# INTRODUCTION TO TIMESERIES MODELS

AGENDA

‣ What are time series

‣ EDA for time series

‣ Time series models

‣ Assumptions for time series models

‣ Model evaluation and forecasting

WHAT ARE TIME SERIES?

‣ A sequence of observations in chronological order

‣ We will mostly focus on

- univariate time series (only one variable)
- of continuous variables
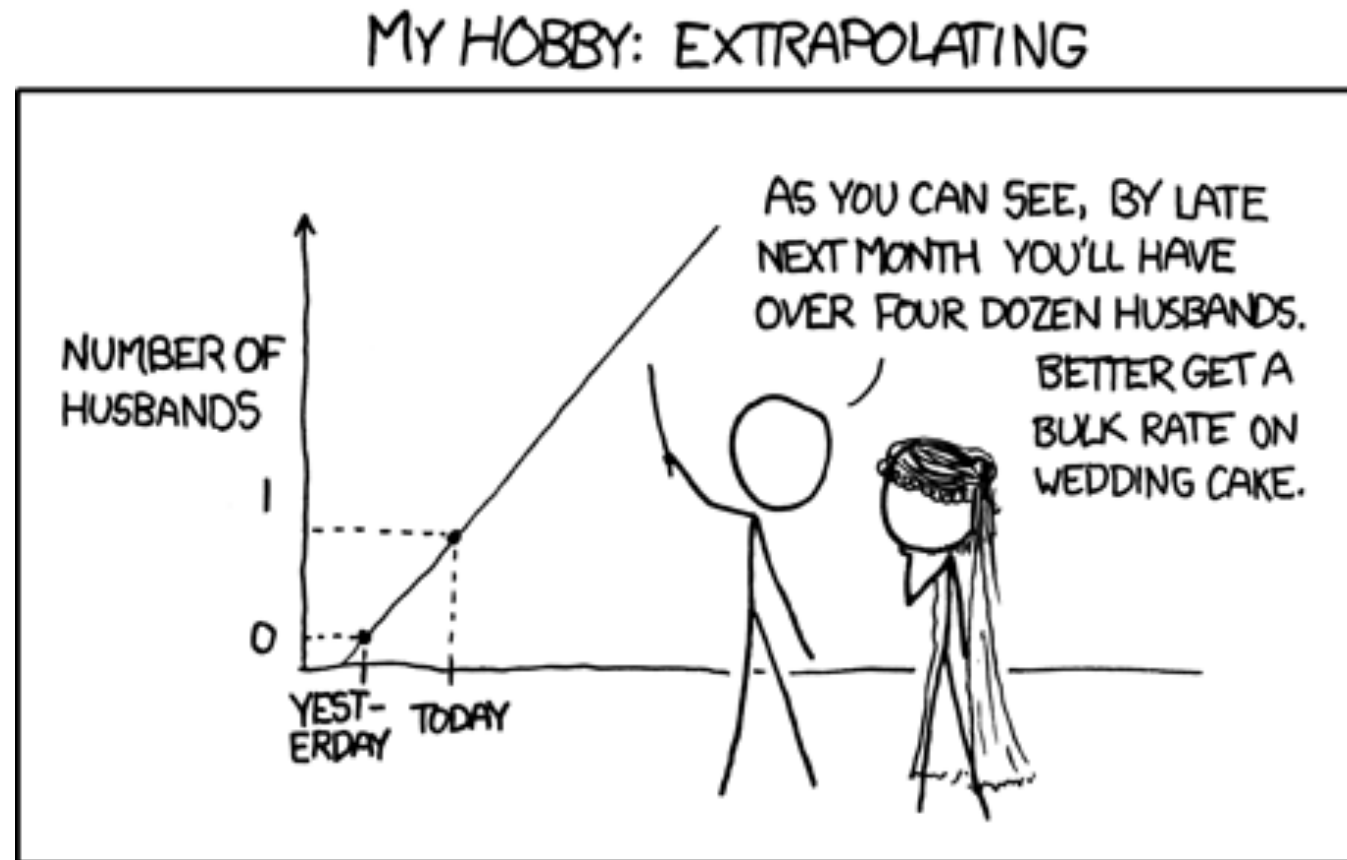- over regular time intervals

VISUALISE THE DATA/EDA

‣ Is there a clear trend in the data?

‣ Are there regular periods/seasonality we observe?

‣ Does time seem explanatory?
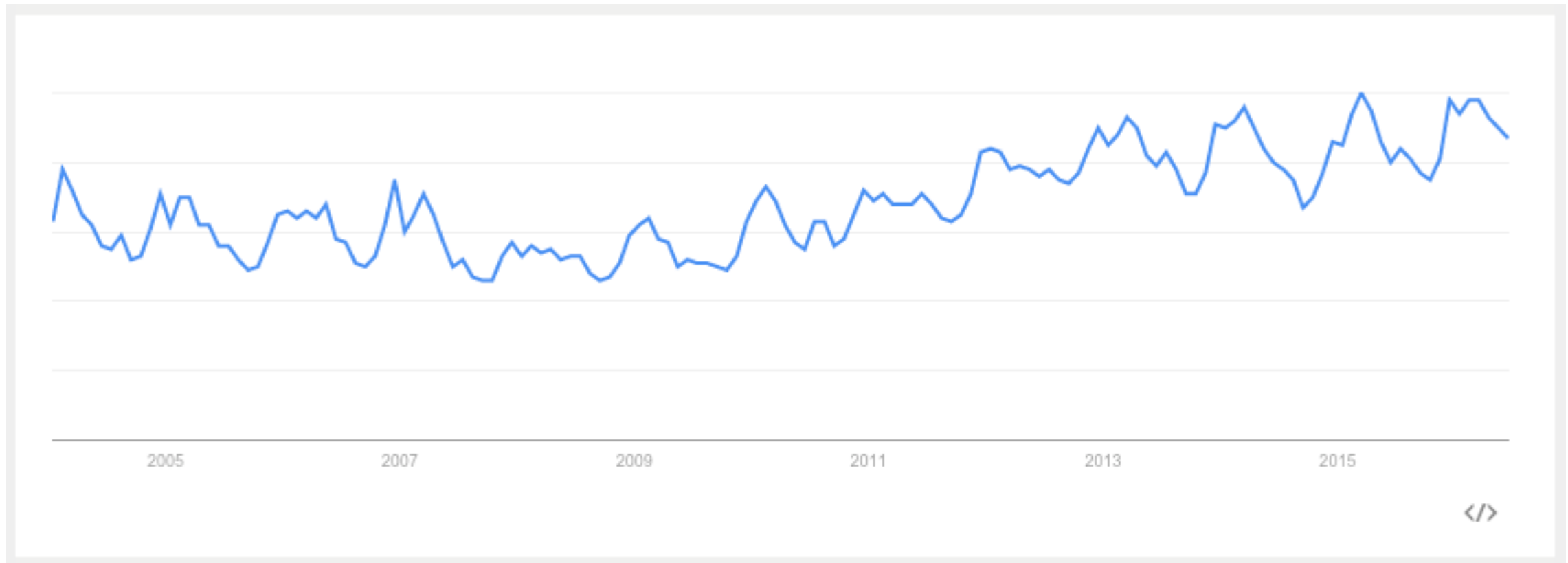
VISUALISE THE DATA/EDA

‣ Is there a clear trend in the data?

‣ Are there regular periods/seasonality we observe?

‣ Does time seem explanatory?

HOW ARE WE GOING TO USE THE DATA?

- Look at the individual data points recorded at different moments of time
- Consider how quantities change over time
- Aggregate the data (for example instead of looking at hourly data we consider the daily or monthly aggregates)
- Transform the data before building the model, e.g. taking the logarithm
- Model the differences between subsequent observations
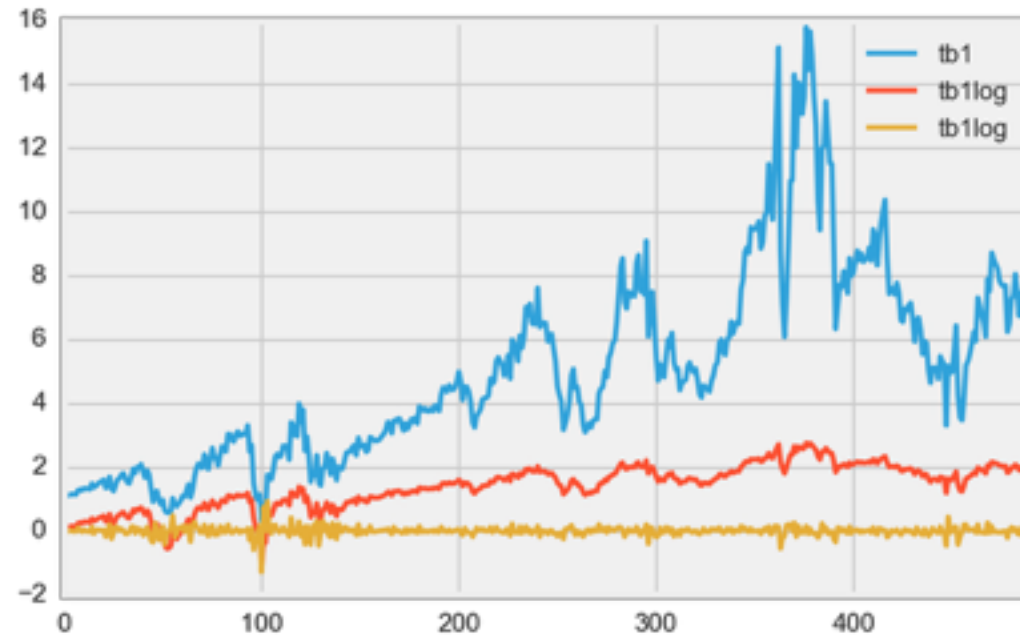
AGGREGATED TIME SERIES
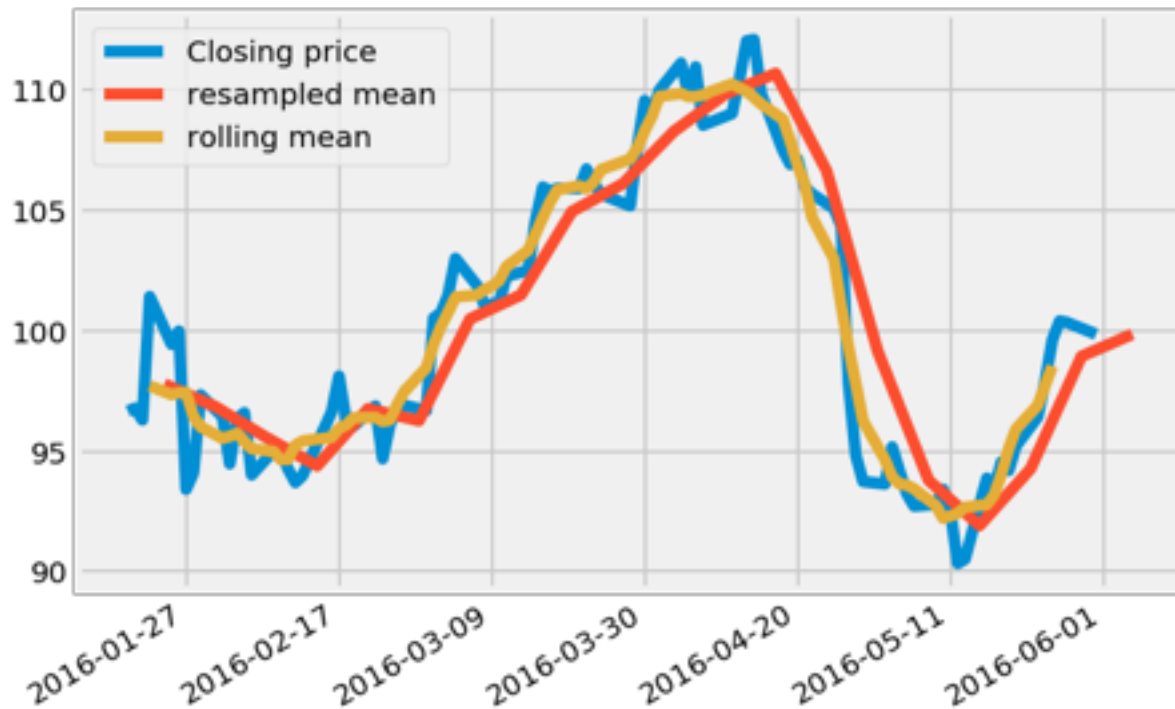
Values, weekly resampled mean values and weekly rolling mean values of Apple stock daily closing prices

TRANSFORMING AND DIFFERENCING

Below, American T-bills data are displayed
(one-month T-bill rate in percent annual rate from R's Ecdat package (Mishkin))
- Blue: returns
- Red: log returns
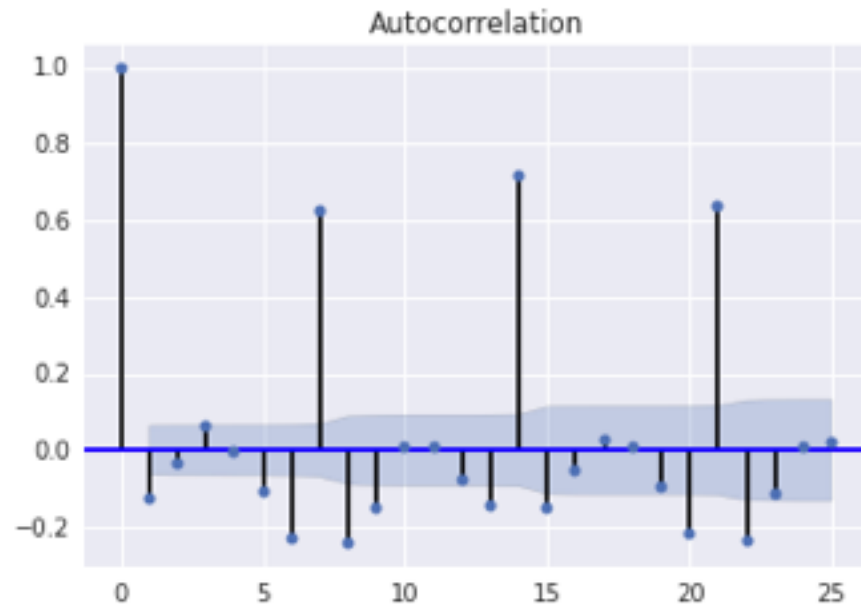- Yellow: differenced log returns

AUTOCORRELATION

- In regression models, we look at correlations between outcome and predictor variables
- For time series, we will look at correlations between observations at different points in time
- Doing so will inform us about which time series model to use

AUTOCORRELATION

$$\mathrm{acf}(k) = \frac{\sum_{t=k+1}^{n} \left(x_t - \bar{x} \right) \left(x_{t-k} - \bar{x} \right)}{\sum_{t=1}^{n} \left(x_t - \bar{x} \right)^2}$$

ACF for the sales data of the German drug store chain Rossmann

MODELLING TIME SERIES

‣ We can develop a number of simple models

‣ These models are similar to regression models

‣ We will model a point in the time series as a function of previous points

‣ The particular way we do this will give us some model coefficients

$$Y_t = f(Y_{t-1}, Y_{t-2}, \ldots, Y_{t-n}) + \epsilon_t$$

TIME SERIES MODEL SELECTION

‣ What kind of model we should choose can be guided by looking at the autocorrelations

‣ We can evaluate our fit using MSE and R2

‣ We have to balance between making an accurate fit and model complexity

‣ Evaluation metrics used are Akaike and Bayesian Information Criterion (AIC/BIC)

‣ Once having fitted a model we can predict future data points

TIME SERIES MODELS

‣ Autoregressive models (AR)

‣ Moving average models (MA)

‣ Autoregressive integrated moving average models (ARIMA)

‣ Seasonal ARIMA models (SARIMA)

‣ Generalised Autoregressive models with conditional heteroscedasticity (GARCH)

OVERVIEW: TIME SERIES FORECASTING STEP-BY-STEP

1. Visualise the time series

2. Make the time series stationary

3. Plot ACF/PACF to seek optimal parameters

4. Build the ARIMA model

5. Predict the future

OVERVIEW: TIME SERIES FORECASTING STEP-BY-STEP

1. Visualise the time series

2. Make the time series stationary
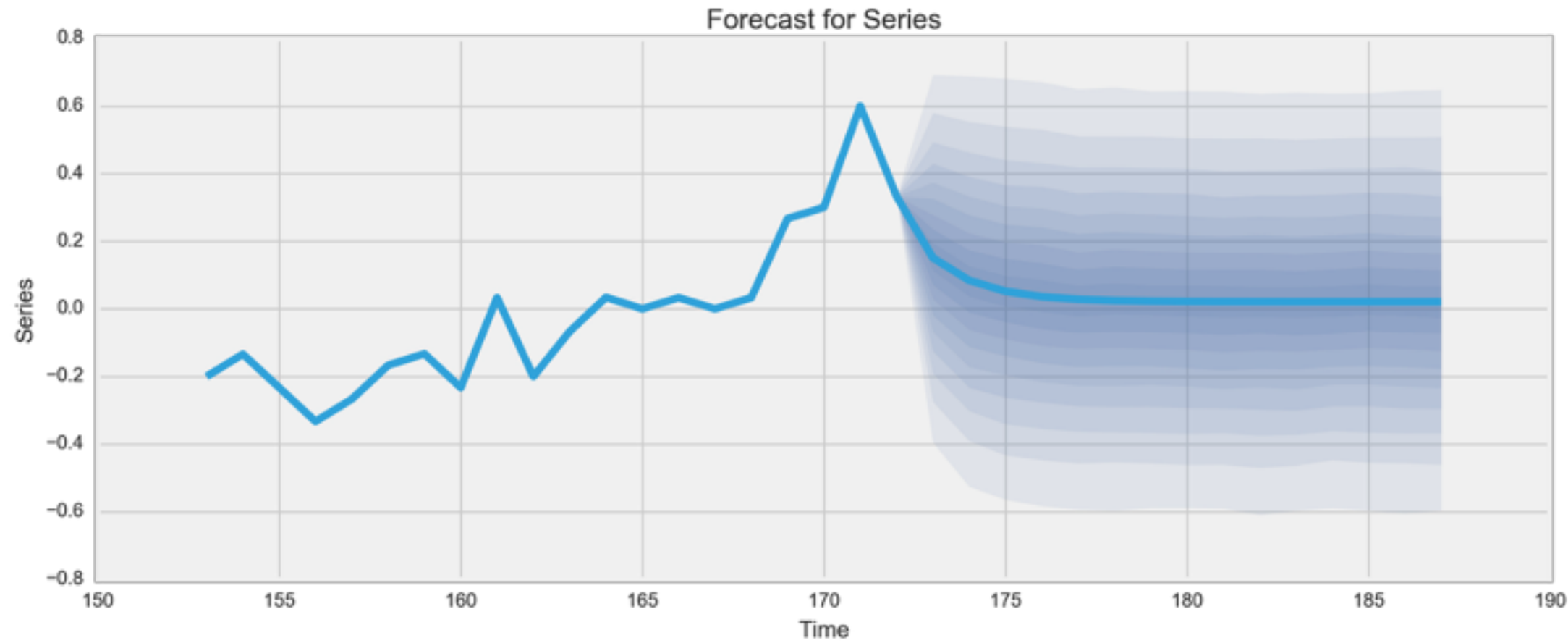
3. Plot ACF/PACF to seek optimal parameters

4. Build the ARIMA model

5. Predict the future

6. Profit*

*Lecture sold separately

FORECASTING WITH OUR MODEL

Forecast for Series

CODE EXAMPLES

‣ To the repo…