Cryptocurrency and S&P 500 Market Trends

Programming for Analytics

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Project Goal and Objectives

Goal:

Generate an **analysis** and **comparison** of cryptocurrency trends versus the market trends of the S&P 500.

Objectives:

To assess whether:

- There is evidence of a **statistical relationship over time** between the performance of Fortune 500 stocks and cryptocurrencies.
- Large capitalization **crypto assets provide a hedge** against a broader market downturn.
- Crypto currency assets can be predicted utilizing other assets' price data and time series data

Project Scope

Analysis will be limited to all **daily closing price** data available for the period between **January 1, 2014 - October 31, 2021** for:

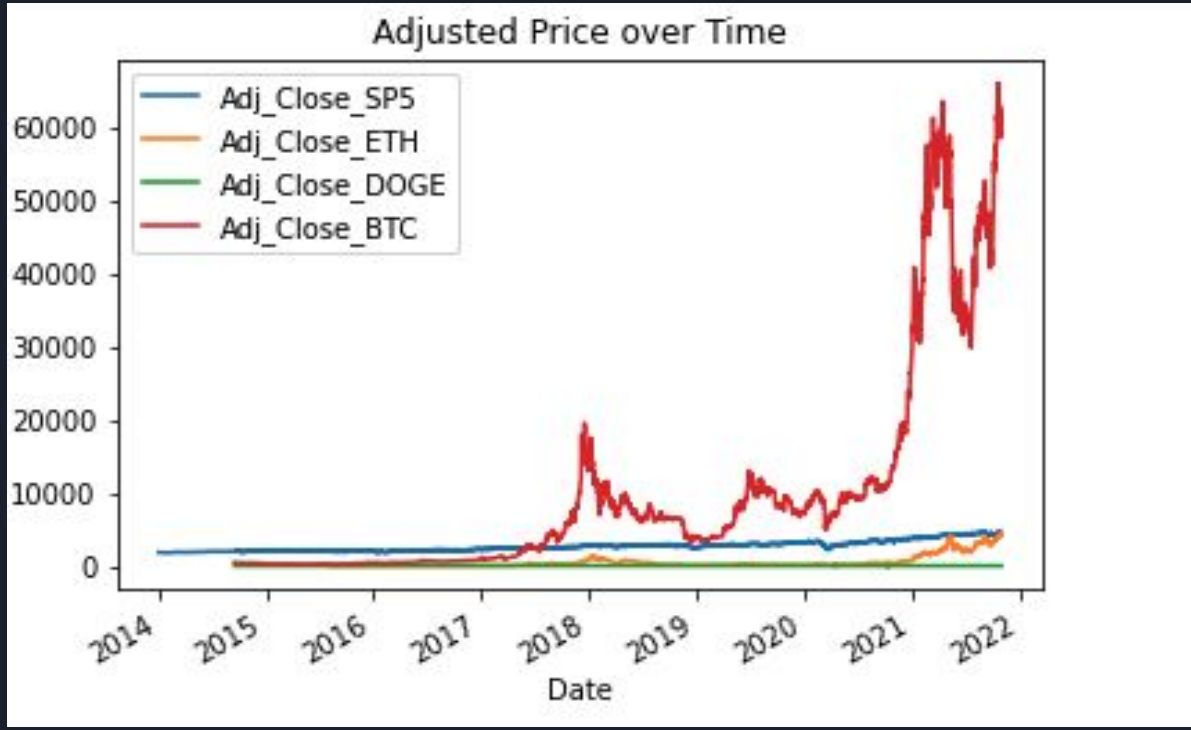
- S&P 500 (SP5)
- Bitcoin (BTC)
- Ethereum (ETC)
- Dogecoin (DOGE)

Project Deliverables

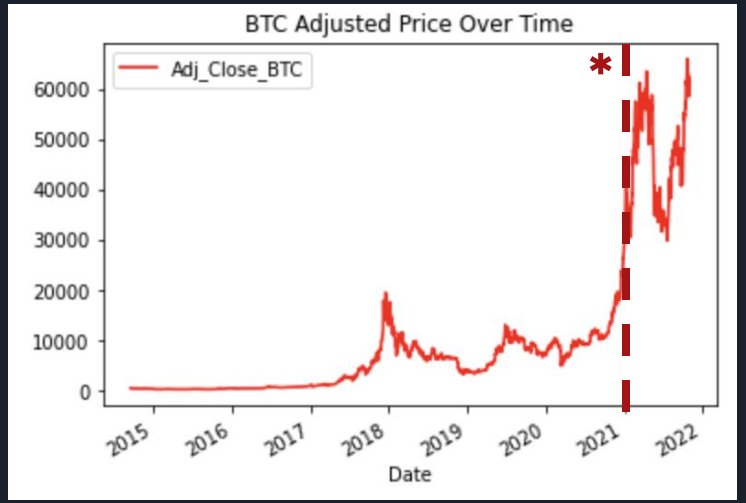
1. Cleaned Data Feed
2. Exploratory Time Series Analysis
3. Percentage Change Analysis and Significant Decline Analysis
4. Predictive Regression
    a. Linear Regression
    b. ARIMA
5. Conclusion

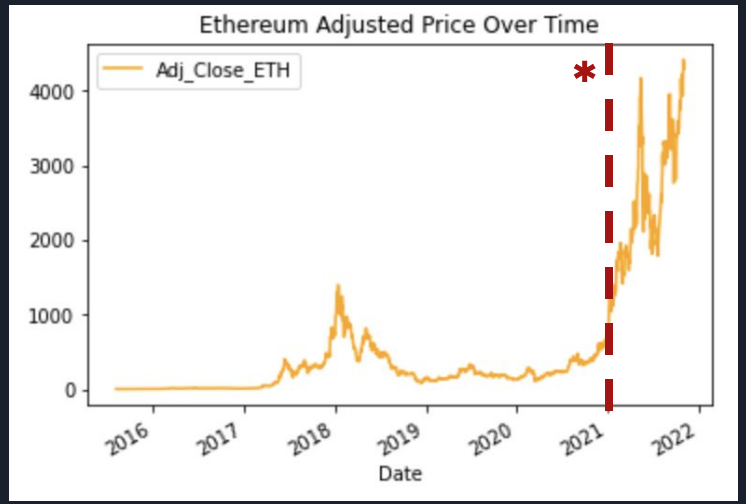
Analysis Methodology

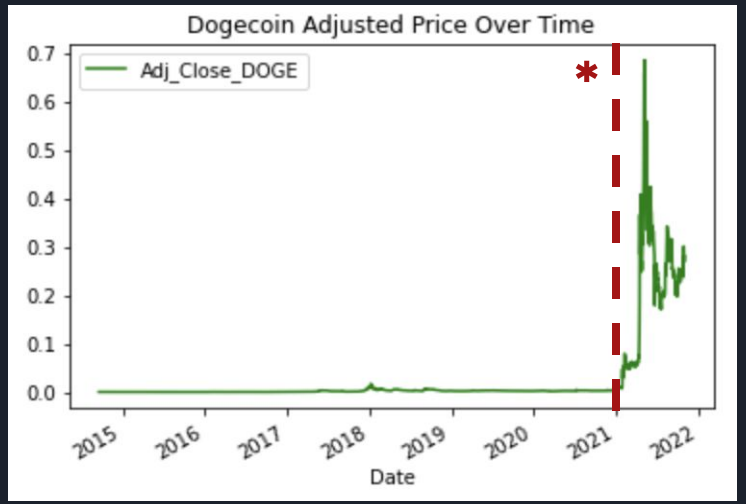
1. **Data Feed Setup and Cleaning**
   a. Cleaned and merged dataset feed from Yahoo Finance
2. **Exploratory Time Series Analysis**
   a. Plotted individual and combined time series analyses for asset classes
   b. Visual evaluation of trend, seasonality and asset volatility
3. **Percent Change Analysis**
   a. Plotted individual and combined daily percent change of assets over time
   b. Calculated correlation of percentage change between assets
4. **S&P 500 Significant Decline Analysis**
   a. Subsetted for the 20 days following a 3 standard deviation drop in the SP500
   b. Calculated Correlation



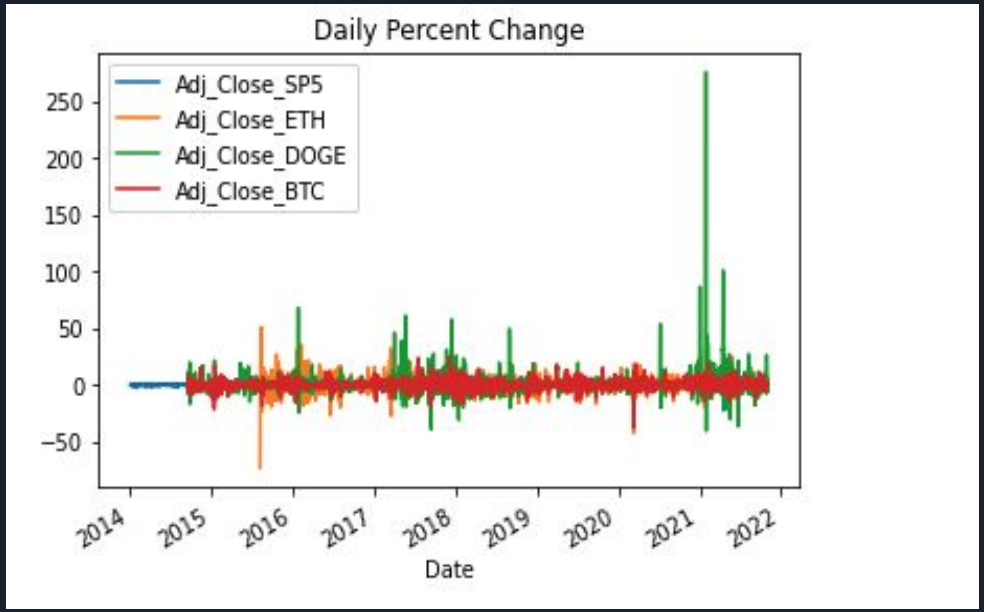
Individual Time Series Plots

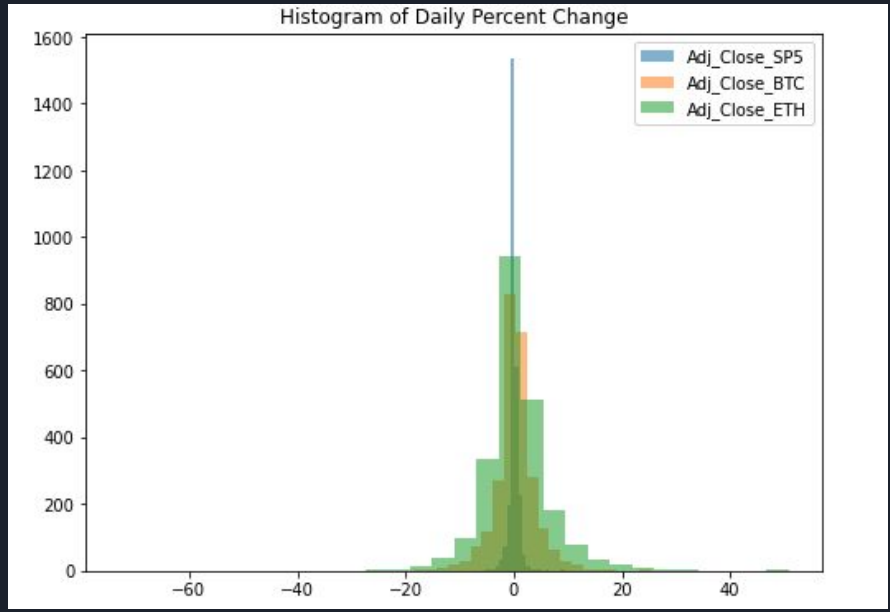






Percent Change Analysis





Takeaway:

- High Volatility
- Limited Correlation over whole time period
- Requires more analysis of recent time and significant drops in SP500

	Adj_Close_SP5	Adj_Close_ETH	Adj_Close_DOGE	Adj_Close_BTC
Adj_Close_SP5	1.000000	0.132394	0.049860	0.134764
Adj_Close_ETH	0.132394	1.000000	0.271434	0.517957
Adj_Close_DOGE	0.049860	0.271434	1.000000	0.376176
Adj_Close_BTC	0.134764	0.517957	0.376176	1.000000

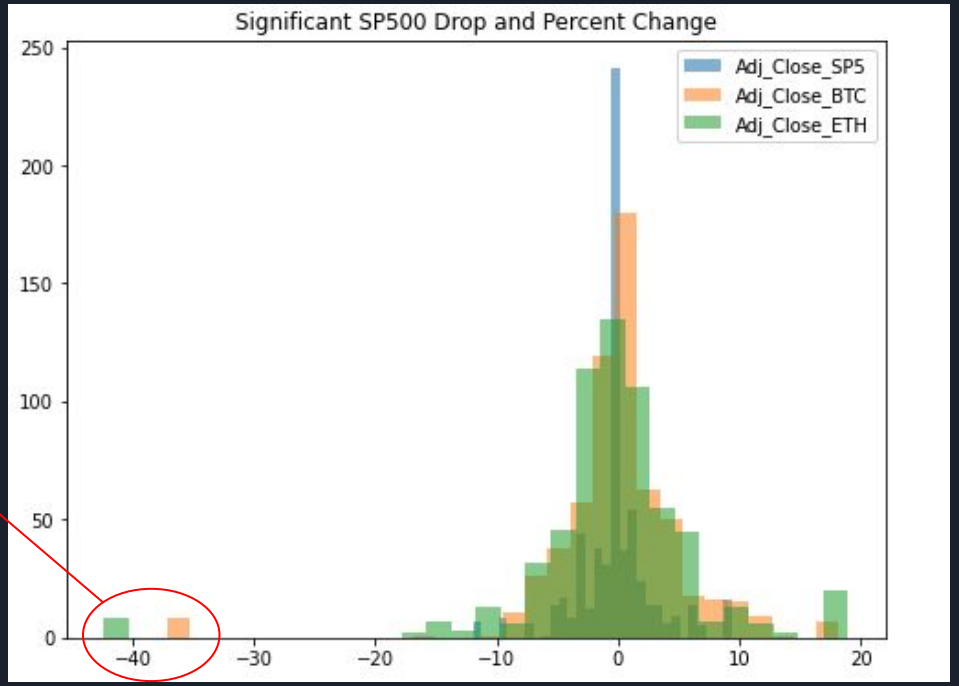
Significant S&P 500 Drops and Next Steps

Significant Drop Analysis

- Evidence of stronger statistical relationship between SP5, BTC and ETH in 20 days following SP5 Drop
- Are ETH and BTC really a viable alternative?

Next Steps

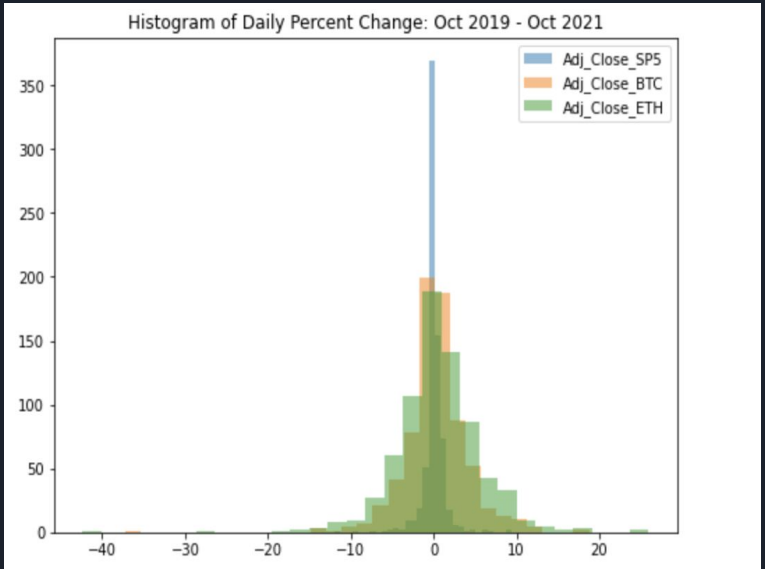
- Rolling Average of Assets and Comparisons
- Time Series Prediction of Assets
  - Individual Assets
  - Combined Dataset and Synchronization
- Recency Analysis
- Finding and/or **creating the next great**
  ~Meme Coin~



	Adj_Close_SP5	Adj_Close_ETH	Adj_Close_DOGE	Adj_Close_BTC
Adj_Close_SP5	1.000000	0.500274	0.432908	0.474462
Adj_Close_ETH	0.500274	1.000000	0.843311	0.907695
Adj_Close_DOGE	0.432908	0.843311	1.000000	0.892301
Adj_Close_BTC	0.474462	0.907695	0.892301	1.000000

UPDATES

Percent Change Analysis (10/31/2019 - 10/31/2021)



Percent Change Descriptive Statistics

	Adj_Close_SP5	Adj_Close_ETH	Adj_Close_DOGE	Adj_Close_BTC
count	732.000000	732.000000	732.000000	732.000000
mean	0.065599	0.572328	1.212792	0.339902
std	1.347426	5.238155	13.848363	3.948297
min	-11.984055	-42.347221	-40.256986	-37.169539
25%	-0.113157	-1.872188	-2.242865	-1.444663
50%	0.000000	0.470788	0.000000	0.203151
75%	0.418236	3.183519	2.031059	2.044688
max	9.382774	25.947533	275.643160	18.746474

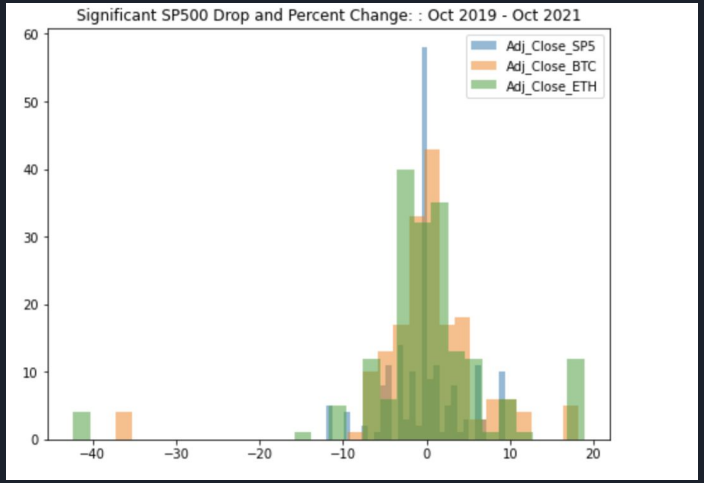
Takeaway:

- Stronger correlation between SP500 and BTC, ETH for the past two years then full dataset (7 Years)
- ETH and BTC volatility (standard deviation) greater than approximately 200% of SP500 volatility

	Adj_Close_SP5	Adj_Close_ETH	Adj_Close_DOGE	Adj_Close_BTC
Adj_Close_SP5	1.000000	0.298257	0.048475	0.306851
Adj_Close_ETH	0.298257	1.000000	0.282551	0.796178
Adj_Close_DOGE	0.048475	0.282551	1.000000	0.312603
Adj_Close_BTC	0.306851	0.796178	0.312603	1.000000

Significant Drop Percent Change Analysis (2019 - 2021):

What happens to BTC and ETH when there is a large negative move in the SP500?



	Adj_Close_SP5	Adj_Close_ETH	Adj_Close_DOGE	Adj_Close_BTC
Adj_Close_SP5	1.000000	0.551959	0.506111	0.501037
Adj_Close_ETH	0.551959	1.000000	0.957943	0.964946
Adj_Close_DOGE	0.506111	0.957943	1.000000	0.966486
Adj_Close_BTC	0.501037	0.964946	0.966486	1.000000

Takeaway:

- Even Stronger statistical relationship between SP500 and BTC, ETH for the past two years then full dataset (7 Years)
- High Upside and High Downside (much more significant)
  - Further analysis suggested: Path Dependence
- Consistent correlation across days after a significant drop (figure below)

	Day 1:Adj_Close_SP5	Day 2:Adj_Close_SP5	3:Adj_Close_				
Adj_Close_SP5	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
Adj_Close_ETH	0.550860	0.520619	0.510777	0.514657	0.507647	0.488956	0.501028
Adj_Close_DOGE	0.477501	0.473434	0.480955	0.488159	0.456752	0.421906	0.433174
Adj_Close_BTC	0.529461	0.495172	0.491731	0.502168	0.479841	0.469774	0.478522

Regression Models:

Can we use weekly percent change to estimate change across other markets?

Model 1:

Dependent Variable: Weekly % change S&P 500

IVs	Coef
BTC % Change	0.0206
ETH % Change	0.0065
DOGE % Change	-0.0009
R^2 Value	0.0179
n	233

Model 2:

Dependent Variable: Weekly % change BTC

IVs	Coef
SP5 % Change	0.3858
ETH % Change	0.2907
DOGE % Change	0.0262
R^2 Value	0.1901
n	233

Takeaway:

- The relationship between the S&P and Cryptocurrency markets is not strong enough to predict change
- More factors need to be added in order to make any type of reasonable prediction

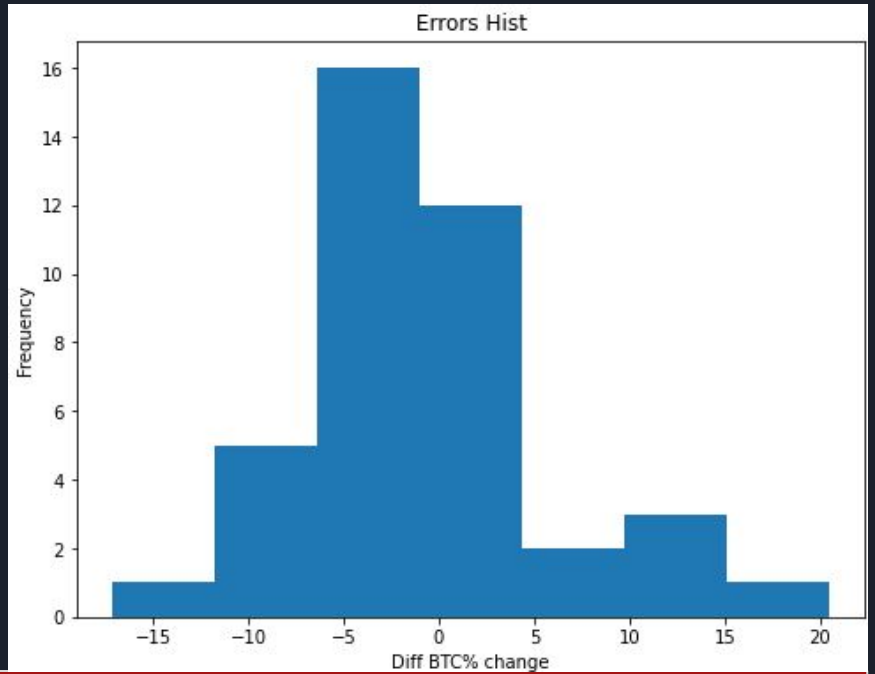
Regression Models:

Can we use other Cryptocurrencies to predict change in BTC?

Model 3:

Dependent Variable: Weekly % change BTC
Added Litecoin, Stellar, Binance Coin

IVs	Coef
LTC % Change	0.3608
XLM % Change	0.0205
BNB % Change	0.0289
ETH % Change	0.2397
DOGE % Change	-0.0172
R^2 Value	0.6841
n	160



Takeaway:

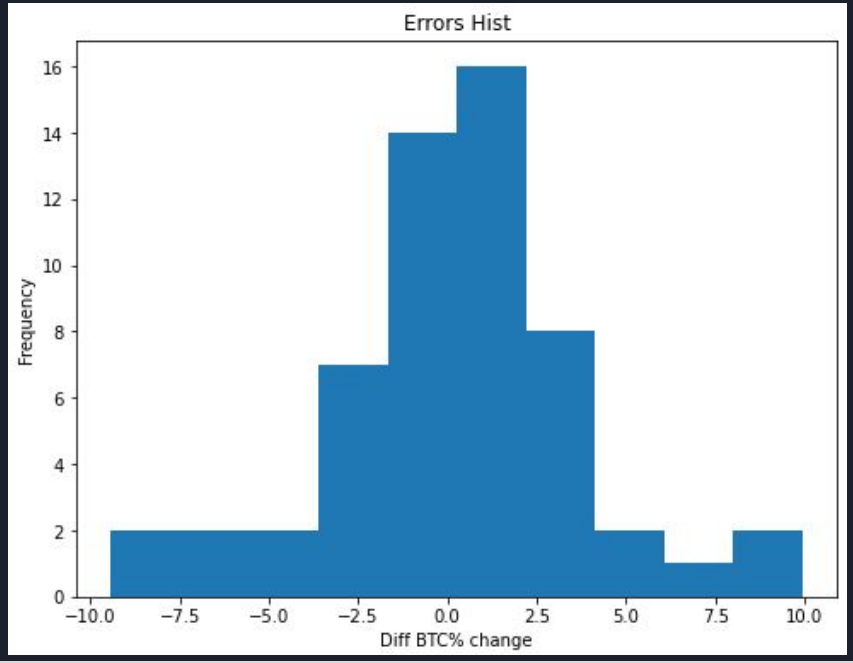
- We can make a much stronger prediction using market data from other cryptos
- Dogecoin and Stellar have low impact, Litecoin and Ethereum have high impact

Regression Models:
Can recency help improve our prediction model?

Model 4:

Dependent Variable: BiWeekly % change BTC
Data from after 2019.

IVs	Coef
LTC % Change	0.2919
BNB % Change	0.1170
ETH % Change	0.2825
R^2 Value	0.7862
n	222



Takeaway:

- Using more recent data, biweekly outputs, and removing DOGE and XLM increases our model accuracy

ARIMA model used in Bitcoin, Ethereum, and Dogecoin — Time Series Analysis

Can we predict cryptocurrency asset price with the asset's own previous price data?

ARIMA forecasting equation

- Let Y denote the *original* series
- Let y denote the *differenced* (stationarized) series

No difference (d=0): $y_t = Y_t$

First difference (d=1): $y_t = Y_t - Y_{t-1}$

Second difference (d=2): $y_t = (Y_t - Y_{t-1}) - (Y_{t-1} - Y_{t-2})$

$= Y_t - 2Y_{t-1} + Y_{t-2}$

Forecasting equation for y

auto-regressive

constant | AR terms (lagged values of y)

$$\hat{y}_t = \mu + \phi_1 y_{t-1} + \ldots + \phi_p y_{t-p} - \theta_1 e_{t-1} \ldots - \theta_q e_{t-q}$$

By convention, the AR terms are + and the MA terms are –

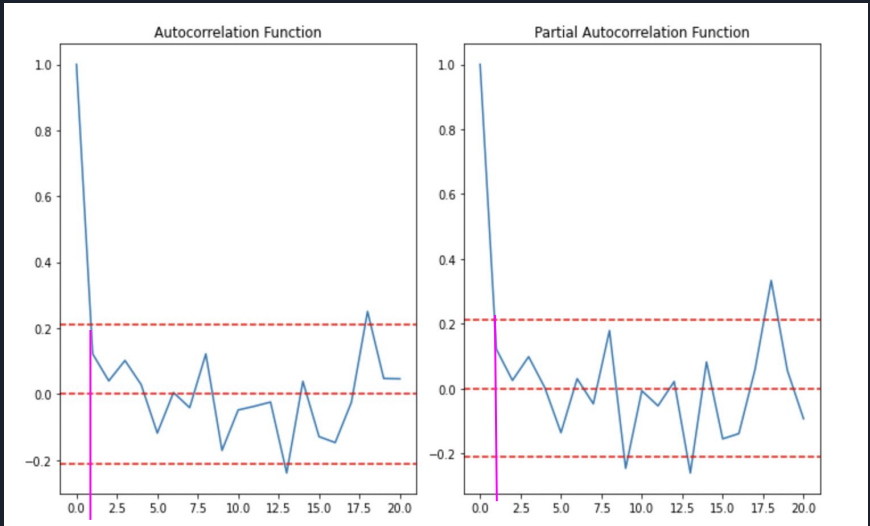
MA terms (lagged errors)

Moving average

Not as bad as it looks! Usually $p+q \le 2$ and either p=0 or q=0 (pure AR or pure MA model)

Interpreted by Robert Nau (2014)
https://people.duke.edu/~rnau/Slides_on_ARIMA_models--Robert_Nau.pdf

After testing the stationary of our Time Series,
We use Autocorrelation Function to find the parameter Q,
And Partial Autocorrelation Function to find the parameter P.
We use first difference (d = 1) to build ARIMA model for each cryptocurrency



ACF for BTC: Q = 1 or 2;

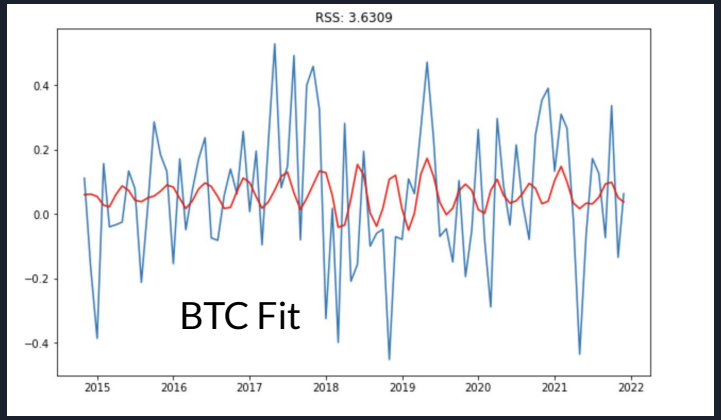
PACF for BTC: P = 1 or 2.

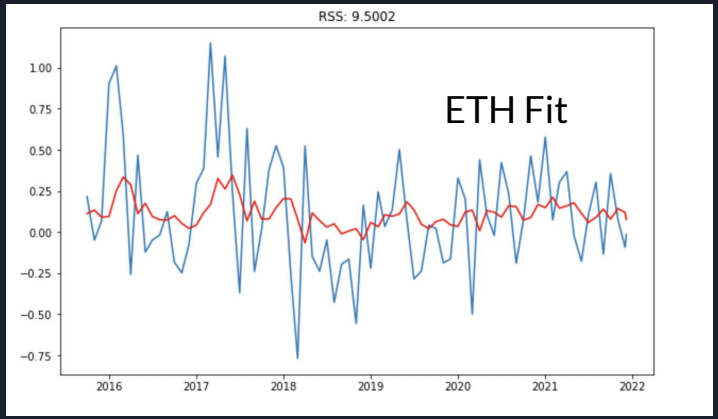
We take order = (2,1,2) in the ARIMA Model to fit BTC,
And order = (2,1,1) to fit ETH,
And order = (2,1,2) to fit DOGE.

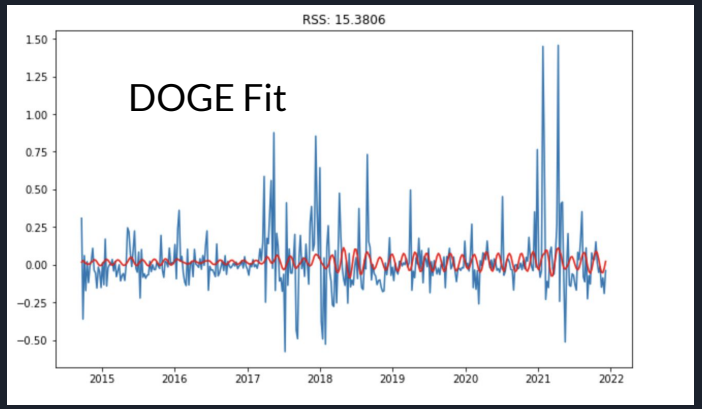
The data we use:

- ✦ Bitcoin monthly data from 2014-10-01 to 2021-11-28 (12 months as lags and rolling window),
- ✦ Ethereum monthly data from 2015-09-01 to 2021-12-06 (12 months as lags and rolling window),
- ✦ Dogecoin weekly from 2012-09-15 to 2021-12-06 (12 weeks as lags and rolling window)

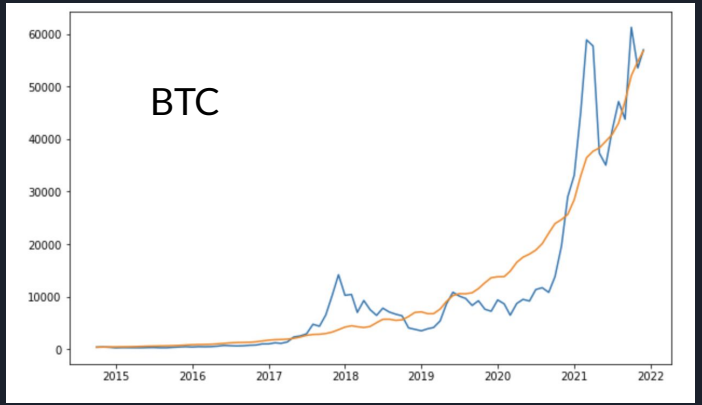
ARIMA model Fit

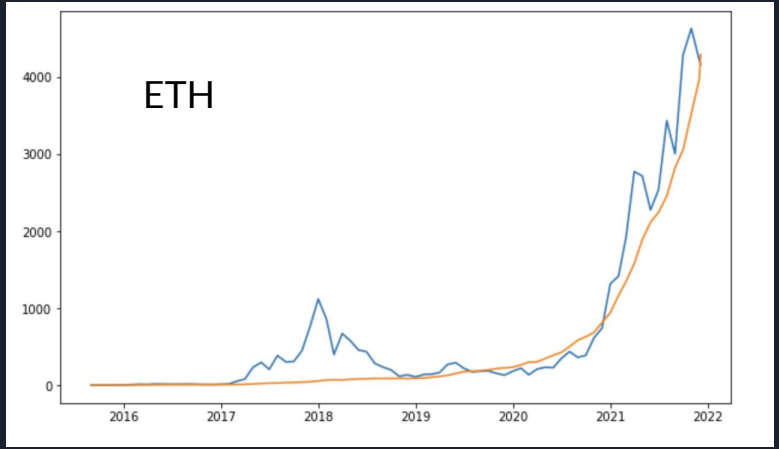


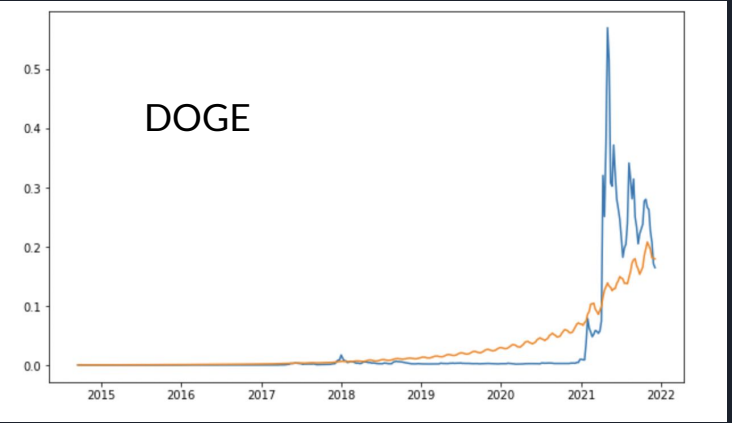




ARIMA model prediction

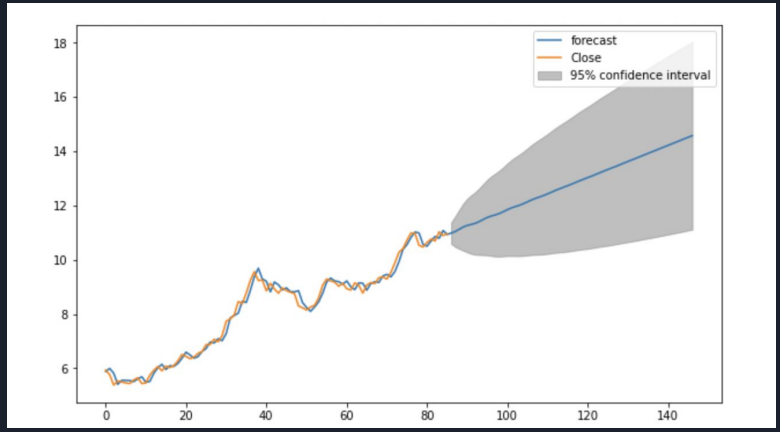


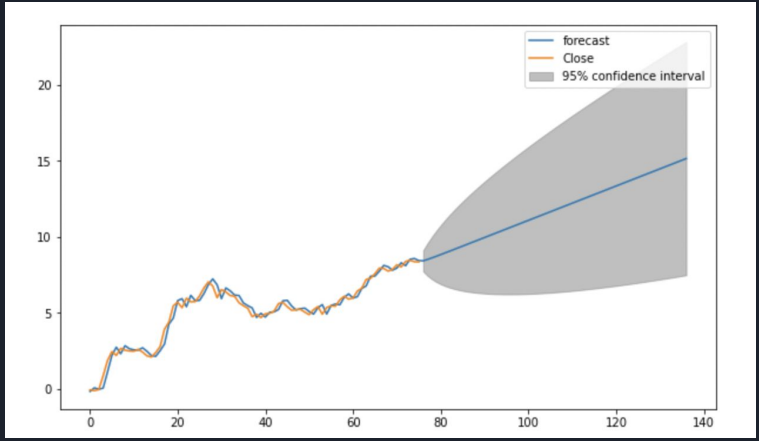




ARIMA model forecasting

Based on our ARIMA models for each asset, our forecasts suggest that all of these assets will likely continue to attain higher prices, but our 95% confidence intervals suggest that there is still a possibility of a decline in the price of all of these assets.





Conclusion

Objectives:

To assess whether:

- There is evidence of a **statistical relationship over time** between the performance of Fortune 500 stocks and cryptocurrencies.
- Large capitalization **crypto assets provide a hedge** against a broader market downturn.
- Crypto currency assets can be predicted utilizing other assets' price data and time series data

Takeaways:

- There is evidence of a **statistical relationship over time** between the performance of Fortune 500 stocks and cryptocurrencies
    - Especially after an SP500 downturn
- Currently, crypto assets do not provide an effective hedge against broader market downturn
- Our team had success with creating regression and time series models to predict the price of cryptocurrency asset prices