

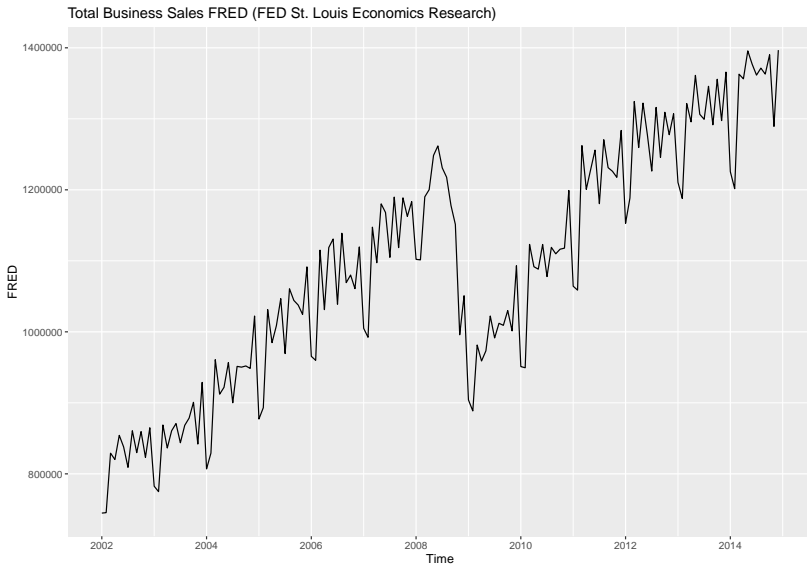
# Intervention analysis

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11/12/2020

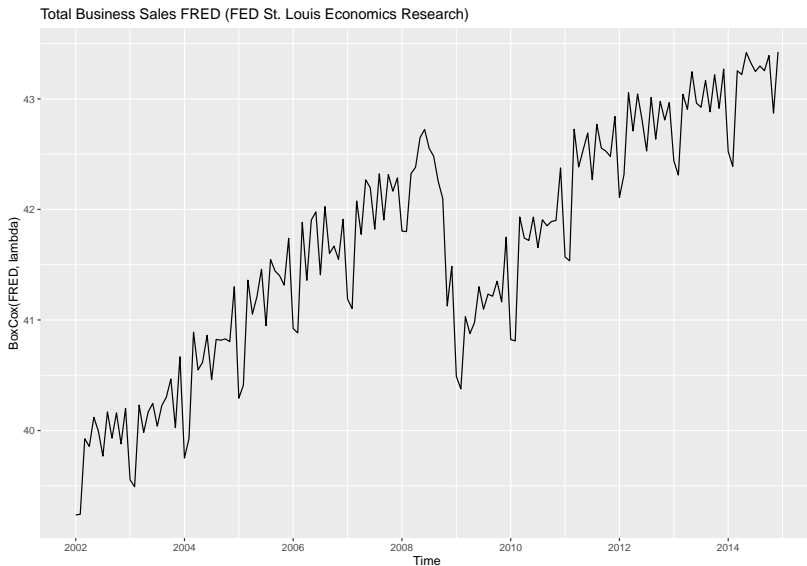
# Total Business Sales FRED

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



# Variance stabilization

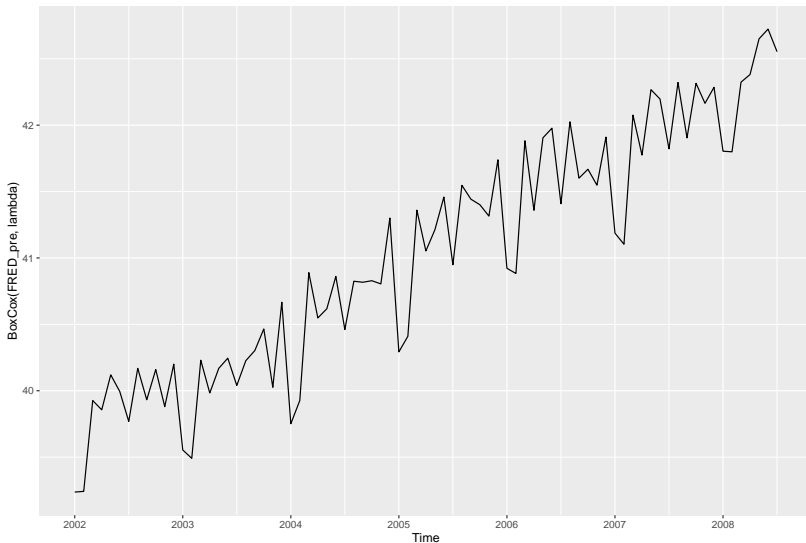
- ▶ With BoxCox, the lambda is 0.1370143.



# SARIMA pre-intervention

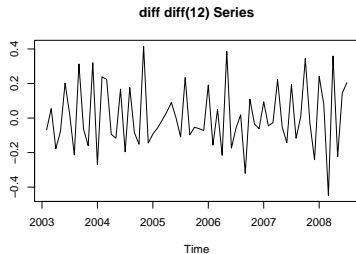
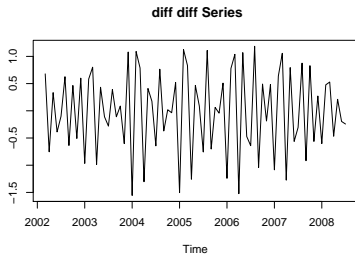
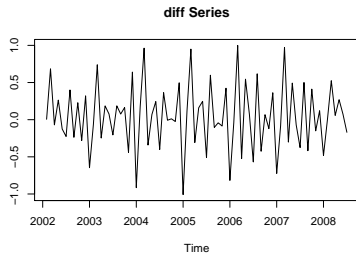
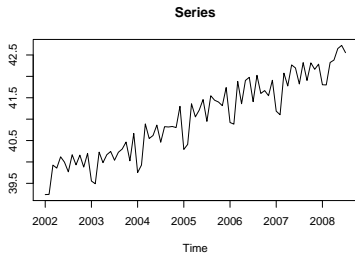
- Model with data until 06/2008. The plots and the models will use the transformed series.

Total Business Sales FRED (FED St. Louis Economics Research)



## Check differences

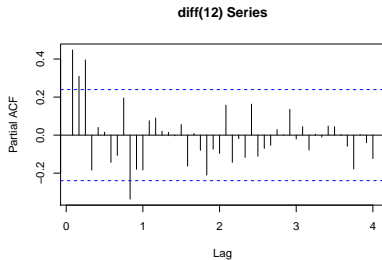
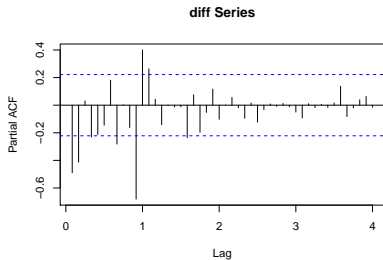
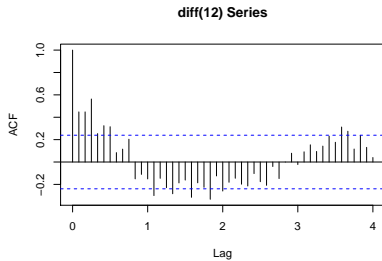
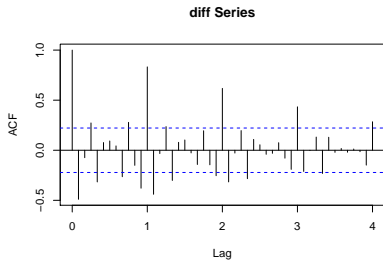
- To identify parameters  $d$  and  $D$  for the SARIMA model.



- ▶ 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  $p, q, P, Q$ .



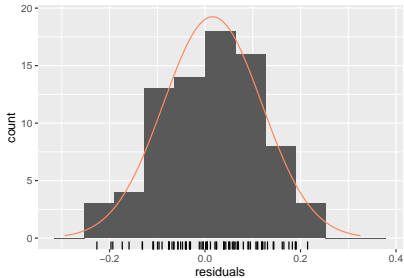
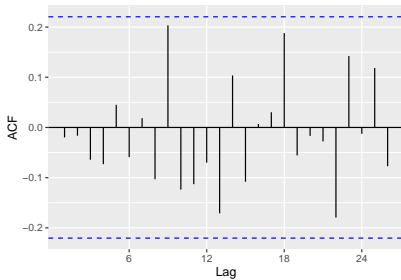
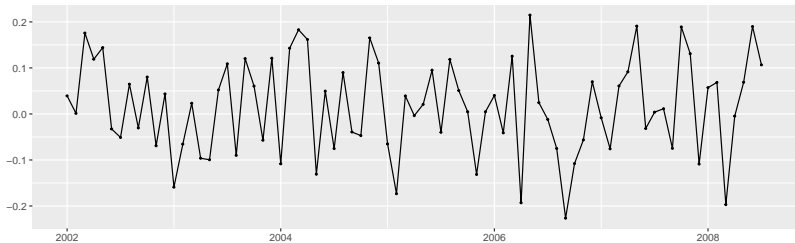
- ▶ Both non-seasonal and seasonal ACFs decrease slowly, indicating an auto regressive model.
- ▶ For the non seasonal PACFs, we have the first two significant lags and for the seasonal we have the first three significant lags.
- ▶ Going to test the following models:
  - ▶ SARIMA(2, 1, 1)(3, 0, 1)
  - ▶ 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      MAPE
## Training set 2520.937 15857.62 12908.28 0.2255516 1.2994
##              ACF1
## Training set -0.008910006
##              ME      RMSE      MAE      MPE      MAPE
```

Residuals from ARIMA(2,1,1)(3,0,1)[12]



##

## Ljung-Box test

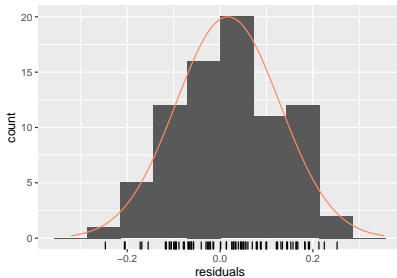
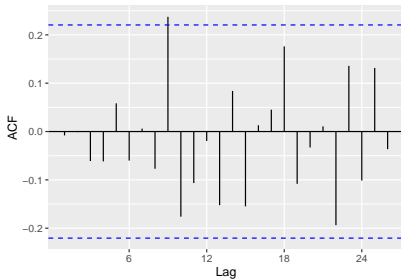
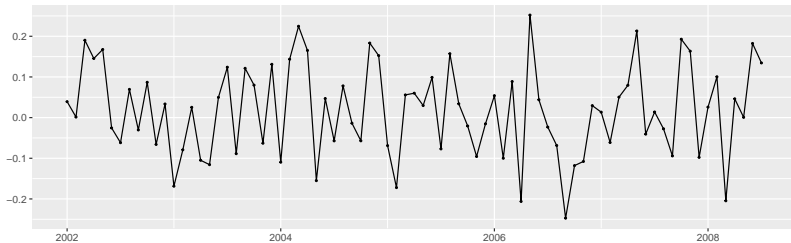
##

## Residuals from ARIMA(2,1,1)(3,0,1)[12]

## 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      MAPE
## Training set 2627.641 17197.02 14037.53 0.2394168 1.4153
##              ACF1
## Training set -0.01155024
##              ME      RMSE      MAE      MPE      MAPE
```

Residuals from ARIMA(2,1,1)(2,0,1)[12]



##

## Ljung-Box test

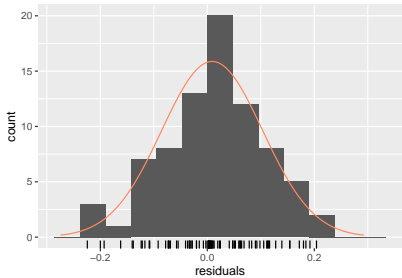
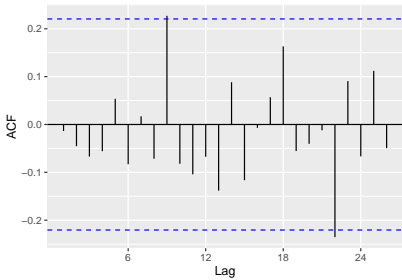
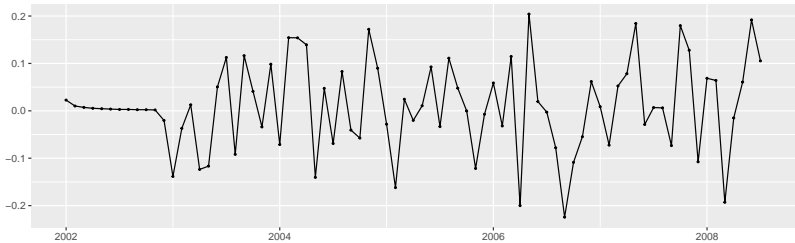
##

## ACF: F = 1.2, p = 0.27, Ljung-Box: F = 1.2, p = 0.27, ACF: F = 1.2, p = 0.27

## 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      MAPE
## Training set 1562.579 14709.87 11070.55 0.1228108 1.0888
##              ME      RMSE      MAE      MPE      MAPE
## Training set 1562.579 14709.87 11070.55 0.1228108 1.0888
```

## Residuals from ARIMA(2,1,1)(2,1,1)[12]



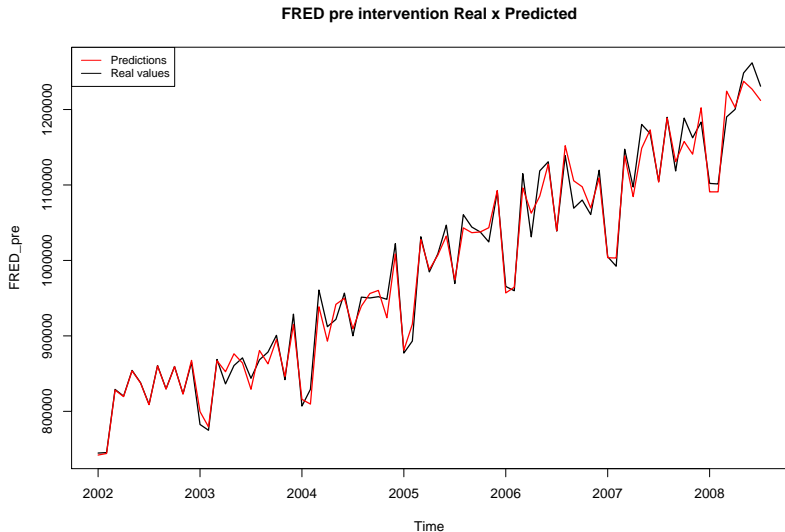
##

## ## Ljung-Box test

##

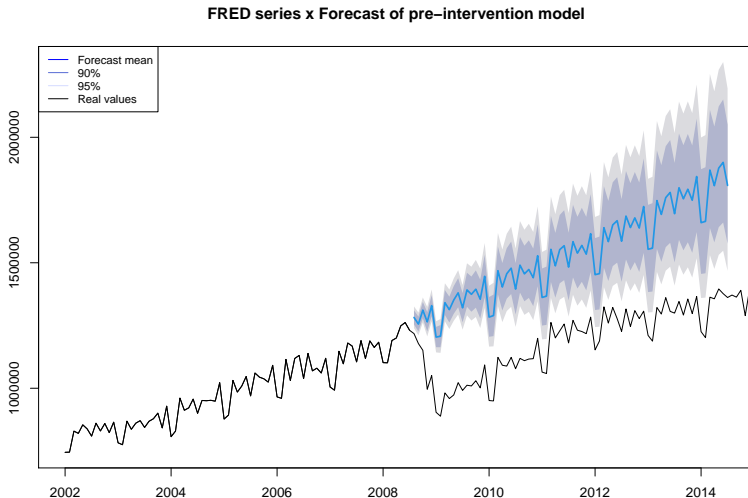
— *Journal of the American Medical Association*, 1997

- 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.





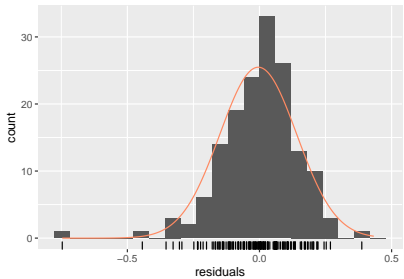
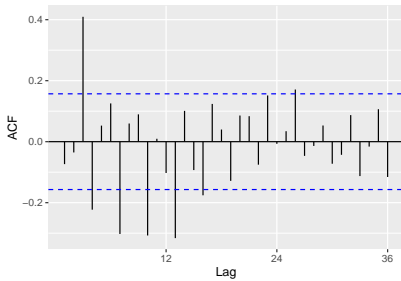
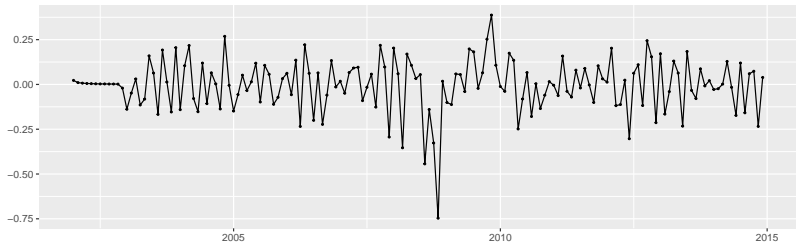
# Intervention modeling

## Permanent constant effect

- ▶ For the first intervention model we will define  $h_t = I(t > \text{Jul/2008})\delta_0$ , so there will be a permanent effect equal to  $\delta_0$  after July of 2008.
- ▶ The estimated  $\delta_0$  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
##
```

Residuals from Regression with ARIMA(2,1,1)(2,1,1)[12] errors

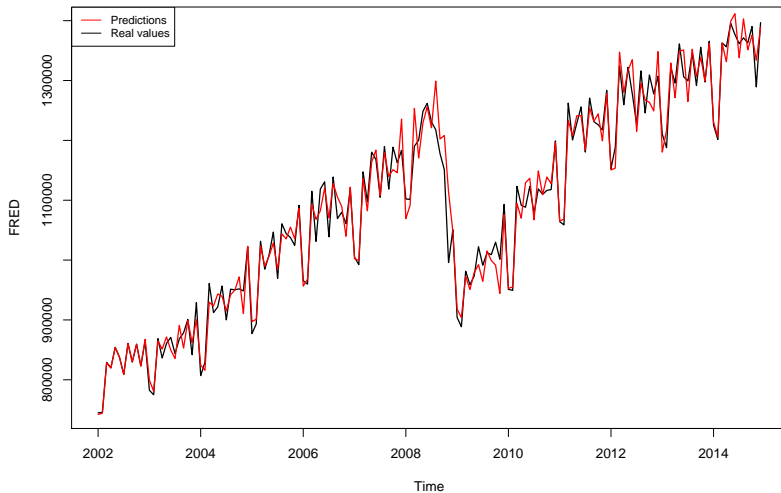


```
##
```

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

```
##
```

**FRED Real x Predicted with permanent constant effect**



## Temporary constant effect

- ▶ Now for the intervention model we will define  $h_t = I(t = \text{jul/2008})\delta_0$ , so there will be a temporary effect equal to  $\delta_0$  on july of 2008.
- ▶ The estimated  $\delta_0$  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 )
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##	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	***
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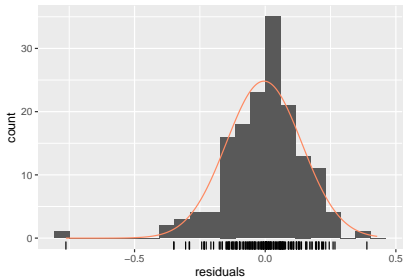
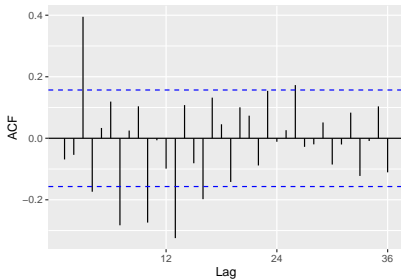
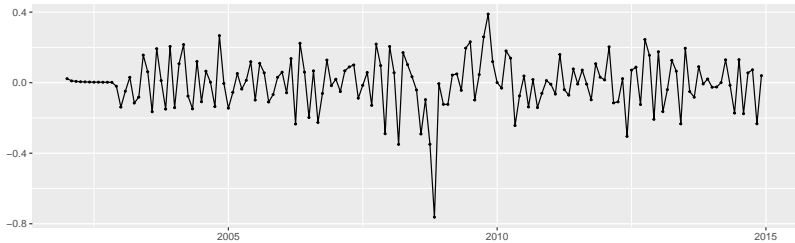
##	sma1	-0.999953	0.110620	-9.0395	< 2.2e-16	***
----	------	-----------	----------	---------	-----------	-----

##	xreg	0.183541	0.106421	1.7247	0.084587	.
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## ---

## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1

Residuals from Regression with ARIMA(2,1,1)(2,1,1)[12] errors



```
##
```

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

```
##
```

**FRED Real x Predicted with temporary constant effect**

