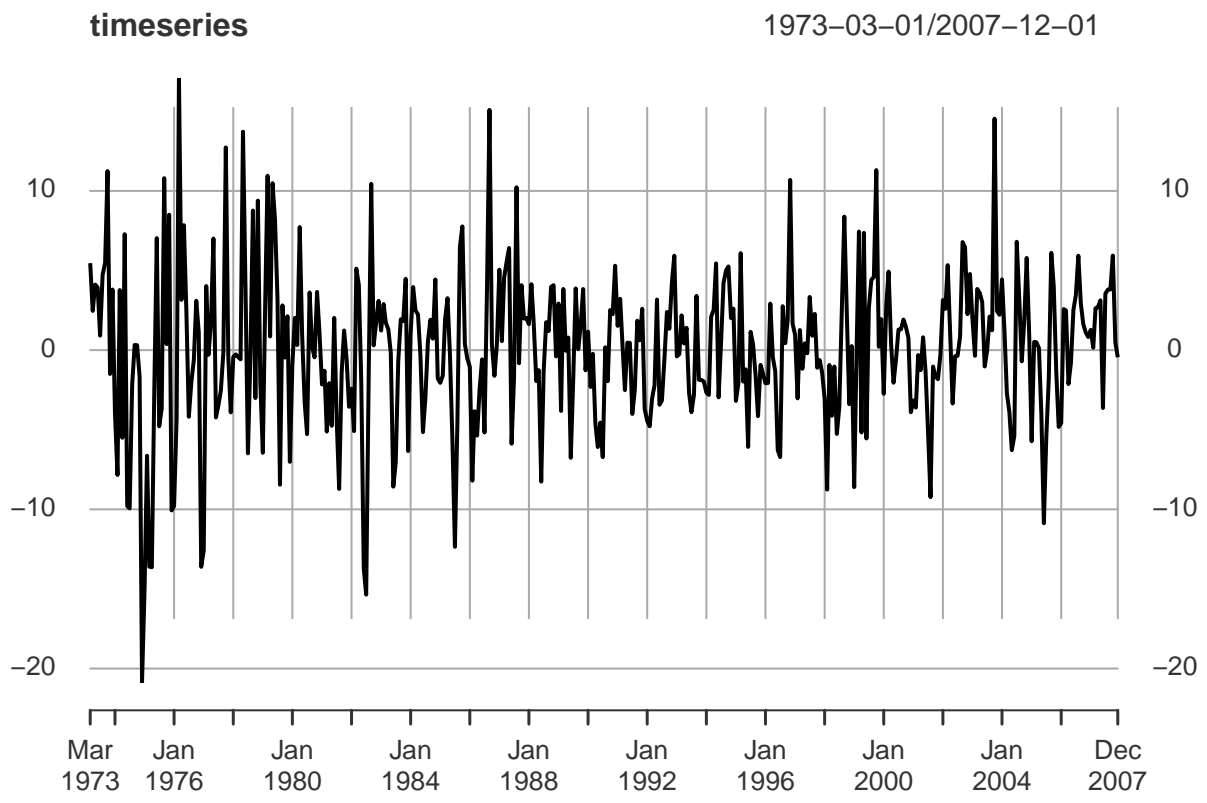


## Series timeseries

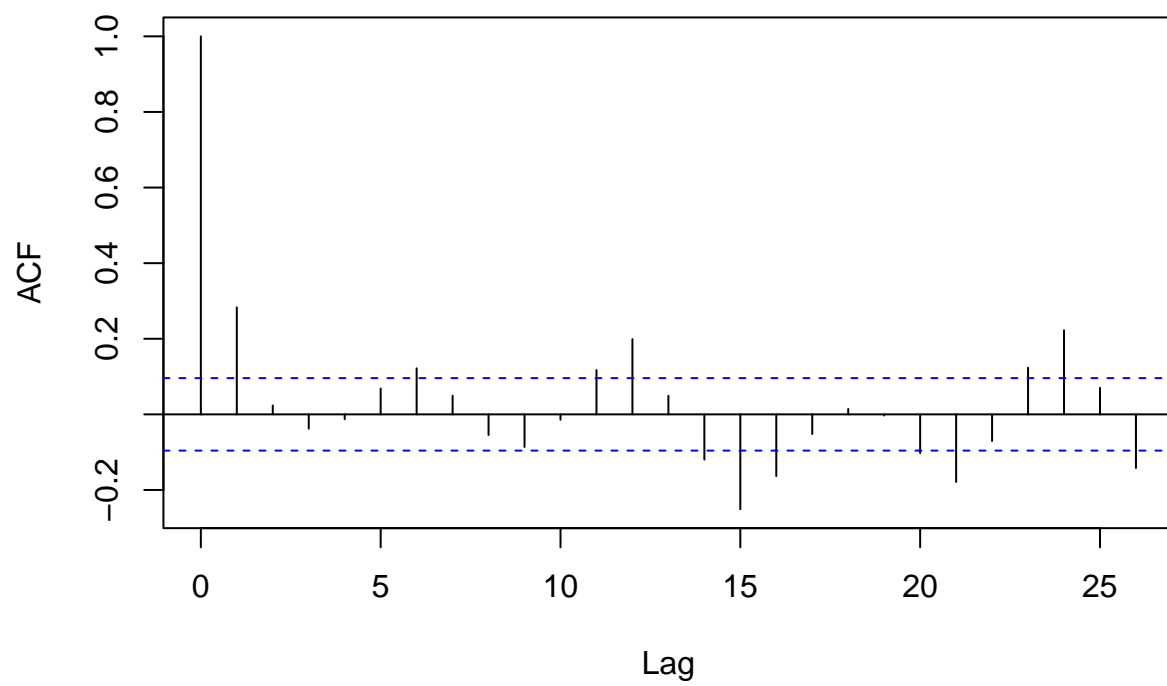


### Series timeseries

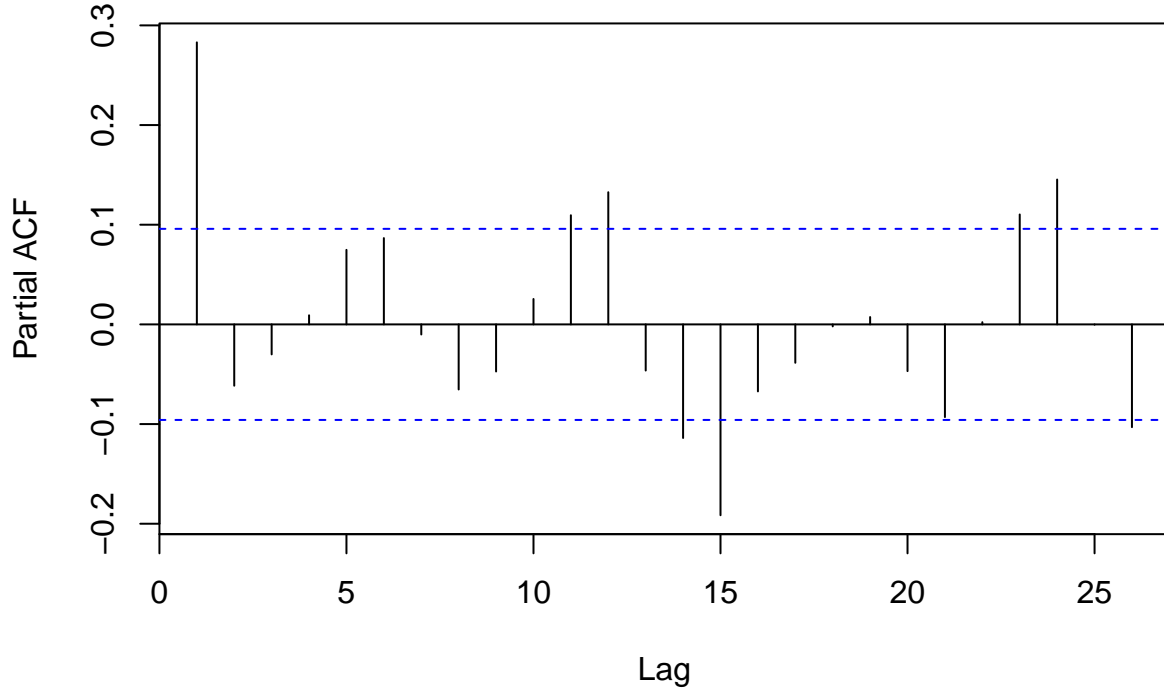




## Series timeseries



## Series timeseries



The above graphs clearly underline stationarity of the process, indeed the acf for the  $lag > 2$  the partial autocorrelation is not statistically different from 0. As for the partial autocorrelation 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:

$$\delta rea_t = \sigma_1 \delta reat(t-1) + \dots + \sigma_{12} \delta reat(t-13)$$

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

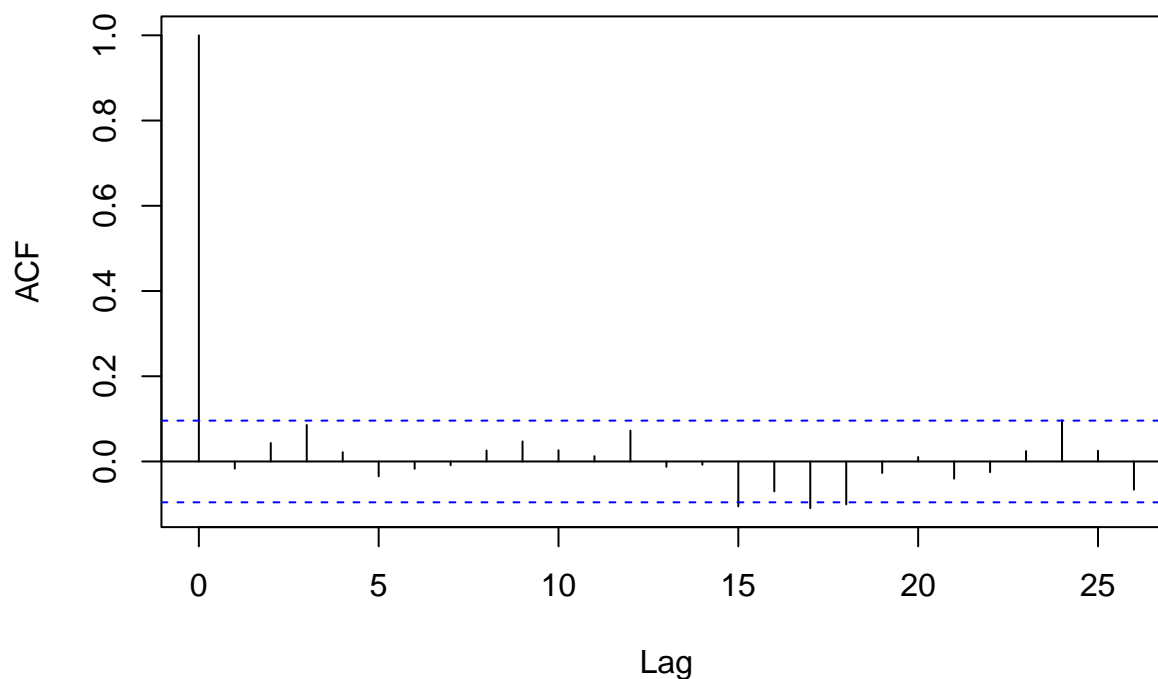
	N of lags	Type	lag	ADF	p.value	Stationary at 5%	Stationary at 10%
rw	12	with drift and trend	3	26.5082	0.99	No Stat.	No Stat.
rw	12	with drift and trend	4	30.9558	0.99	No Stat.	No Stat.
rw	12	with drift and trend	5	34.4187	0.99	No Stat.	No Stat.
rw	12	with drift and trend	6	37.0336	0.99	No Stat.	No Stat.
rw	12	with drift and trend	7	39.4714	0.99	No Stat.	No Stat.
rw	12	with drift and trend	8	41.7807	0.99	No Stat.	No Stat.
rw	12	with drift and trend	9	44.5401	0.99	No Stat.	No Stat.
rw	12	with drift and trend	10	47.1528	0.99	No Stat.	No Stat.
rw	12	with drift and trend	11	48.9888	0.99	No Stat.	No Stat.
rw	12	with drift and trend	12	50.0282	0.99	No Stat.	No Stat.

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

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

### Point 3

#### Series out\$residuals



```
## 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
```

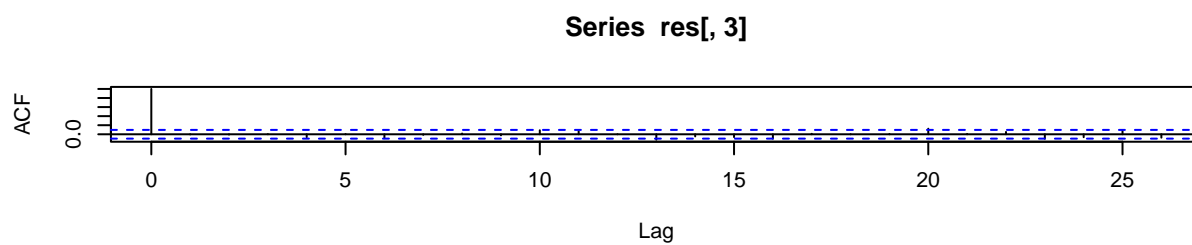
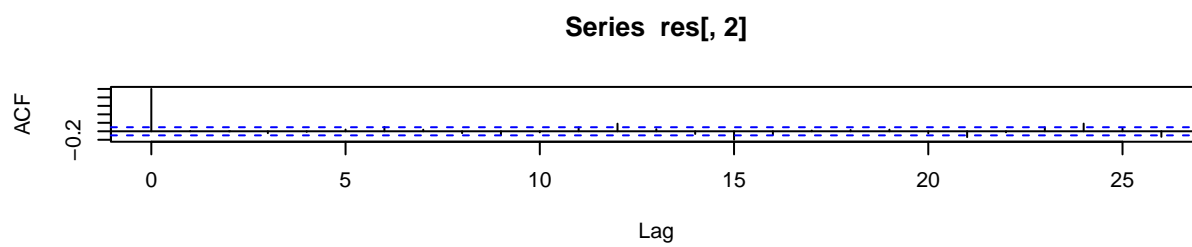
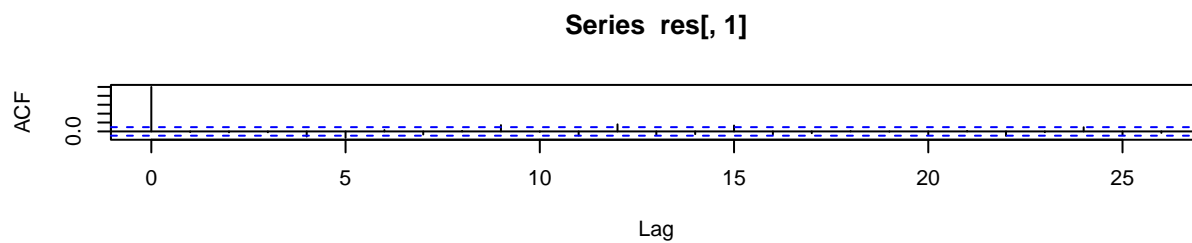
```

##      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

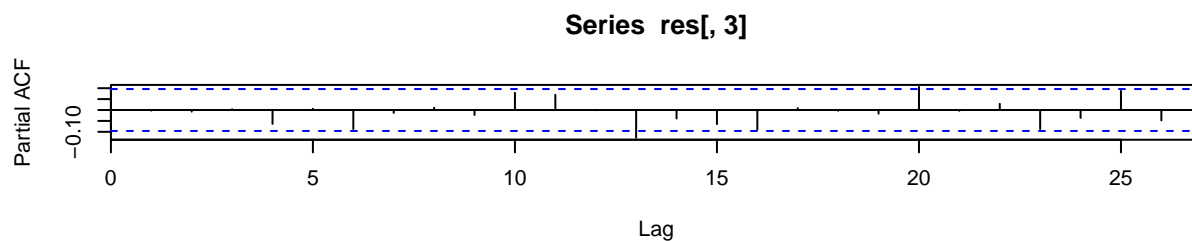
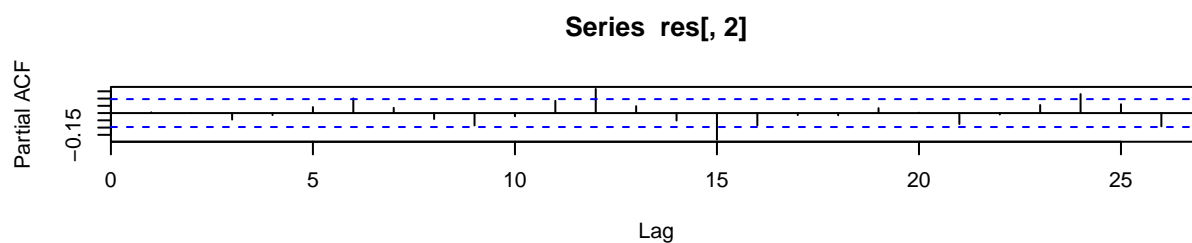
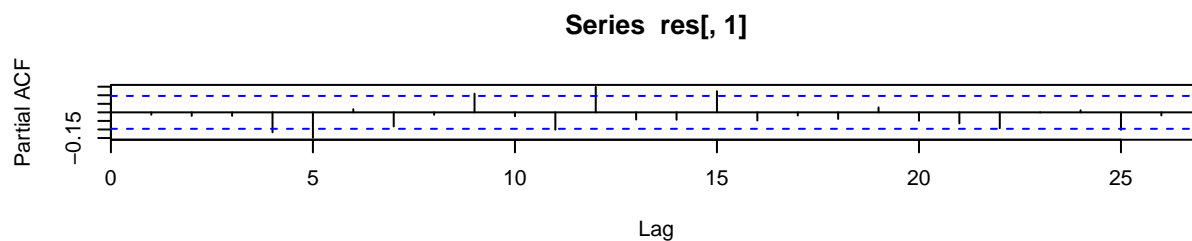
## Augmented Dickey-Fuller Test
## alternative: stationary
##
## Type 1: no drift no trend
##      lag  ADF p.value
## [1,]   0 1.852  0.984
## [2,]   1 0.579  0.811
## [3,]   2 0.886  0.899
## [4,]   3 0.933  0.906
## [5,]   4 1.072  0.923
## [6,]   5 1.081  0.924
## Type 2: with drift no trend
## 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

```





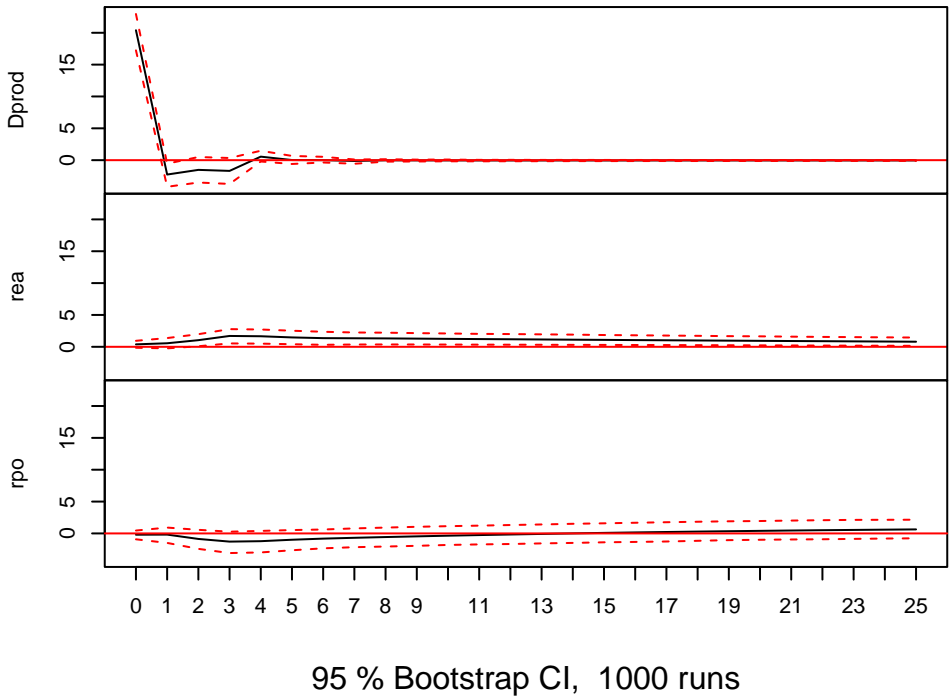


```
##          Dprod      rea      rpo
## Dprod 416.145308  7.824951 -4.099590
## rea    7.824951 20.483391  1.765876
## rpo   -4.099590  1.765876 38.132342

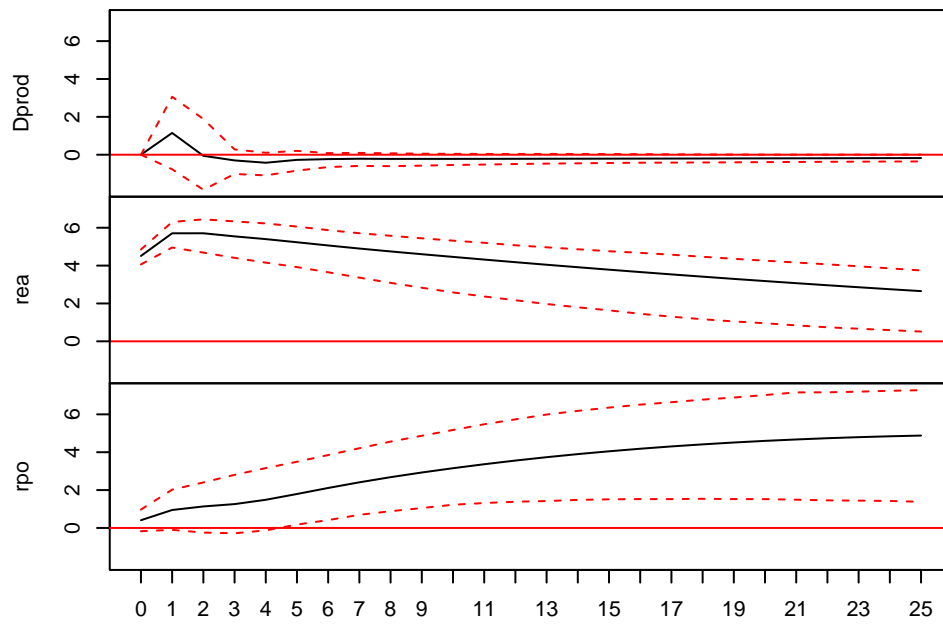
##          Dprod      rea      rpo
## Dprod  1.00000000 0.08475361 -0.03254402
## rea    0.08475361 1.00000000  0.06318480
## rpo   -0.03254402 0.06318480  1.00000000

## [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

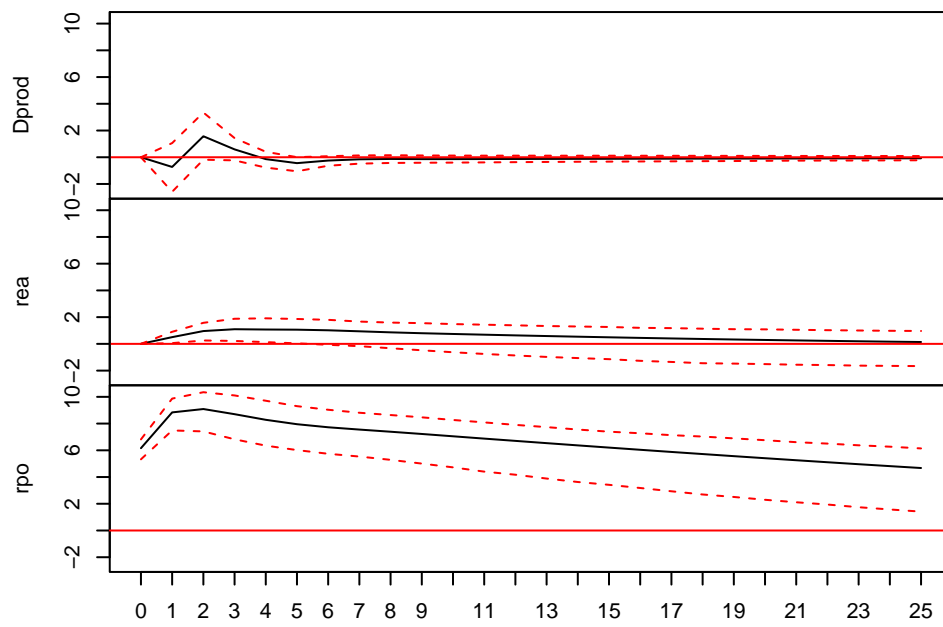


### Orthogonal Impulse Response from rea



95 % Bootstrap CI, 1000 runs

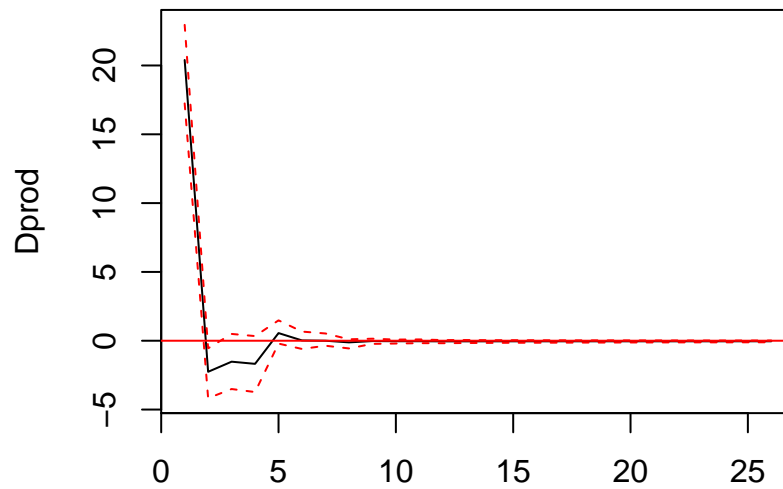
### Orthogonal Impulse Response from rpo



95 % Bootstrap CI, 1000 runs

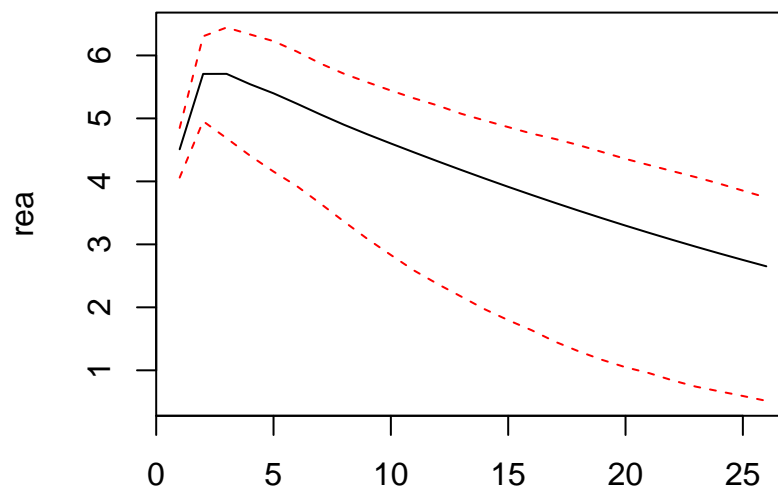
## Point 5

Orthogonal Impulse Response from Dprod



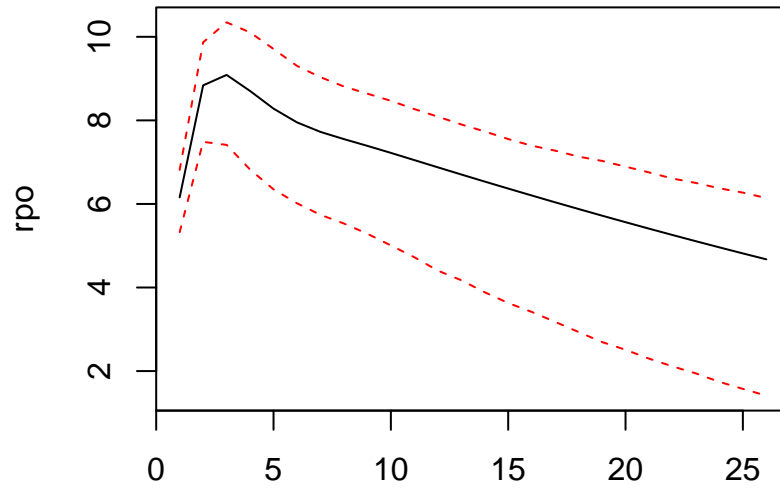
95 % Bootstrap CI, 1000 runs

Orthogonal Impulse Response from rea



95 % Bootstrap CI, 1000 runs

### Orthogonal Impulse Response from rpo



95 % Bootstrap CI, 1000 runs