

# I SPY: TIME SERIES ANALYSIS + PREDICTIONS

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SPY ETF

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...

...

Profit?



“The stock market is a device for  
transferring money from the  
impatient to the patient.”

—WARREN BUFFETT





# 01

## INTRODUCTION

We're all in this together.

# SPDR® S&P 500® ETF TRUST

Passively managed exchange-traded fund that seeks to correspond generally to the price and performance of the underlying S&P 500® Index.

- NAV:  
\$415.62
- Base Currency:  
USD
- Assets Under Management:  
\$362,928.37 MM
- Gross Expense Ratio  
0.0945%



# BUSINESS PROBLEM



## UNCERTAINTY

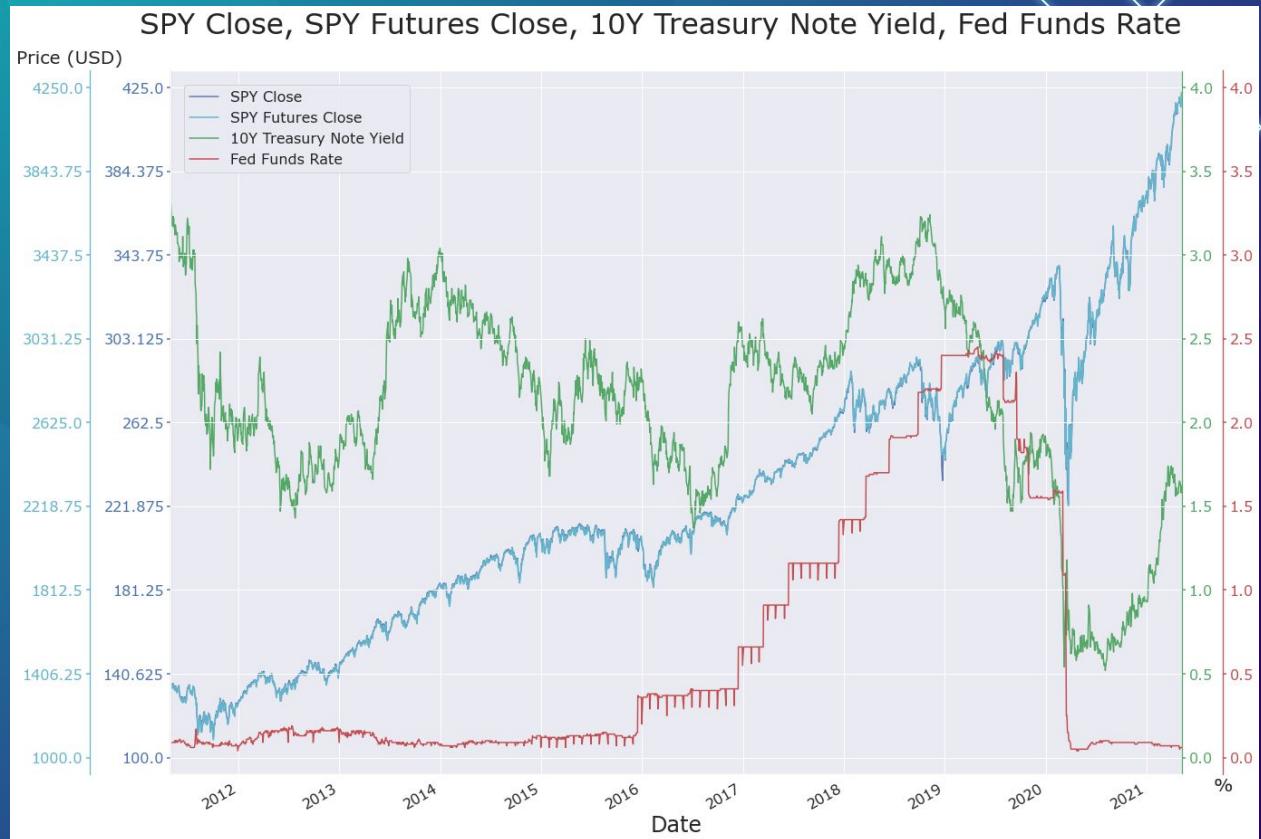
Volatility in the markets may cause investments to lose money.



## INFORMATION

If we can forecast the future closing prices of SPY, we can make better trading decisions.

# STOCK BEHAVIOR



# CHALLENGES



## STATIONARITY

Trending up  
Unstable variance



## MARKET SHOCKS

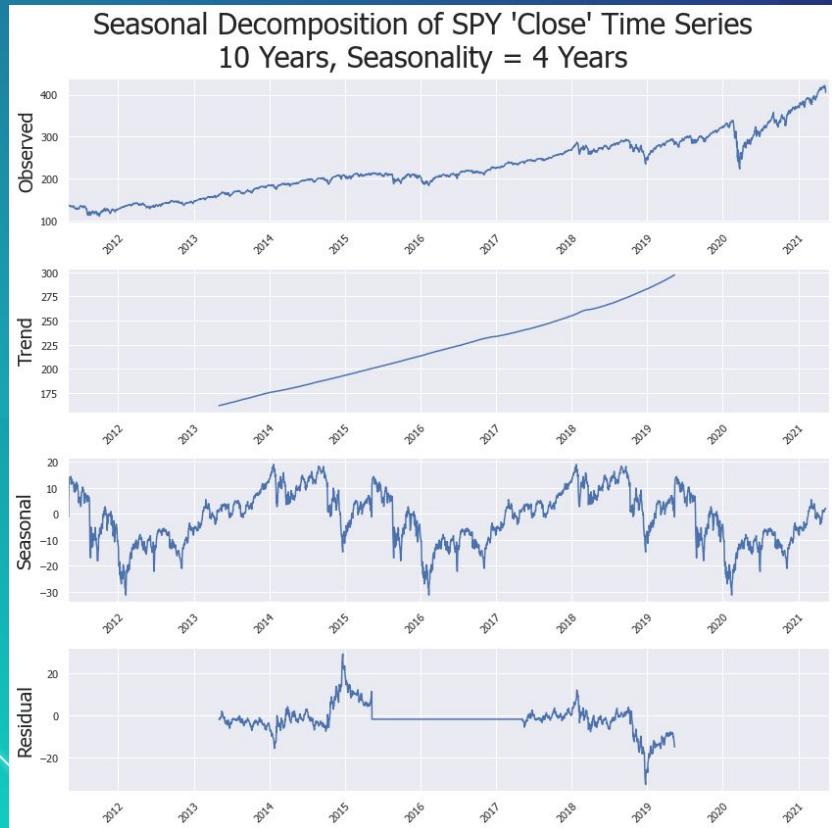
Recessions +  
black swan events =  
volatility



## EXOGENEITY

Interest rates, options  
trading, FOMC decisions...

# CLOSING PRICE TIME SERIES ANALYSIS



# 02

## MODELING

Let's crunch some data.





**WE EXAMINED SEVERAL  
TIMEFRAMES, FREQUENCIES,  
SEASONALITIES BEFORE  
CHOOSING THE MOST  
SUITABLE  
TIME SERIES...**

**10 Years,  
1 Day Frequency**

# EXOGENOUS FEATURES

**SPY OHLC - C**

**OPTION EXPIRY**

**US TSY 10Y**

**FED FUNDS %**

**SPY FUTURES**



# MODELING TOOLS

**SARIMAX**

Inefficient,  
memory-intensive

**PMDARIMA**

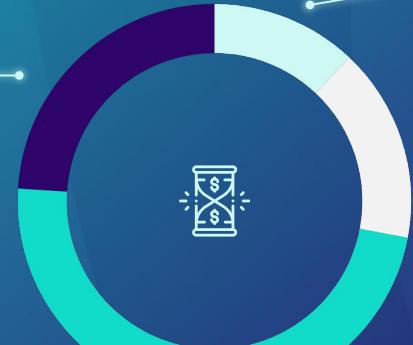
Additional transforms

**LOGISTIC**

Low accuracy

**PROPHET**

Difficult to tune



# GRID-SEARCH

When all else fails, iterate. And iterate. And iterate...

# STEP-WISE TEST + PREDICTION

10Y

RMSE:  
4.66

RMSE%:  
2.32% of  
mean value

SMAPE:  
0.98%



**03**



More accurate than the weather.

# **FORECASTING**

# HISTORICAL SIMULATION

For each day:

Predict price and  
confidence interval...

Actual price below  
confidence interval

Actual price within  
confidence interval

Actual price above  
confidence interval



**BUY**



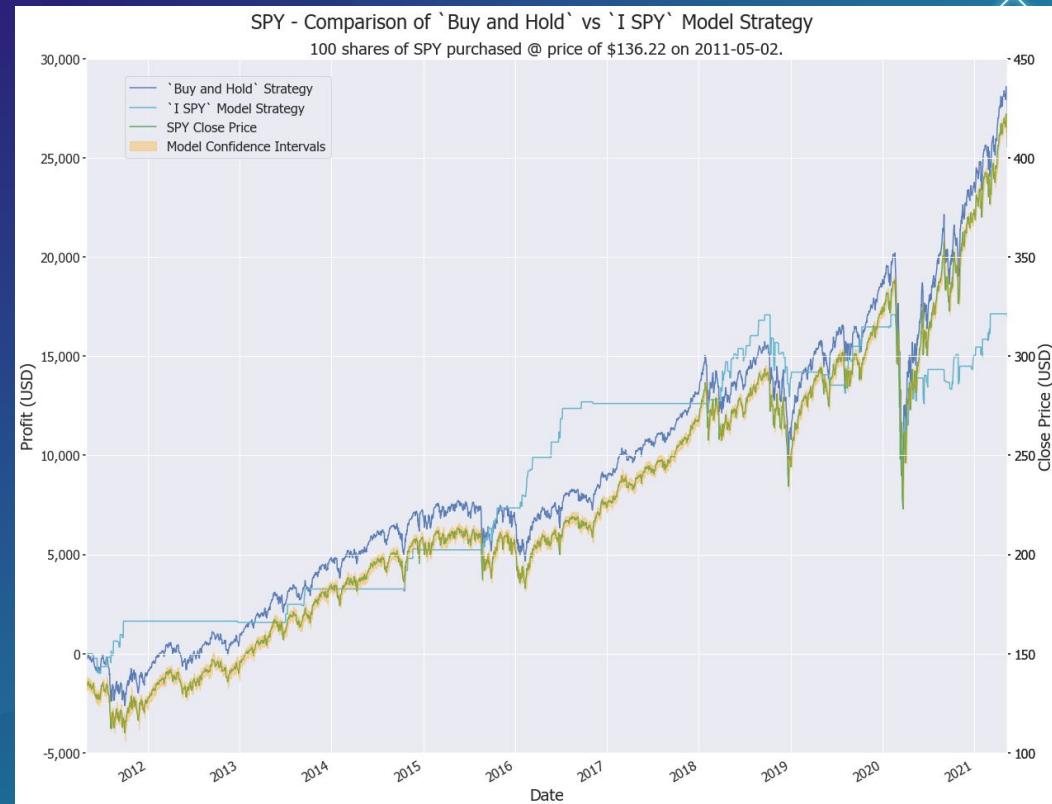
**HOLD**



**SELL**

# COMPARISON WITH BUY + HOLD

But wait,  
there are  
*more*  
parameters...



# MODEL PROFIT GRIDSEARCH

**z**

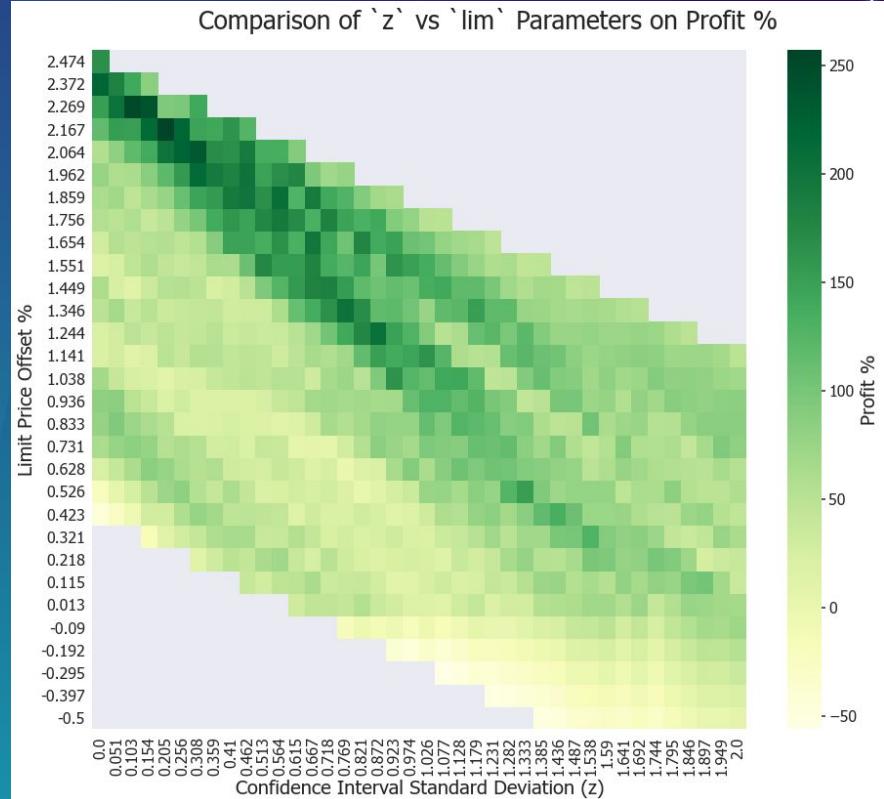
Standard deviations of  
model confidence interval

**Limit Price Offset %**

Percent difference from  
confidence interval

**Impact**

Trades execute at  
different prices



# NEW AND IMPROVED



$z = 0.205$   
 $\text{lim} = 2.167\%$

Buy and Hold:  
197.61%.

I SPY Profit:  
**257.09%**





# PRICE PREDICTIONS

Learn from the past, evaluate the present, influence the future (maybe).

# FORECASTING 52 DAYS OUT

10Y

It's follow-ing the trend, which is a good sign.

One day confidence interval is **2.43%** of price.



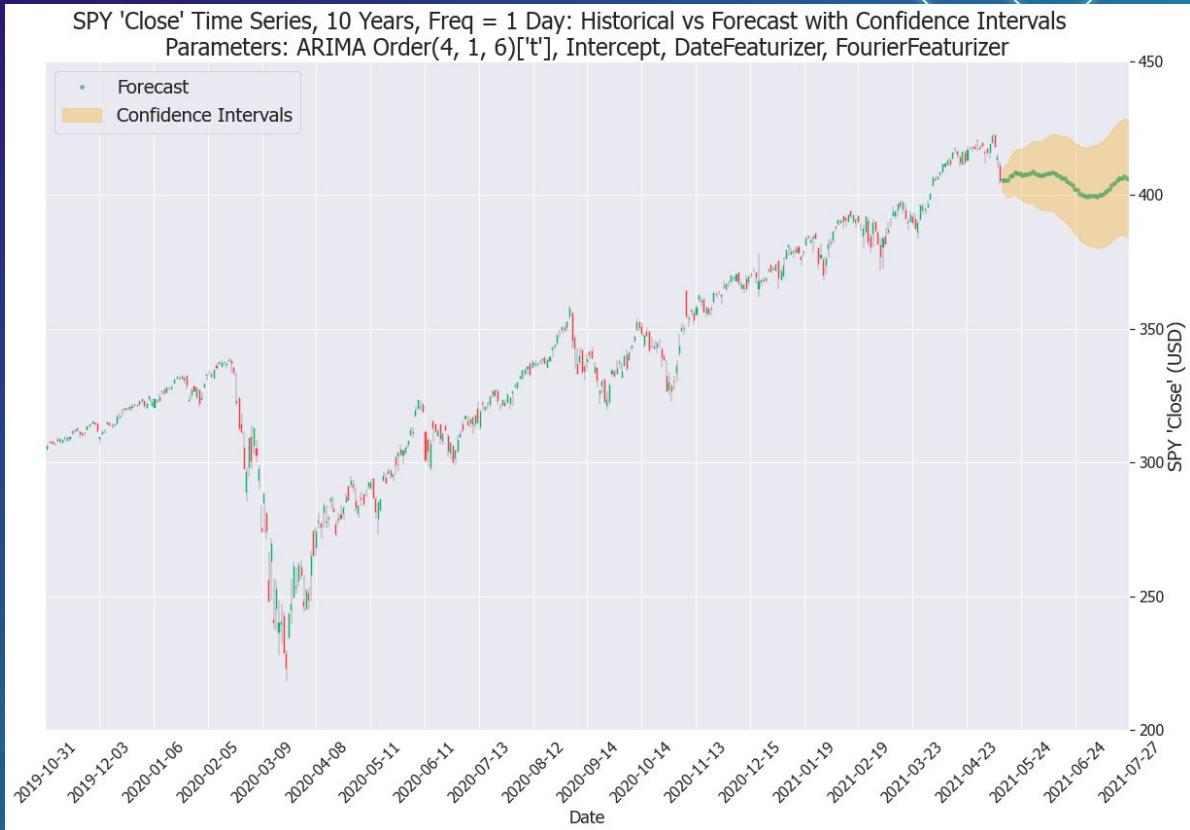
# BETTER MODEL

10Y

Uses multiple seasonalities via Fourier transform.



Higher order, chance of over-fit.  
Sideways movement!



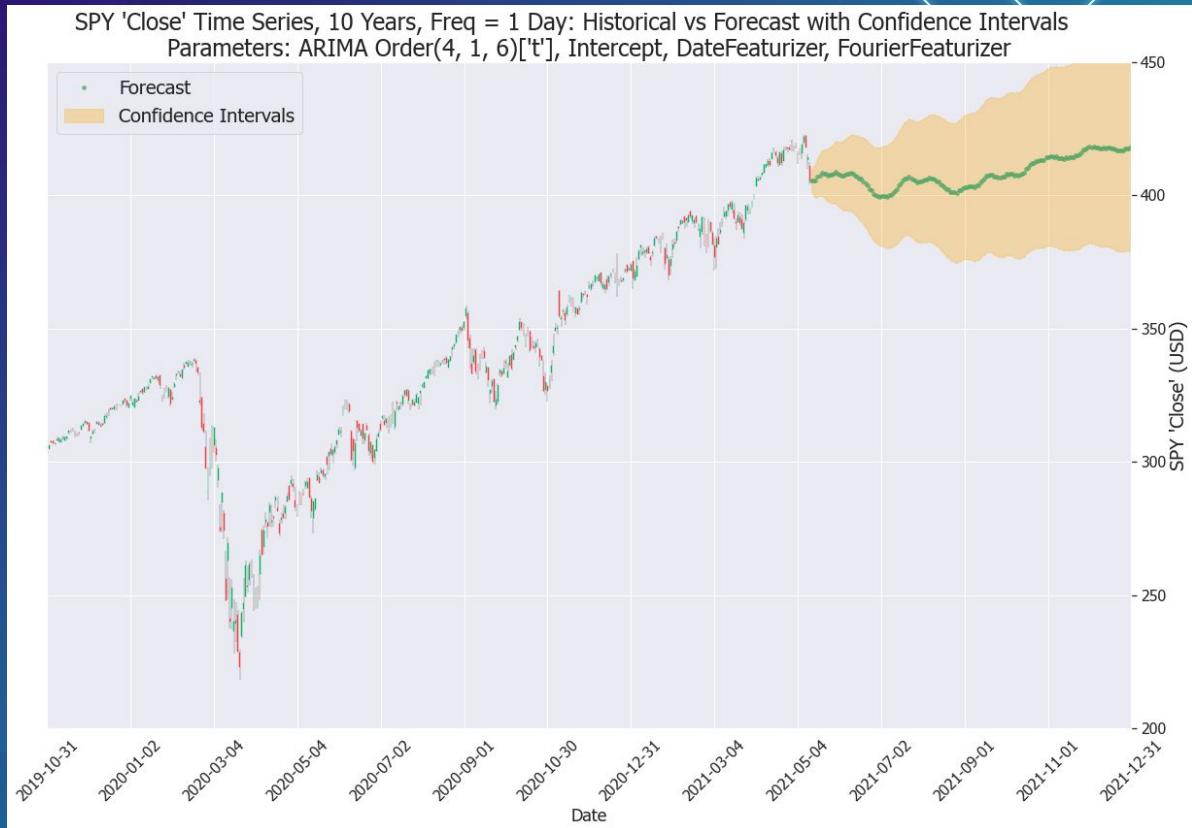
# FORECASTING YEAR-END

10Y

Anyone the  
betting type?  
Model says:  
**\$418.34.**



Average  
projection on  
Wall-Street:  
**\$420.70**



# CONCLUSIONS

None of this was financial advice.

04



# BY THE NUMBERS

**57%\***

**SUCCESS RATE**

Arbitrarily defined as  $\pm 50\%$

**6000+**

**LINES OF CODE**

Including lines deleted

**∞**

**HOURS SPENT**

Good ROI

\* - for the past few days

# NEXT STEPS



## TRADING STRATEGIES

Different actions to take, tiered trading, different order types



## SENTIMENT

Web-scraping of Twitter, Reddit, etc.; FOMC meeting dates



## MORE DATA

Recession dates, **option trades / prices / interest data**, short interest, jobs data, unemployment data



## INDICATORS

MACD, RSI, Bollinger Bands, Support/Resistance, Stochastic, CCI, OBV, Elliot Wave Analysis



## MORE MODELS

TBATS, ANN, RNN, LSTM, XGBClassifier



## REAL-TIME

Flask web app, cloud-computing, get up-to-date model predictions

# THANK YOU

What questions do you have for me?

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