Intervention analysis

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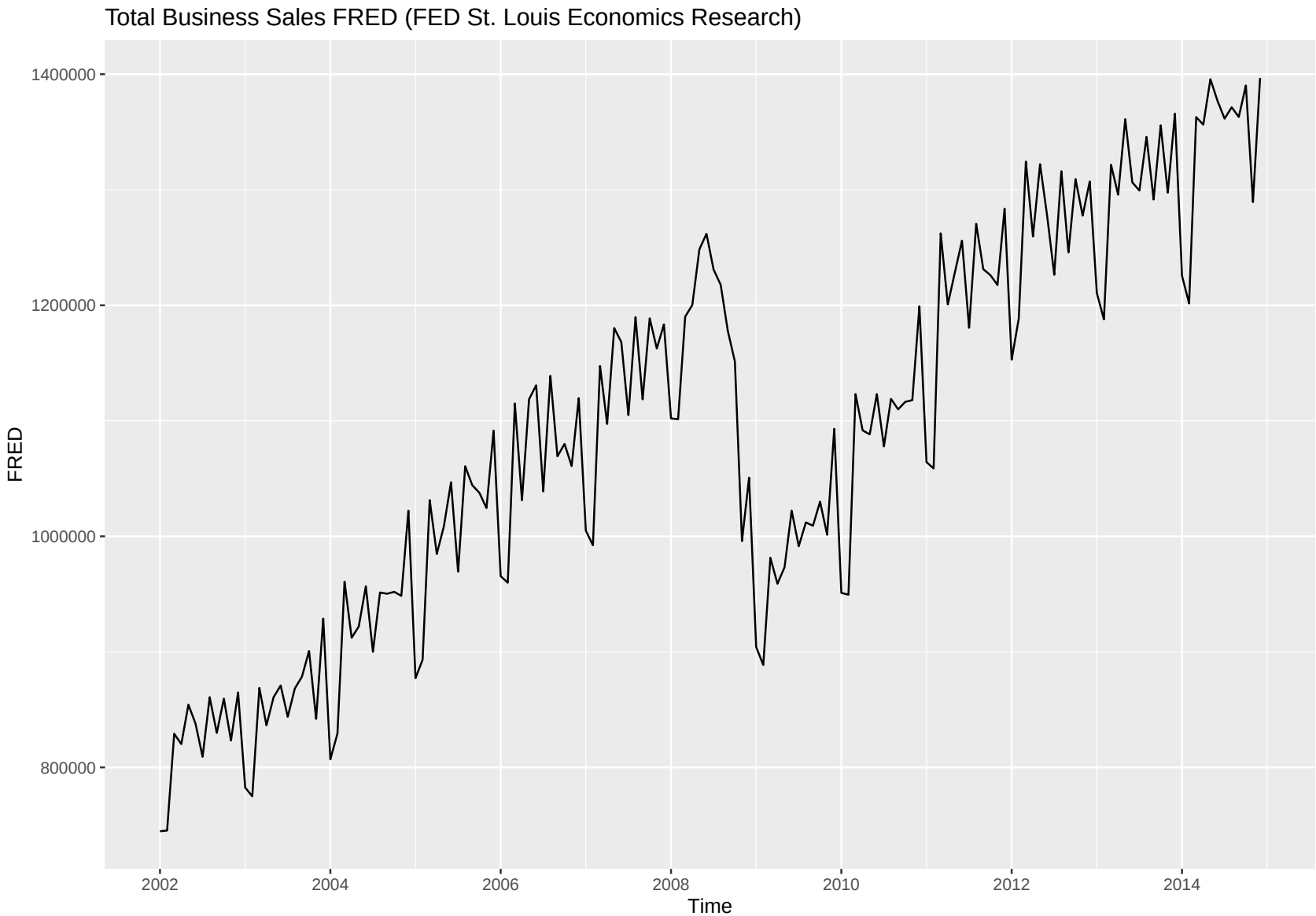
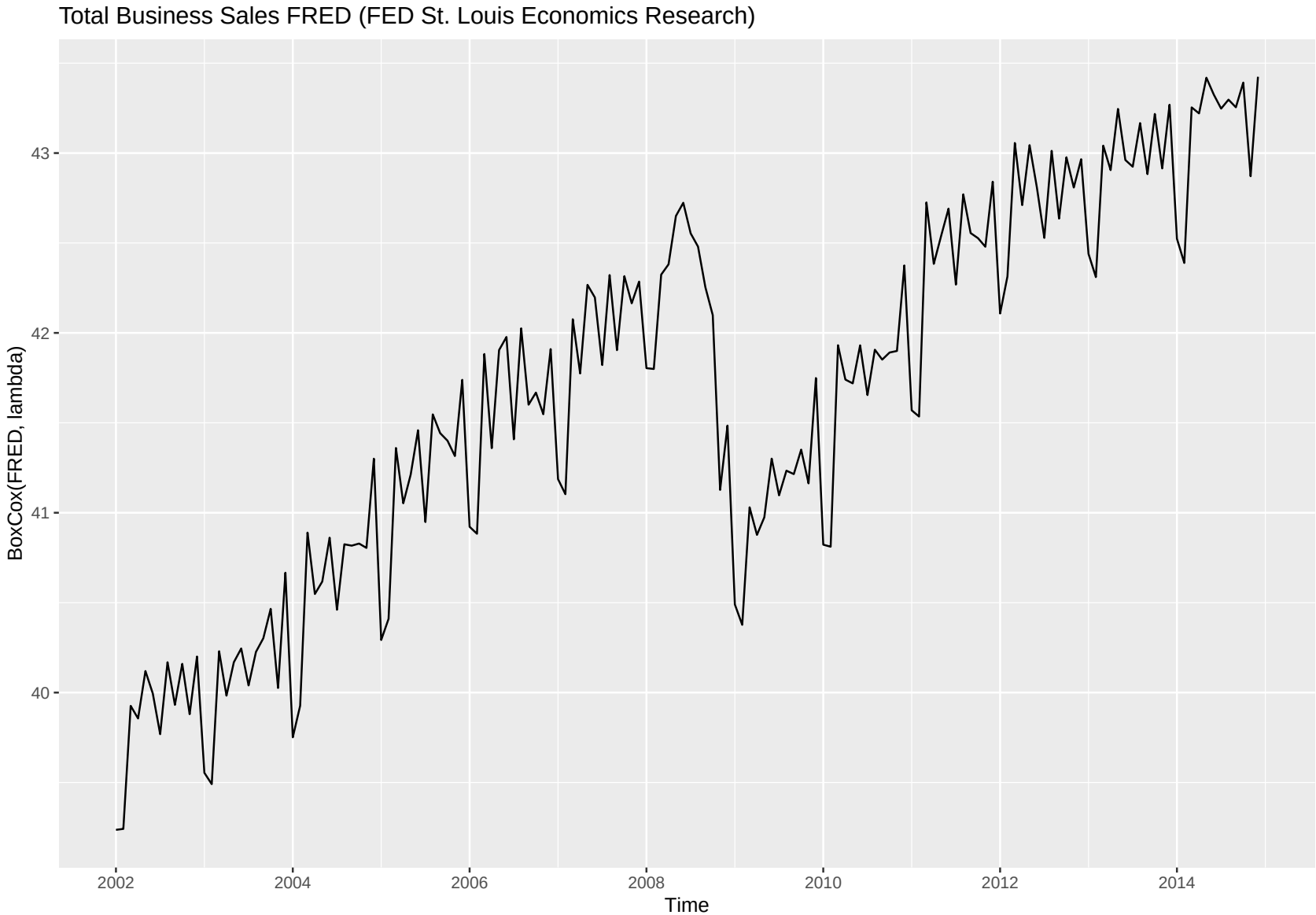
Total Business Sales FRED

- Data from 01/2002 to 12/2012, intervention on 07/2008.



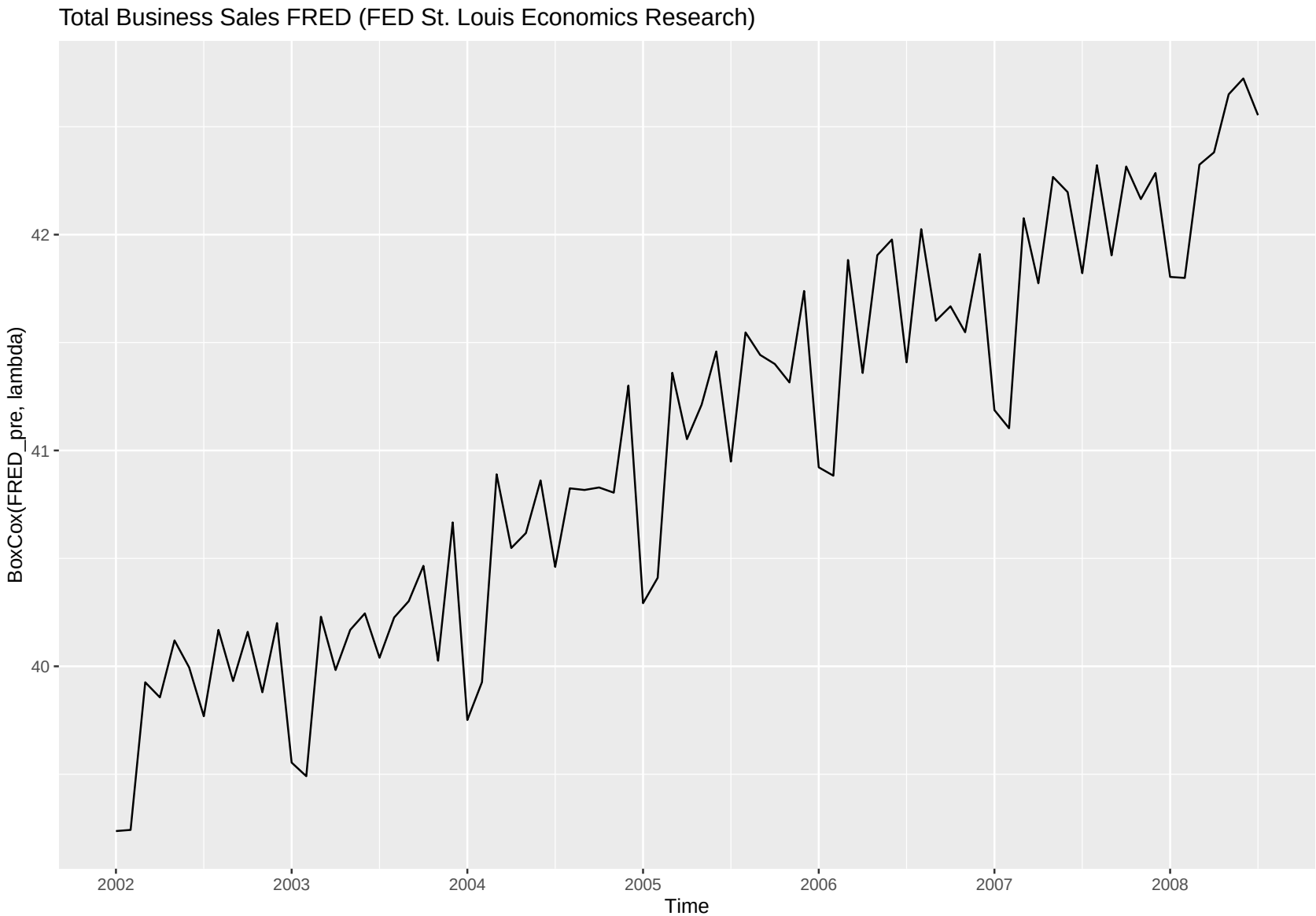
Variance stabilization

- With BoxCox, the lambda is 0.1370143.



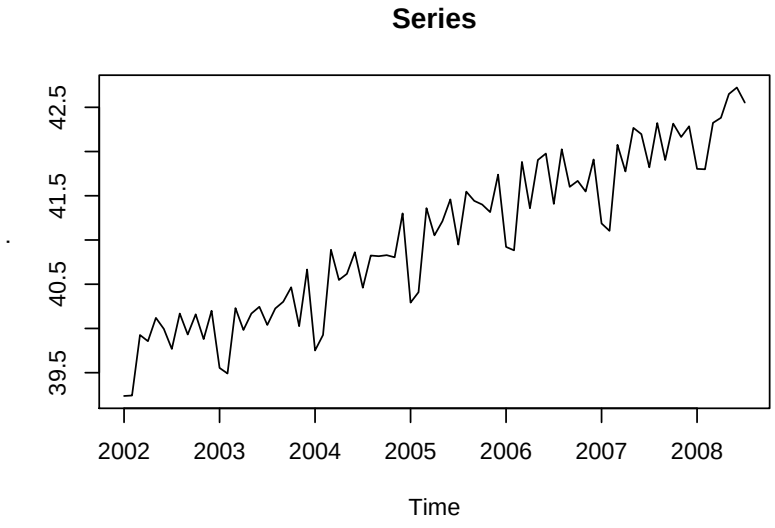
SARIMA pre-intervention

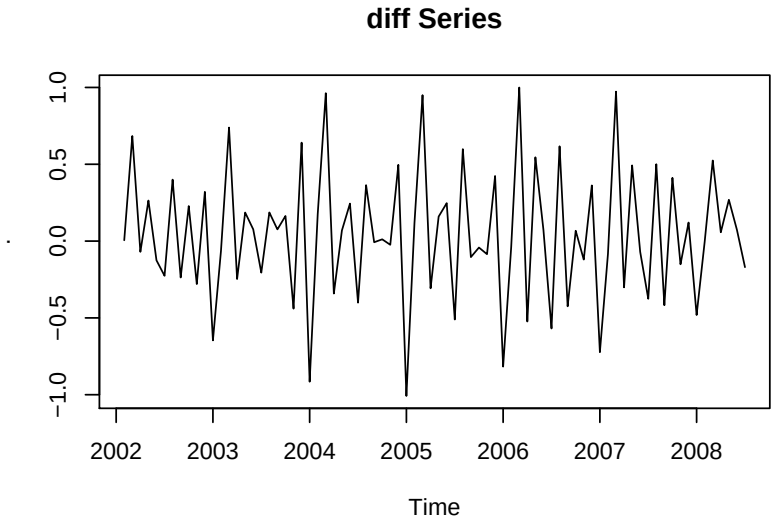
- Model with data until 06/2008. The plots and the models will use the transformed series.

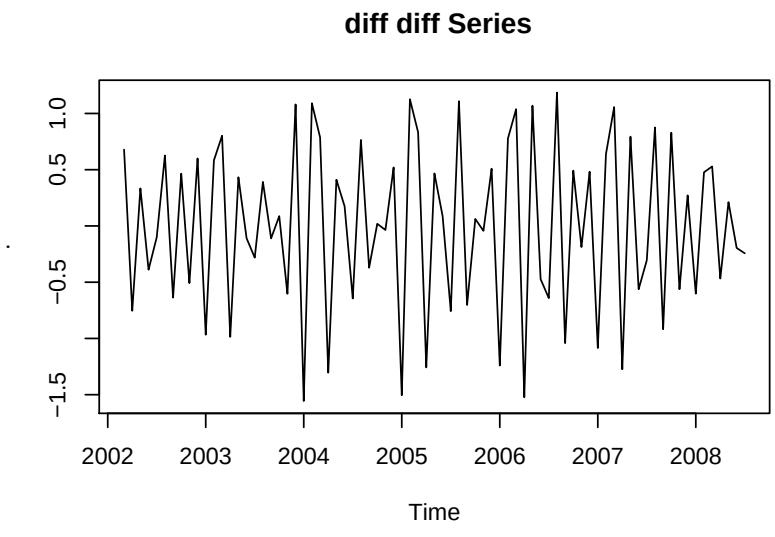


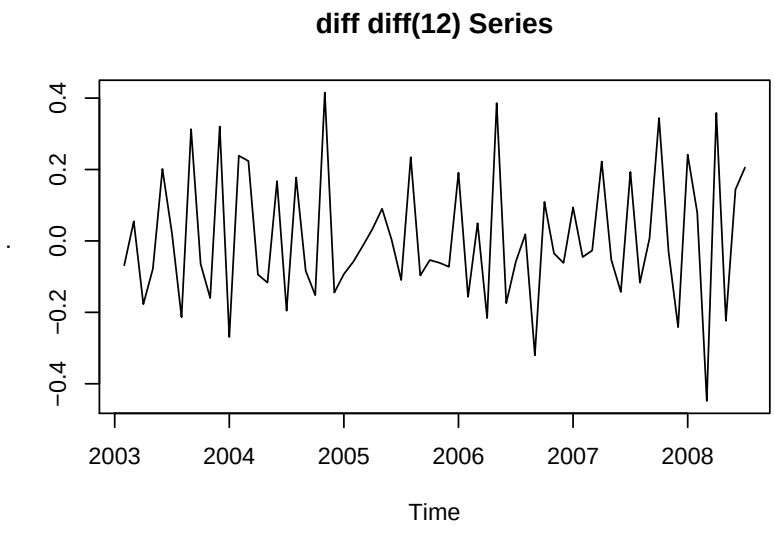
Check differences

- To identify parameters d and D for the SARIMA model.





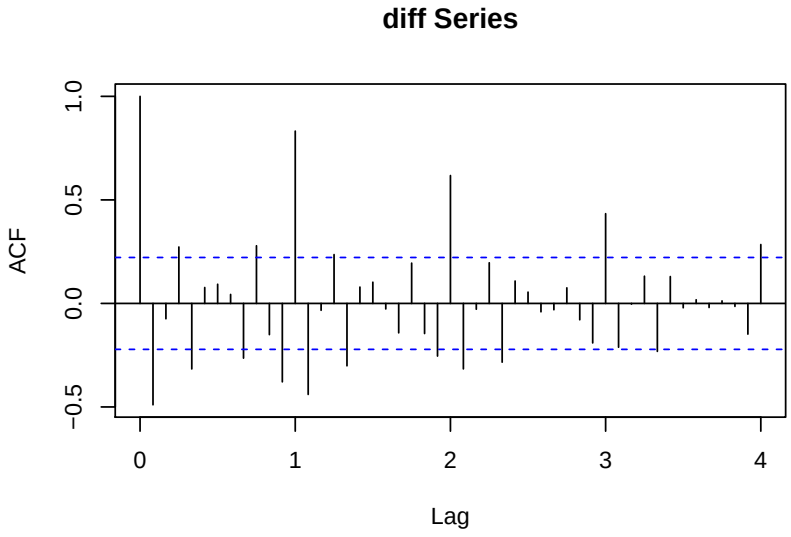


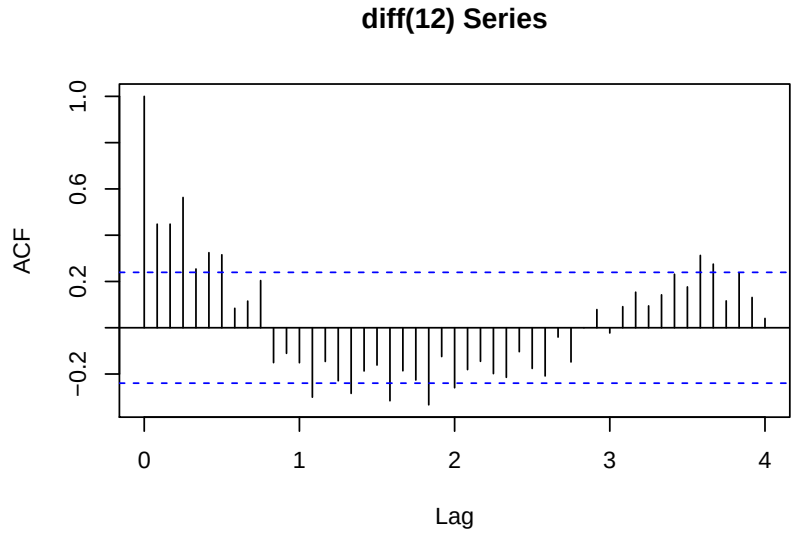


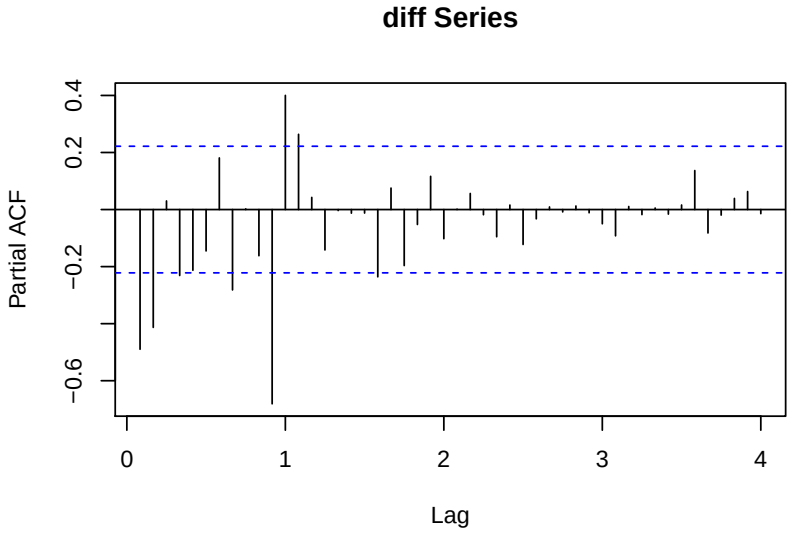
- Use Augmented Dickey Fuller test to verify if there is trend.
- ADF test p-values:
  - Original series: 0.01
  - Diff() series: 0.0206
  - Diff() Diff() series: 0.01
  - Diff() Diff(12) series: 0.01
- We will be using $d = 1$ and $D = 0$ or $D = 1$.

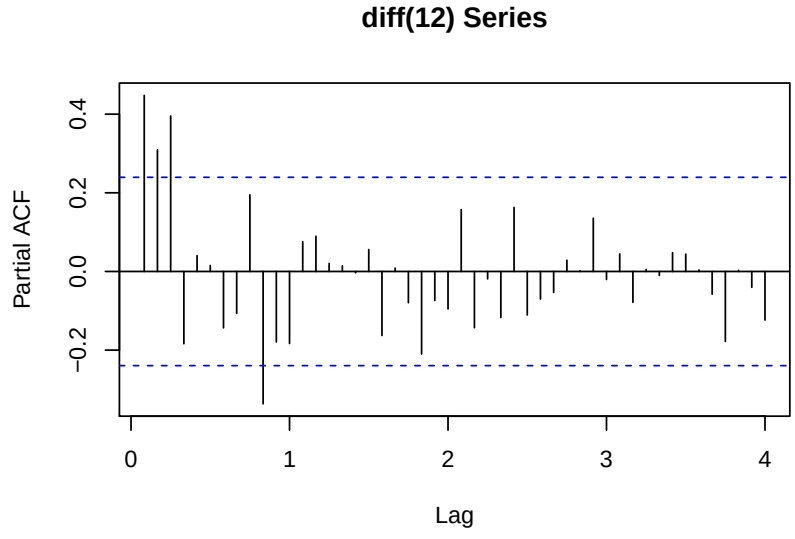
ACF and PACF

- Plot of ACF and PACF for model to identify parameters p, q, P, Q.





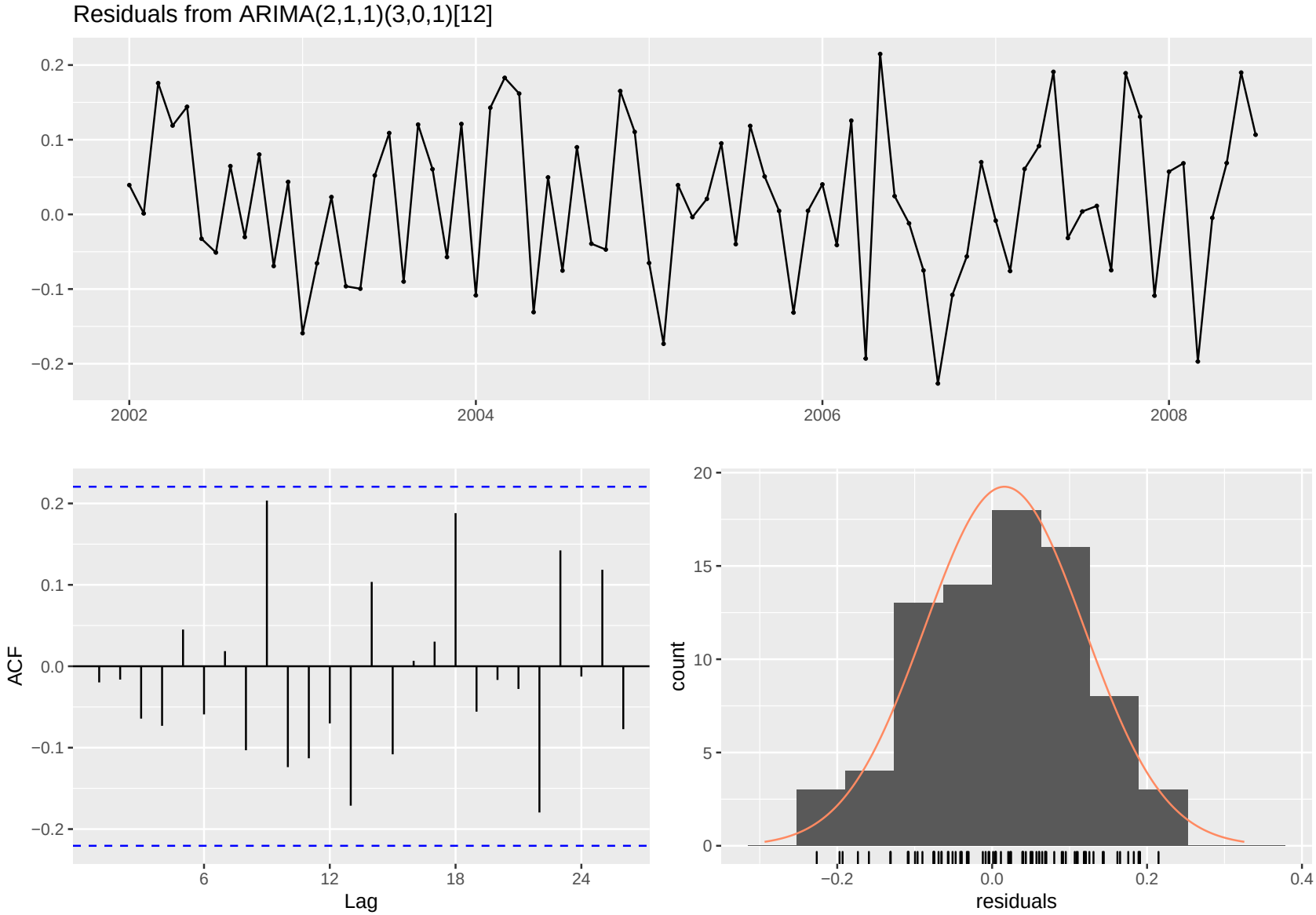




- Both non-seasonal and seasonal ACFs decrease slowly, indicating an auto regressive model.
- For the non seasonal PACFs, we have the first two significant lags and for the seasonal we have the first three significant lags.
- Going to test the following models:
  - SARIMA(2, 1, 1)(3, 0, 1)
  - SARIMA(2, 1, 1)(2, 0, 1)
  - SARIMA(2, 1, 1)(2, 1, 1)

SARIMA(2, 1, 1)(3,0 ,1)

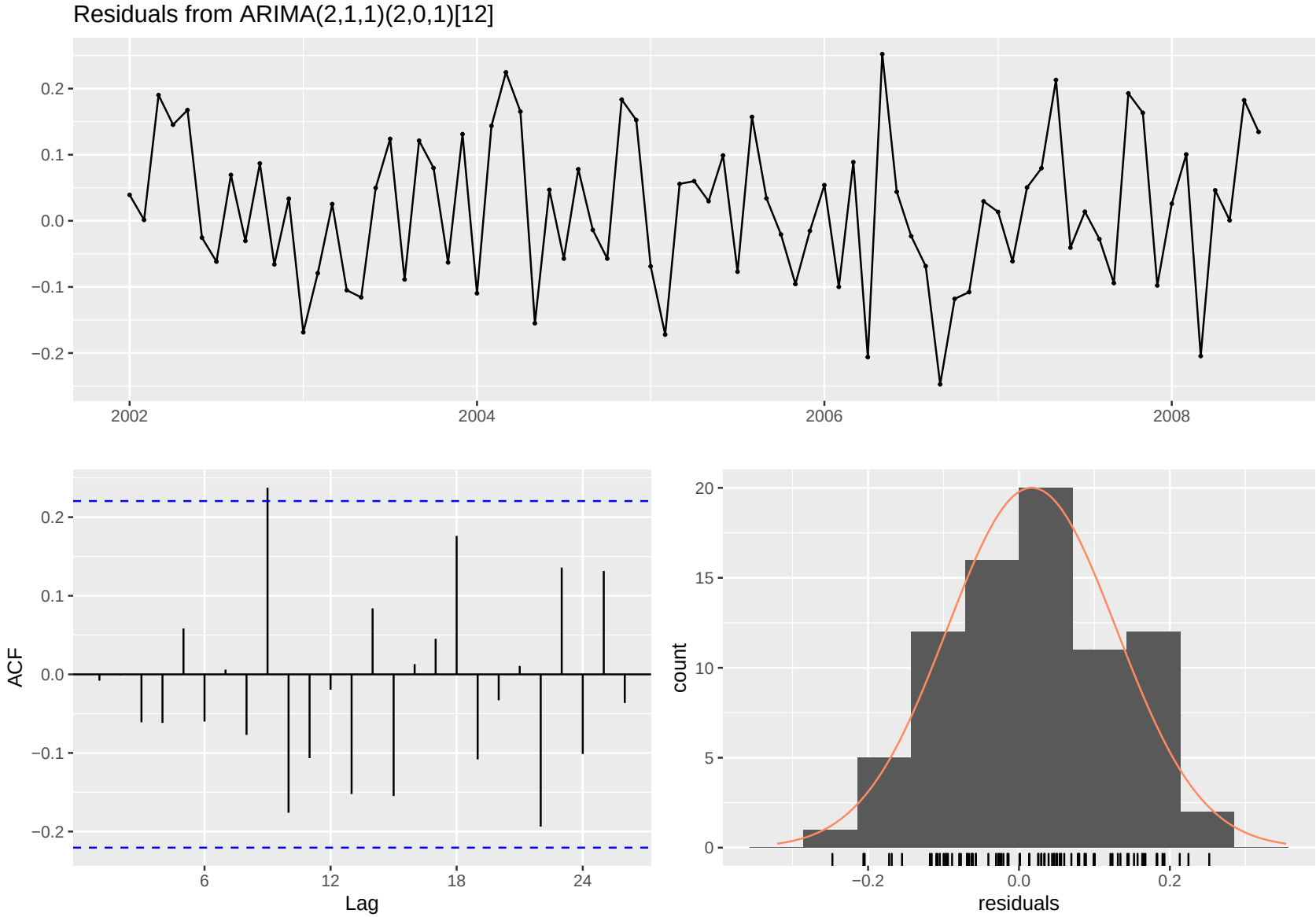
```
## Series: FRED_pre
## ARIMA(2,1,1)(3,0,1)[12]
## Box Cox transformation: lambda= 0.1370143
##
## Coefficients:
##           ar1      ar2     ma1    sar1     sar2    sar3
##       -1.0512  -0.6526  0.4358  1.3318  -0.6488  0.3169
## s.e.   0.1522   0.0967  0.2066  0.1446   0.2147  0.1664
##
## sigma^2 estimated as 0.01199:  log likelihood=40.37
## AIC=-64.75   AICc=-62.66   BIC=-45.89
##
## Training set error measures:
##                     ME     RMSE      MAE        MPE      MA
## Training set 2520.937 15857.62 12908.28 0.2255516 1.2994
##                      ACF1
## Training set -0.008910006
##                     ME     RMSE      MAE        MPE      MA
```




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

SARIMA(2, 1, 1)(2,0 ,1)

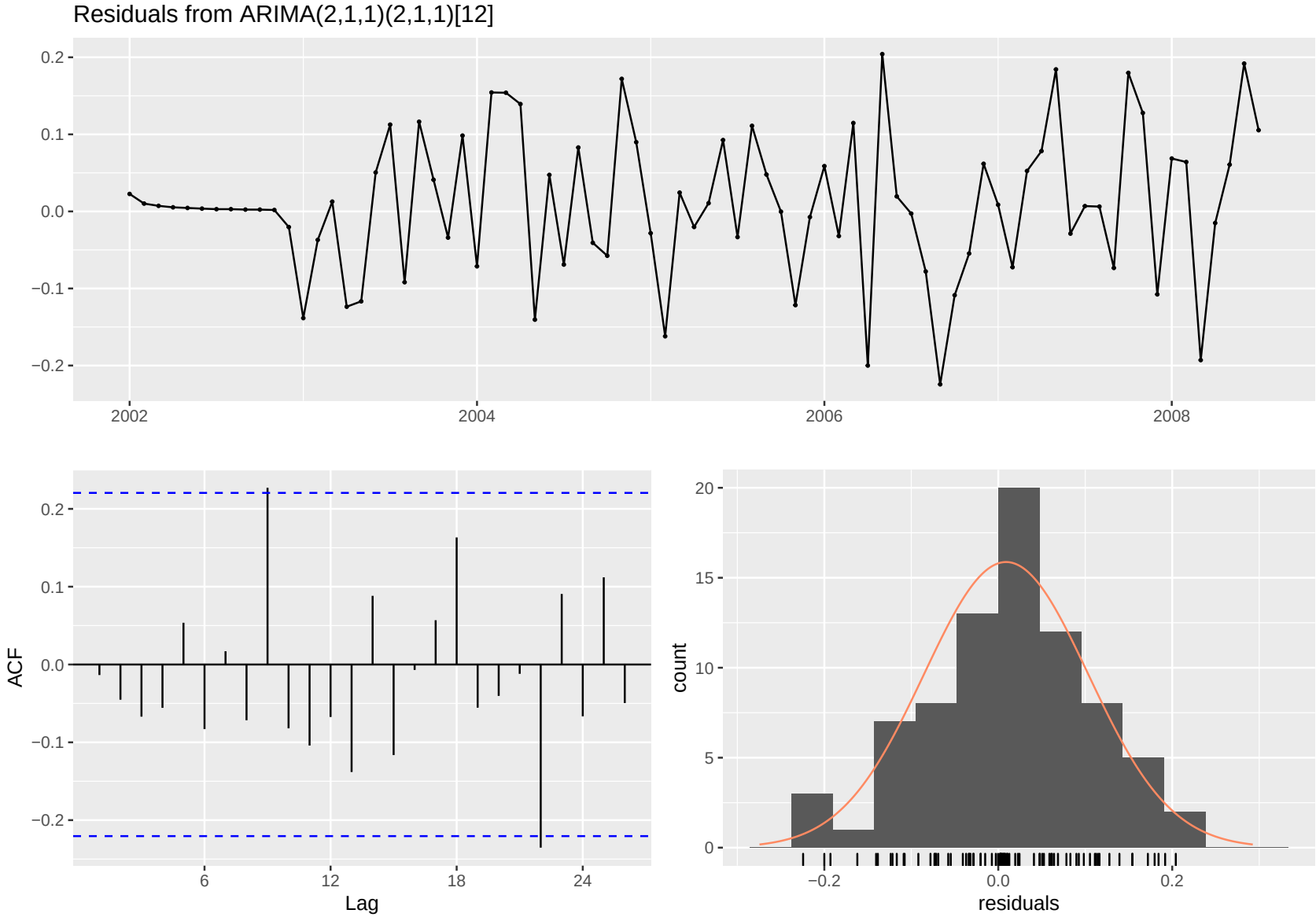
```
## Series: FRED_pre
## ARIMA(2,1,1)(2,0,1)[12]
## Box Cox transformation: lambda= 0.1370143
##
## Coefficients:
##           ar1      ar2     ma1    sar1     sar2     sma1
##       -1.0241  -0.6449  0.3274  1.3619  -0.3620  -0.9710
## s.e.   0.1519   0.1015  0.1898  0.1587   0.1587   0.0839
##
## sigma^2 estimated as 0.014:  log likelihood=38.87
## AIC=-63.74   AICc=-62.14   BIC=-47.24
##
## Training set error measures:
##                     ME     RMSE      MAE       MPE      MA
## Training set 2627.641 17197.02 14037.53 0.2394168 1.4153
##                      ACF1
## Training set -0.01155024
##                     ME     RMSE      MAE       MPE      MA
```




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

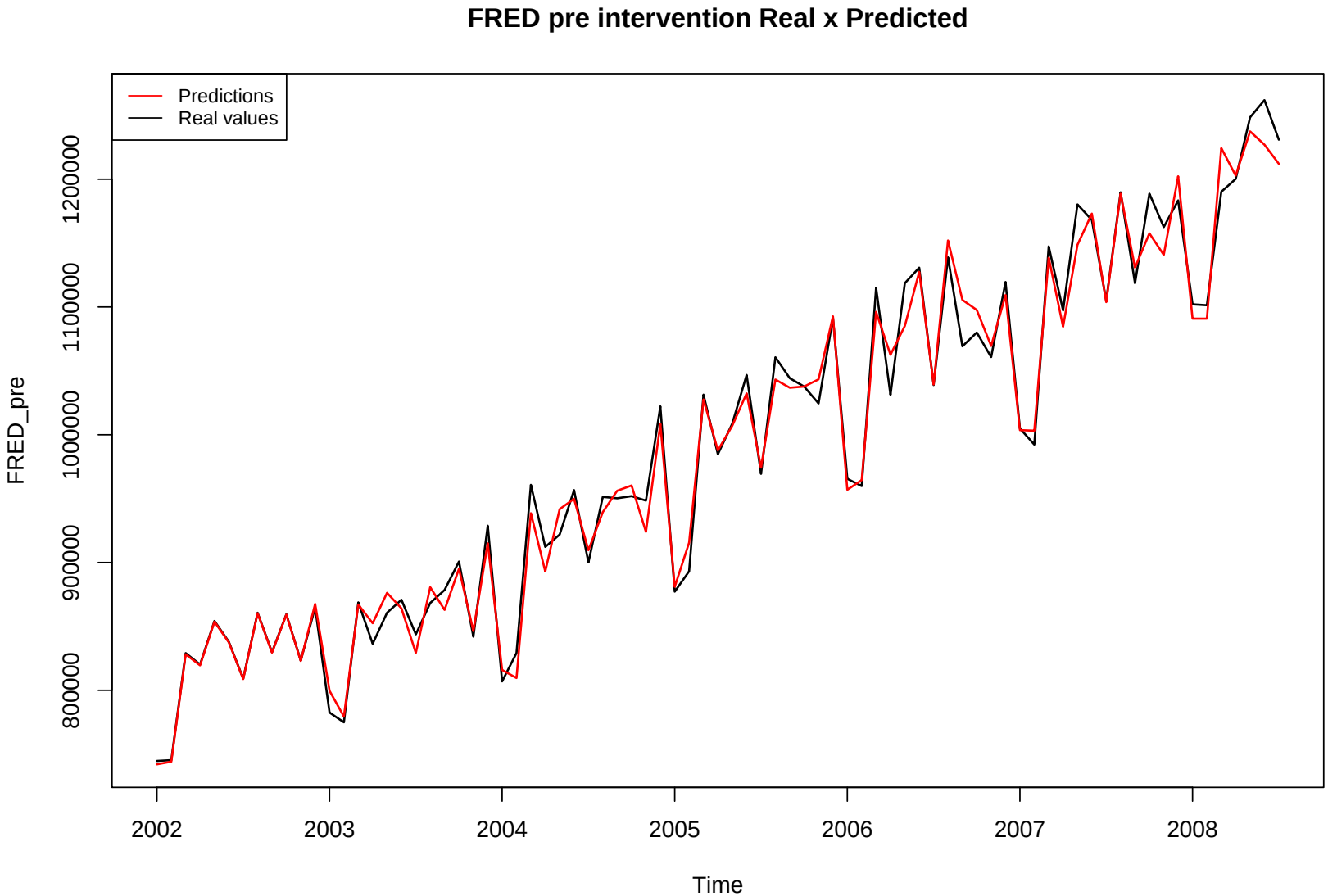
SARIMA(2, 1, 1)(2,1 ,1)

```
## Series: FRED_pre
## ARIMA(2,1,1)(2,1,1)[12]
## Box Cox transformation: lambda= 0.1370143
##
## Coefficients:
##           ar1      ar2     ma1    sar1     sar2      sma1
##       -1.0398  -0.6653  0.4239  0.3215  -0.3262  -0.9998
## s.e.   0.1517   0.0968  0.2184  0.1410   0.1683   0.4228
##
## sigma^2 estimated as 0.01172:  log likelihood=44.27
## AIC=-74.54   AICc=-72.61   BIC=-59.21
##
## Training set error measures:
##                      ME     RMSE      MAE       MPE     MAP
## Training set 1562.579 14709.87 11070.55 0.1228108 1.0888
##                      ME     RMSE      MAE       MPE     MAP
## Training set 1562.579 14709.87 11070.55 0.1228108 1.0888
```



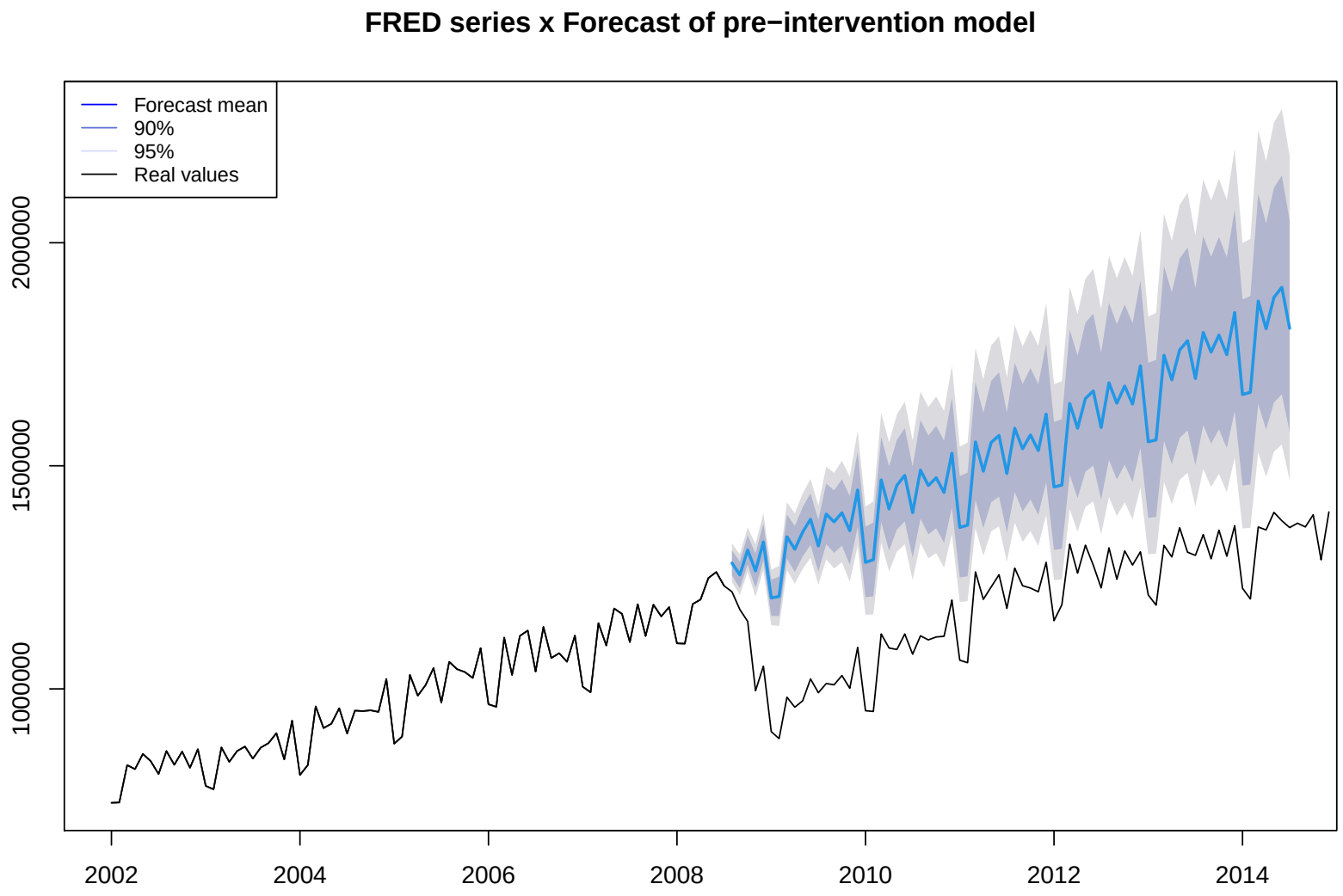

```
##
##  Ljung-Box test
##
```

- The model with lowest AIC is the SARIMA(2, 1, 1)(2, 1, 1).



Forecast of pre intervention

- We now look on how our model says that the series should be without the intervention, predicting the next six years after july 2008.

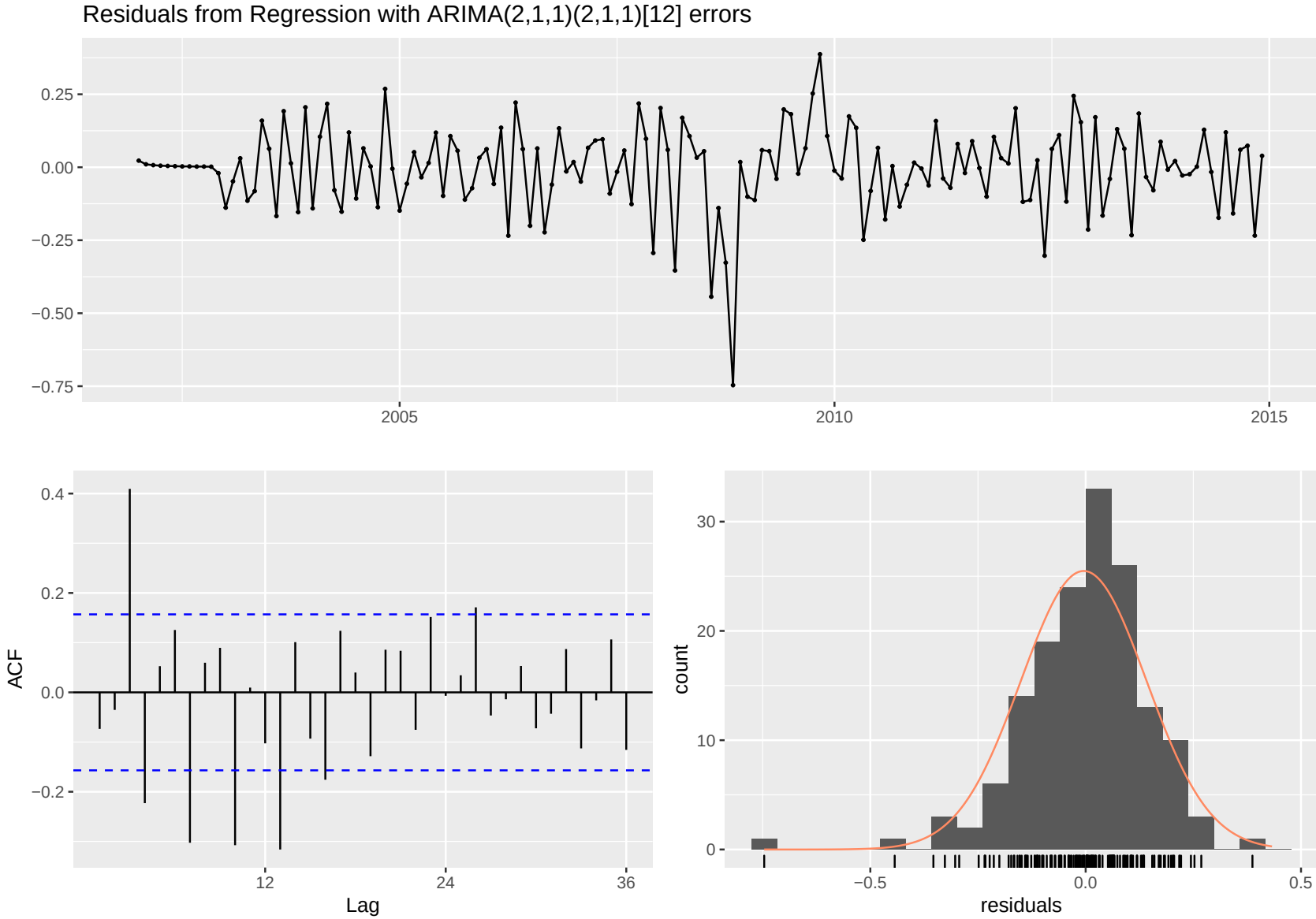


Intervention modeling

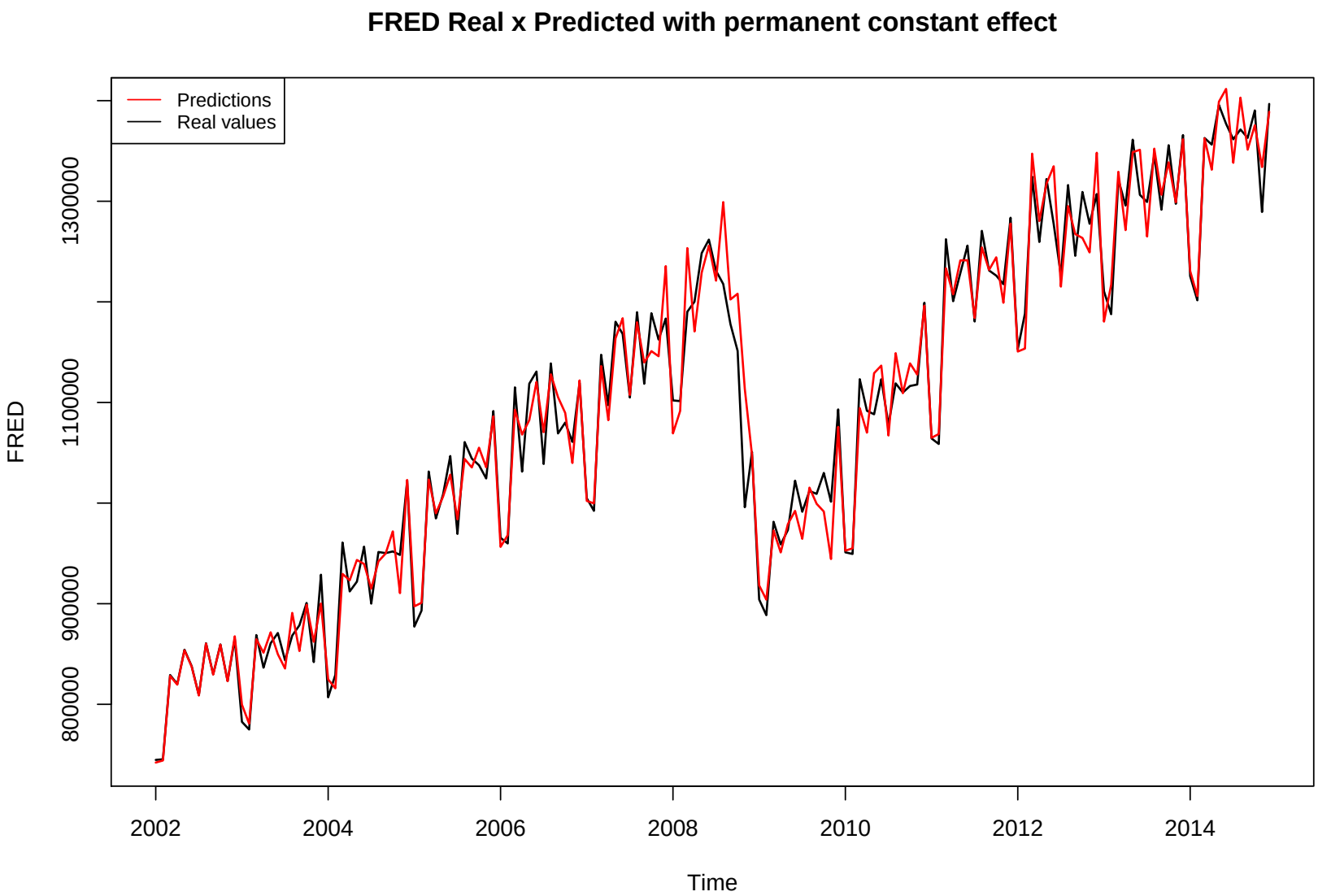
Permanent constant effect

- For the first intervention model we will define $h_t = I(t > jul2008)\delta_0$, so there will be a permanent effect equal to δ_0 after july of 2008.
- The estimated δ_0 value is 0.0759 with s.e. 0.1385, so the interval includes 0.

```
## Series: FRED
## Regression with ARIMA(2,1,1)(2,1,1)[12] errors
## Box Cox transformation: lambda= 0.1370143
##
## Coefficients:
##          ar1     ar2      ma1    sar1     sar2     sma1
##       0.4136  0.2755  -0.5898  0.3468  -0.3696  -1.0000
## s.e.  0.1413  0.0813   0.1256  0.0841   0.0842   0.1084
##
## sigma^2 estimated as 0.02422:  log likelihood=49.68
## AIC=-83.35   AICc=-82.28   BIC=-59.65
```




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

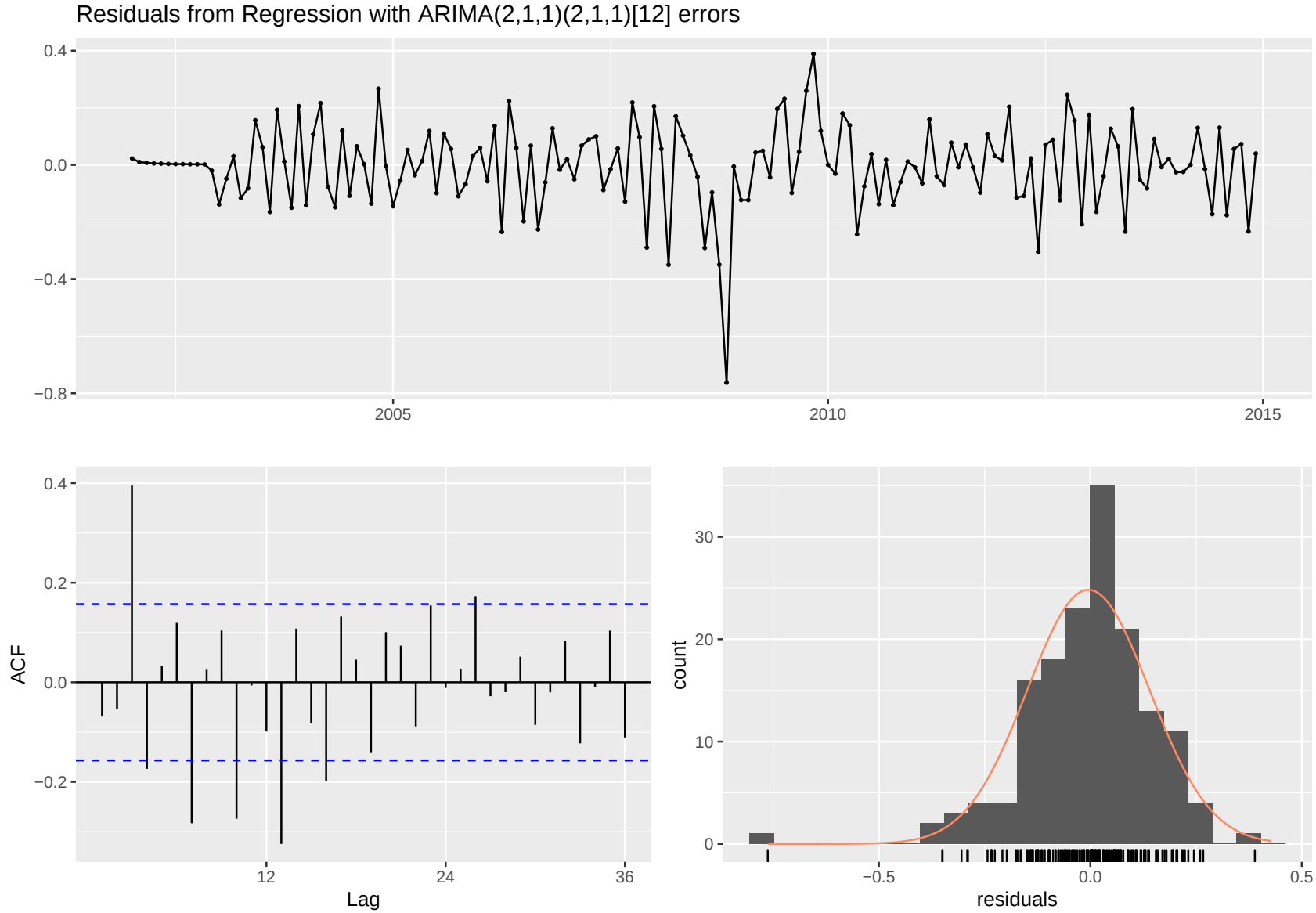

FRED Real x Predicted with permanent constant effect
Predictions
Real values
FRED
800000
900000
1100000
1300000
2002
2004
2006
2008
2010
2012
2014
Time

Temporary constant effect

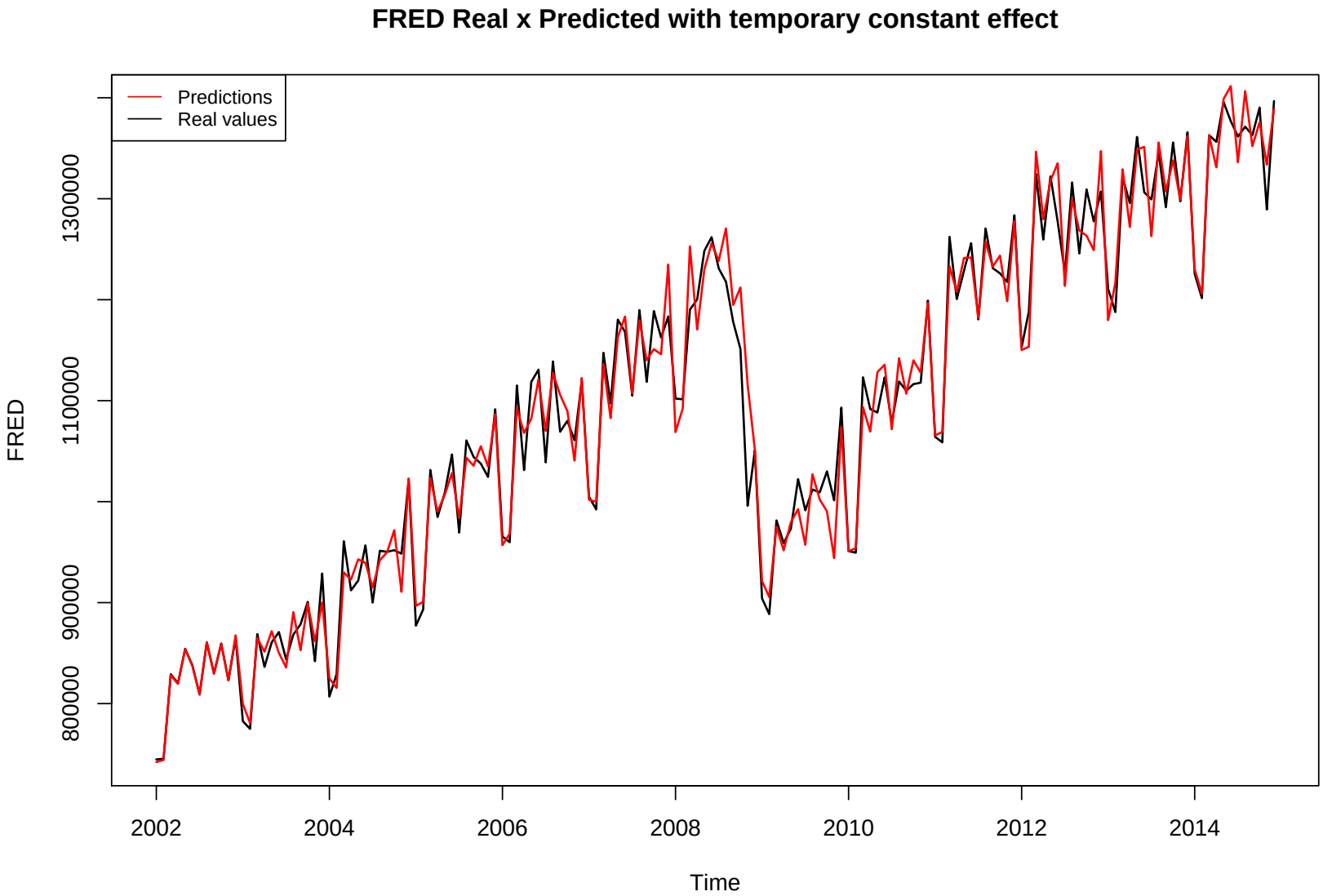
- Now for the intervention model we will define $h_t = I(t = jul2008)\delta_0$, so there will be a temporary effect equal to δ_0 on july of 2008.
- The estimated δ_0 value is 0.1835 with s.e. 0.1064, so the interval doesn't include 0.

```
## Series: FRED
## Regression with ARIMA(2,1,1)(2,1,1)[12] errors
## Box Cox transformation: lambda= 0.1370143
##
## Coefficients:
##          ar1     ar2      ma1    sar1     sar2     sma1
##       0.4276  0.2601  -0.6093  0.3375  -0.3652  -1.0000
## s.e.  0.1474  0.0822   0.1328  0.0853   0.0852   0.1106
##
## sigma^2 estimated as 0.02377:  log likelihood=51.04
## AIC=-86.07   AICc=-85   BIC=-62.37
##
## Training set error measures:
```

```
##
## z test of coefficients:
##
##       Estimate Std. Error z value  Pr(>|z|)
## ar1   0.427649   0.147396  2.9014  0.003716 **
## ar2   0.260076   0.082171  3.1651  0.001550 **
## ma1  -0.609346   0.132751 -4.5901 4.429e-06 ***
## sar1  0.337458   0.085268  3.9576 7.570e-05 ***
## sar2 -0.365227   0.085162 -4.2886 1.798e-05 ***
## sma1 -0.999953   0.110620 -9.0395 < 2.2e-16 ***
## xreg  0.183541   0.106421  1.7247  0.084587 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1
```

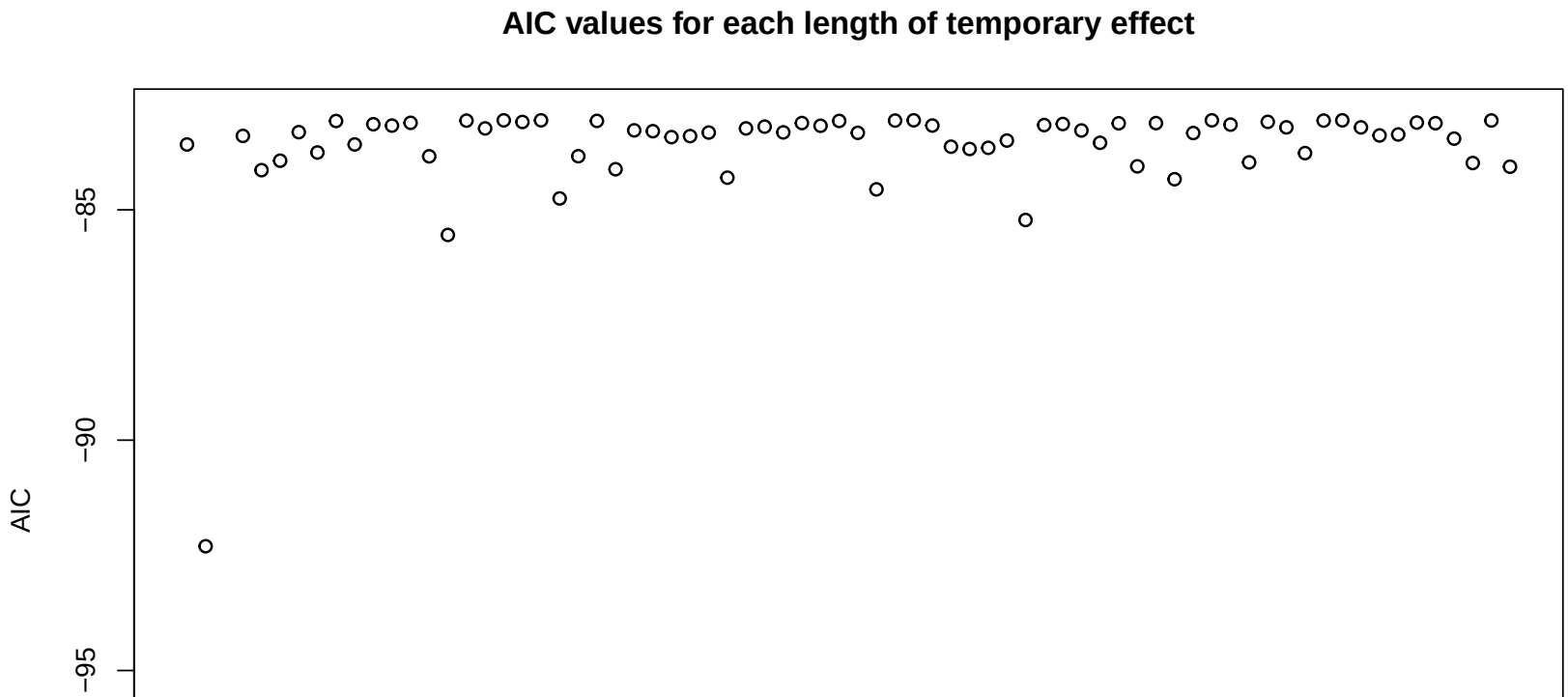



```
##
##  Ljung-Box test
##
```

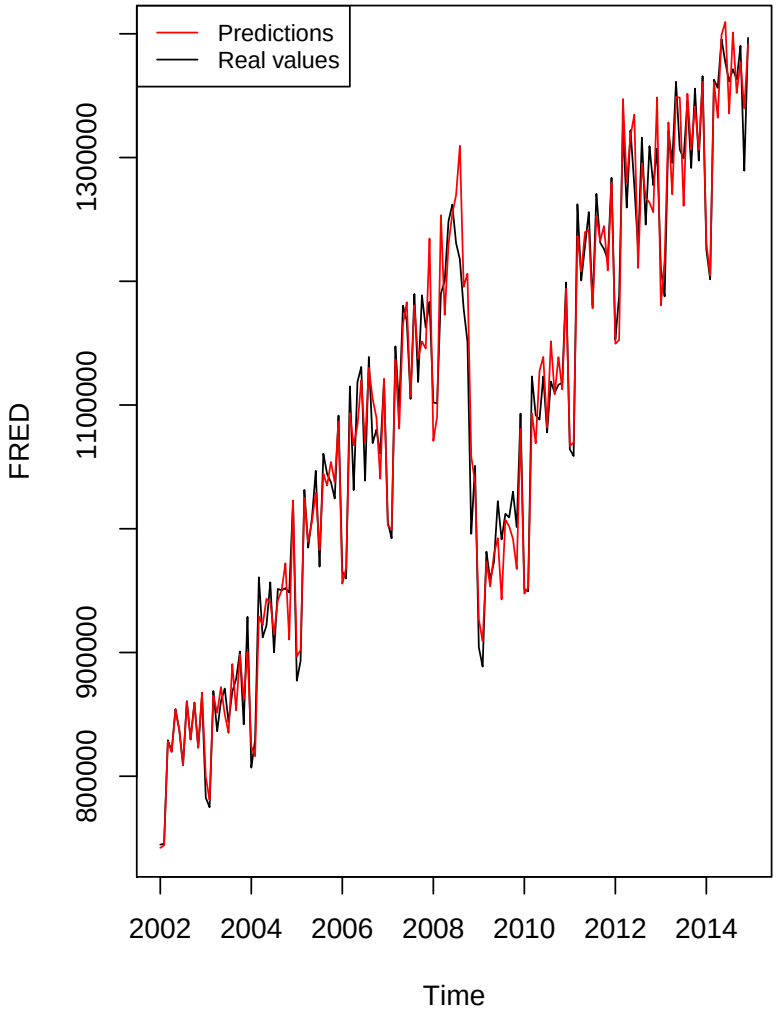

FRED Real x Predicted with temporary constant effect
Predictions
Real values
FRED
800000
900000
1100000
1300000
2002
2004
2006
2008
2010
2012
2014
Time

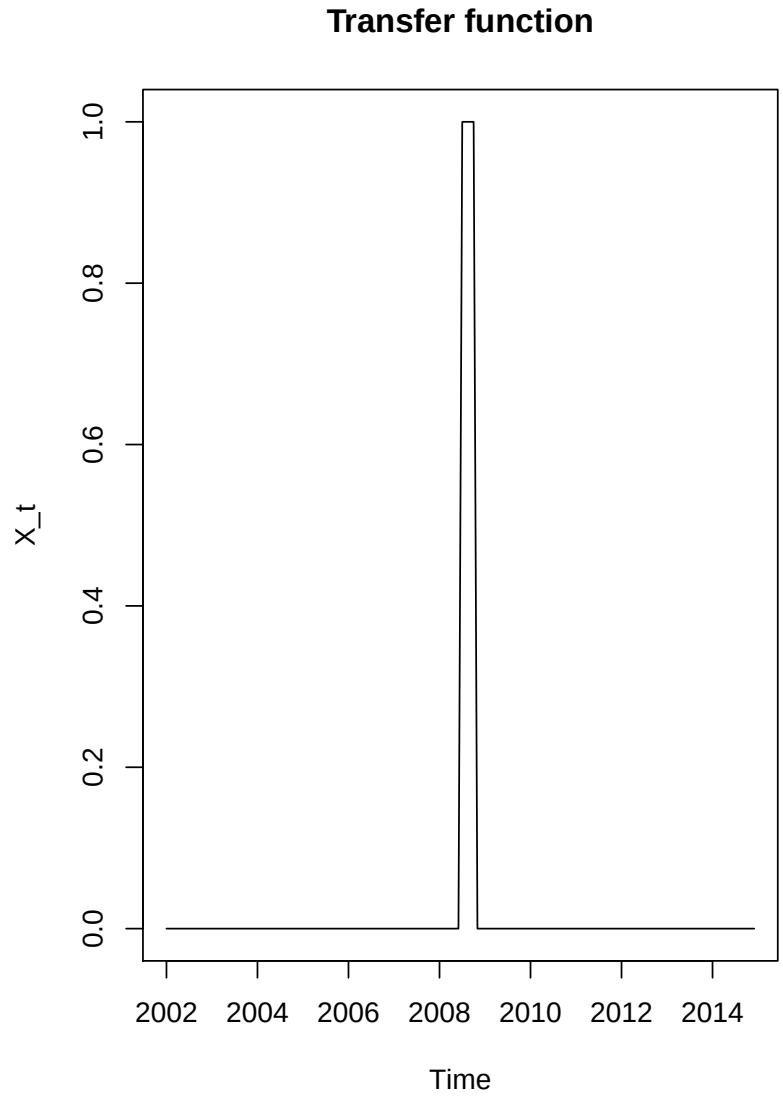
Optimizing the duration of the effect

- As the constant permanent effect doesn't show good results, and the temporary effect show significance, we can evaluate the significance of a set o values m, with $h_t = I((jul2008 + m) \geq t \geq jul2008)\delta_0$, that is, the effect will be the constant δ_0 for m months after july of 2008. For each value, we keep the AIC and will look at the m value that minimize the AIC.
- The duration that minimize the AIC is $m = 3$.



```
## Series: FRED
## Regression with ARIMA(2,1,1)(2,1,1)[12] errors
## Box Cox transformation: lambda= 0.1370143
##
## Coefficients:
##          ar1     ar2      ma1    sar1     sar2     sma1
##       0.4233  0.2897  -0.6271  0.3838  -0.3790  -1.0000
## s.e.  0.1324  0.0812   0.1162  0.0847   0.0864   0.1155
##
## sigma^2 estimated as 0.02162:  log likelihood=57.99
## AIC=-99.99   AICc=-98.91   BIC=-76.28
##
## Training set error measures:
##                      ME     RMSE      MAE          MPE
## Training set -917.1745 23005.39 17195.01 -0.08674129 1.5
##                      ACF1
## Training set -0.09547755
```


Predictions
Real values
FRED
800000
900000
1100000
1300000
2002
2004
2006
2008
2010
2012
2014
Time


Transfer function
X_t
0.0
0.2
0.4
0.6
0.8
1.0
2002
2004
2006
2008
2010
2012
2014
Time