Masters Project: Forecasting Application

Wednesday - April 17, 2019

Agenda:

- Overview of Project
- Time Series Model Selection
- Programming Application
- Performance
- Demo
- Possible Improvements
- Questions

Overview of Project

Project

Create a web application that allows the user to forecast stock prices

Application includes:

- Traditional stock graphs (time series line and candlestick)
- Usable for any stock on the NYSE
- Automated daily and intraday (5 min., 15 min., 30 min., 60 min) forecasting
- Graph of forecasts with error bars

Motivation of Project

Statistics being integrated with technology and programming

Desire to automate and streamline processes for users

Academic background for project:

- Time series and statistical modeling courses
- Web application courses
- Visualization courses
- Information system courses

Time Series Model Selection: ARMA+GARCH

Time Series Modeling

Choose a time series model:

- When a time element is part of the data
- When consecutive points are correlated
- Sufficient amount of history is available (4-5 complete cycles)

Typically models the conditional mean

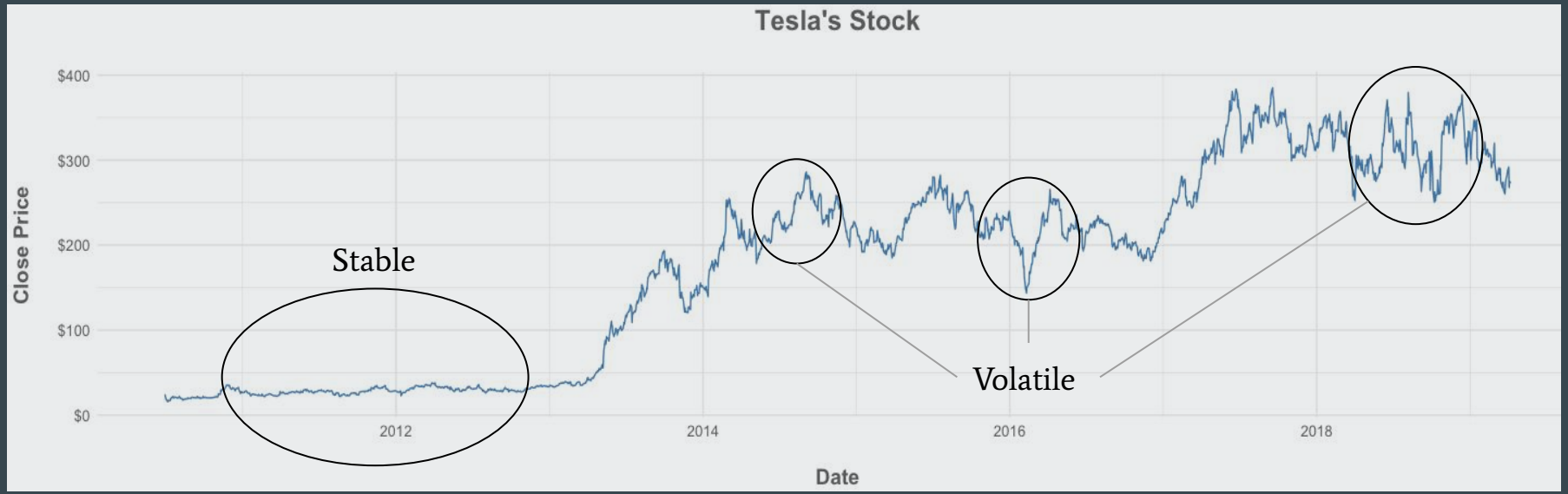
- What will the future look like given the previous actual values
- “ARMA” part of the ARMA+GARCH model

Does well identifying trends, seasonality, and cycles

GARCH Forecasting

Useful when the variance of an entity is changing

Motivated by financial data due to volatility



GARCH Forecasting

Measures the conditional variance of a forecast given the previous variances

Concerned with **volatility clustering**

- If a stock is volatile today, then it is likely to be volatile tomorrow (eventually it will become stable)
- If a stock is stable today, then it is likely to be stable tomorrow (eventually it will become volatile)

Measures the uncertainty of inflation and risk of a stock

ARMA + GARCH Forecasting

ARMA Forecasting:

- Models the conditional mean of a stock
- i.e. Forecasted return given the previous historical data

GARCH Forecasting:

- Models the conditional variance of a stock
- i.e. Volatility of forecasted return given the previous volatility

ARMA + GARCH Forecasting is done on the log returns:

- $Ret = log\left(\frac{Close_t}{Close_{t-1}}\right)$

Return to Close Price

$$Ret_t = log\left(\frac{Close_t}{Close_{t-1}}\right)$$

Ret_t is our last known return

Our first forecast will give $\hat{Ret}_{t+1}$

$$\hat{Ret}_{t+1} = log\left(\frac{\hat{Close}_{t+1}}{Close_t}\right)$$

$$e^{\hat{Ret}_{t+1}} = \frac{\hat{Close}_{t+1}}{Close_t}$$

$$\hat{Close}_{t+1} = Close_t * e^{\hat{Ret}_{t+1}}$$

Automation of ARMA+GARCH Model

Grid search of ARMA parameters and fixed GARCH parameters

ARMA parameters:

- AR parameter search space: (0, 1, 2, 3, 4, 5)
- MA parameter search space: (0, 1, 2, 3, 4, 5)

GARCH parameters:

- Fixed parameters of 1
- i.e. GARCH(1, 1)

Automation of ARMA+GARCH Model

Total number of parameters evaluated:

- AR parameters = 6
- MA parameters = 6
- GARCH parameters = 1

Total number of fitted models: 36

Each model is compared to each other using the AIC (relative quality) metric

Best model is chosen by the model with the lowest AIC value

Programming Application

Issues

Forecasting Part:

- Sometimes the grid search does not come up with a significant model
- The predictions would sometimes fail (fixed using Dr. Swift's prediction function)

Application Design Part:

- Getting the action buttons to work together
- Designing the modal popups within the application

Successes

Forecasting Part:

- Grid search of ARMA+GARCH parameters typically finds a significant model
- Converting the forecasted returns and errors into close prices

Application Design Part:

- Designing the graphs and generalizing them
- Making the automated forecast easy to interpret

Performance

Performance Methodology (Generalized)

Generalized Methodology

- Train an automated ARMA+GARCH model on a date range
- Forecast the returns of the next 5 trading days
- Convert the returns into prices
- Compare forecasted prices with actuals
- Compare forecasted price change direction with actual change direction
- Shift the training window and forecast window up one trading day

Performance Methodology (Actual)

First Iteration

- Trained a model from January 1, 2010 to January 1, 2019
- Forecasted the returns for Jan. 2, Jan. 3, Jan. 4, Jan. 7, and Jan. 8
- Converted the returns into prices and compared with actuals

Second Iteration

- Trained a model from January 1, 2010 to January 2, 2019
- Forecasted the returns for Jan. 3, Jan. 4, Jan. 7, Jan. 8, and Jan. 9
- Converted the returns into prices and compared with actuals

And so on...

Performance Methodology

Several stocks were evaluated:

- Apple Inc. (AAPL)
- Amazon.com Inc. (AMZN)
- General Electric Co. (GE)
- Tesla Inc. (TSLA)
- Walt Disney Co. (DIS)
- Micron Technology Inc. (MU)
- Hemp Inc. (HEMP)
- S&P 500 ETF (SPY)
- Dow Industrial Average (DIA)
- Walmart Inc. (WMT)
- Coca-Cola Co. (KO)
- Home Depot Inc. (HD)
- McDonald's Corp. (MCD)
- TDAmeritrade Corp. (AMTD)

Using 7 out of 8 CPUs, it took 8 hours to run the history on these 14 stocks

Performance Metrics

Percent Accuracy on Change Direction

- Concerned with forecasted and actual stock directional change (inc. or dec.)
- Determine if the forecast was an increase or decrease from last known value
- Determine if the actual was an increase or decrease from last known value
- Compare forecasted increase and decrease to actual
- Calculate the accuracy (number of correct forecast / to number of forecasts)

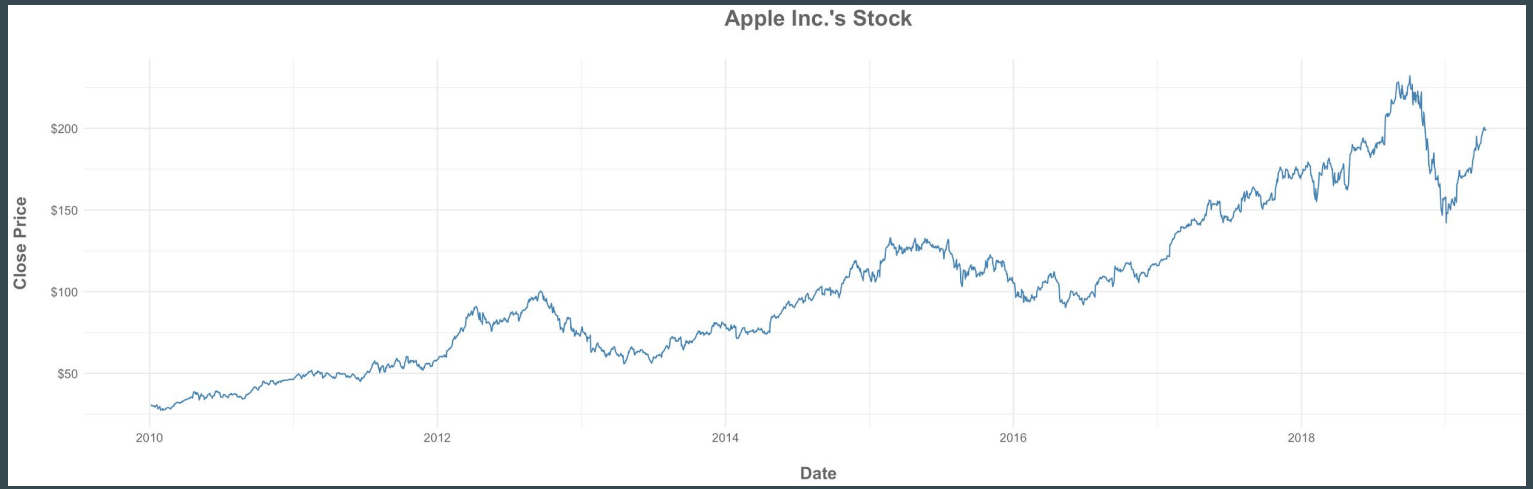
Mean Absolute Percent Error (MAPE)

- Concerned with comparing forecasted and actual values
- $MAPE = \frac{1}{n} \sum \frac{|P_{Forecast} - P_{Actual}|}{P_{Actual}}$

Apple Inc. (AAPL)

- Best forecasts from the list of stocks evaluated

Stock	Total Forecasts	Correct Direction	Percent Accuracy	MAPE
AAPL	280	195	69.6%	2.1%



General Electric Co. (GE)

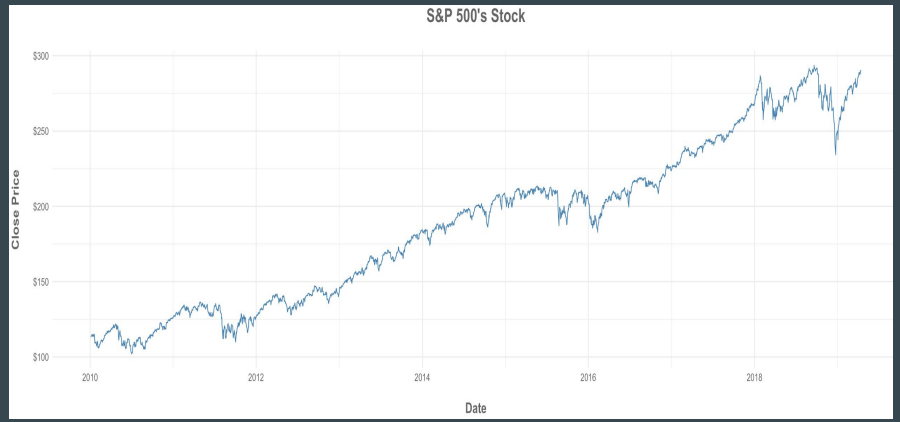
- Worst forecasts from the list of stocks evaluated

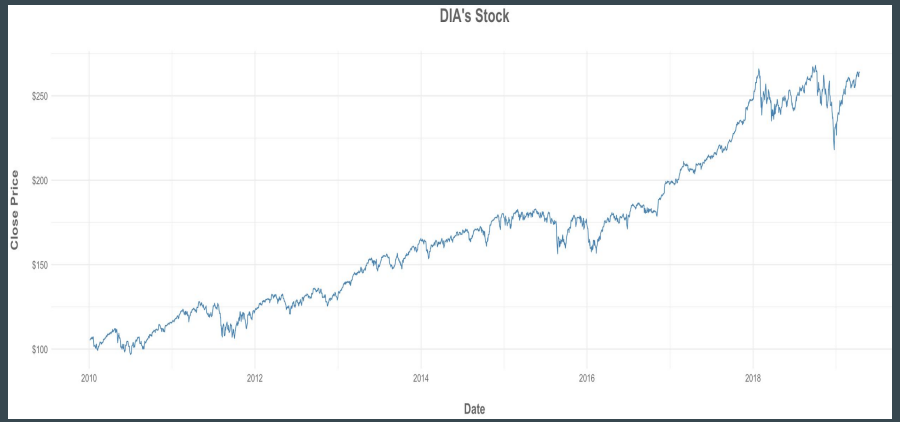
Stock	Total Forecasts	Correct Direction	Percent Accuracy	MAPE
GE	280	131	46.8%	4.0%

S&P 500 (SPY) and Dow Jones Index (DIA)

- Both the S&P 500 and the Dow Jones Index performed slightly better than the average

Stock	Total Forecasts	Correct Direction	Percent Accuracy	MAPE
SPY	280	181	64.6%	0.9%
DIA	280	178	63.6%	0.9%





Overall Performance

Stock	Total Forecasts	Correct Direction	Percent Accuracy	MAPE
AAPL	280	195	69.6%	2.1%
HEMP	280	193	68.9%	3.1%
SPY	280	181	64.6%	0.9%
DIA	280	178	63.6%	0.9%
AMZN	280	168	60.0%	2.2%
MU	280	166	59.3%	3.7%
T	280	165	58.9%	1.4%
MCD	280	164	58.6%	1.3%
AMTD	280	161	57.5%	2.3%
HD	280	160	57.1%	1.5%
FB	280	154	55.0%	1.8%
KO	280	148	52.9%	1.6%
TSLA	280	146	52.1%	4.1%
GE	280	131	46.8%	4.0%
Overall	**3,920**	**2,310**	**58.9%**	**2.2%**

Demo of Application

Improvements

Possible Improvements

- Increasing the search space of model
- Multithreading the automated modeling (increase performance)
- Incorporate stock market holidays and half days
- Adding social media sentiment analysis
- Adding graphs to compare two different stocks (see correlations between stock prices)

Questions