Intervention analysis

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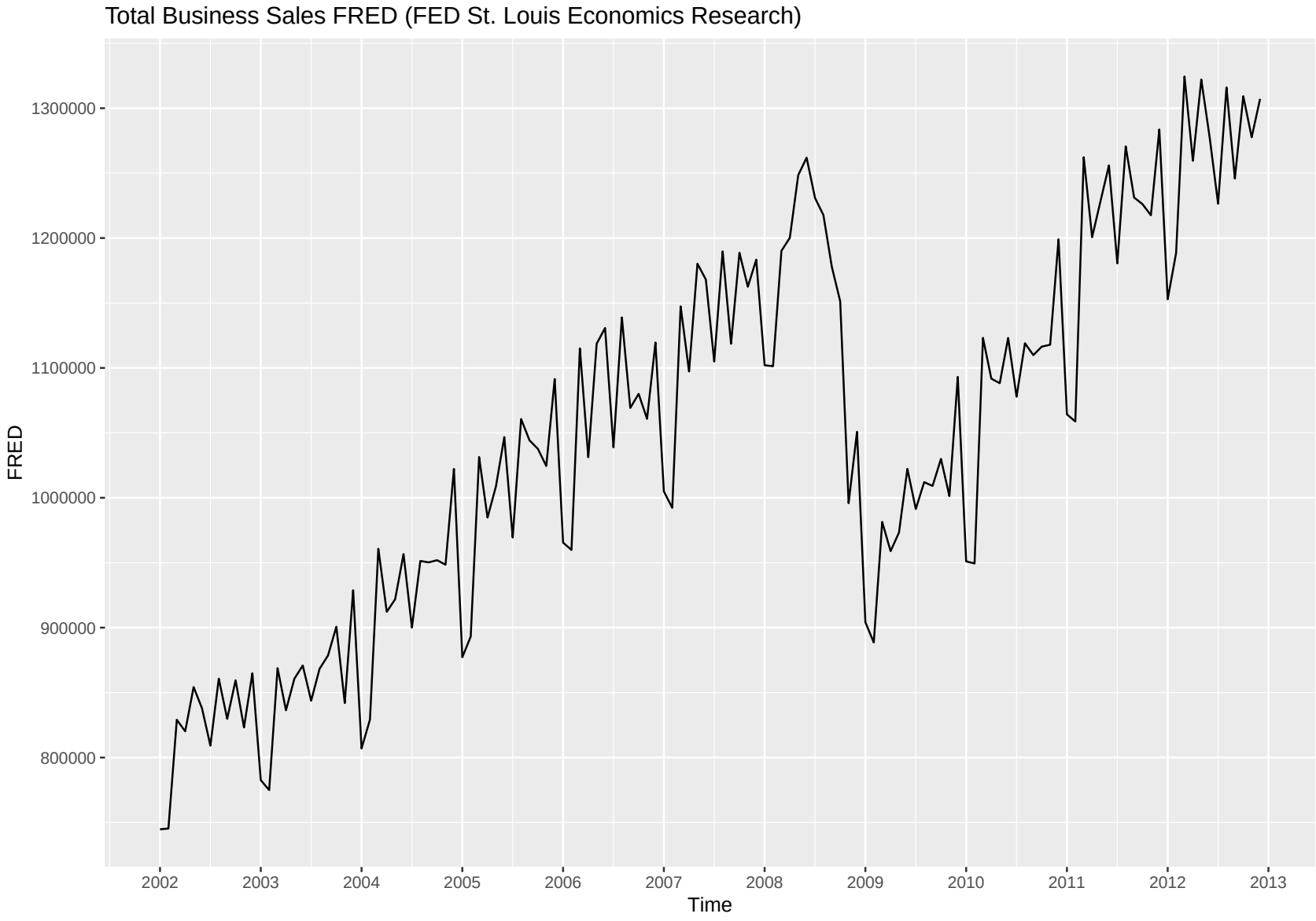
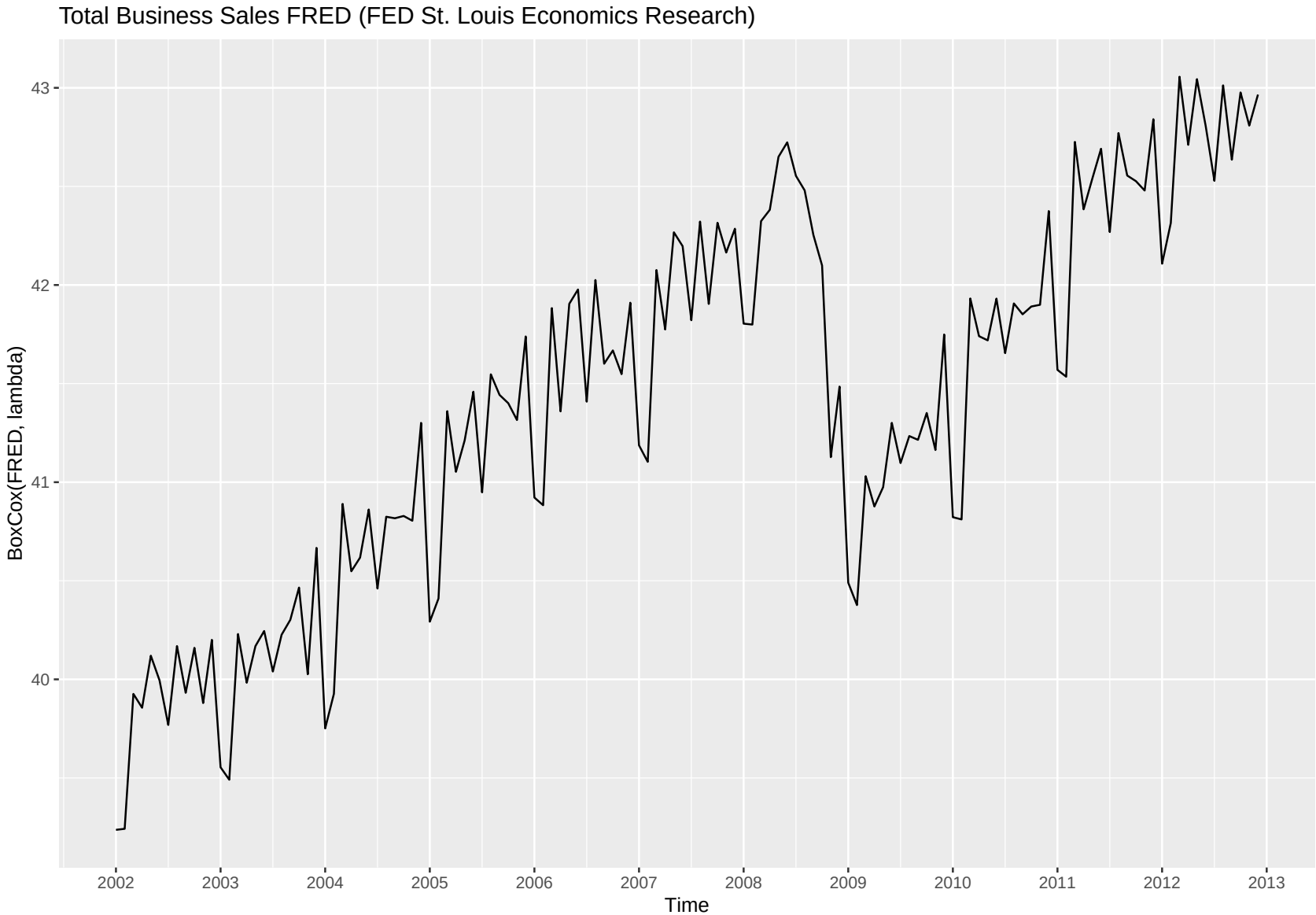
Total Business Sales FRED

- Data from 01/2002 to 12/2012, intervention on 07/2008. The period of 01/2013 to 12/2014 will be used as model validation.
- In 2008 we have a international banking crisis, strongly affecting sales on the US.


Total Business Sales FRED (FED St. Louis Economics Research)
FRED
1300000
1200000
1100000
1000000
900000
800000
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Time

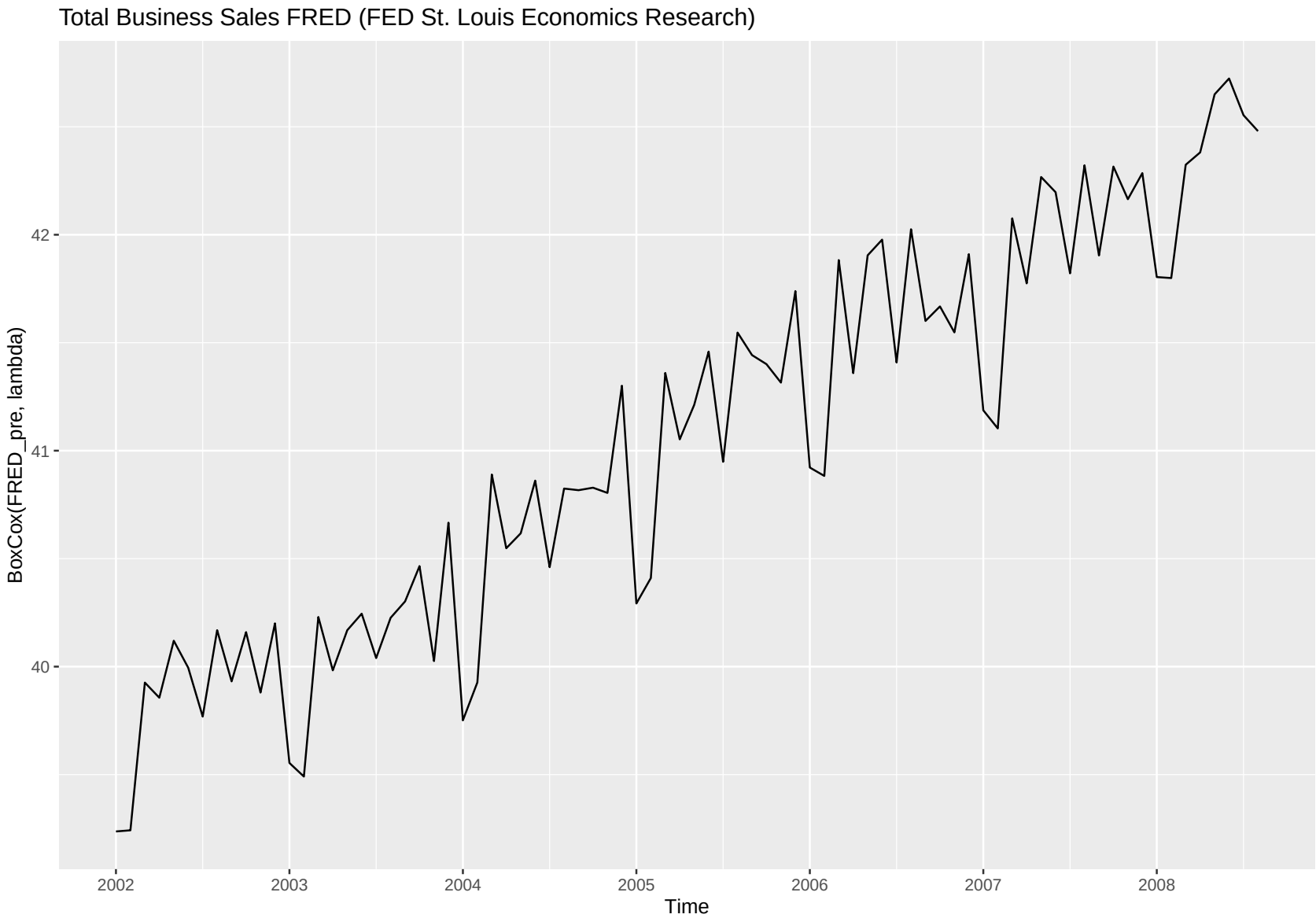
Variance stabilization

- With BoxCox transformation, the lambda is 0.1370143.



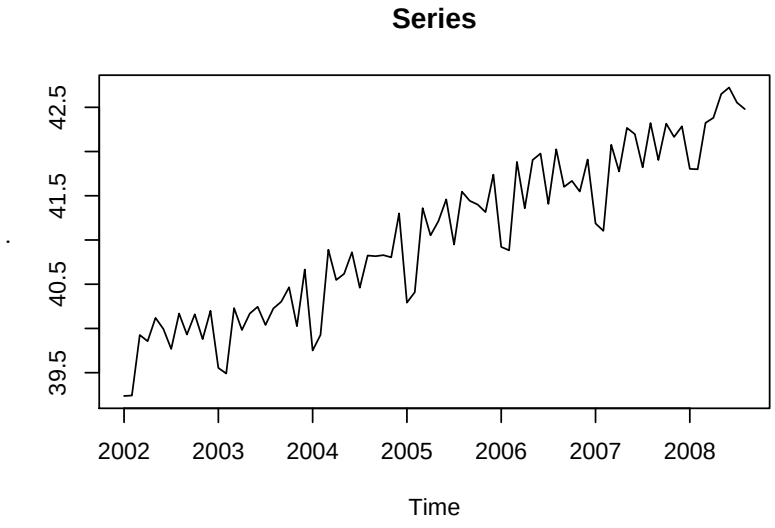
SARIMA pre-intervention

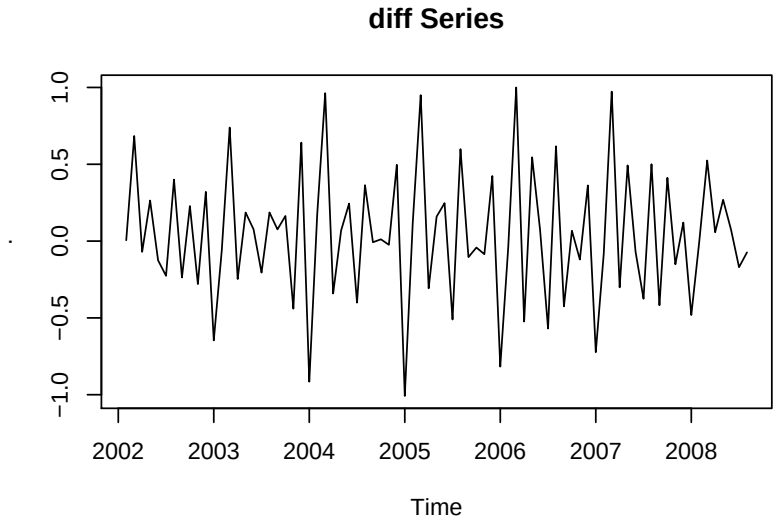
- Model with data until 07/2008. The plots and the models will use the transformed series.

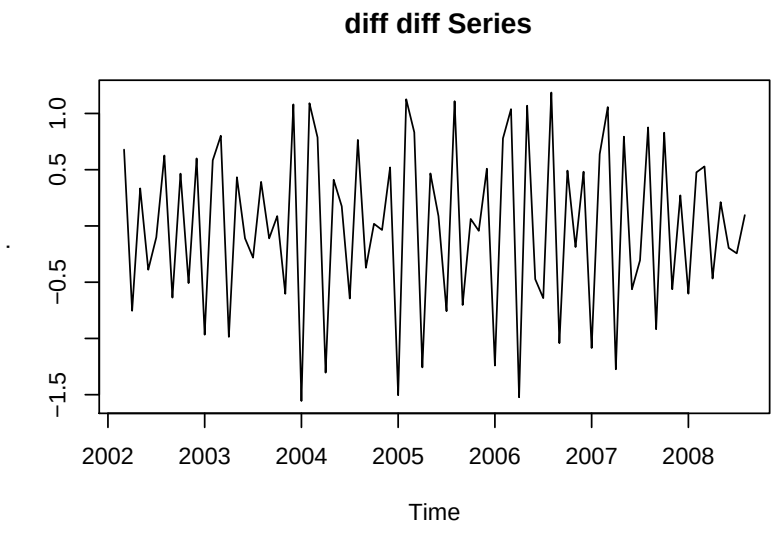


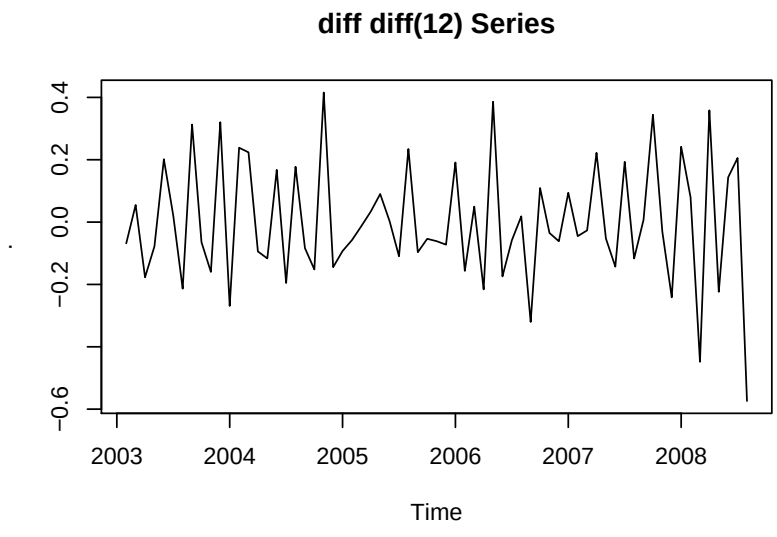
Check differences

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





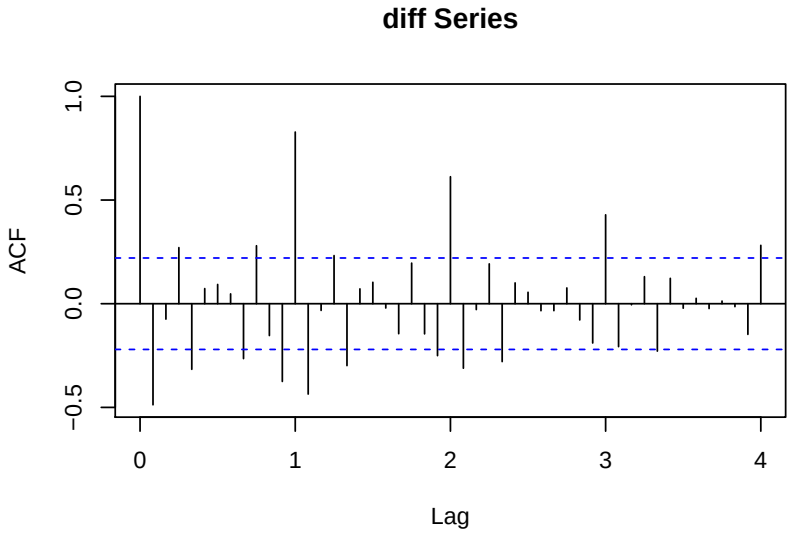


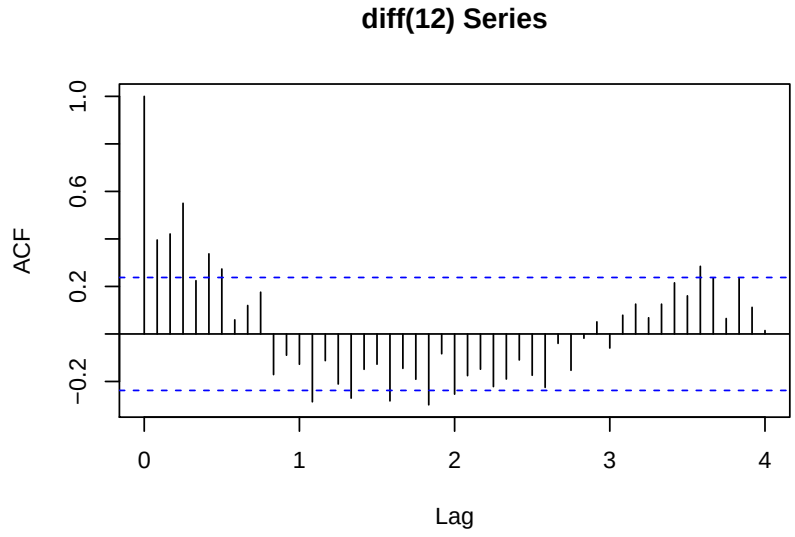


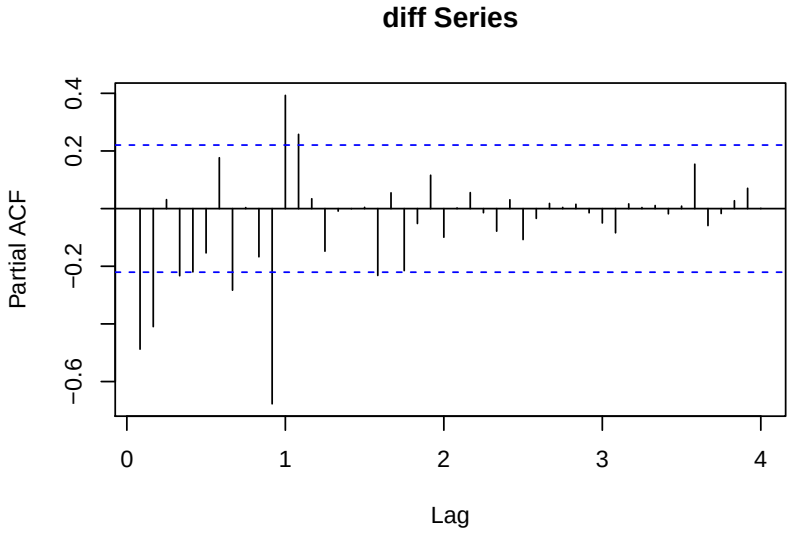
- Use Augmented Dickey Fuller test to verify if there is trend.
- ADF test p-values:
  - Original series: 0.01
  - Diff() series: 0.0206
  - Diff() Diff() series: 0.01
  - Diff() Diff(12) series: 0.01
- We will be using $d = 1$ and $D = 0$ or $D = 1$.

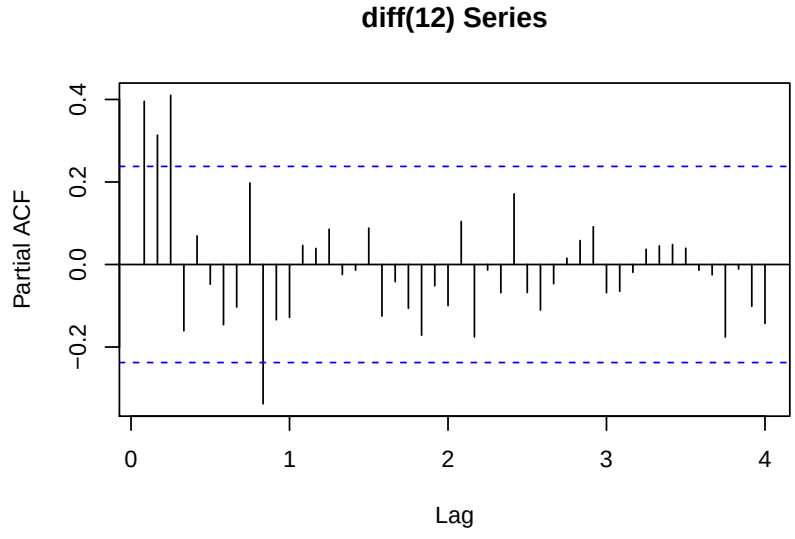
ACF and PACF

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









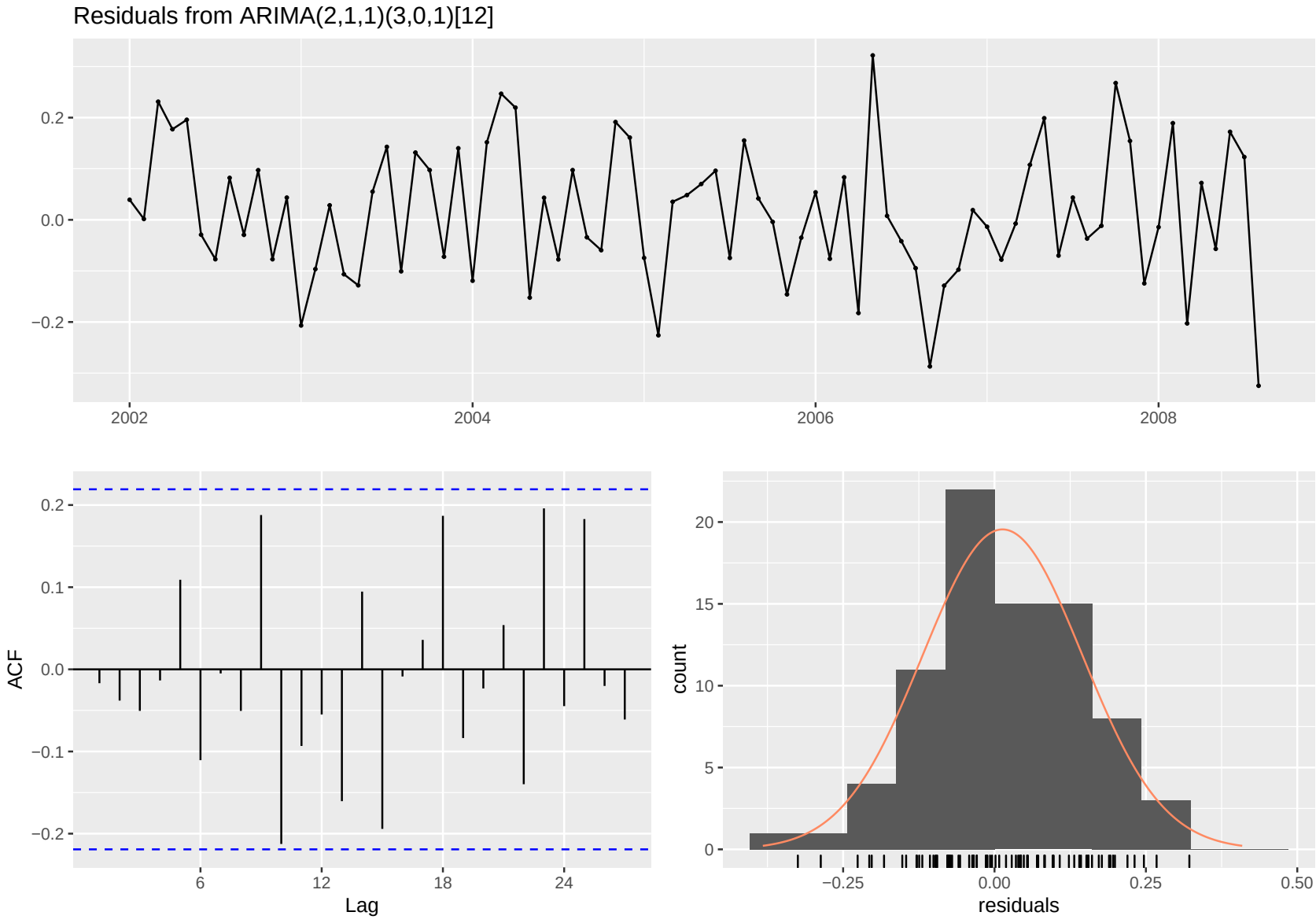
- Both non-seasonal and seasonal ACFs decrease slowly, indicating an auto regressive model.
- For the non seasonal PACFs, we have the first two significant lags and for the seasonal we have the first three significant lags.
- Going to test the following models:
  - SARIMA(2, 1, 1)(3, 0, 1)
  - SARIMA(2,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

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

```
Call:
Arima(y = FRED_pre, order = c(2, 1, 1), seasonal = c(3, 0, 1), lambda = lambda)

NaNs produzidos
```

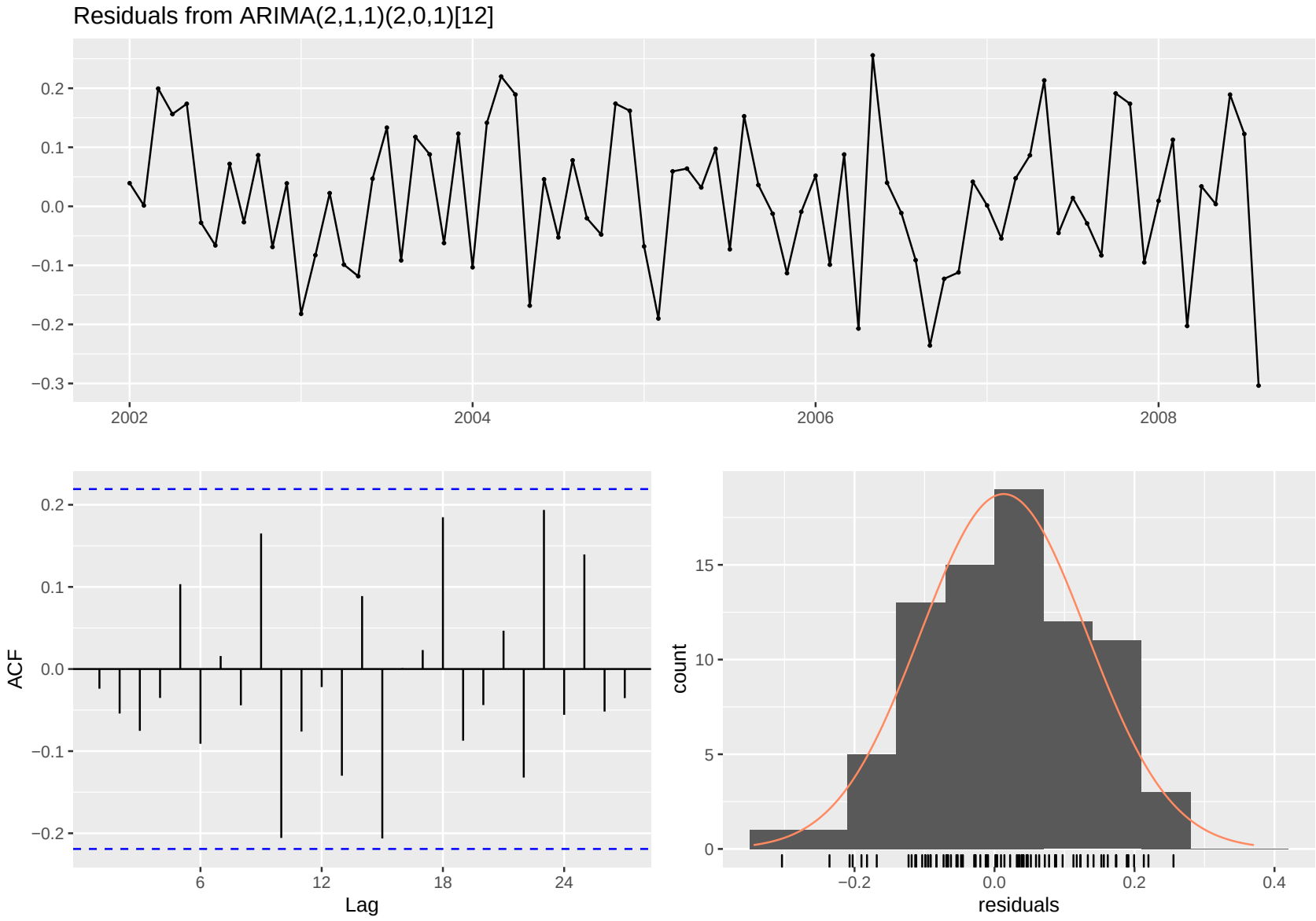
	ar1	ar2	ma1	sar1	sar2	sar3	sma1
	-1.084	-0.6725	0.3762	-0.002842	0.6105	0.2732	0.8088
s.e.	0.1669	0.09877	0.2214	NA	NA	0.1557	NA

```
Table: Coefficients


sigma^2 estimated as 0.0193:  log likelihood = 34.32,  aic = -52.63
```


Residuals from ARIMA(2,1,1)(3,0,1)[12]
0.2
0.0
−0.2
2002
2004
2006
2008
ACF
0.2
0.1
0.0
−0.1
−0.2
6
12
18
24
Lag
count
20
15
10
5
0
−0.25
0.00
0.25
0.50
residuals

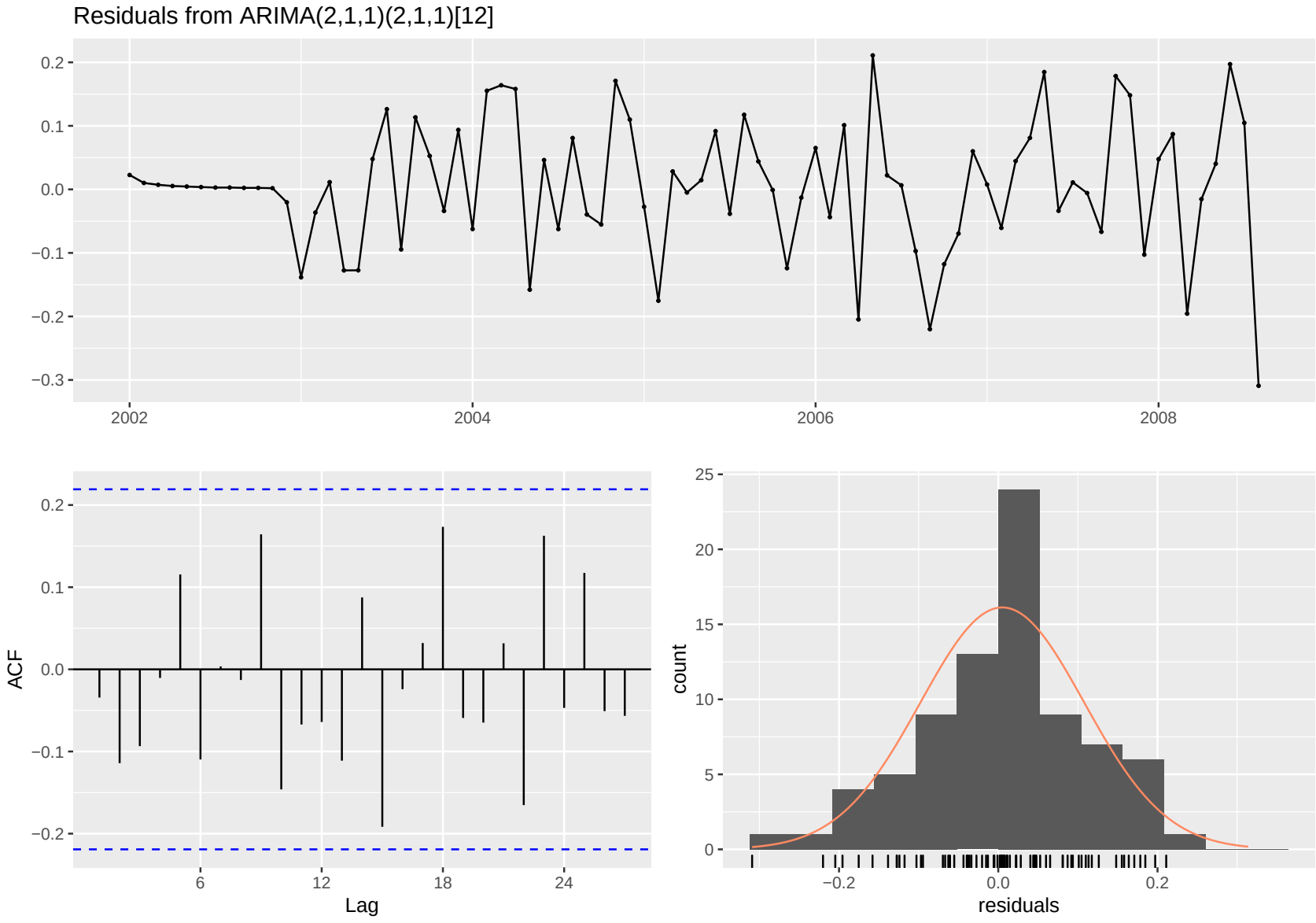
SARIMA(2, 1, 1)(2,0 ,1)

```
Call:
Arima(y = FRED_pre, order = c(2, 1, 1), seasonal = c(2, 0, 1), lambda = lambda)


-------------------------------------------------------------------
         ar1       ar2      ma1      sar1     sar2      sma1
---------- -------- --------- -------- -------- --------- ---------
             -1.1     -0.6944   0.3887   1.389    -0.3895   -0.9628

 **s.e.**   0.1522    0.1011    0.2013   0.1652   0.1651    0.1334
-------------------------------------------------------------------

Table: Coefficients


sigma^2 estimated as 0.01554:  log likelihood = 36.49,  aic = -58.99
```

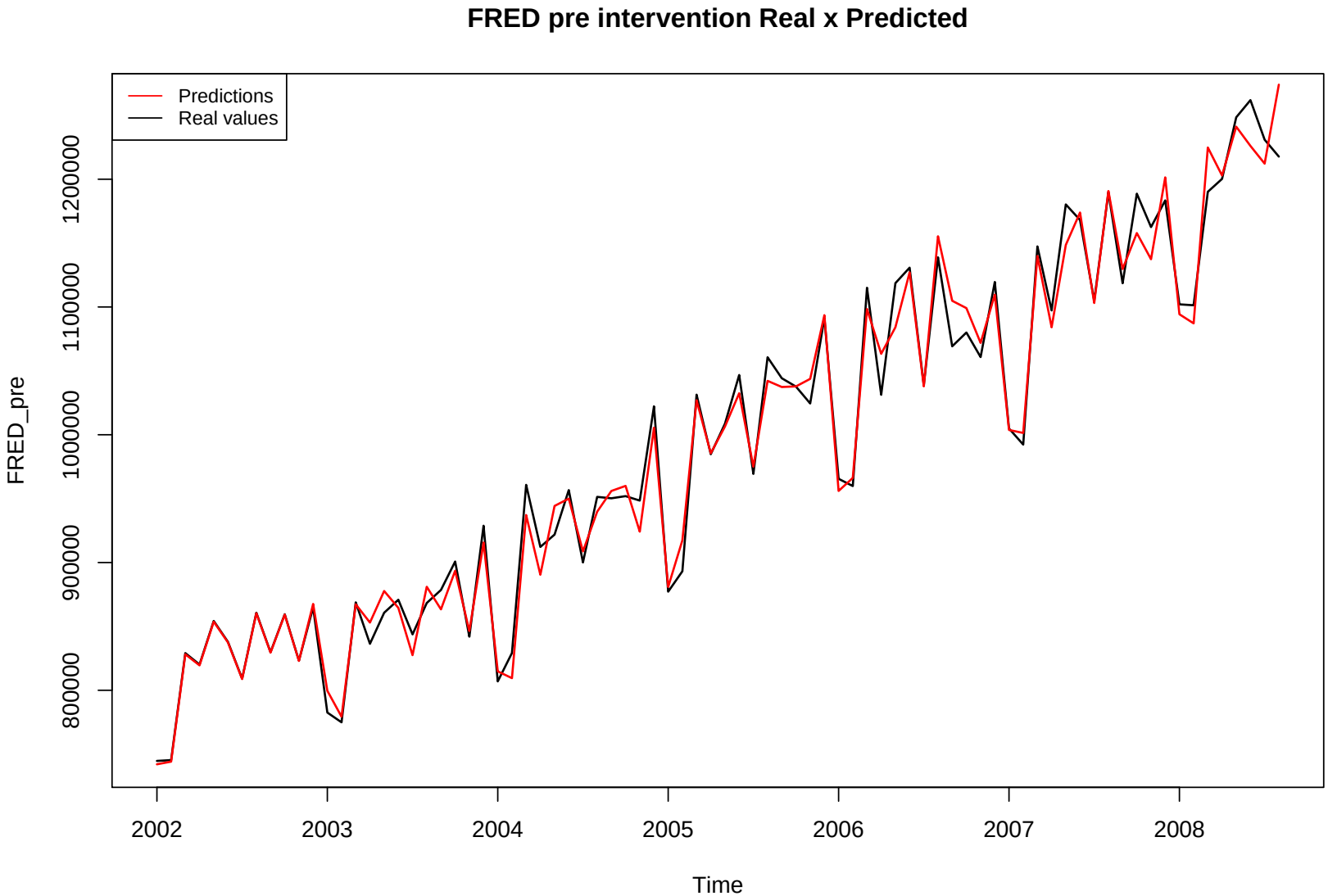

Residuals from ARIMA(2,1,1)(2,0,1)[12]
0.2
0.1
0.0
−0.1
−0.2
−0.3
2002
2004
2006
2008
ACF
Lag
6
12
18
24
count
residuals
15
10
5
0
−0.2
0.0
0.2
0.4

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

```
Call:
Arima(y = FRED_pre, order = c(2, 1, 1), seasonal = c(2, 1, 1), lambda = lambda)


-------------------------------------------------------------------
         ar1       ar2      ma1      sar1     sar2      sma1
---------- -------- --------- -------- -------- --------- ---------
           -1.098    -0.7046   0.4394   0.3592   -0.2377   -0.9998

 **s.e.**  0.1599    0.09892   0.2389   0.1512   0.1785    0.4891
-------------------------------------------------------------------

Table: Coefficients


sigma^2 estimated as 0.01376:  log likelihood = 41.06,  aic = -68.13
```

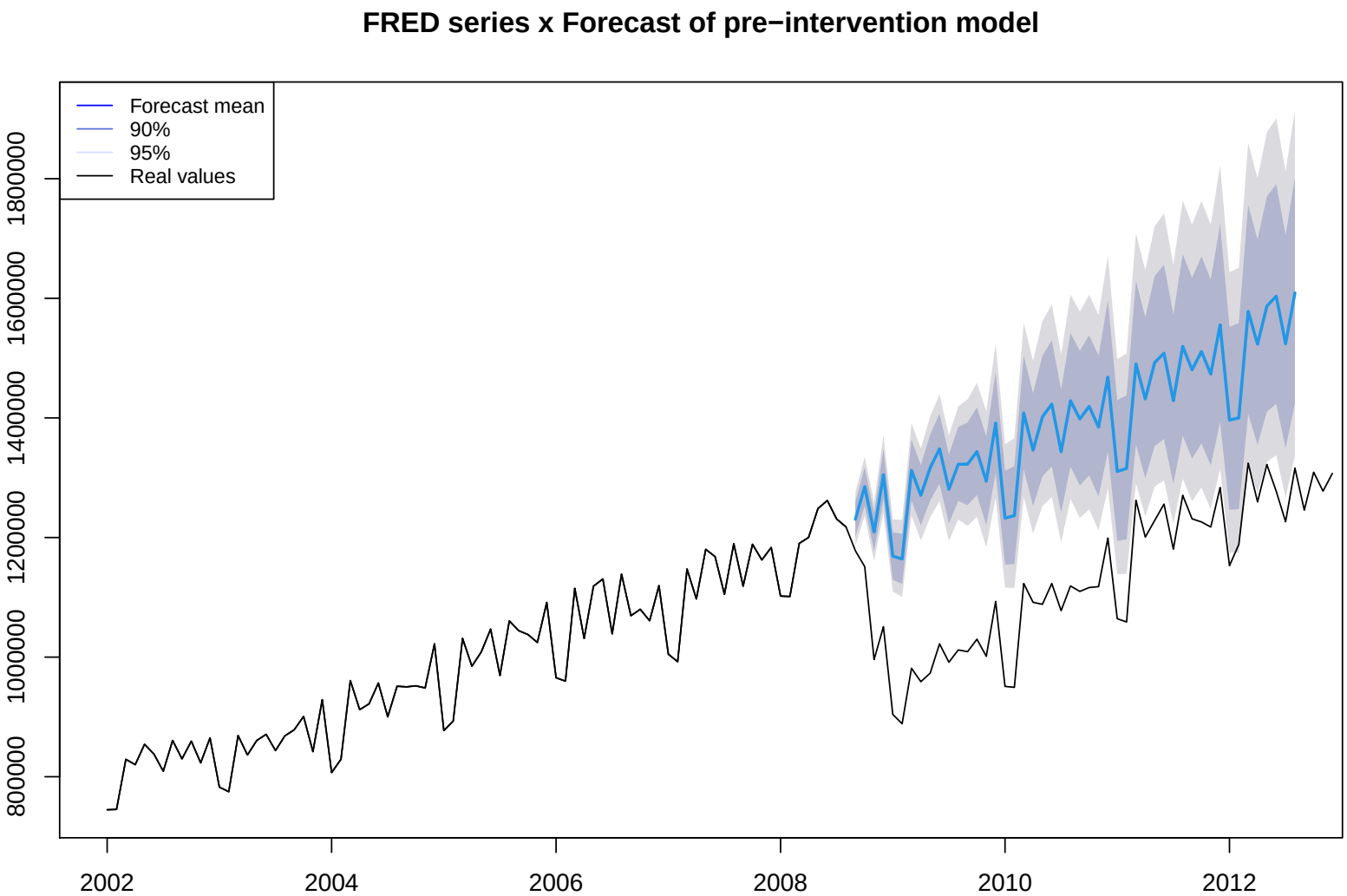

Residuals from ARIMA(2,1,1)(2,1,1)[12]
0.2
0.1
0.0
−0.1
−0.2
−0.3
2002
2004
2006
2008
ACF
Lag
6
12
18
24
count
residuals
25
20
15
10
5
0
−0.2
0.0
0.2

- 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.

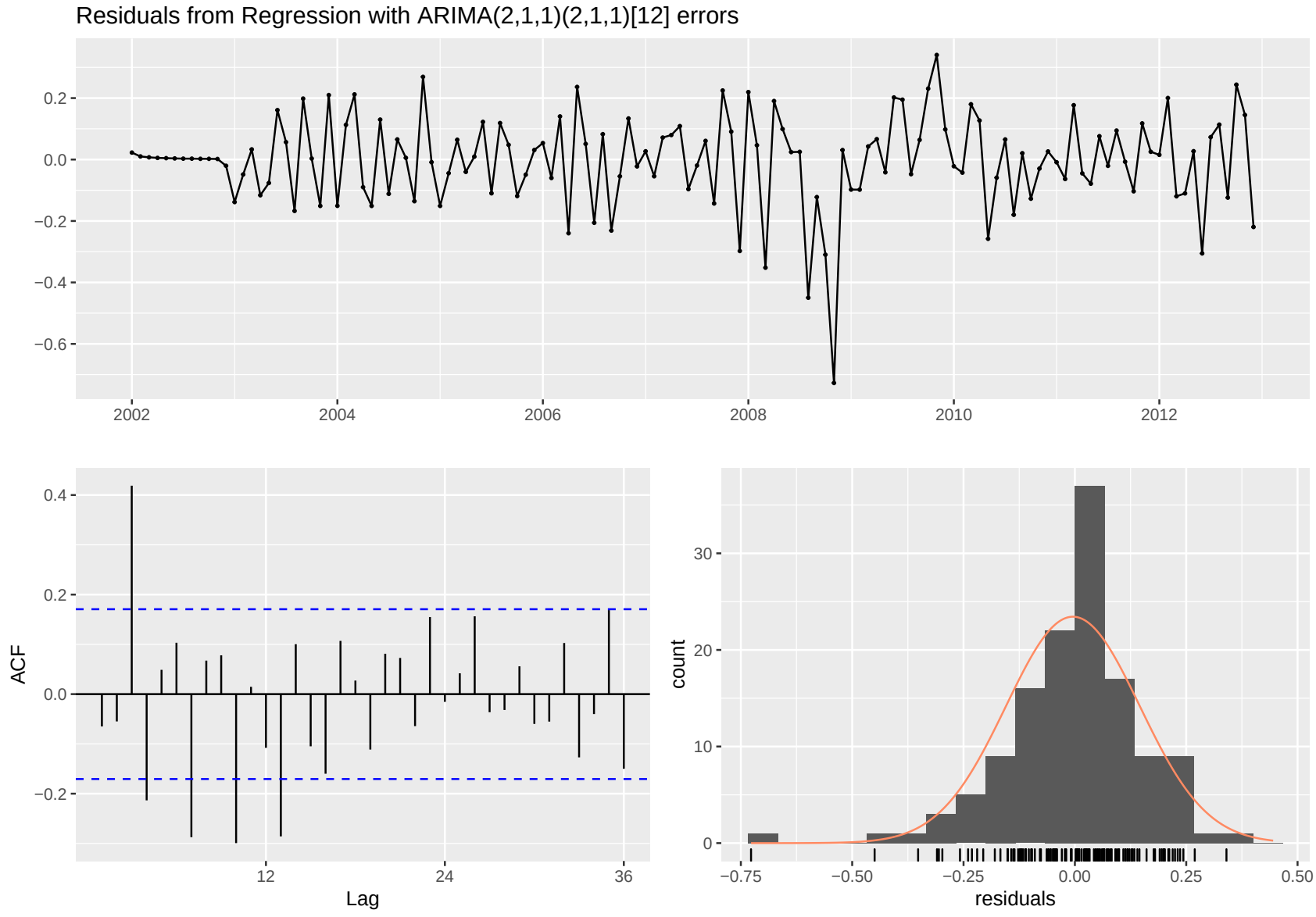


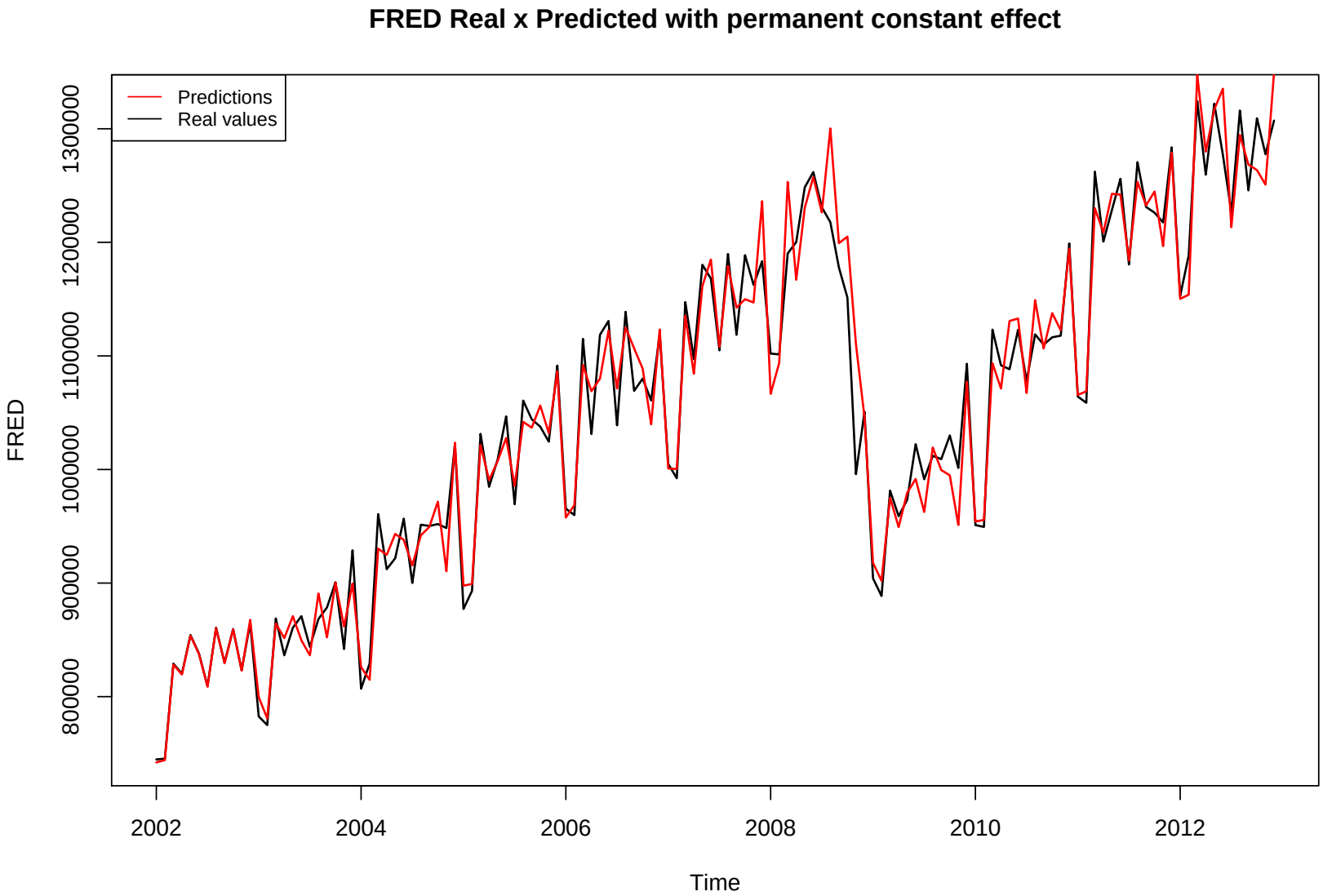
Intervention modeling

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.

```
Call:
Arima(y = FRED, order = c(2, 1, 1), seasonal = c(2, 1, 1), xreg =
permanent_const_eff, lambda = lambda)


-------------------------------------------------------------------------------
         ar1       ar2       ma1      sar1      sar2      sma1     xreg
--------- -------- --------- --------- --------- --------- ------ --------
            0.4543    0.2465   -0.5897    0.2995   -0.3439     -1    0.1105

 **s.e.**   0.1585   0.09035    0.1395   0.09685   0.09461    0.1    0.1492
-------------------------------------------------------------------------------

Table: Coefficients


sigma^2 estimated as 0.0263:  log likelihood = 35.34,  aic = -54.69
```


Residuals from Regression with ARIMA(2,1,1)(2,1,1)[12] errors
0.2
0.0
−0.2
−0.4
−0.6
2002
2004
2006
2008
2010
2012
0.4
0.2
0.0
−0.2
ACF
12
24
36
Lag
30
20
10
0
count
−0.75
−0.50
−0.25
0.00
0.25
0.50
residuals

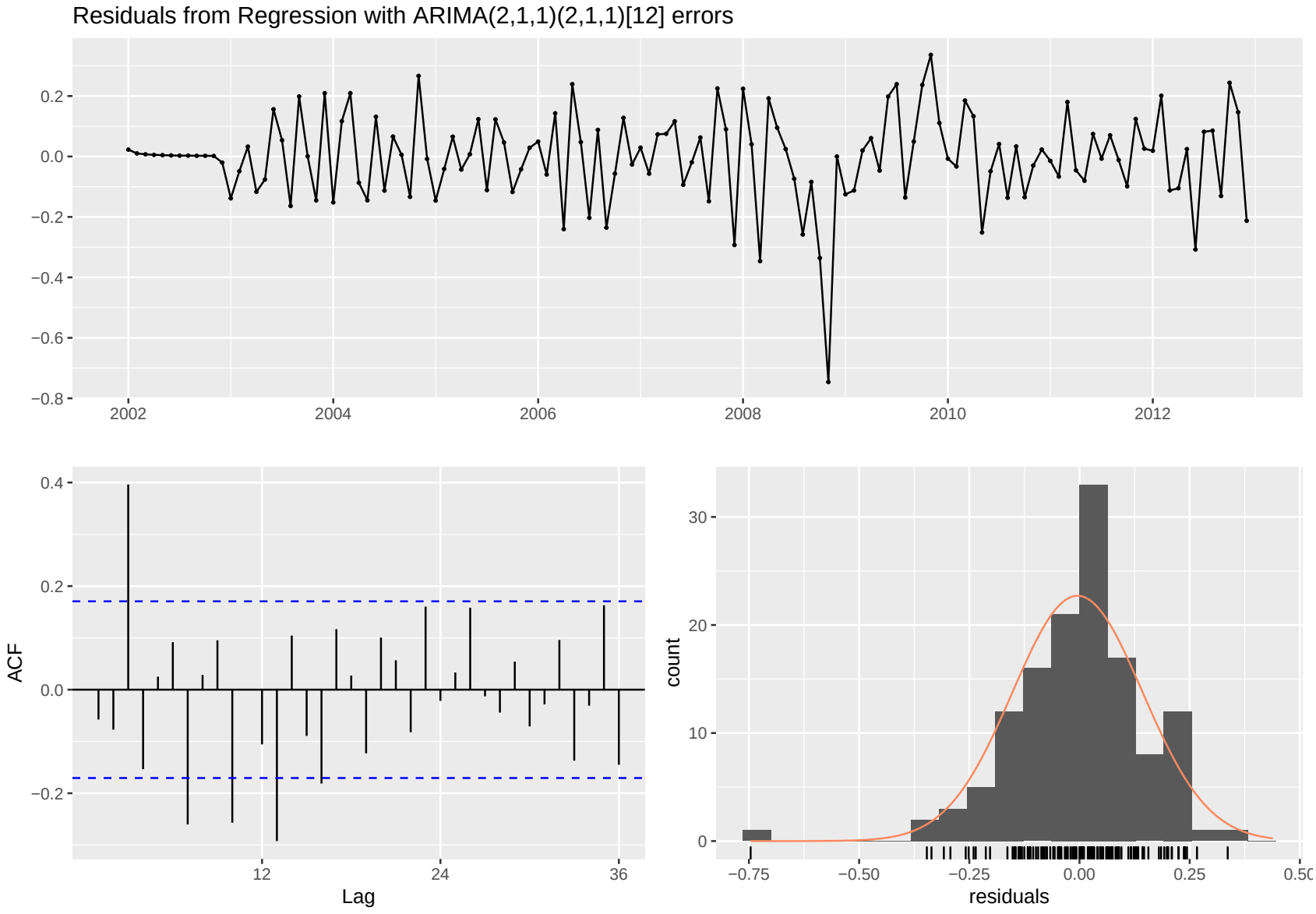

FRED Real x Predicted with permanent constant effect
Predictions
Real values
FRED
800000
900000
1000000
1100000
1200000
1300000
2002
2004
2006
2008
2010
2012
Time

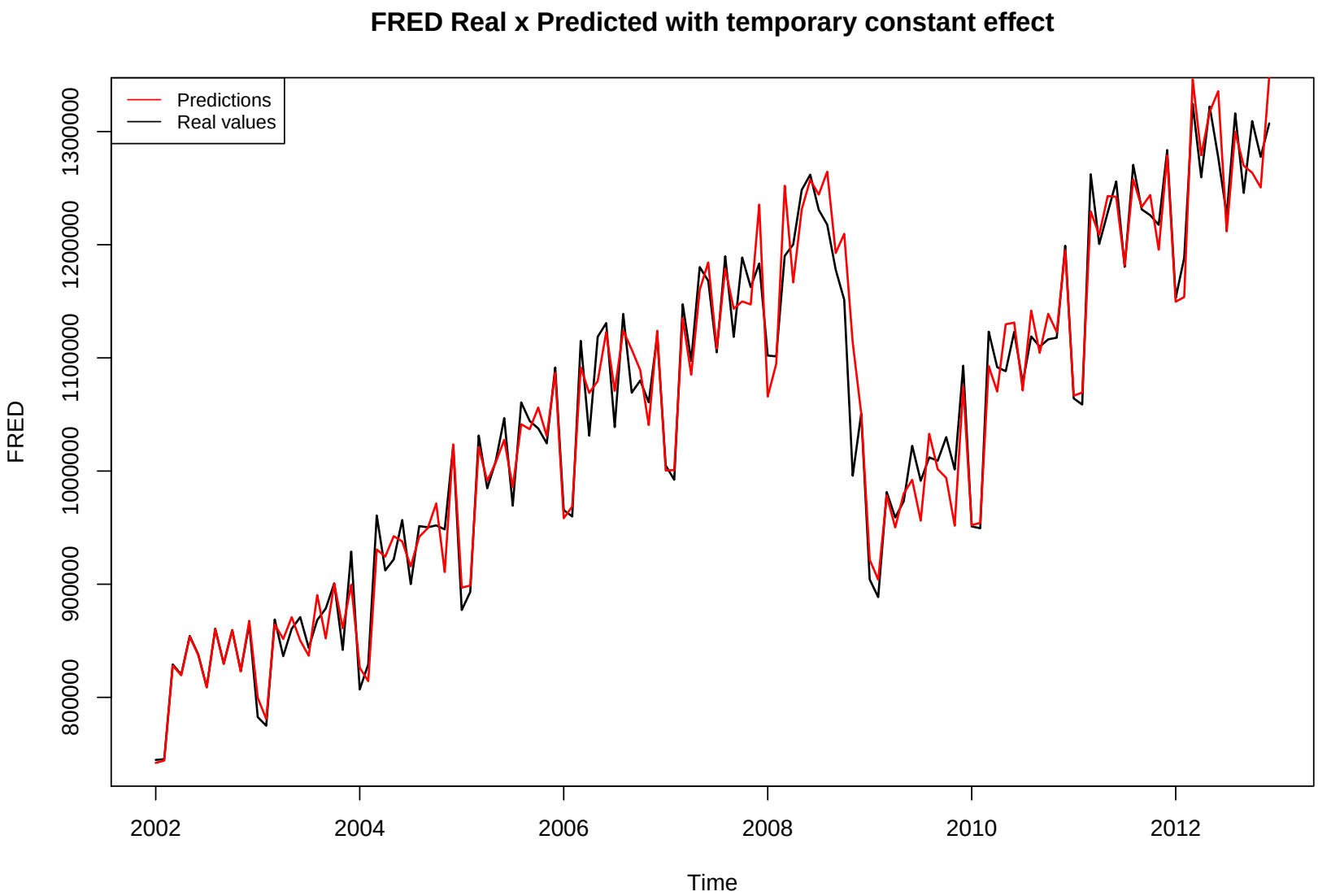
Temporary constant effect

- 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.

```
Call:
Arima(y = FRED, order = c(2, 1, 1), seasonal = c(2, 1, 1), xreg =
temporary_const_eff, lambda = lambda)


------------------------------------------------------------------------------
         ar1       ar2       ma1      sar1      sar2      sma1      xreg
---------- -------- --------- --------- --------- --------- -------- --------
           0.4749    0.223    -0.6151    0.2804    -0.3408     -1      0.2209

 **s.e.**  0.1695    0.09176   0.1521    0.09886   0.09546   0.0992    0.1134
------------------------------------------------------------------------------

Table: Coefficients


sigma^2 estimated as 0.02554:  log likelihood = 37,  aic = -58
```

```
##
## z test of coefficients:
##
##       Estimate Std. Error  z value  Pr(>|z|)
## ar1   0.474910   0.169522   2.8015 0.0050873 **
## ar2   0.223007   0.091760   2.4303 0.0150849 *
## ma1  -0.615083   0.152137  -4.0430 5.278e-05 ***
## sar1  0.280412   0.098862   2.8364 0.0045626 **
## sar2 -0.340759   0.095457  -3.5698 0.0003573 ***
## sma1 -0.999978   0.099198 -10.0806 < 2.2e-16 ***
## xreg  0.220942   0.113434   1.9478 0.0514443 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1
```


Residuals from Regression with ARIMA(2,1,1)(2,1,1)[12] errors
0.2
0.0
−0.2
−0.4
−0.6
−0.8
2002
2004
2006
2008
2010
2012
ACF
0.4
0.2
0.0
−0.2
12
24
36
Lag
count
30
20
10
0
−0.75
−0.50
−0.25
0.00
0.25
residuals


FRED Real x Predicted with temporary constant effect
Predictions
Real values
FRED
800000
900000
1000000
1100000
1200000
1300000
2002
2004
2006
2008
2010
2012
Time