Practice of AI

Time Series Forecasting

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Demo

Forecasting for the count infected by COVID-19

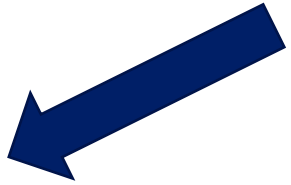
(USA)

https://www.kaggle.com/sudalairajkumar/covid19-in-usa

Sample

Dataset： 147 (2020-01-22 to 2020-06-16)
Dimension： 25

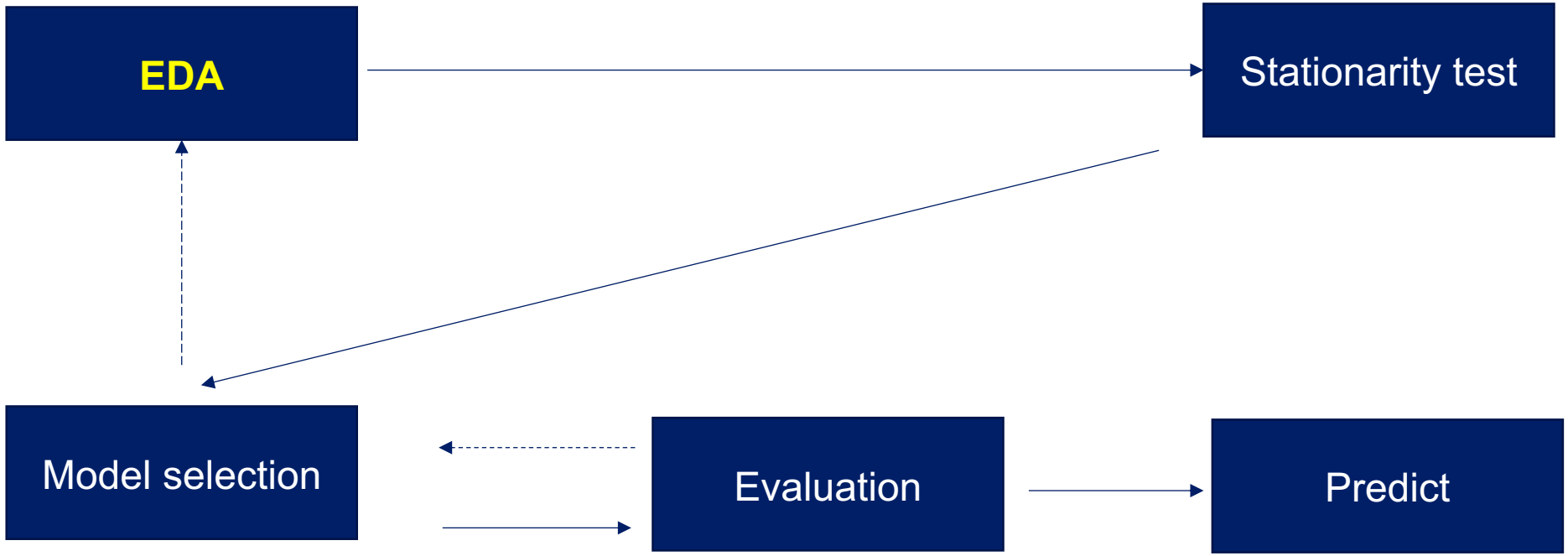
- Date
- PositiveIncrease
- States
- TotalTestResults



Out[6]:

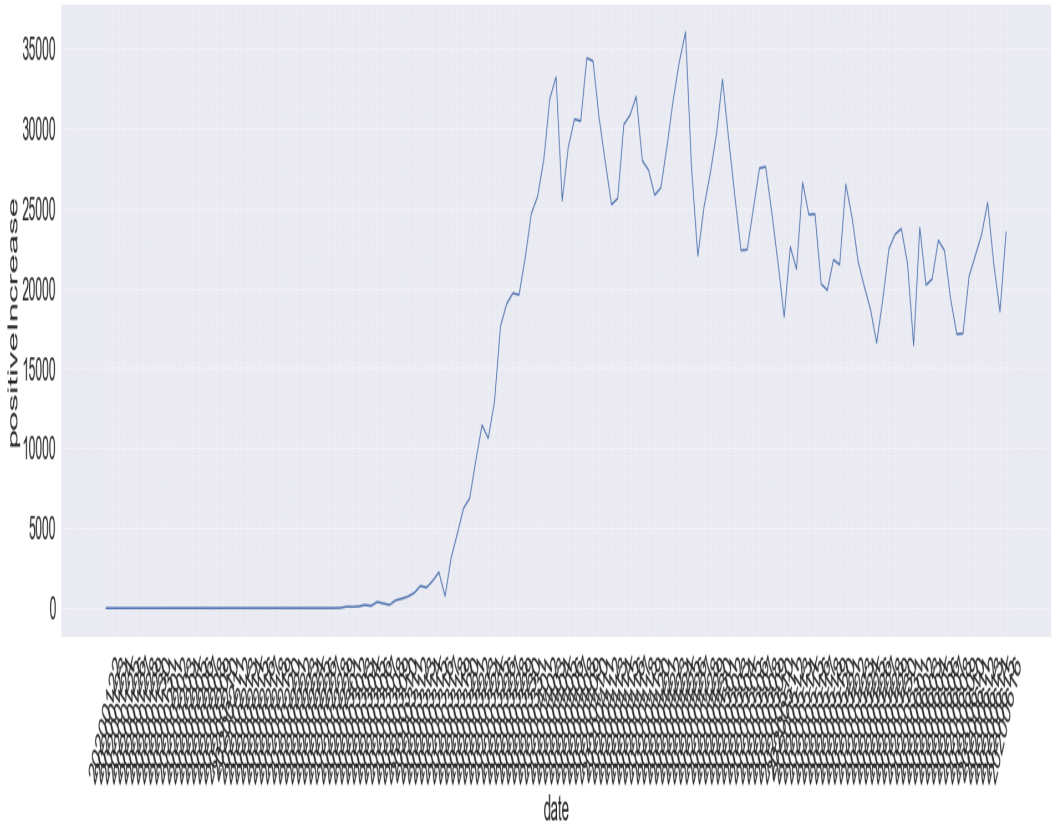
date	object
states	int64
positive	int64
negative	float64
pending	float64
hospitalizedCurrently	float64
hospitalizedCumulative	float64
inIcuCurrently	float64
inIcuCumulative	float64
onVentilatorCurrently	float64
onVentilatorCumulative	float64
recovered	float64
dateChecked	object
death	float64
hospitalized	float64
lastModified	object
total	int64
totalTestResults	int64
posNeg	int64
deathIncrease	int64
hospitalizedIncrease	int64
negativeIncrease	int64
positiveIncrease	int64
totalTestResultsIncrease	int64
hash	object

Workflow

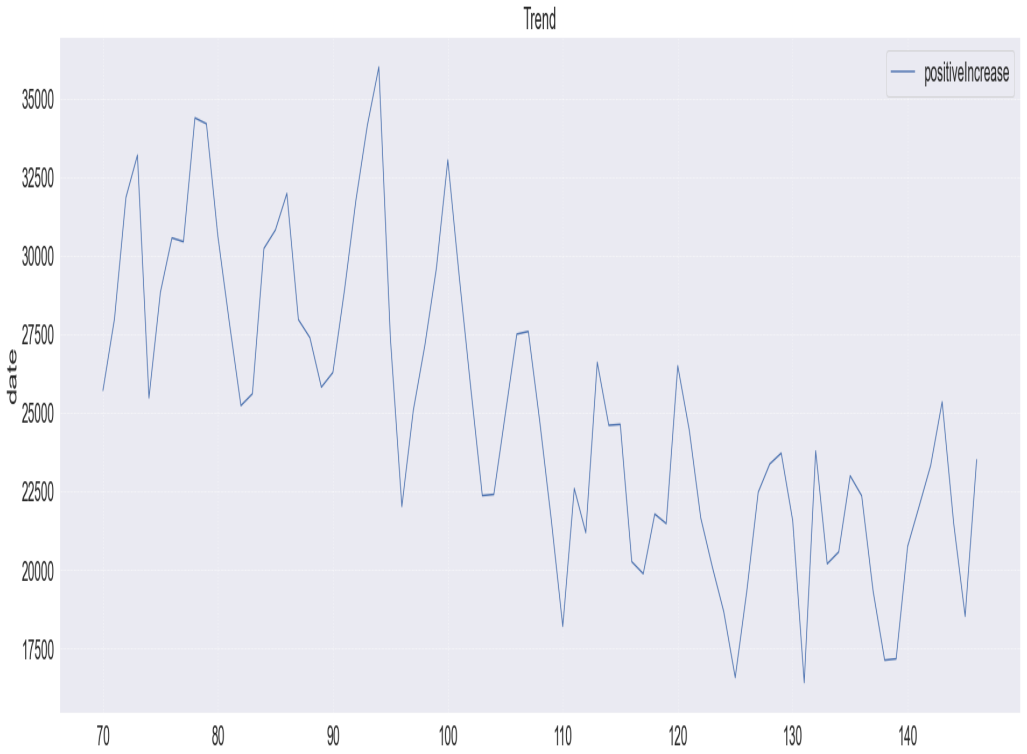

EDA
Stationarity test
Model selection
Evaluation
Predict

EDA # Positive Increase

- Increase trend

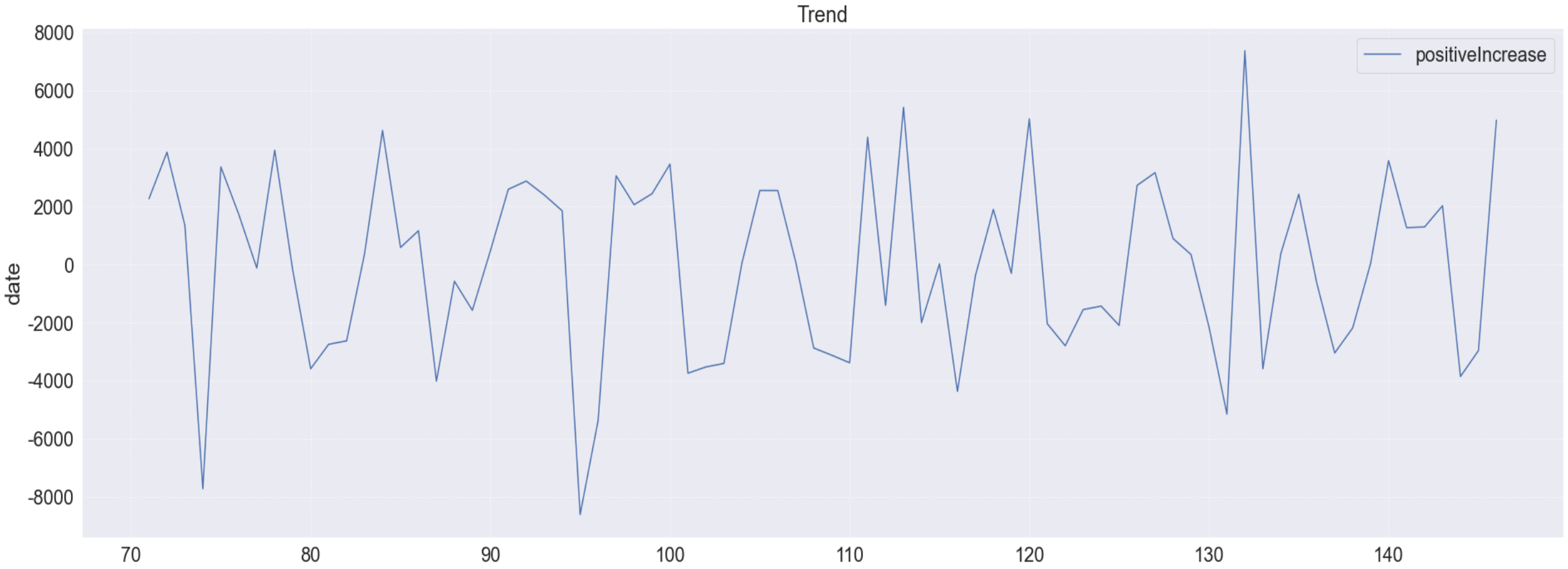


- Decline convulsively after 4/1



EDA # Positive Increase

- Stable after difference



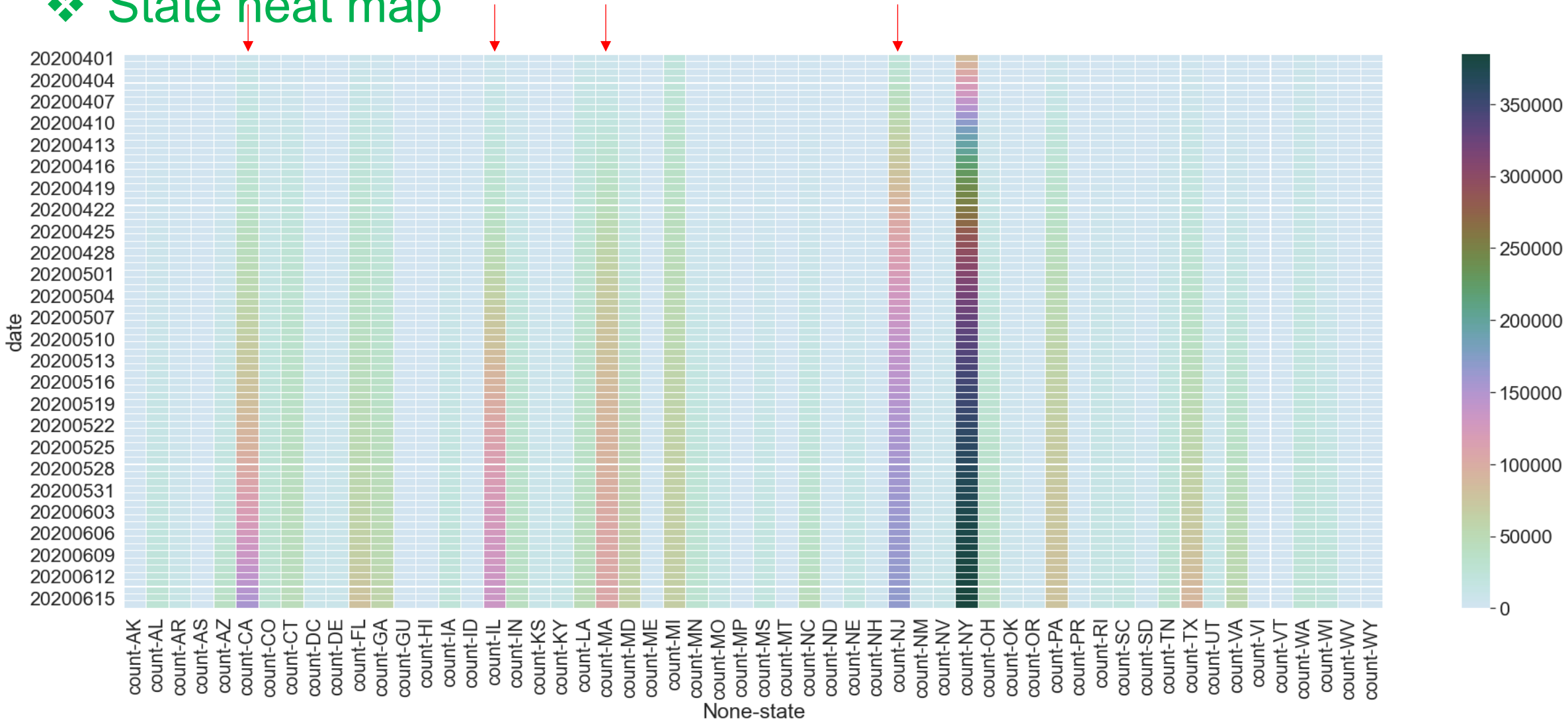
EDA # Positive Increase & Test

- Correlation matrix

	positive	positiveIncrease	test	testIncrease
positive	1.00	-0.74	0.97	0.94
positiveIncrease	-0.74	1.00	-0.71	-0.62
test	0.97	-0.71	1.00	0.93
testIncrease	0.94	-0.62	0.93	1.00

EDA # Positive Count & State

❖ State heat map

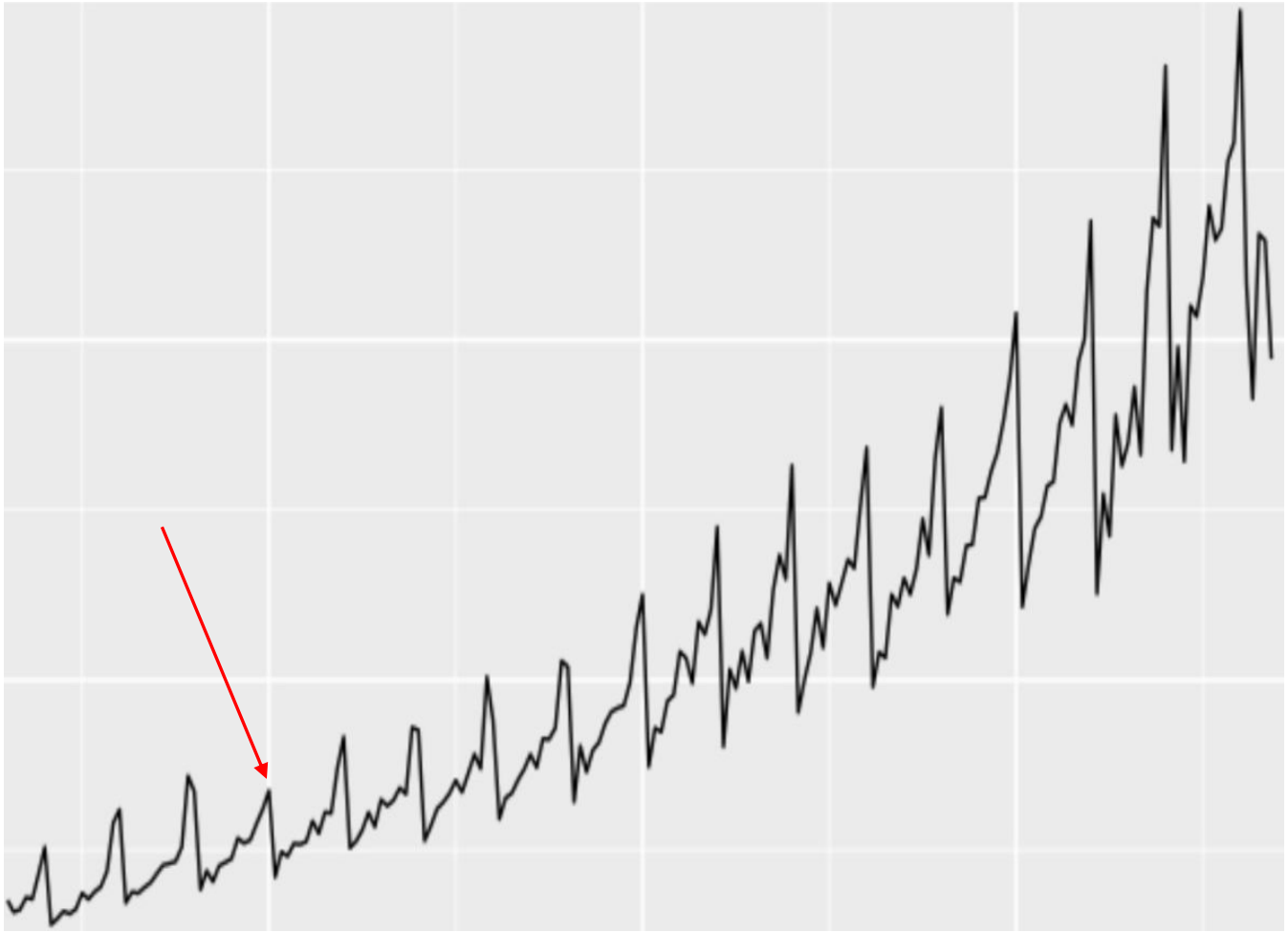


EDA

- ✓ Increase declines convulsively after 4/1
- ✓ Increase becomes stable after difference
- ✓ High correlation between increase and test
- ✓ No increase pattern found in different states

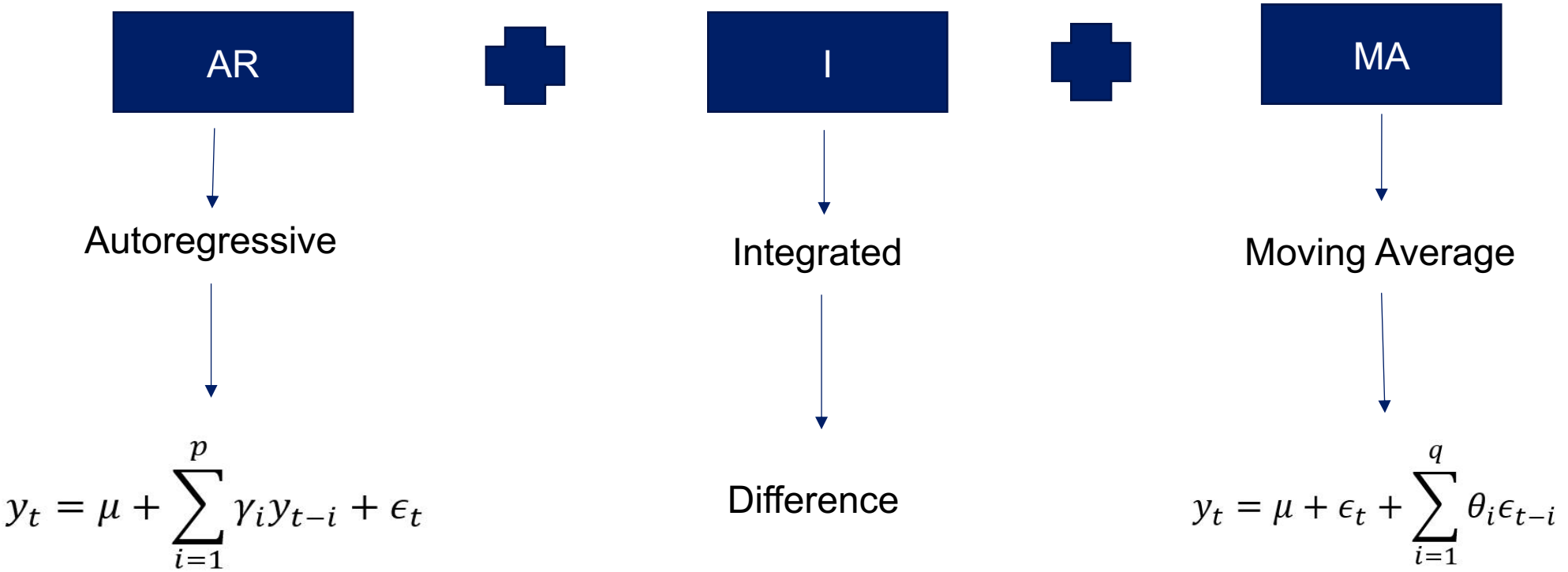
Time Series Data

- Trend
- Seasonal
- Cyclical
- Irregular

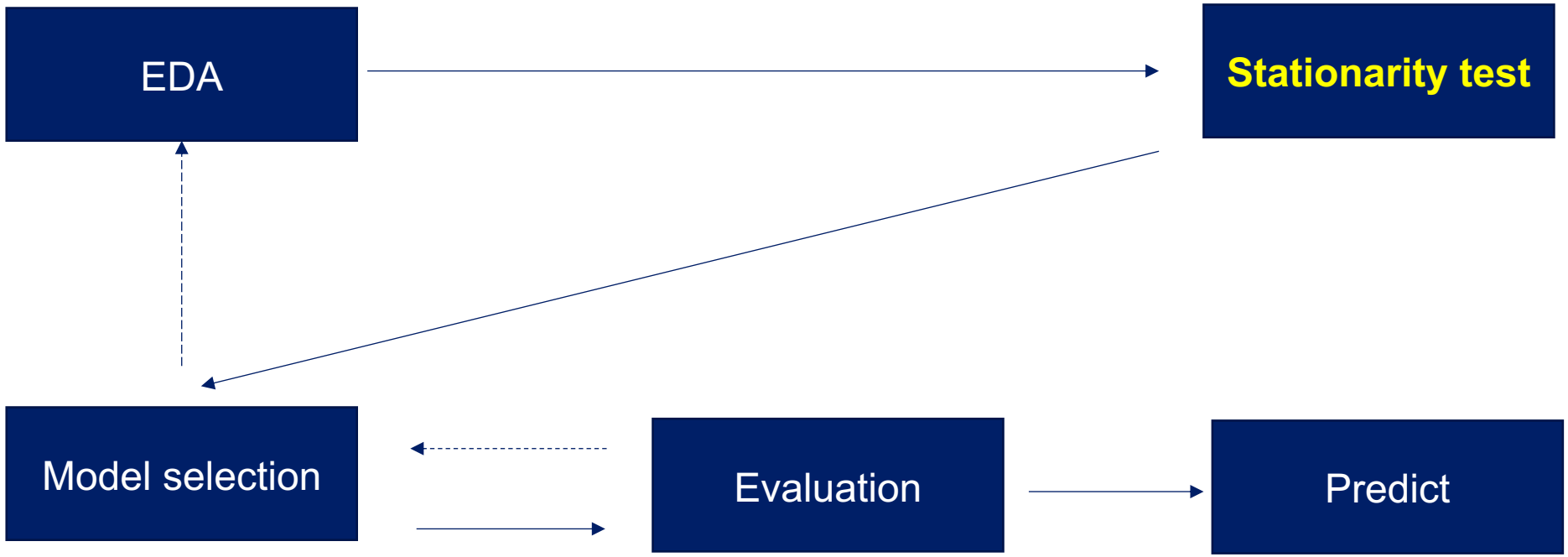


Model

❖ ARIMA $y_t = \mu + \sum_{i=1}^{p} \gamma_i y_{t-i} + \epsilon_t + \sum_{i=1}^{q} \theta_i \epsilon_{t-i}$



Workflow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Stationarity Test

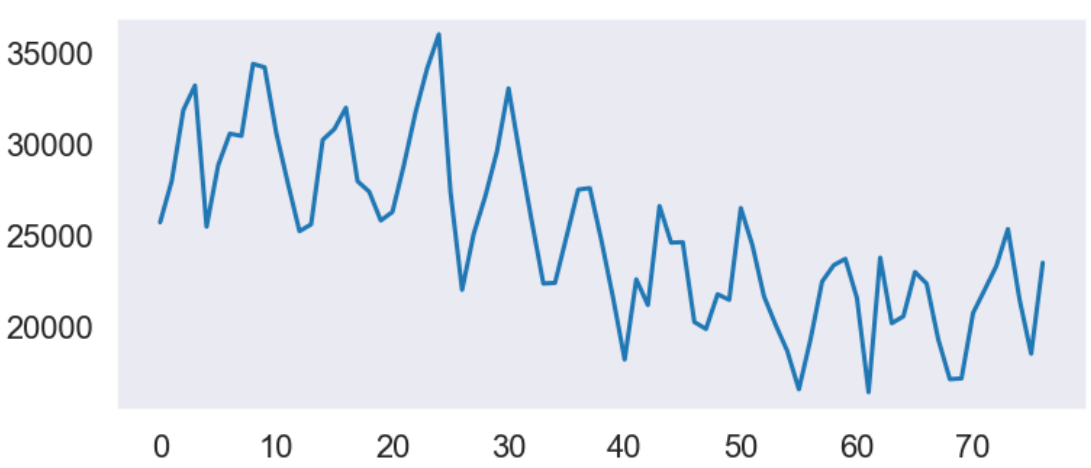
❖ ADF test result

- ✓ P Value < 0.05
- ✓ Test Statistic < Critical Value

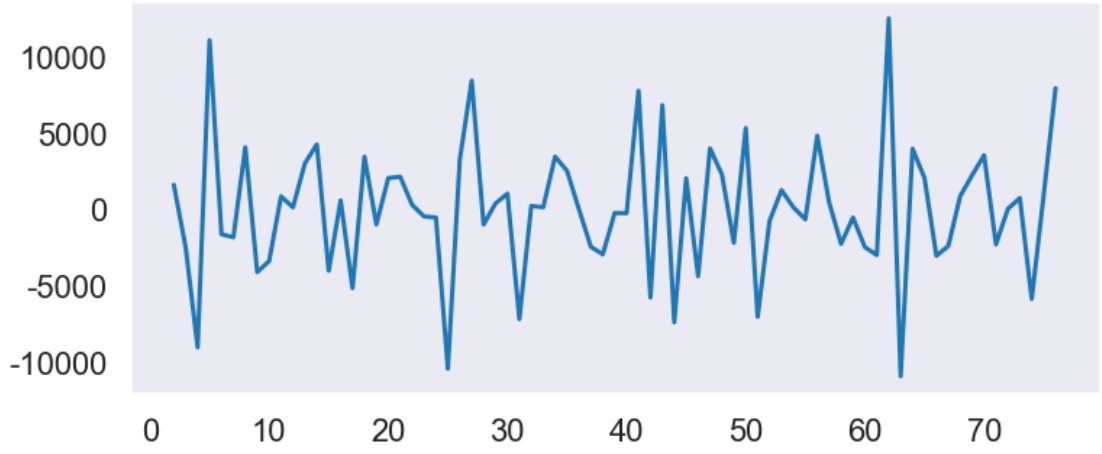
Stage	Test result
Raw data	Test Statistic -0.94 p-value 0.78 Critical Value (1%) -3.53 Critical Value (5%) -2.90 Critical Value (10%) -2.59
After smooth	Test Statistic -1.20 p-value 0.68 Critical Value (1%) -3.54 Critical Value (5%) -2.91 Critical Value (10%) -2.59
After difference 1	Test Statistic -9.86 p-value 0.00 Critical Value (1%) -3.53 Critical Value (5%) -2.90 Critical Value (10%) -2.59
After difference 2	Test Statistic -8.07 p-value 0.00 Critical Value (1%) -3.53 Critical Value (5%) -2.91 Critical Value (10%) -2.59

Stationarity

- Stable after difference 2



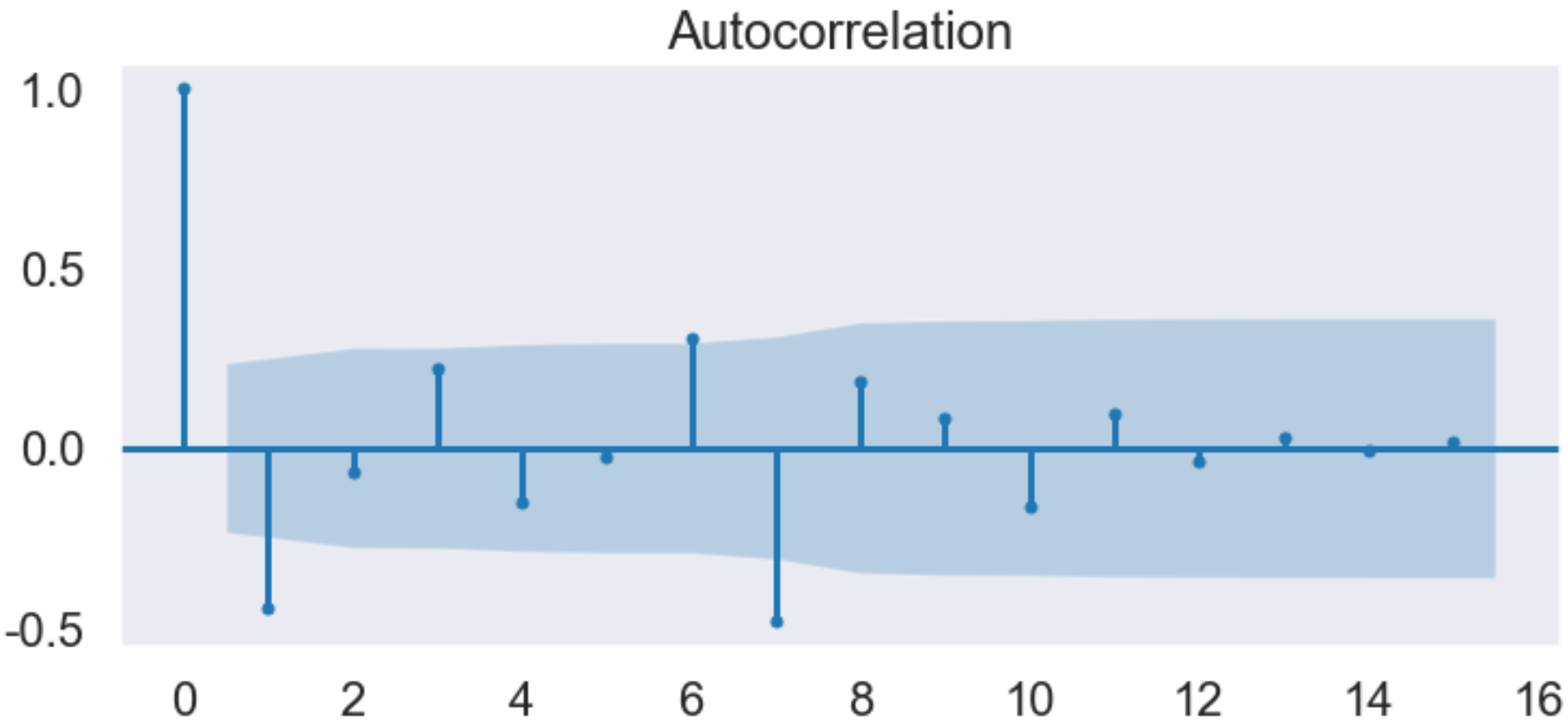
Raw data



After difference 2

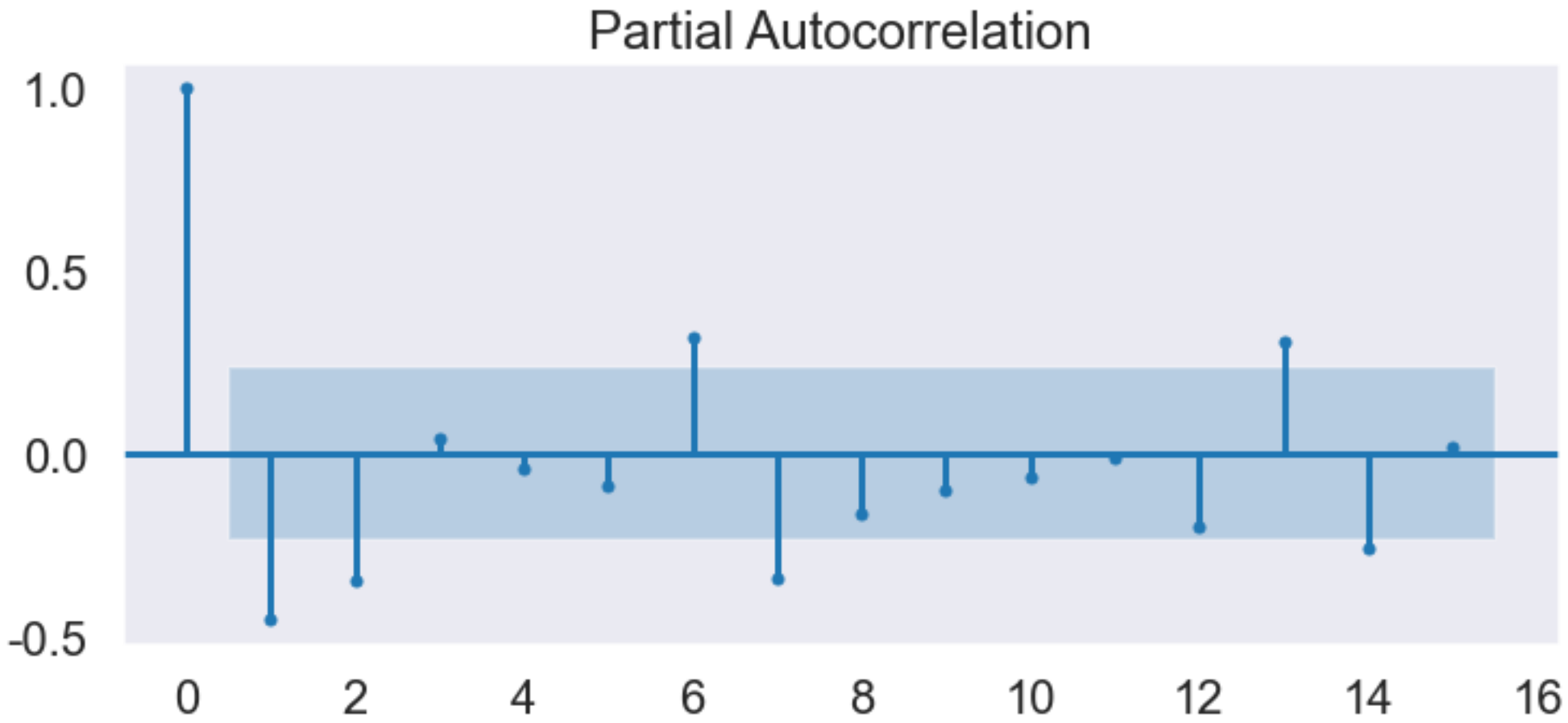
ACF

- Q = 2



PACF

- P = 3



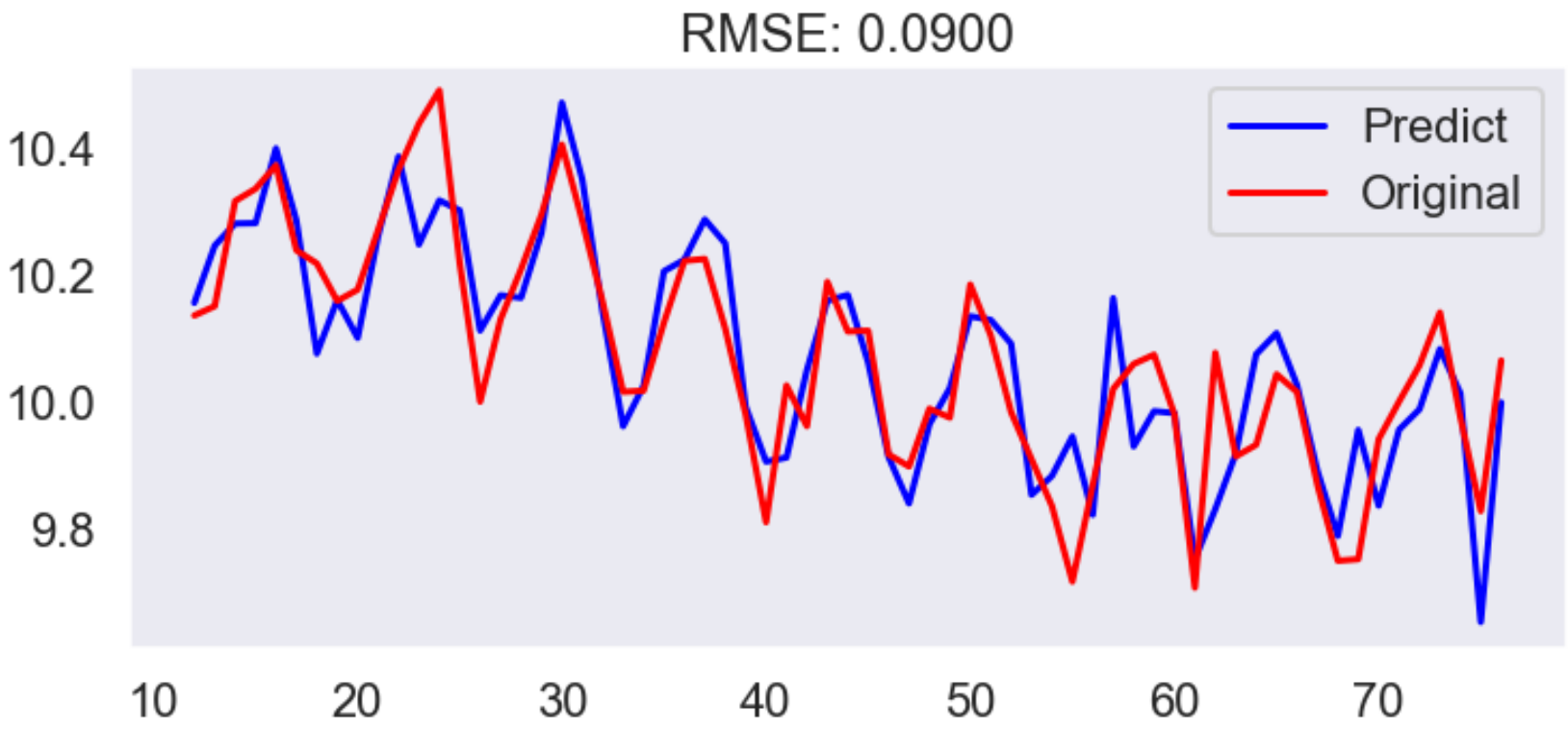
Model/P/Q

Model	AR(p)	MA(q)	ARMA(p,q)
ACF	Tails off	Truncated after N Lag	Tails off
PACF	Truncated after N Lag	Tails off	Tails off

- Recommended parameter pair (P=3,D=2,Q =2)
- Try parameter pair (p in [0:5],q in [0:5]

Verify

- $RMSE(X,h) = \sqrt{\frac{1}{m}\sum_{i=1}^{m}(h(x_i) - y_i)^2}$



Best performance (P=4,Q=4)

P=1,Q=0,Error=3044.832934
P=1,Q=1,Error=2945.576680
P=1,Q=2,Error=2966.281480
P=1,Q=3,Error=2896.684189
P=1,Q=4,Error=2860.274045
P=1,Q=5,Error=2788.130198
P=2,Q=0,Error=2855.045201
P=2,Q=1,Error=2839.954995
P=2,Q=2,Error=2741.163190
P=2,Q=3,Error=2638.373490
P=2,Q=5,Error=2861.528584
P=3,Q=0,Error=2710.645780
P=3,Q=1,Error=2704.595950
P=3,Q=2,Error=2611.901070
P=3,Q=3,Error=2428.514544
……

Forecast

❖Predict

Date	Real	Predicted	Error	E(%)
20200621	27287	21909	5378	19.7090
20200620	31958	21816	10142	31.7354
20200619	31055	22319	8736	28.1307
20200618	27512	23633	3879	14.0993
20200617	**23871**	**23407**	**464**	**1.9438**

Further

- Samples
  1. More verify samples
  2. Decompose
  3. Infected count explode
  4. ……..
- More features
  1. Medical information
  2. Population density
  3. Seasonality
  4. ……..
- More models
  1. RNN
  2. LSTM
  3. Model with CNN
  4. ……..

Demo

Full flow

Learn from demo

- ✓ More effort in EDA and FE
- ✓ Model has pre-condition and limitation
- ✓ Try several models or parameter pairs
- ✓ Evaluate and select suitable model

Thanks

2020-8-15

Backlog

❖ I (Difference)

Raw data： [1,3,5,9,11,15,16]

After difference： [2,2,4,2,4,1]

Mean & Average

Data: [1,1,2,2,2,2,3,4,5]

Mean: (2/9)*1 + (4/9)*2 + (2/9)*3+(1/9)*4+(1/9)*5

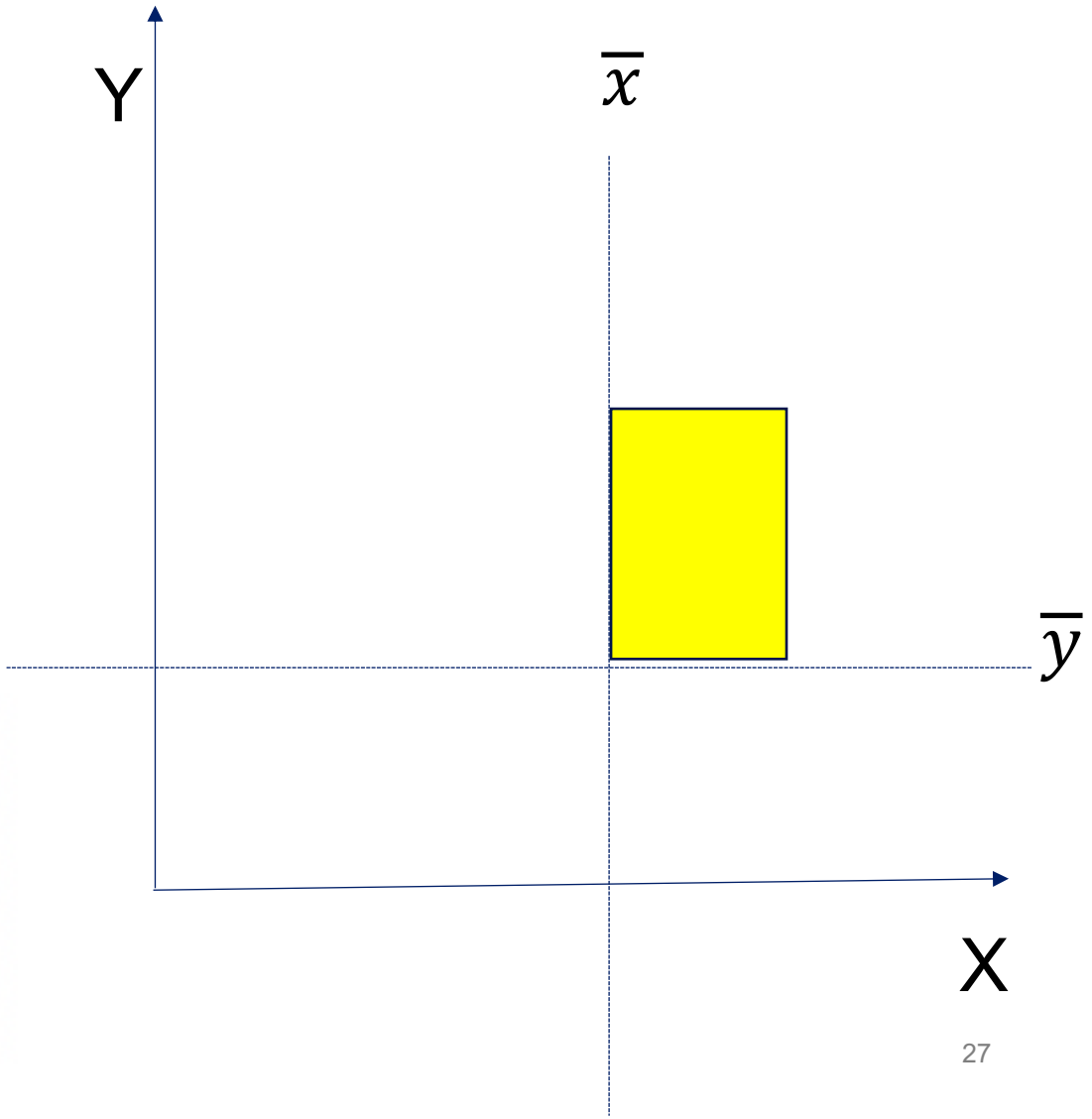
Average: (1+1+2+2+2+2+3+3+4+5)/9

❖ Variance & standard deviation & covariance

$$s^2 = \frac{\sum_{i=1}^{n} (x_i - x)^2}{n}$$

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \mu)^2}$$

$$cov(X,Y) = \frac{\sum_{i=1}^{n}(X_i - \bar{X})(Y_i - \bar{Y})}{n-1}$$



❖ 单位根

DF检验

假设Y是由一阶自回归过程生成

$$Y_t = \gamma Y_{t-1} + v_t \tag{35}$$

若 $|\gamma| < 1$，则Y是平稳的，若 $|\gamma| = 1$，则Y是非平稳的

检验问题： $H_0 : \gamma = 1, \quad H_A : \gamma < 1$

模型转换之后

$$\Delta Y_t = (\gamma - 1) Y_{t-1} + v_t = \beta Y_{t-1} + v_t \tag{36}$$

检验问题： $H_0 : \beta = 0, \quad H_A : \beta < 1$

❖ 单位根&白噪音检验

单位根检验

方法：statsmodels.tsa.stattools import adfuller

判断：

1. 结果同时小于1%、5%、10%对应的值，表示平稳
2. P-value (不变显著性) 接近0 ，表示平稳

白噪音检验

方法: statsmodels.stats.diagnostic import acorr_ljungbox

判断：

1. P-value < 0.05 表示不是白噪音