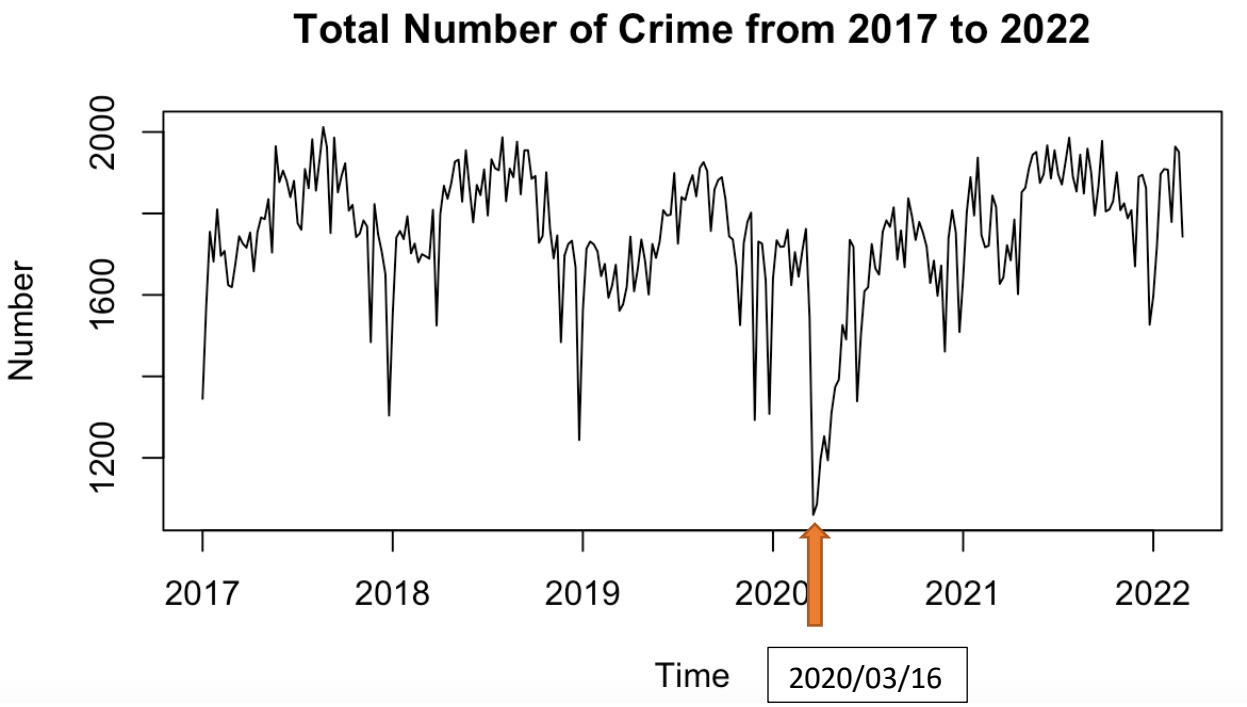
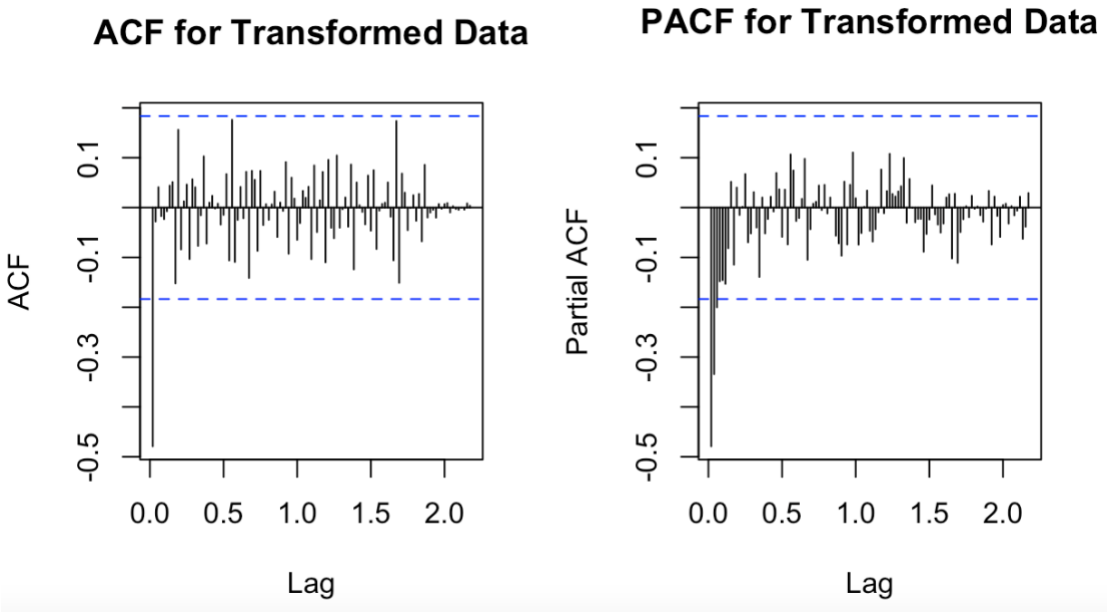
- **Original data**



Train: 167 observations
Test: 102 observations

- **Take log transformation, regular and seasonal differences**



No tentative seasonal ARIMA model

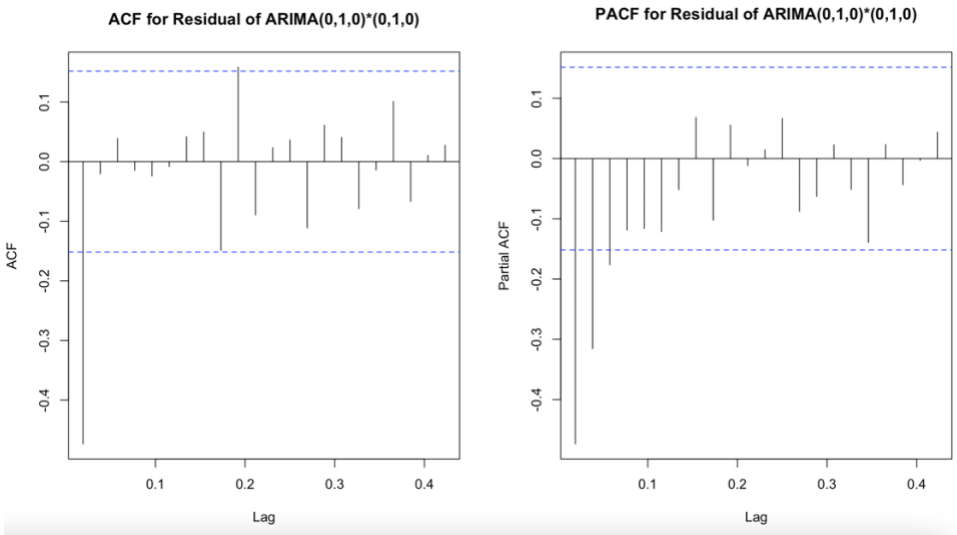
- **Check stationarity of transformed data**

```
        Augmented Dickey-Fuller Test

data:  ddlog_cr
Dickey-Fuller = -8.006, Lag order = 4, p-value = 0.01
alternative hypothesis: stationary

Warning message:
In adf.test(ddlog_cr) : p-value smaller than printed p-value
```

- **Check ACF and PACF to determine p and q orders**



MA(1)
p-value for residuals of ARIMA(0,1,1)*(0,1,0) is 0.9793

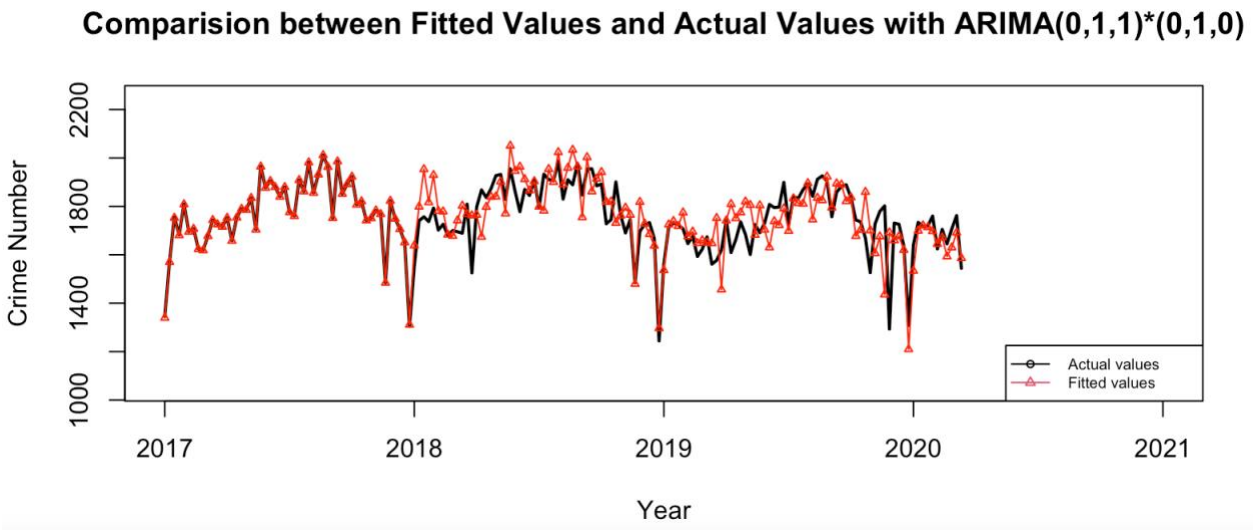
AR(3)
p-value for residuals of ARIMA(3,1,0)*(0,1,0) is 0.8025

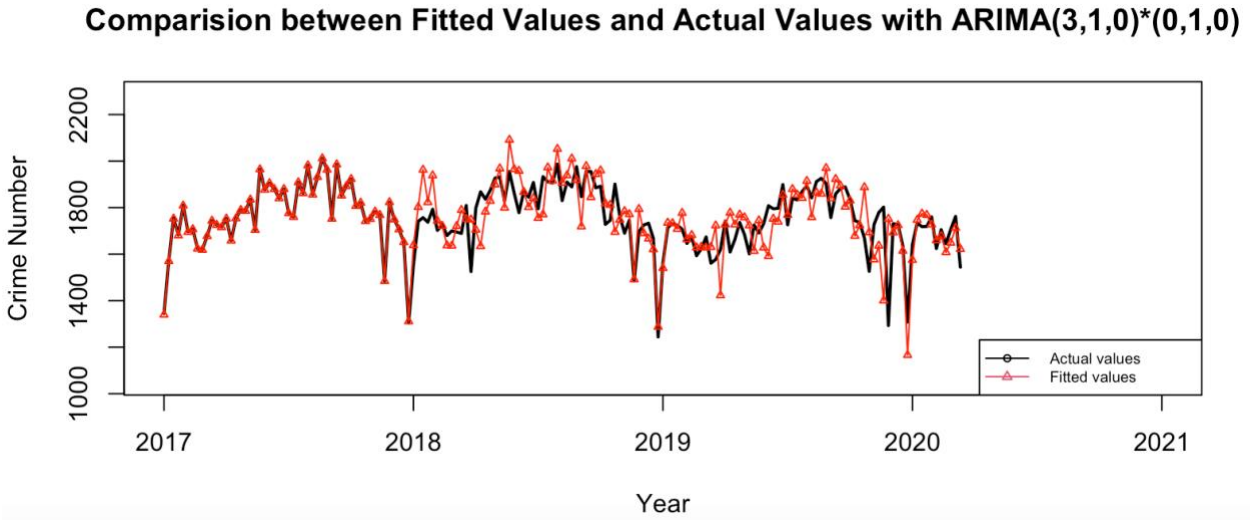
All AR and MA terms are significant
Check AR polynomials => all out of unit root

```
AR/MA
  0 1 2 3 4 5 6 7 8 9 10 11 12 13
0 x                             o
1 x x o o o o o o o o  o  o  o
2 x x x o o o o o o o  o  o  o
3 x o o x o o o o o o  o  o  o
4 x o o o o o o o o o  o  o  o
5 x o o o o o o o o o  o  o  o
6 x x o o o o o o o o  o  o  o
7 x o o o o x o o o o  o  o  o
```

Tentative models are: ARIMA(0,1,1)*(0,1,0) and ARIMA(3,1,0)*(0,1,0).

- **Fitted Models for train data**





Rolling forecast shows ARIMA(3,1,0)*(0,1,0) is better:

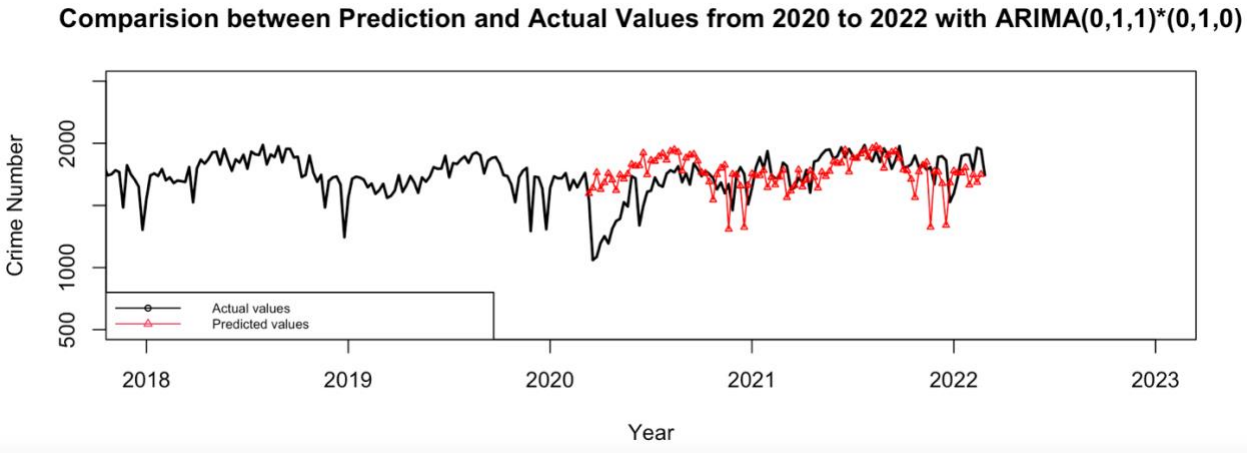
```
0.0014378787 0.0015041534 0.0006189400 0.0021502021 0.0048902019 0.0067756195 0.0034852587
0.0011721909 0.0003950582 0.0008873423 0.0008372706 0.0023424955 0.0035833035 0.0015633521
```

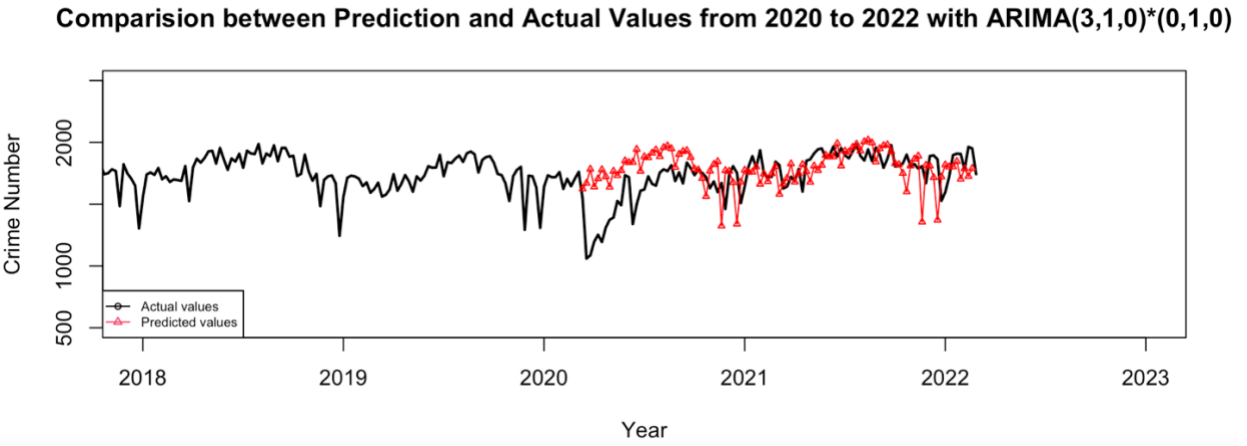
AIC shows ARIMA(0,1,1)*(0,1,0) is better:

AIC = -315.92

AIC = -299.29

- **Prediction compared with test data**



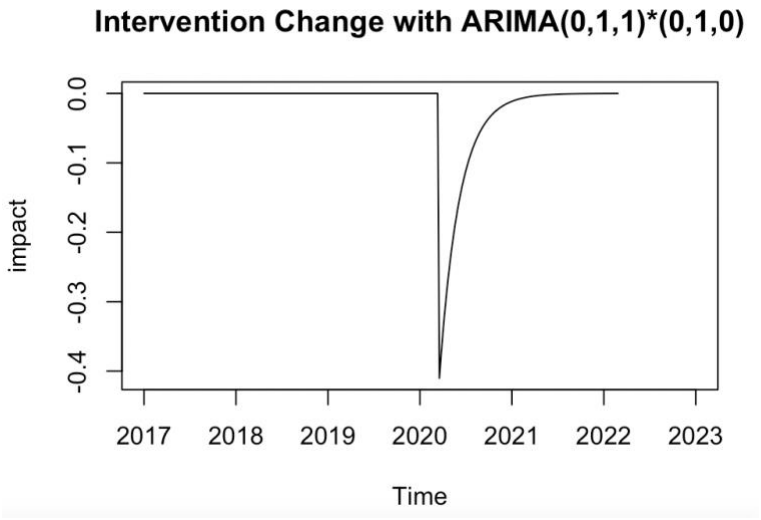


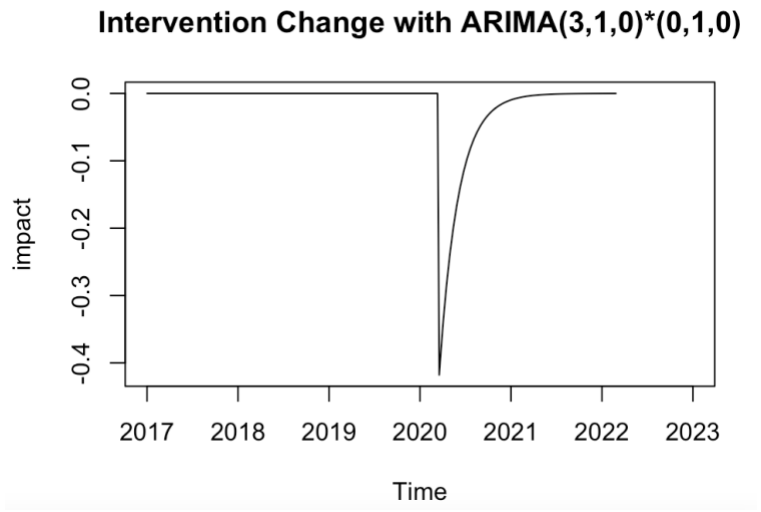
- **Check outliers**
  To much outlier returns
  ARIMA(0,1,1)*(0,1,0): 80 outliers
  ARIMA(3,1,0)*(0,1,0): 65 outliers

- **Add intervention variables**

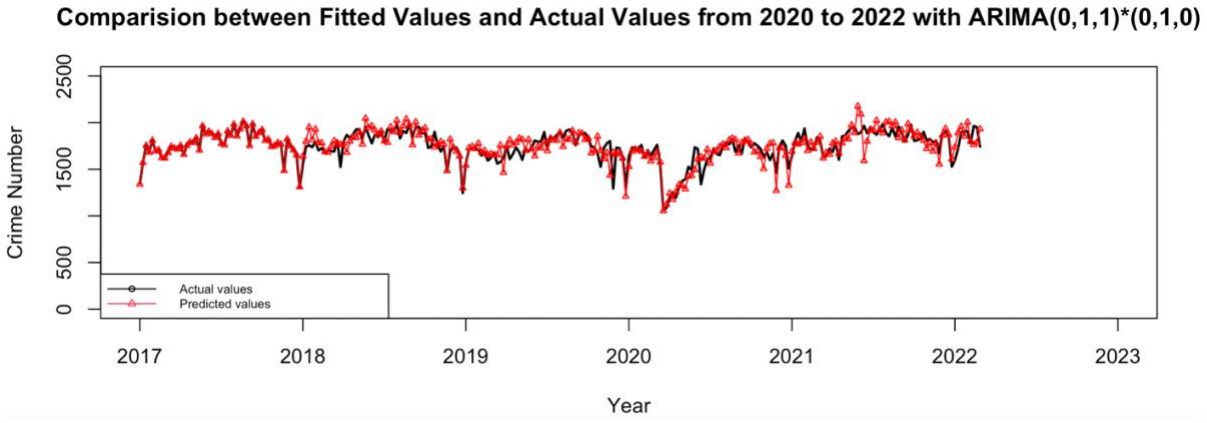
Model	AIC
ARIMA(0,1,1)*(0,1,0)	
• without intervention	-473.73
• with step function	-548.13
• **with pulse function**	-587.77
• with step and pulse function	-586.6
ARIMA(3,1,0)*(0,1,0)	
• without intervention	-471.71
• with step function	-542.64
• **with pulse function**	-556.91
• with step and pulse function	-554.91

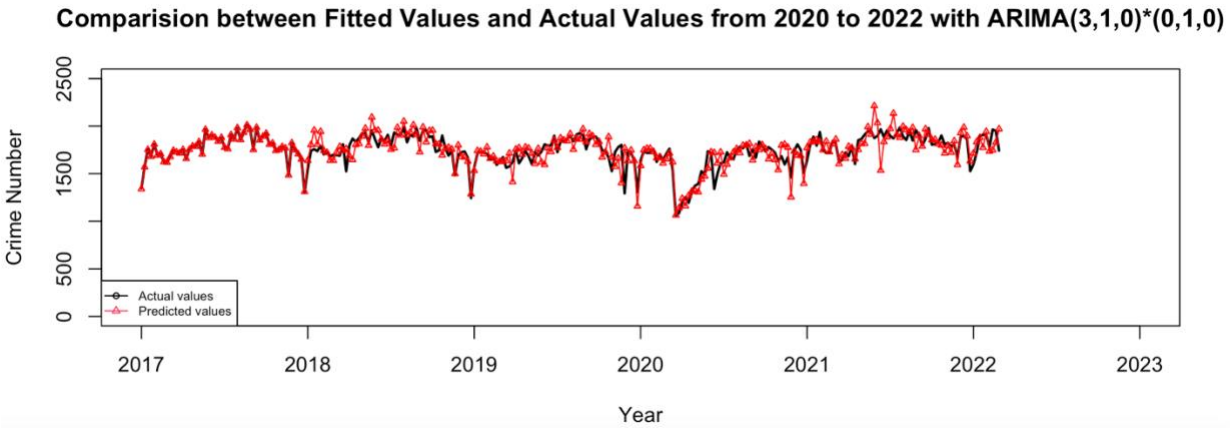
- **intervention changes**





- **Comparison between Fitted Values and Actual Values after adding intervention variables**





- **Prediction for future**