INTRODUCTION TO TIME SERIES ANALYSIS IN PYTHON

Describe Model

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Mathematical Decription of MA(1) Model

$$R_t \; = \; \mu \; + \; \epsilon_t 1 \; + \; \theta \, \epsilon_{t-1}$$

- Since only one lagged error on right hand side, this is called:
  - MA model of order 1, or
  - MA(1) model
- MA parameter is θ
- Stationary for all values of θ

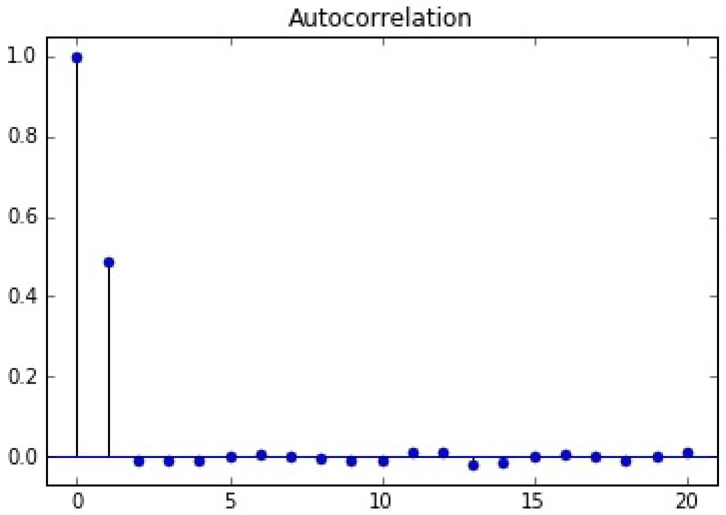
Interpretation of MA(1) Parameter

$$R_t \;=\; \mu \;+\; \epsilon_t \;+\; \theta\,\epsilon_{t-1}$$

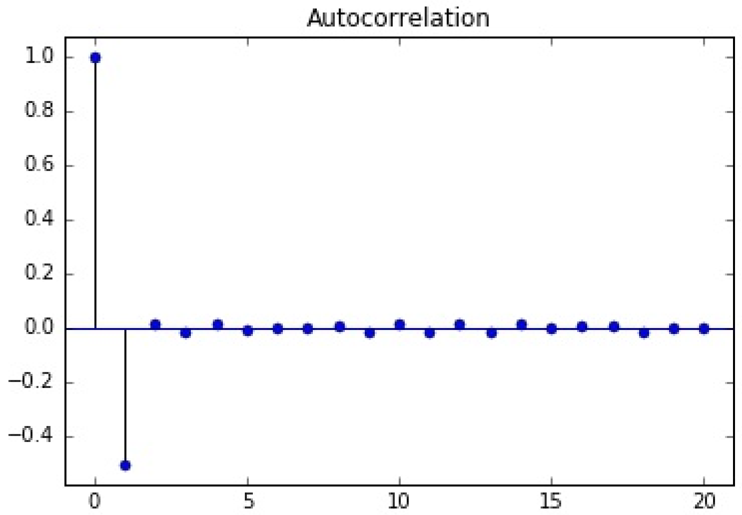
- Negative θ: One-Period Mean Reversion
- Positive θ: One-Period Momentum
- Note: One-period autocorrelation is $\theta/(1+\theta^2)$, not θ

Comparison of MA(1) Autocorrelation Functions

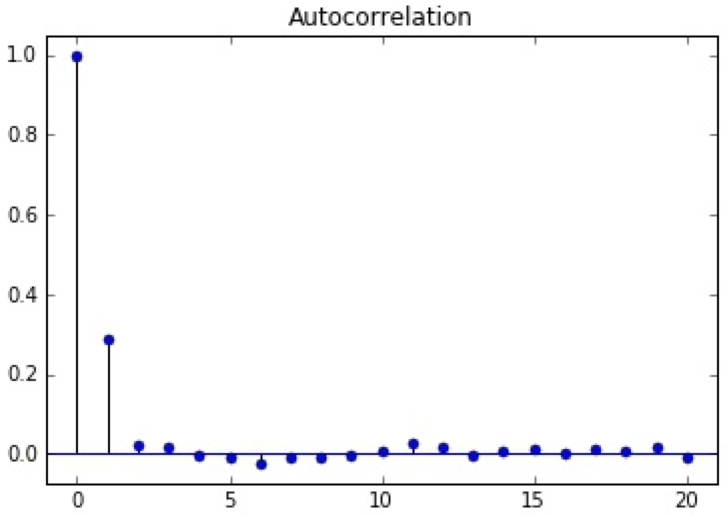
- $\theta = 0.9$



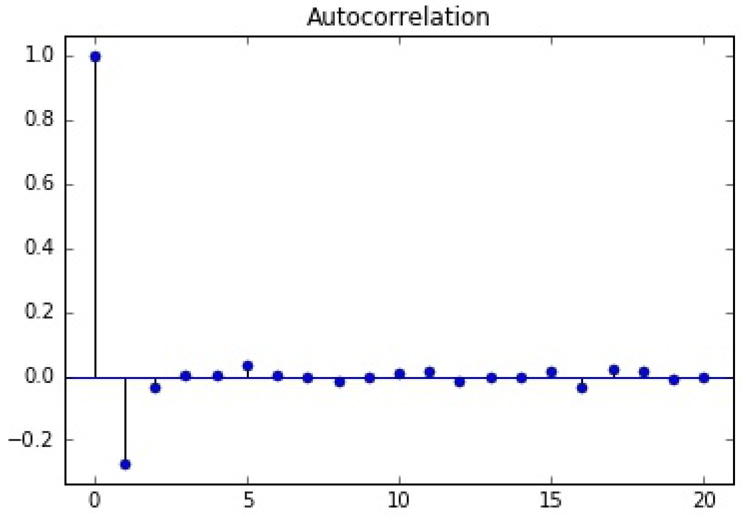
- $\phi = -0.9$



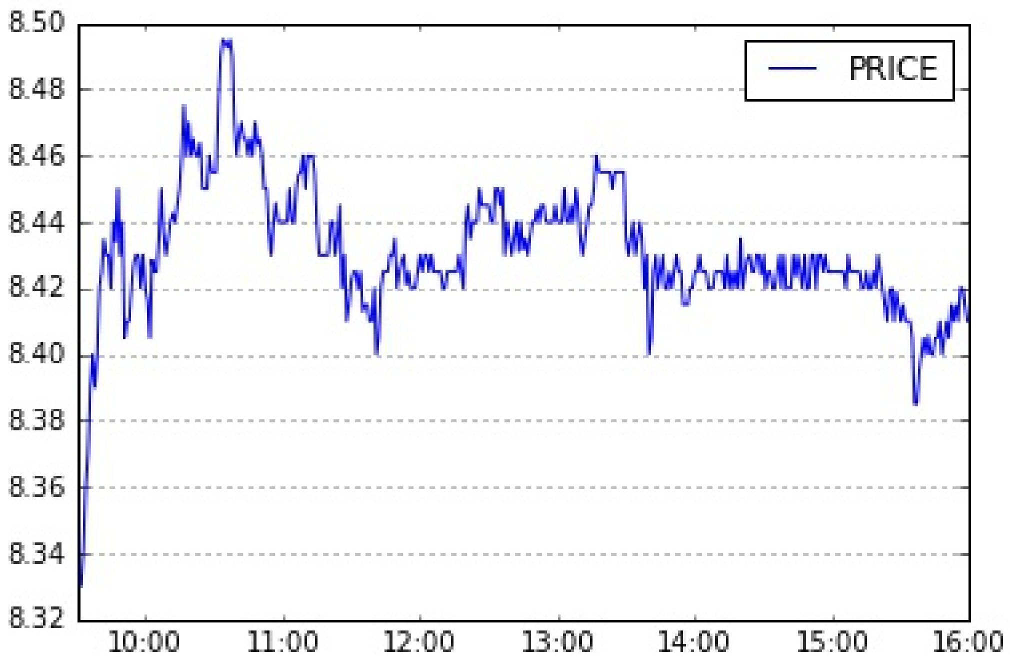
- $\phi = 0.5$



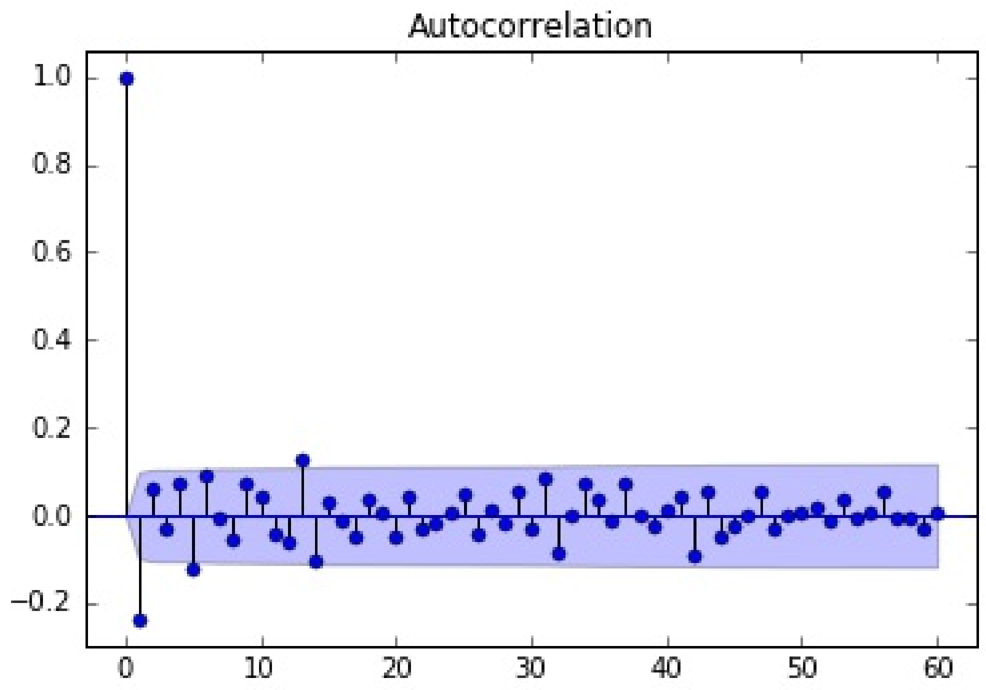
- $\phi = -0.5$



Example of MA(1) Process: Intraday Stock Returns



Autocorrelation Function of Intraday Stock Returns



Higher Order MA Models

- MA(1)

$$R_t = \mu + \epsilon_t - \theta_1 \, \epsilon_{t-1}$$

- MA(2)

$$R_t = \mu + \epsilon_t - \theta_1 \, \epsilon_{t-1} - \theta_2 \, \epsilon_{t-2}$$

- MA(3)

$$R_t = \mu + \epsilon_t - \theta_1 \, \epsilon_{t-1} - \theta_2 \, \epsilon_{t-2} - \theta_3 \, \epsilon_{t-3}$$

- ...

Simulating an MA Process

```
from statsmodels.tsa.arima_process import ArmaProcess
ar = np.array([1])
ma = np.array([1, 0.5])
AR_object = ArmaProcess(ar, ma)
simulated_data = AR_object.generate_sample(nsample=1000)
plt.plot(simulated_data)
```

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Let's practice!

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Estimation and Forecasting an MA Model

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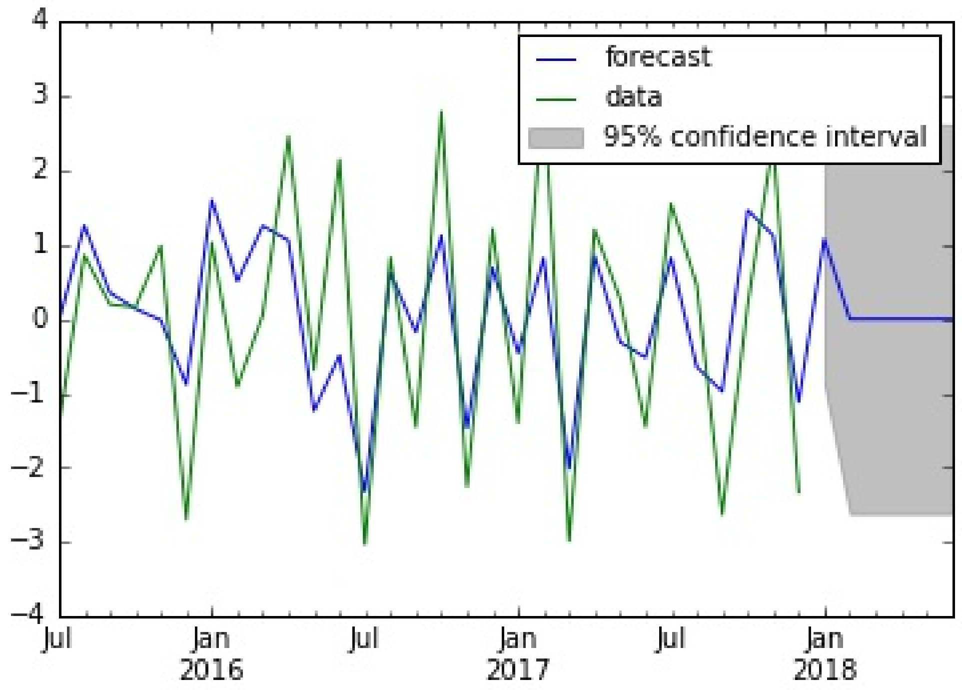
Estimating an MA Model

- Same as estimating an AR model (except order=(0,1))

```
from statsmodels.tsa.arima_model import ARMA
mod = ARMA(simulated_data, order=(0,1))
result = mod.fit()
```

Forecasting an MA Model

```
from statsmodels.tsa.arima_model import ARMA
mod = ARMA(simulated_data, order=(0,1))
res = mod.fit()
res.plot_predict(start='2016-07-01', end='2017-06-01')
plt.show()
```



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ARMA models

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ARMA Model

- ARMA(1,1) model:

$$R_t = \mu + \phi R_{t-1} + \epsilon_t + \theta \epsilon_{t-1}$$

Converting Between ARMA, AR, and MA Models

- Converting AR(1) into an MA(infinity)

$$R_t = \mu \ + \ \phi R_{t-1} + \epsilon_t$$

$$R_t = \mu \ + \ \phi(\mu + R_{t-2} + \epsilon_{t-1}) + \epsilon_t$$

$$R_t = \mu \ + \ \phi(\mu + \phi(\mu + R_{t-3} + \epsilon_{t-2}) + \epsilon_{t-1}) + \epsilon_t$$

$$\vdots$$

$$R_t = \mu \ + \ \epsilon_t \ + \ \phi \, \epsilon_{t-1} \ + \ \phi^2 \, \epsilon_{t-2} \ + \ \phi^3 \, \epsilon_{t-3} \ + \ \phi^4 \, \epsilon_{t-4} \ + \ \cdots$$

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