WALL STREET

BUY LOW ST AV SELL HIGH

Data Driven

Trend Following

Introduction and Objective

Introduction and objectives

- Who am I
 - ✓ Freelance writer
- Organization / Department
 - ✓ Financial Blog / Education
- Target Audience
 - Anyone looking to invest their money without having to look at the financial markets 24/7.

- Business case
 - ✓ Find a simplistic trend following model.
- How will your prediction work help
 - ✓ Systematic buy/sell signal, no emotions involved.
 - Better returns for your money than your saving account.

Objectives

Optimize the 50/200 crossover strategy

S&P500 (^GSPC) - SMA Crossover



Objectives

2012-03-15 00:00:00 1402.6 1337.78 1336.59 1 Buy 2012-06-14 00:00:00 1329.1 1349.57 1350.31 0 Sell 2012-08-14 00:00:00 1403.93 1354.76 1353.56 1 Buy 2015-08-28 00:00:00 1988.87 2074.53 2075.41 0 Sell 2015-12-21 00:00:00 2021.15 2061.51 2061.41 1 Buy 2016-01-11 00:00:00 1923.67 2055.59 2057.64 0 Sell 2018-12-07 00:00:00 2087.79 2017.85 2014.85 1 Buy 2018-04-01 00:00:00 2633.08 2758.02 2761.71 0 Sell 2019-04-01 00:00:00 2867.19 2760.23 2756.75 1 Buy	Date	e Price 50_SMA 200_S	MA Signal Position
	2012-03-15 00:00:00 2012-06-14 00:00:00 2012-08-14 00:00:00 2015-08-28 00:00:00 2015-12-21 00:00:00 2016-01-11 00:00:00 2018-12-07 00:00:00 2019-04-01 00:00:00	1402.6 1337.78 1336. 1329.1 1349.57 1350. 1403.93 1354.76 1353. 1988.87 2074.53 2075. 2021.15 2061.51 2061. 1923.67 2055.59 2057. 2087.79 2017.85 2014. 2633.08 2758.02 2761. 2867.19 2760.23 2756. 2626 65 3018 65 3028	59 1 Buy 1 31 0 Sell 1 56 1 Buy 1 56 1 Buy 1 41 0 Sell 1 41 1 Buy 1 64 0 Sell 1 85 1 Buy 1 71 0 Sell 1 75 1 Buy 1
2020-07-09 00:00:00 3152.05 3028.79 3026.08 1 Buy	2020-07-09 00:00:00	3152.05 3028.79 3026.	08 1 Buy

Objectives

+					
Date	Close Price	50_SMA	200_SMA	Signal	Position
2012-03-15 00:00:00 2012-06-14 00:00:00 2012-08-14 00:00:00 2015-08-28 00:00:00 2015-12-21 00:00:00	1402.6 1329.1 1403.93 1988.87 2021.15	1337.78 1349.57 1354.76 2074.53 2061.51	1336.59 1350.31 1353.56 2075.41 2061.41	1 0 1 0 1	Buy Sell Buy Sell Buy
2016-01-11 00:00:00	1923.67	2055.59	2057.64	0	Sell
2018-12-07 00:00:00	2633.08	2758.02	2761.71	0	Sell
2019-04-01 00:00:00 2020-03-30 00:00:00	2867.19 2626.65	2760.23 3018.65	2756.75 3028.23	1 0	Buy Sell
2020-07-09 00:00:00	3152.05	3028.79	3026.08	1	Buy

Profit = \$1734.25

Methodology / Process workflow

- ✓ Read in data from Yahoo Finance for the S&P500 using an API. (Application Programming Interface)
- ✓ Create a column with the moving average spread differential.
- ✓ Set desired number of points as threshold for spread difference.
- ✓ Create columns containing daily market (and daily strategy) log returns.
- \checkmark Set strategy equity to 1 (i.e. 100%) and generate equity curve.
- Create loop to test multiple Moving Average Crossover combinations within a given range.
- \checkmark Show the results.

Finding the best Moving Average Crossover combination



Finding the best Moving Average Crossover combination

Finding the best Moving Average Crossover combination

Simple Moving Average Crossover Strategy

Crossover Strategy in numbers

Date 	Close Price	38_SMA	245_SMA	Signal	Position
2012-02-28 00:00:00	1372.18	1326.8	1325.53	1	Buy
2012-06-05 00:00:00	1285.5	1351.04	1352.36	0	Sell
2012-08-03 00:00:00	1390.99	1351.93	1351.28	1	Buy
2015-09-04 00:00:00	1921.22	2051.47	2054.85	0	Sell
2015-11-30 00:00:00	2080.41	2060.95	2060.94	1	Buy
2016-01-04 00:00:00	2012.66	2060.51	2061.78	0	Sell
2016-04-19 00:00:00	2100.8	2031.58	2030.64	1	Buy
2018-11-26 00:00:00	2673.45	2749.52	2754.99	0	Sell
2019-03-14 00:00:00	2808.48	2739.6	2737.16	1	Buy
2020-03-25 00:00:00	2475.56	2985.9	3003.18	0	Sell
2020-06-23 00:00:00	3131.29	3008.17	3006.24	1	Buy

50/200 SMAs vs 38/245 SMAs

-						
	Date	Close Price	50_SMA	200_SMA	Signal	Position
i	2012-03-15 00:00:00	1402.6	1337.78	1336.59	1	Buy
i	2012-06-14 00:00:00	1329.1	1349.57	1350.31	0	Sell
İ	2012-08-14 00:00:00	1403.93	1354.76	1353.56	1	Buy
İ	2015-08-28 00:00:00	1988.87	2074.53	2075.41	0	Sell
İ	2015-12-21 00:00:00	2021.15	2061.51	2061.41	1	Buy
İ	2016-01-11 00:00:00	1923.67	2055.59	2057.64	0	Sell
İ	2016-04-25 00:00:00	2087.79	2017.85	2014.85	1	Buy
İ	2018-12-07 00:00:00	2633.08	2758.02	2761.71	0	Sell
Ĩ	2019-04-01 00:00:00	2867.19	2760.23	2756.75	1	Buy
Ì	2020-03-30 00:00:00	2626.65	3018.65	3028.23	0	Sell
Ì	2020-07-09 00:00:00	3152.05	3028.79	3026.08	1	Buy
+	<u></u>	·	+	+		+
+	+	+	+	+	+	+
+	Date	Close Price	38_SMA	245_SMA	+Signal	Position
+	Date	Close Price	38_SMA	245_SMA	+ Signal +	+ Position
	Date 2012-02-28 00:00:00	Close Price 1372.18	38_SMA	245_SMA 1325.53	+ Signal + 1	Position Buy
	Date 2012-02-28 00:00:00 2012-06-05 00:00:00	Close Price 1372.18 1285.5	38_SMA 1326.8 1351.04	245_SMA 1325.53 1352.36	Signal + 1 0	Position Buy Sell
	Date 2012-02-28 00:00:00 2012-06-05 00:00:00 2012-08-03 00:000 2012-08-03 00:000 2012-08-03 00:000 2012-08-03 00:000 2012-08-03 00:000 200 200 200 200 200 200 200 200	Close Price 1372.18 1285.5 1390.99	38_SMA 1326.8 1351.04 1351.93	245_SMA 1325.53 1352.36 1351.28	Signal + 1 0 1	Position Buy Sell Buy
	Date 2012-02-28 00:00:00 2012-06-05 00:00:00 2012-08-03 00:00:00 2015-09-04 00:00:00	Close Price 1372.18 1285.5 1390.99 1921.22	38_SMA 1326.8 1351.04 1351.93 2051.47	245_SMA 1325.53 1352.36 1351.28 2054.85	Signal 1 0 1 0	Position Buy Sell Buy Sell
	Date 2012-02-28 00:00:00 2012-06-05 00:00:00 2012-08-03 00:00:00 2015-09-04 00:00:00 2015-11-30 00:00:00	Close Price 1372.18 1285.5 1390.99 1921.22 2080.41	38_SMA 1326.8 1351.04 1351.93 2051.47 2060.95	245_SMA 1325.53 1352.36 1351.28 2054.85 2060.94	Signal 1 0 1 0 1 1	Position Buy Sell Buy Sell Buy Buy
	Date 2012-02-28 00:00:00 2012-06-05 00:00:00 2012-08-03 00:00:00 2015-09-04 00:00:00 2015-11-30 00:00:00 2016-01-04 00:00:00	Close Price 1372.18 1285.5 1390.99 1921.22 2080.41 2012.66	38_SMA 1326.8 1351.04 1351.93 2051.47 2060.95 2060.51	245_SMA 1325.53 1352.36 1351.28 2054.85 2060.94 2061.78	Signal 1 0 1 0 1 0	Position Buy Sell Buy Sell Sell Buy Sell Sell
	Date 2012-02-28 00:00:00 2012-06-05 00:00:00 2012-08-03 00:00:00 2015-09-04 00:00:00 2015-11-30 00:00:00 2016-01-04 00:00:00 2016-04-19 00:00:00	Close Price 1372.18 1285.5 1390.99 1921.22 2080.41 2012.66 2100.8	38_SMA 1326.8 1351.04 1351.93 2051.47 2060.95 2060.51 2031.58	245_SMA 1325.53 1352.36 1351.28 2054.85 2060.94 2061.78 2030.64	Signal + 0 1 0 1 0 1 1	Position Buy Sell Buy Sell Buy Sell Buy Sell
	Date 2012-02-28 00:00:00 2012-06-05 00:00:00 2012-08-03 00:00:00 2015-09-04 00:00:00 2015-11-30 00:00:00 2016-01-04 00:00:00 2016-04-19 00:00:00 2018-11-26 00:00:00	Close Price 1372.18 1285.5 1390.99 1921.22 2080.41 2012.66 2100.8 2673.45	38_SMA 1326.8 1351.04 1351.93 2051.47 2060.95 2060.51 2031.58 2749.52	245_SMA 1325.53 1352.36 1351.28 2054.85 2060.94 2061.78 2030.64 2754.99	Signal 1 0 1 0 1 0 1 0	Position Buy Sell Buy Sell Buy Sell Buy Sell Sell
	Date 2012-02-28 00:00:00 2012-06-05 00:00:00 2012-08-03 00:00:00 2015-09-04 00:00:00 2015-11-30 00:00:00 2016-01-04 00:00:00 2016-04-19 00:00:00 2018-11-26 00:00:00 2019-03-14 00:00:00	Close Price 1372.18 1285.5 1390.99 1921.22 2080.41 2012.66 2100.8 2673.45 2808.48	38_SMA 1326.8 1351.04 1351.93 2051.47 2060.95 2060.51 2031.58 2749.52 2739.6 2030.50	245_SMA 1325.53 1352.36 1351.28 2054.85 2060.94 2061.78 2030.64 2754.99 2737.16	Signal 1 0 1 0 1 0 1 0 1 0	Position Buy Sell Buy Sell Buy Sell Buy Sell Buy Sell Buy Sell
	Date 2012-02-28 00:00:00 2012-06-05 00:00:00 2012-08-03 00:00:00 2015-09-04 00:00:00 2015-11-30 00:00:00 2016-01-04 00:00:00 2016-04-19 00:00:00 2018-11-26 00:00:00 2019-03-14 00:00:00 2020-03-25 00:00:00	Close Price 1372.18 1285.5 1390.99 1921.22 2080.41 2012.66 2100.8 2673.45 2808.48 2475.56	38_SMA 1326.8 1351.04 1351.93 2051.47 2060.95 2060.51 2031.58 2749.52 2739.6 2985.9	245_SMA 1325.53 1352.36 1351.28 2054.85 2060.94 2061.78 2030.64 2754.99 2737.16 3003.18	Signal 1 0 1 0 1 0 1 0 1 0 1	Position Buy Sell Buy Sell Buy Sell Buy Sell Buy Sell Buy Sell
	Date 2012-02-28 00:00:00 2012-06-05 00:00:00 2012-08-03 00:00:00 2015-09-04 00:00:00 2015-11-30 00:00:00 2016-01-04 00:00:00 2016-04-19 00:00:00 2018-11-26 00:00:00 2019-03-14 00:00:00 2020-06-23 00:00:00	Close Price 1372.18 1285.5 1390.99 1921.22 2080.41 2012.66 2100.8 2673.45 2808.48 2475.56 3131.29	38_SMA 1326.8 1351.04 1351.93 2051.47 2060.95 2060.51 2031.58 2749.52 2739.6 2985.9 3008.17	245_SMA 1325.53 1352.36 1351.28 2054.85 2060.94 2061.78 2030.64 2754.99 2737.16 3003.18 3006.24	Signal 	Position Buy Sell Buy Sell Buy Sell Buy Sell Buy Sell Buy Sell Buy

50/200 SMAs vs 38/245 SMAs

Date	Close Price	50_SMA	200_SMA	Signal	Positio
2012-03-15 00:00:00	1402.6	1337.78	1336.59	1	Buy
2012-06-14 00:00:00	1329.1	1349.57	1350.31	0	Sell
2012-08-14 00:00:00	1403.93	1354.76	1353.56	1	Buy
2015-08-28 00:00:00	1988.87	2074.53	2075.41	0	Sell
2015-12-21 00:00:00	2021.15	2061.51	2061.41	1	Buy
2016-01-11 00:00:00	1923.67	2055.59	2057.64	0	Sell
2016-04-25 00:00:00	2087.79	2017.85	2014.85	1	Buy
2018-12-07 00:00:00	2633.08	2758.02	2761.71	0	Sell
2019-04-01 00:00:00	2867.19	2760.23	2756.75	1	Buy
2020-03-30 00:00:00	2626.65	3018.65	3028.23	0	Sell
	7452 05	2020 70	3026 08	1	Buy
2020-07-09 00:00:00 +	3152.05	++		+ +	+
2020-07-09 00:00:00 + Date	3152.05 Close Price	++ 38_SMA	245_SMA	 Signal	Positio
2020-07-09 00:00:00 + Date 2012-02-28 00:00:00	3152.05 Close Price 1372.18	38_SMA	245_SMA 1325.53	+ Signal +	Position Buy
2020-07-09 00:00:00 + Date 2012-02-28 00:00:00 2012-06-05 00:00:00	3152.05 Close Price 1372.18 1285.5	38_SMA 1326.8 1351.04	245_SMA 1325.53 1352.36	Signal 1 0	Positio Buy Sell
2020-07-09 00:00:00 + Date 2012-02-28 00:00:00 2012-06-05 00:00:00 2012-08-03 00:00:00	3152.05 Close Price 1372.18 1285.5 1390.99	1326.8 1351.04 1351.93	245_SMA 1325.53 1352.36 1351.28	Signal 1 0 1	Positio Buy Sell Buy
2020-07-09 00:00:00 + Date 2012-02-28 00:00:00 2012-06-05 00:00:00 2012-08-03 00:00:00 2015-09-04 00:00:00	3152.05 Close Price 1372.18 1285.5 1390.99 1921.22	38_SMA 1326.8 1351.04 1351.93 2051.47	245_SMA 1325.53 1352.36 1351.28 2054.85	Signal 1 0 1 0	Position Buy Sell Buy Sell
2020-07-09 00:00:00 	3152.05 Close Price 1372.18 1285.5 1390.99 1921.22 2080.41	38_SMA 1326.8 1351.04 1351.93 2051.47 2060.95	245_SMA 1325.53 1352.36 1351.28 2054.85 2060.94	Signal 1 0 1 0 1	Positio Buy Sell Buy Sell Buy Sell Buy
2020-07-09 00:00:00 Date 2012-02-28 00:00:00 2012-06-05 00:00:00 2012-08-03 00:00:00 2015-09-04 00:00:00 2015-11-30 00:00:00 2016-01-04 00:00:00	3152.05 Close Price 1372.18 1285.5 1390.99 1921.22 2080.41 2012. <u>66 </u>	38_SMA 1326.8 1351.04 1351.93 2051.47 2060.95 2060.51	245_SMA 1325.53 1352.36 1351.28 2054.85 2060.94 2061.78	Signal 1 0 1 0 1 0	Position Buy Sell Buy Sell Buy Sell Buy Sell
2020-07-09 00:00:00 Date 2012-02-28 00:00:00 2012-06-05 00:00:00 2012-08-03 00:00:00 2015-09-04 00:00:00 2015-11-30 00:00:00 2016-01-04 00:00:00 2016-04-19 00:00:00	3152.05 Close Price 1372.18 1285.5 1390.99 1921.22 2080.41 2012.66 2100.8	1326.8 1351.04 1351.93 2051.47 2060.95 2060.51 2031.58	245_SMA 1325.53 1352.36 1351.28 2054.85 2060.94 2061.78 2030.64	Signal 1 0 1 0 1 0 1	Position Buy Sell Buy Sell Buy Sell Buy Sell Buy
2020-07-09 00:00:00 Date 2012-02-28 00:00:00 2012-06-05 00:00:00 2012-08-03 00:00:00 2015-09-04 00:00:00 2015-11-30 00:00:00 2016-01-04 00:00:00 2016-04-19 00:00:00 2018-11-26 00:00:00	Close Price 1372.18 1285.5 1390.99 1921.22 2080.41 2012.66 2100.8 2673.45	1326.8 1351.04 1351.93 2051.47 2060.95 2060.51 2031.58 2749.52	245_SMA 1325.53 1352.36 1351.28 2054.85 2060.94 2061.78 2030.64 2754.99	Signal 1 0 1 0 1 0 1 0	Position Buy Sell Buy Sell Buy Sell Buy Sell Buy Sell
2020-07-09 00:00:00 Date 2012-02-28 00:00:00 2012-06-05 00:00:00 2012-08-03 00:00:00 2015-09-04 00:00:00 2015-11-30 00:00:00 2016-01-04 00:00:00 2016-04-19 00:00:00 2018-11-26 00:00:00 2019-03-14 00:00:00	Close Price 1372.18 1285.5 1390.99 1921.22 2080.41 2012.66 2100.8 2673.45 2808.48	38_SMA 1326.8 1351.04 1351.93 2051.47 2060.95 2060.51 2031.58 2749.52 2739.6	245_SMA 1325.53 1352.36 1351.28 2054.85 2060.94 2061.78 2030.64 2754.99 2737.16	Signal 1 0 1 0 1 0 1 0 1	Position Position Sell Buy Sell Buy Sell Buy Sell Buy Sell Buy
2020-07-09 00:00:00 	Close Price 1372.18 1285.5 1390.99 1921.22 2080.41 2012.66 2100.8 2673.45 2808.48 2475.56	38_SMA 1326.8 1351.04 1351.93 2051.47 2060.95 2060.51 2031.58 2749.52 2739.6 2985.9	245_SMA 1325.53 1352.36 1351.28 2054.85 2060.94 2061.78 2030.64 2754.99 2737.16 3003.18	Signal 1 0 1 0 1 0 1 0 1 0	Positio Positio Buy Sell Buy Sell Buy Sell Buy Sell Buy Sell

50/200 = \$1734.25

38/245 = \$1651.83

ARIMA

ARIMA is an acronym that stands for AutoRegressive Integrated *Moving Average*. A model that uses the dependent relationship between an observation and some number of *lagged observations*.

An **ARIMA model** is a class of statistical **model** for analyzing and **forecasting** time series data.

An autoregressive integrated moving average, or ARIMA, is a statistical analysis model that uses time series data to either better understand the data set or to **predict future trends**.

ARIMA uses several lagged observations of time series to forecast observations. A weight is applied to each of the past term and the weights can vary based on how recent they are. AR(x) means x lagged error terms are going to be used in the ARIMA model. Methodology

Methodology

- Datasets
 ✓ Yahoo Finance API
- Model
 ✓ Time-Series Forecasting
- Metrics
 - Root Mean Squared Error on 2 different underlying

- Tools
 - ✓ Math (sqrt)
 - ✓ Matplotlib (pyplot)
 - ✓ Pandas (DataFrame, datetime)
 - ✓ Sklearn (metrics)
 - ✓ Statsmodels (ARIMA)
 - ✓ yfinance

Process Workflow

Process Workflow

- EDA / Data preparation / Data analysis
 - ✓ Retrieve date and closing price only
 - ✓ Price chart visualization
 - ✓ Add a moving average as test

- ML model training / evaluation
 - ✓ 2/3 training, 1/3 testing
 - ✓ RMSE
 - ✓ Test vs Prediction chart

Results

Results

- S&P500 (^GSPC)
 Microsoft (MSFT)
 ✓ RMSE = 26.155
 ✓ RMSE = 3.099

 - ✓ ARIMA (p, d, q) = 4, 2, 1 ✓ ARIMA = 6, 2, 2
- p: The number of lag observations included in the model, also called the lag order. The order of the auto-regressive part.
- d: The number of times that the raw observations are differenced, also called the degree of differencing. The number of differentiation steps.
- q: The size of the moving average window, also called the order of moving average. The order of the moving average part

Results

Conclusions

Conclusions

- Even-though MSFT has a lower RMSE, the model worked better on S&P500.
 ✓ RMSE 26.155 on 4100 vs. 3.099 on 260.
- Continue to pursue the ARIMA model instead of the Moving Average Crossover strategy.
 ✓ Forecasting time-series data vs. lagging indicator on time-series data.

Future Opportunities

Future Opportunities

- Test various underlying with the ARIMA Model and compare the outcomes
 - ✓ Stocks (old economy vs new economy)
 - ✓ Sectors (Consumer Defensive vs. Technology)
 - ✓ Cryptos / Commodities / Foreign Exchange
- Evaluate the Model not only with RMSE but also with other metrics.
- Create a Buy/Sell signal.

