



**AN ANALYSIS OF CRYPTOCURRENCIES AND AN IDEA APPLICABLE VIA SMART  
CONTRACTS**

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FA595: Financial Technology

Spring 2023

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## Part I: Cryptocurrency Ecosystem and Interlinkages

Blockchain technology has been transforming the financial market in various aspects. Specifically, cryptocurrencies have emerged as a new asset class that attracts huge amount of interest and capital investments around the world. The cryptocurrency industry is growing at a staggering pace. There are currently over 21,000 different coins/tokens in existence, across a variety of subsectors. Their total market capitalization is over \$800 billion.

In part 1 of this project, your group surveys a subset of cryptocurrency market and the blockchain ecosystem. Your group also performs simple empirical analysis on the interlinkages among various cryptocurrency assets and blockchain systems.

1. Choose five cryptocurrencies of your group's interest. When choosing the five cryptocurrencies, make sure that they all have daily price data from January 1, 2022 to December 31, 2022 on Yahoo Finance. You will need these data to perform analysis.

a) Visually inspect your data and make sure that there is no missing data during the sample period.

For this report, we've selected the following five cryptocurrencies:

Name	Symbol
Bitcoin USD	BTC-USD
Litecoin USD	LTC-USD
Gridcoin USD	GRC-USD
Dogecoin USD	D-USD
Peercoin USD	PPC-USD

In the table above, the left column lists the names of the five cryptocurrencies, and the right column represents the symbol for each cryptocurrency.

For the data analysis portion of this research report, we've decided to utilize R, a programming language for statistical computing and graphics. Using the quantmod package in R, we downloaded Bitcoin's, Litecoin's, Gridcoin's, Dogecoin's, and Peercoin's historical data from January 1, 2022 to December 31, 2022 on Yahoo Finance. In order to check for missing values in our data frame, we decided to install the dplyr package and use the summary() function which is used to calculate the summary statistics for variables. If there are any "NA" values present in the

data frame, the function `summary()` will return the number of missing values found in each variable. The summary function in R returned the following results:

```
> summary(coindata)
      Index      Bitcoin      Litecoin      Gridcoin      Dogecoin
Min.   :2022-01-01  Min.   :15787    Min.   : 43.30    Min.   :0.002935  Min.   :0.05301
1st Qu.:2022-04-02  1st Qu.:19547    1st Qu.: 56.03    1st Qu.:0.005369  1st Qu.:0.06718
Median :2022-07-02  Median :23165    Median : 66.15    Median :0.007054  Median :0.08458
Mean   :2022-07-02  Mean   :28198    Mean   : 80.09    Mean   :0.007295  Mean   :0.09794
3rd Qu.:2022-10-01  3rd Qu.:39105    3rd Qu.:107.00    3rd Qu.:0.009233  3rd Qu.:0.13277
Max.   :2022-12-31  Max.   :47687    Max.   :151.67    Max.   :0.013684  Max.   :0.18510

      Peercoin
Min.   :0.2351
1st Qu.:0.3600
Median :0.4484
Mean   :0.4615
3rd Qu.:0.5518
Max.   :0.7903
```

From the summary statistics of the five variables, we note that there are no missing values in our data (there are no “NA” values reported by R). To further examine our data for missing values, we used both `head()` and `tail()` functions in R. We coded the `head()` function to display the first 10 rows of the data, as well as the `tail()` function to show the last 10 rows of the data. The following is the head of our five cryptocurrencies:

```
> head(coindata, n=10)
      Bitcoin Litecoin Gridcoin Dogecoin Peercoin
2022-01-01 47686.81 150.6974 0.010443 0.173035 0.790275
2022-01-02 47345.22 151.2555 0.010260 0.174403 0.761727
2022-01-03 46458.12 148.4616 0.009988 0.170088 0.763410
2022-01-04 45897.57 146.8123 0.010025 0.168803 0.758668
2022-01-05 43569.00 136.0891 0.009236 0.159420 0.723560
2022-01-06 43160.93 136.5038 0.008381 0.160213 0.718513
2022-01-07 41557.90 131.4884 0.008505 0.155023 0.681019
2022-01-08 41733.94 130.1375 0.008597 0.151954 0.697357
2022-01-09 41911.60 131.2983 0.009346 0.151065 0.709431
2022-01-10 41821.26 126.8338 0.008774 0.143359 0.675649
```

And the image below shows us the tail of our data:

```
> tail(coindata, n=10)
      Bitcoin Litecoin Gridcoin Dogecoin Peercoin
2022-12-22 16830.34  66.15167  0.006637  0.076967  0.369764
2022-12-23 16796.95  65.77222  0.006903  0.077129  0.355622
2022-12-24 16847.76  65.77479  0.006815  0.077648  0.352856
2022-12-25 16841.99  69.20627  0.006673  0.075952  0.359783
2022-12-26 16919.80  70.68475  0.006508  0.075783  0.364866
2022-12-27 16717.17  68.74791  0.007020  0.073724  0.360552
2022-12-28 16552.57  66.33907  0.006997  0.070381  0.366425
2022-12-29 16642.34  66.75108  0.007256  0.071042  0.368295
2022-12-30 16602.59  67.99403  0.007693  0.068404  0.367222
2022-12-31 16547.50  69.99622  0.007907  0.070294  0.362524
```

From the two images above, we observe that both the head and tail of our data frame do not contain any missing values. In addition, we confirm the data was stored for the appropriate time period.

b) Detailed overview of each of the cryptocurrencies chosen.

Bitcoin (BTC) is a cryptocurrency, a virtual currency designed to act as money and a form of payment outside the control of any one person, group, or entity, thus removing the need for third-party involvement in financial transactions. Bitcoin was officially launched in January 2009, even though it was invented in 2008.

Litecoin (LTC) is a decentralized digital currency like Bitcoin. It uses the same encryption techniques to transfer and create funds and to confirm transactions. The main difference between Bitcoin and Litecoin is that Litecoin has a larger number of coins that can be created, and it has faster transaction rates. Litecoin started in October 2011.

Gridcoin (GRC) is a cryptocurrency. Among the users of cryptocurrencies, there are many people who volunteer for distributed computing using the BOINC platform. It was created in October 2013.

Dogecoin (DOGE) is an open-source, peer-to-peer cryptocurrency that was made as a parody of the crypto market following the establishment of Bitcoin. It was introduced in December 2013.

Peercoin (PPC) is a decentralized, open-source cryptocurrency that uses a unique algorithm called proof of stake to secure its network. Peercoin is one of the oldest and most successful cryptocurrencies in the world. It was created in August 2012.

c) What is the protocol adopted for each of the cryptocurrency.

Bitcoin (BTC) adopts proof-of-work.

Litecoin (LTC) adopts Segregated Witness (SegWit) protocol. The Litecoin protocol is based on Bitcoin but has some modifications which differentiate it. Namely, the block confirmation time has been reduced from 10 minutes to 2.5 minutes, allowing new blocks to be added to the blockchain faster, with quicker transaction confirmations.

Gridcoin (GRC) adopts proof-of-stake protocol.

Dogecoin (DOGE) adopts proof-of-stake protocol (It transformed from proof-of-work to proof-of-stake.).

Peercoin (PPC) adopts both the proof-of-work and proof-of-stake.

d) Why your group choose these five cryptocurrencies? What interest you in your choices.

We chose these five cryptocurrencies for three main reasons. First of all, we learned about Bitcoin in class and are very familiar with it. The other four cryptocurrencies have different degrees of connection with Bitcoin. This connection greatly stimulates our curiosity. Besides, by systematically studying and comparing these five cryptocurrencies, we can have a deeper understanding and further application of the knowledge learned in class. In addition, we were able to download the complete historical data, for the given sample period, for all five cryptocurrencies using the get Symbols function in R.

Analyze and discuss in detail the following:

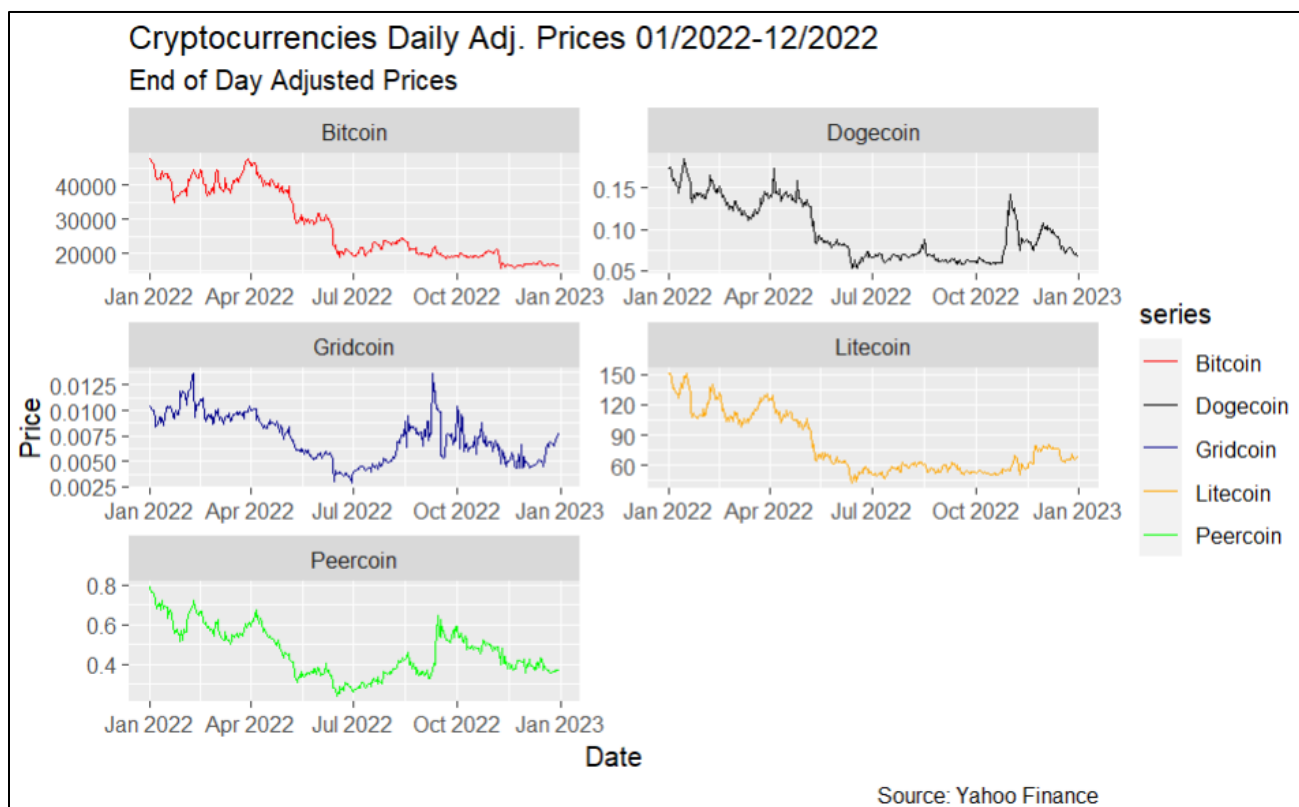
2. Using the cryptocurrency data on Yahoo Finance during time period from January 1, 2022 to December 31, 2022. Plot the daily prices for the five cryptocurrencies.

Hint: You can either plot them in single plot or plot them in five separate plots depending on their comparative price levels.

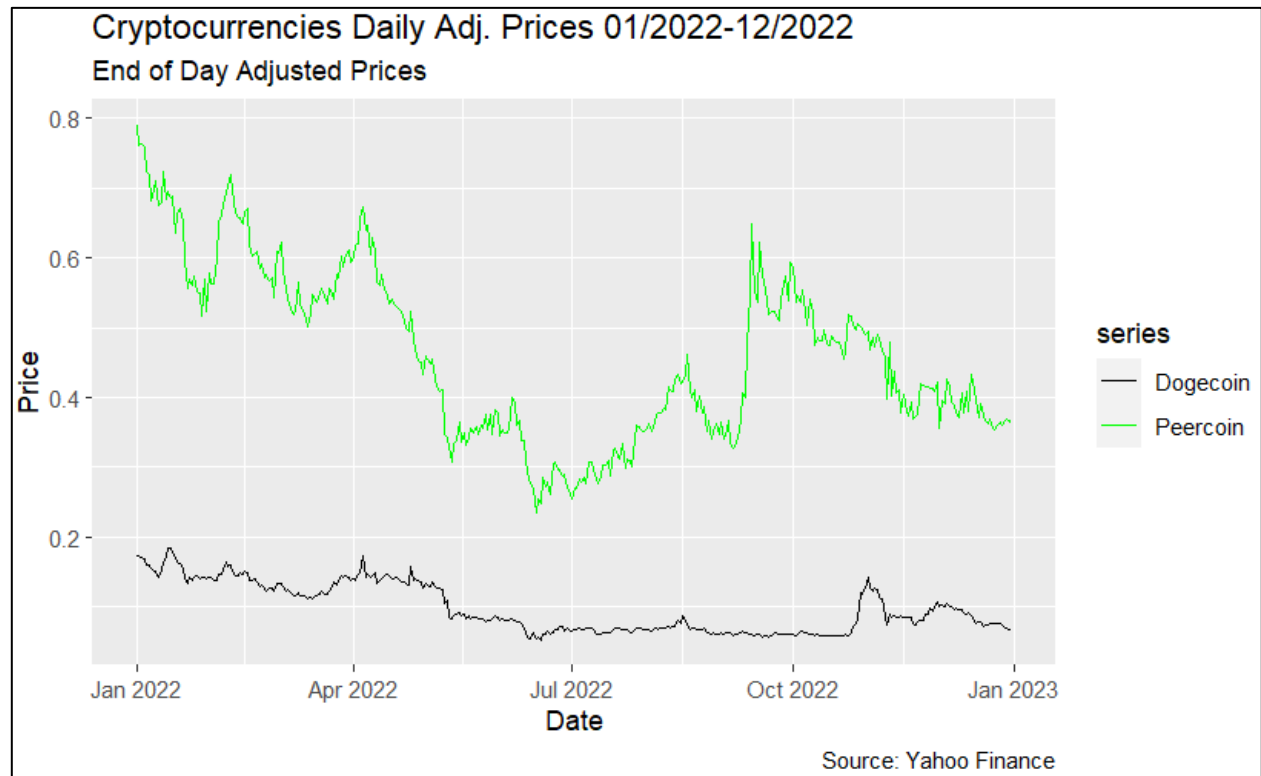
To plot the daily prices for our five cryptocurrencies, we used three different packages in R:

- `ggplot2` for Data Visualization. This plotting package provides helpful commands to create complex plots from data in a data frame.
- `magrittr` as a Forward-Pipe Operator, `%>%`. This operator will forward a value, or the result of an expression, into the next function call/expression.
- `broom` to “tidy the data”. This package is used for tidying statistical models into data frames.

First, we plotted all five cryptocurrencies adjusted close prices to observe any comparative price level:



From the graph above, we found a comparative price level between Peercoin and Dogecoin, so we re-plotted the 2 cryptocurrencies on a separate graph:



3. Comment on the price trends from your plots. What can you conclude from the price variations?

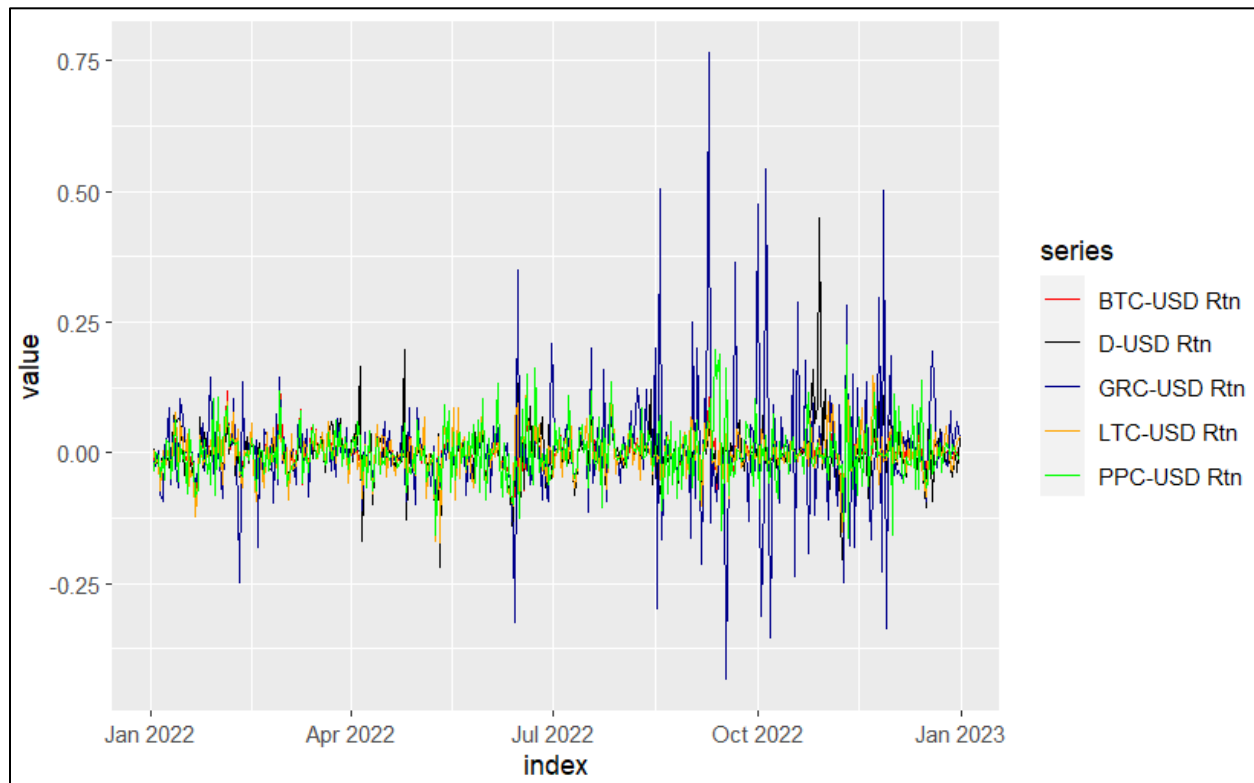
Overall, there is a strong correlation between them. Specifically, the prices of all five cryptocurrencies are on a downtrend throughout 2022. Among them, the price fluctuation charts of some cryptocurrencies have high consistency, such as Bitcoin and Litecoin.

4. Compute daily returns from the five cryptocurrencies' prices, then calculate standard deviations during the sample period. Which cryptocurrency has the highest variation? And which one has the lowest variation? Explain why their variation differs?

To compute the daily returns from the five cryptocurrencies' prices, we used the function `Return.calculate()` with a `[-1]` at the end. We then used `head()` to view the first ten rows of our data:

	BTC-USD Rtn	LTC-USD Rtn	GRC-USD Rtn	D-USD Rtn	PPC-USD Rtn
2022-01-02	-0.007163275	0.003703182	-0.017523700	0.007905915	-0.036124134
2022-01-03	-0.018736877	-0.018471389	-0.026510721	-0.024741547	0.002209453
2022-01-04	-0.012065555	-0.011109324	0.003704445	-0.007554913	-0.006211603
2022-01-05	-0.050734061	-0.073040038	-0.078703242	-0.055585505	-0.046275841
2022-01-06	-0.009366159	0.003047070	-0.092572542	0.004974282	-0.006975234
2022-01-07	-0.037140705	-0.036741362	0.014795370	-0.032394375	-0.052182772
2022-01-08	0.004235995	-0.010274416	0.010817166	-0.019797062	0.023990520
2022-01-09	0.004256970	0.008920128	0.087123415	-0.005850455	0.017313944
2022-01-10	-0.002155485	-0.034002726	-0.061202654	-0.051011154	-0.047618444
2022-01-11	0.021869109	0.037144343	0.061773421	0.070033971	0.006451575

Plot of the daily returns:





We then used the function `sapply()` to compute the volatility and the annualized volatility for the daily returns, over the given sample period:

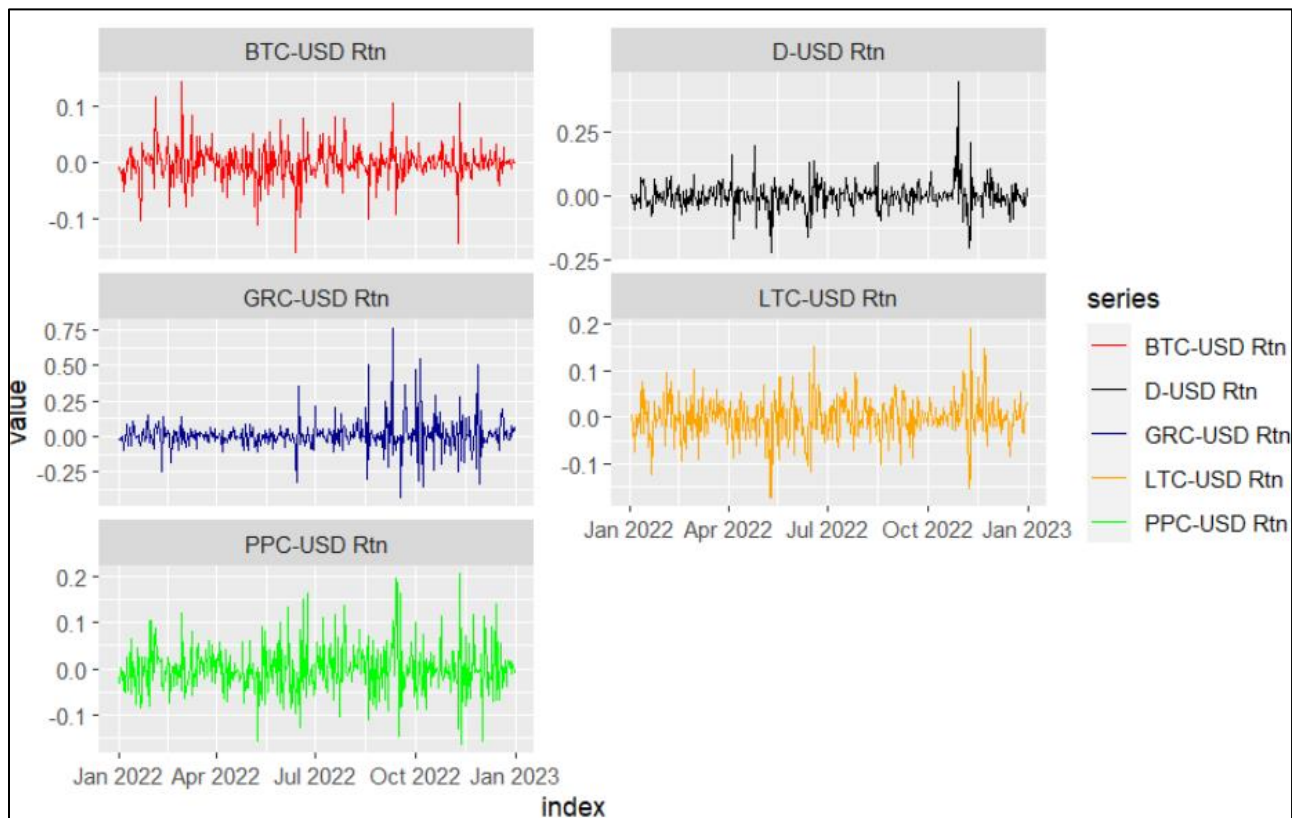
```
> vol
BTC-USD Rtn LTC-USD Rtn GRC-USD Rtn D-USD Rtn PPC-USD Rtn
0.03326190 0.04503774 0.11260409 0.05634327 0.05513586
> annualized_vol
BTC-USD Rtn LTC-USD Rtn GRC-USD Rtn D-USD Rtn PPC-USD Rtn
0.5280162 0.7149520 1.7875345 0.8944217 0.8752546
```

Note that we computed both volatility and annualized volatility ( $\text{volatility} \times \sqrt{252}$ , where 252 corresponds to the number of trading days per year). Using `rank()` function in R, we then ranked the five cryptocurrencies' volatilities to find out which ones had the highest and lowest volatilities:

```
> rank(vol)
BTC-USD Rtn LTC-USD Rtn GRC-USD Rtn D-USD Rtn PPC-USD Rtn
1 2 5 4 3
> rank(annualized_vol)
BTC-USD Rtn LTC-USD Rtn GRC-USD Rtn D-USD Rtn PPC-USD Rtn
1 2 5 4 3
```

From the table above, we observe that “BTC-USD Rtn” is ranked the least volatile, and “GRC-USD Rtn” is the most volatile.

To look at why their variation differs we plotted the daily returns for the five cryptocurrencies on the same axis:



From the plotted daily returns, we note that Bitcoin Daily Price Returns (“BTC Rtn”) swing very little and remain closely around the mean return price, indicating low volatility of an asset. The graph of the Gridcoin Price Returns (“GRC Rtn”), on the other hand, is characterized by big swings in both positive and negative directions, indicating greater volatility in price returns.

Since cryptocurrency prices fluctuate based on supply and demand, investor and user sentiments, government regulations, and media hype. All these factors work together to create price volatility. We could stipulate that Bitcoin is less volatile than Gridcoin and other cryptocurrencies because it has been established for longer and is more appealing to investors.

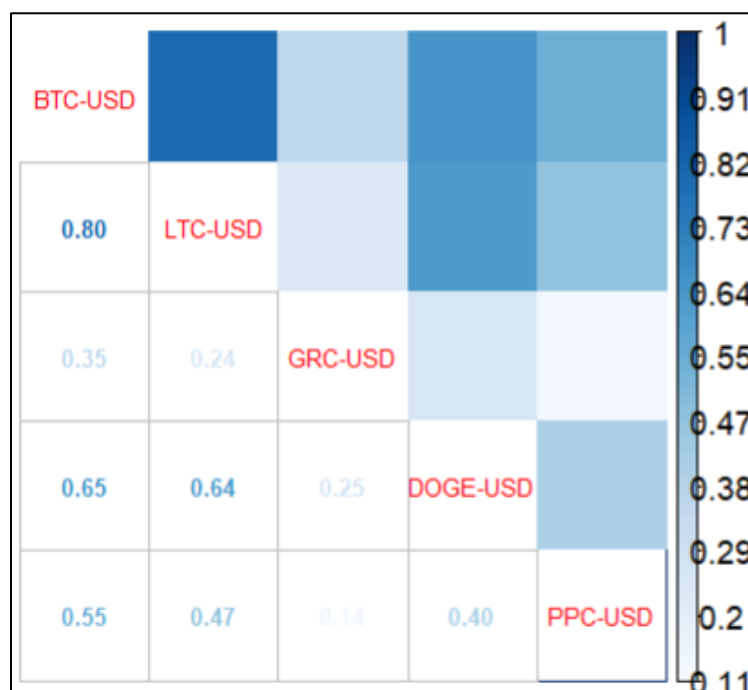
5. Generate a correlation matrix using the five cryptocurrencies' daily returns. What can you conclude from the correlation matrix?

To generate a correlation matrix using the five cryptocurrencies' daily returns, we used the function `cor()` in R, and generated the following correlation matrix:

> cor>Returns						
	BTC-USD Rtn	LTC-USD Rtn	GRC-USD Rtn	D-USD Rtn	PPC-USD Rtn	
BTC-USD Rtn	1.0000000	0.8002019	0.3460760	0.6497345	0.5541583	
LTC-USD Rtn	0.8002019	1.0000000	0.2424668	0.6360655	0.4689038	
GRC-USD Rtn	0.3460760	0.2424668	1.0000000	0.2547499	0.1362374	
D-USD Rtn	0.6497345	0.6360655	0.2547499	1.0000000	0.3999603	
PPC-USD Rtn	0.5541583	0.4689038	0.1362374	0.3999603	1.0000000	

From this correlation matrix we can clearly see how much the correlation between each two cryptocurrencies is. Obviously, “BTC-USD” and “LTC-USD” have the highest correlation and their correlation is about 0.8. “PPC-USD” and “GRC-USD” have the lowest correlation and their correlation is about 0.136.

Additionally, we also computed a correlation chart for better visualization:



From the correlation chart, we can get the same conclusion as the correlation matrix. We know that the darker the color, the stronger the correlation. The darkest colored number is 0.8. It represents “BTC-USD” and “LTC-USD” have the highest correlation and their correlation is about 0.8. The lightest colored number is 0.14. It represents “PPC-USD” and “GRC-USD” have the lowest correlation and their correlation is about 0.14. Finally, we conclude that all five cryptocurrencies have some level of correlation with each other, but some seem more correlated than others.

6. Note that there is the news of failure of FTX in mid-November 2022 that impacts the cryptocurrency market tremendously. Specifically, on November 11, FTX files for bankruptcy and Bankman-Fried steps down. Do you observe the FTX impact in mid-November 2022 in your dataset? How much does the five cryptocurrencies’ prices decrease/increase on November 11, 2022? And much does the five cryptocurrencies’ prices decrease/increase in November 2022?

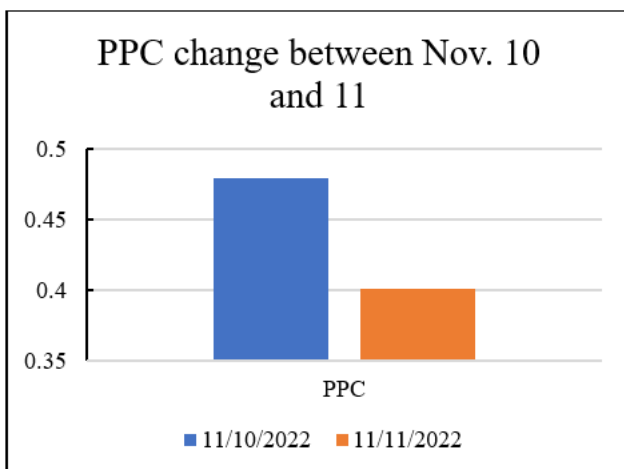
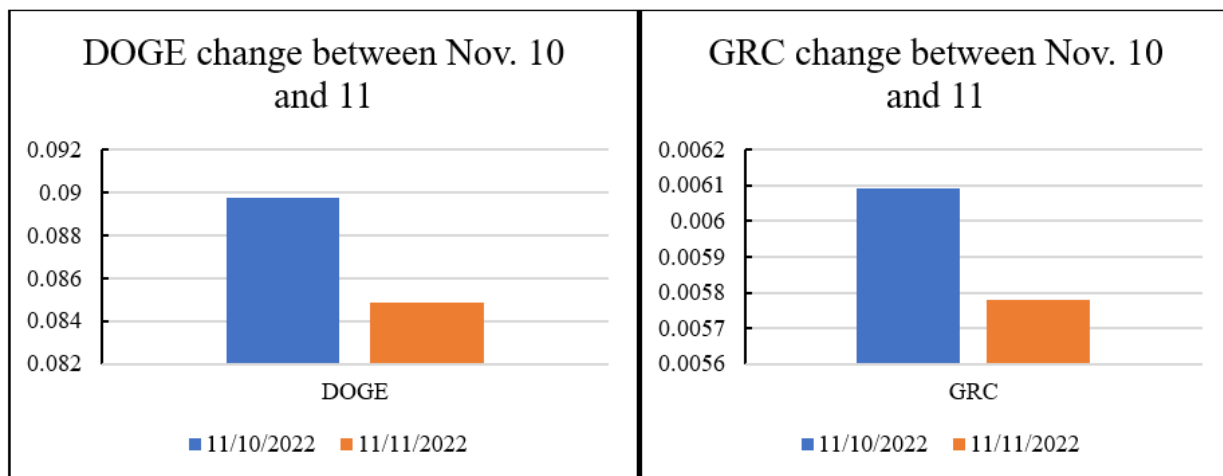
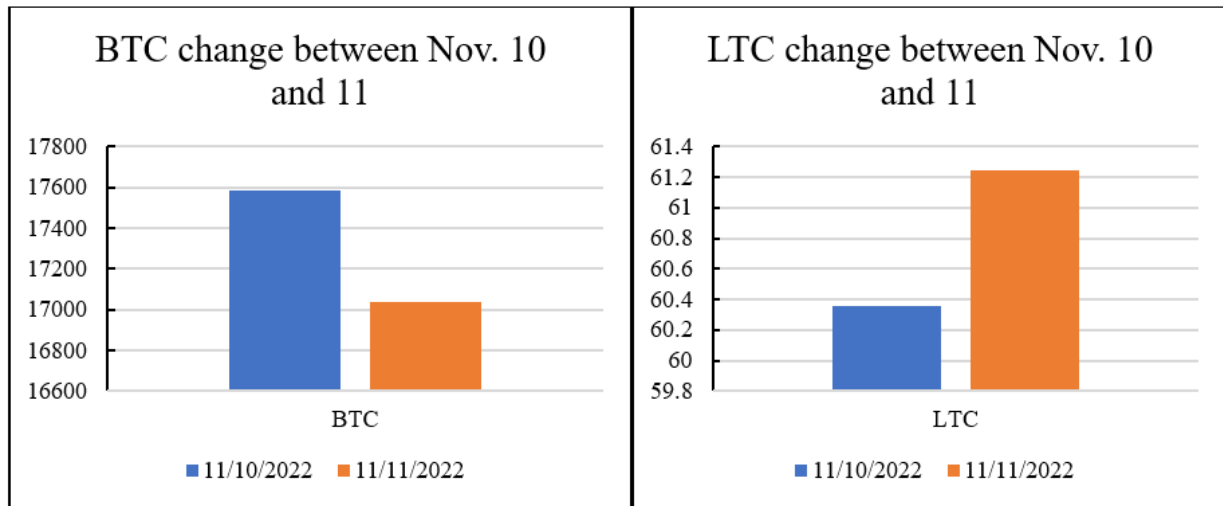
Yes, the FTX have a big impact on our research subjects in mid-November 2022. Specifically, among the cryptocurrencies of Bitcoin, Litecoin, Gridcoin, Dogecoin and Peercoin, except for Litecoin, the prices of the other four have dropped significantly. It is worth mentioning that the trading volume of all five cryptocurrencies has dropped.

Date	BTC volume	LTC volume	GRC volume	DOGE volume	PPC volume
11/11/2022	55,871,616,488	1,292,495,839	33,567	1,305,192,050	7,314
11/10/2022	83,202,283,721	1,623,775,451	34,576	2,421,832,556	10,573
change	-27,330,667,233	-331,279,612	-1,009	-1,116,640,506	-3,259
rate of change	-32.85%	-20.40%	-2.92%	-46.11%	-30.82%

The five cryptocurrencies’ prices decrease/increase on November 11, 2022:

Date	BTC	LTC	GRC	DOGE	PPC
11/10/2022	17586.77	60.3611	0.00609	0.08979	0.48002
11/11/2022	17034.29	61.2423	0.00578	0.08489	0.40157
growth quantity	-552.4785	0.8812	-0.0003	-0.0049	-0.0785
growth rate	-3.14%	1.46%	-5.17%	-5.46%	-16.34%

The FTX impacted the five cryptocurrencies on November 11, 2022. On November 11, 2022, except for Litecoin, the prices of the other four cryptocurrencies have all dropped to varying degrees. From the growth rate data, it has the least impact on Bitcoin and the greatest impact on Peercoin.



In order to see the changes in the two days between the 10th and the 11th more clearly, we create the chart. Obviously, we can get the same conclusion as the table.

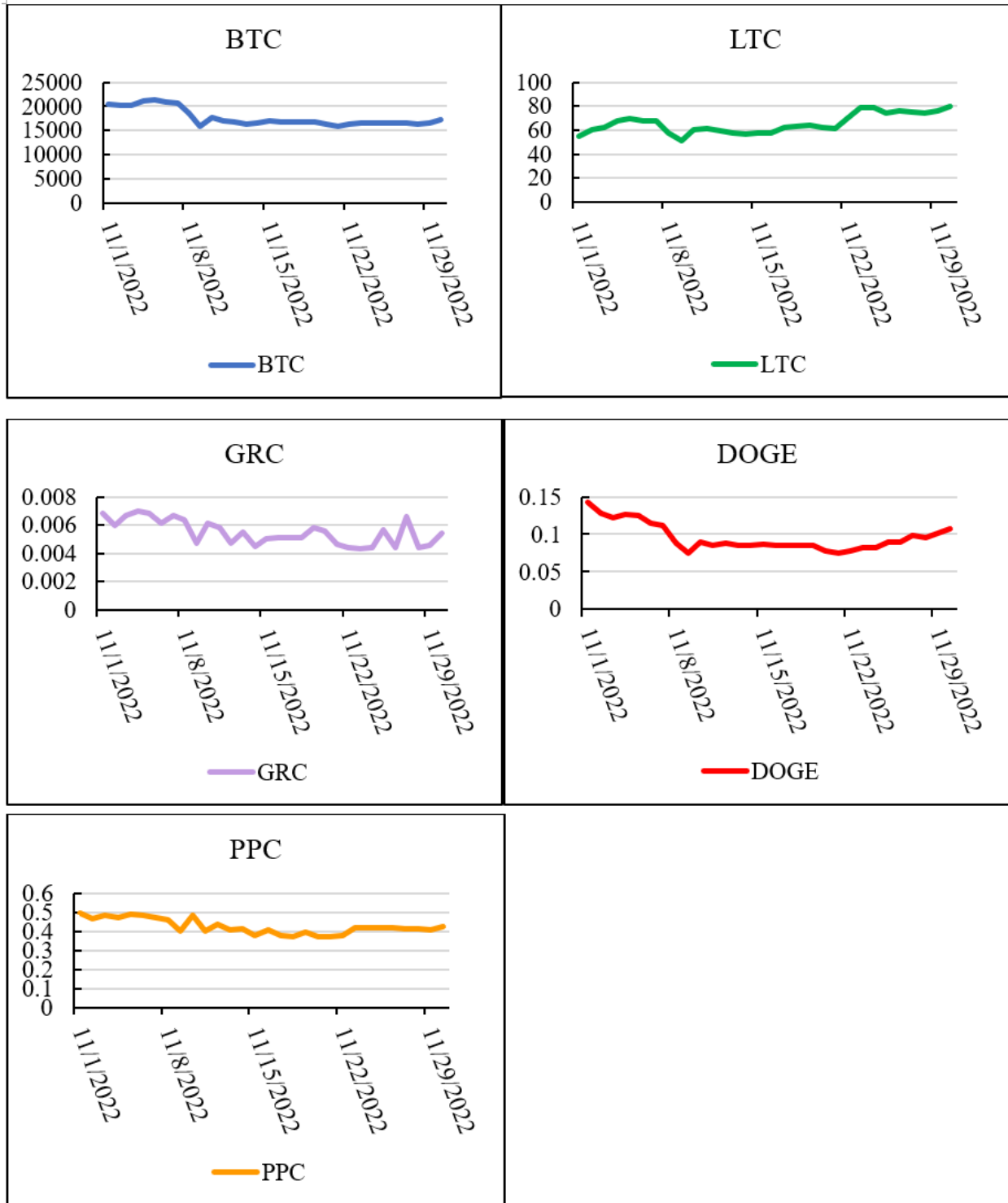
After analyzing the FTX impact on the 11th, we will analyze the impact of it on these five cryptocurrencies throughout November. From the table below, we see that most growth quantity of these five cryptocurrencies is negative. Even Litecoin, the least affected, had 15 days of negative growth in November. The four other cryptocurrencies have more days of negative growth. The five cryptocurrencies' prices decrease/increase in November 2022:

	growth quantity						growth quantity				
Date	BTC	LTC	GRC	DOGE	PPC	Date	BTC	LTC	GRC	DOGE	PPC
11/2/2022	-325.77	5.43128	-0.0009	-0.0147	-0.0256	11/16/2022	-215.17	-0.4908	2.9E-05	-0.0014	0.02637
11/3/2022	50.4844	1.36285	0.00066	-0.0052	0.01762	11/17/2022	18.0781	4.96769	3.8E-05	-0.0008	-0.0257
11/4/2022	937.242	5.67528	0.00035	0.00369	-0.013	11/18/2022	10.2598	0.15965	-7E-06	-9E-05	-0.0057
11/5/2022	135.461	2.1246	-0.0002	-0.0019	0.01728	11/19/2022	13.7695	1.16863	0.00069	-9E-05	0.01982
11/6/2022	-356.21	-1.6351	-0.0007	-0.0098	-0.006	11/20/2022	-419.71	-1.8101	-0.0002	-0.0074	-0.0247
11/7/2022	-323.67	-0.4338	0.00056	-0.0033	-0.0148	11/21/2022	-504.55	-0.6288	-0.0009	-0.0025	0.00424
11/8/2022	-2061.5	-10.26	-0.0003	-0.0229	-0.011	11/22/2022	402.485	9.06931	-0.0002	0.00378	0.0035
11/9/2022	-2660.5	-6.7332	-0.0016	-0.0141	-0.06	11/23/2022	420.938	8.55727	-7E-05	0.0033	0.04365
11/10/2022	1705.99	9.70248	0.00134	0.0155	0.08191	11/24/2022	-6.2422	-0.1699	3.4E-05	-0.0003	-0.0039
11/11/2022	-552.48	0.88123	-0.0003	-0.0049	-0.0785	11/25/2022	-82.623	-4.8012	0.0013	0.00799	-0.0002
11/12/2022	-235.11	-1.3867	-0.001	0.00315	0.03573	11/26/2022	-57.561	2.34399	-0.0013	-0.0005	-0.0008
11/13/2022	-445.82	-2.3684	0.00071	-0.0031	-0.0308	11/27/2022	-19.654	-1.3286	0.00221	0.00972	-0.0029
11/14/2022	264.834	-0.941	-0.001	0.00099	0.00534	11/28/2022	-227.3	-0.9241	-0.0022	-0.0036	-0.0006
11/15/2022	266.414	1.46106	0.00056	0.00109	-0.0329	11/29/2022	227.66	1.86355	0.00016	0.00673	-0.0033
						11/30/2022	723.584	3.31394	0.00085	0.00501	0.01315

From the growth rate table below, the left is for the first half of November and the right is for the second half of November. We see the rate of change in the right table is smaller than that in the left one, especially after the 11th. It indicates the enthusiasm of the cryptocurrency market has decreased.

growth rate						growth rate					
Date	BTC	LTC	GRC	DOGE	PPC	Date	BTC	LTC	GRC	DOGE	PPC
11/2/2022	-1.59%	9.85%	-12.93%	-10.34%	-5.18%	11/16/2022	-1.27%	-0.85%	0.57%	-1.60%	6.96%
11/3/2022	0.25%	2.25%	11.02%	-4.10%	3.76%	11/17/2022	0.11%	8.64%	0.75%	-0.96%	-6.34%
11/4/2022	4.64%	9.17%	5.33%	3.01%	-2.68%	11/18/2022	0.06%	0.26%	-0.14%	-0.11%	-1.49%
11/5/2022	0.64%	3.14%	-2.85%	-1.50%	3.66%	11/19/2022	0.08%	1.87%	13.54%	-0.11%	5.30%
11/6/2022	-1.67%	-2.35%	-10.23%	-7.86%	-1.22%	11/20/2022	-2.51%	-2.84%	-3.55%	-8.76%	-6.28%
11/7/2022	-1.55%	-0.64%	9.10%	-2.89%	-3.07%	11/21/2022	-3.10%	-1.01%	-16.55%	-3.19%	1.15%
11/8/2022	-10.01%	-15.17%	-4.78%	-20.57%	-2.34%	11/22/2022	2.55%	14.78%	-5.18%	5.06%	0.94%
11/9/2022	-14.35%	-11.73%	-24.94%	-15.97%	-13.10%	11/23/2022	2.60%	12.15%	-1.58%	4.20%	11.59%
11/10/2022	10.74%	19.15%	28.11%	20.87%	20.57%	11/24/2022	-0.04%	-0.22%	0.78%	-0.37%	-0.92%
11/11/2022	-3.14%	1.46%	-5.17%	-5.46%	-16.34%	11/25/2022	-0.50%	-6.09%	29.61%	9.81%	-0.04%
11/12/2022	-1.38%	-2.26%	-17.74%	3.72%	8.90%	11/26/2022	-0.35%	3.17%	-22.83%	-0.54%	-0.18%
11/13/2022	-2.65%	-3.96%	15.04%	-3.57%	-7.05%	11/27/2022	-0.12%	-1.74%	50.32%	10.93%	-0.70%
11/14/2022	1.62%	-1.64%	-17.94%	1.16%	1.31%	11/28/2022	-1.38%	-1.23%	-33.55%	-3.64%	-0.15%
11/15/2022	1.60%	2.58%	12.53%	1.27%	-7.99%	11/29/2022	1.40%	2.51%	3.69%	7.08%	-0.80%
						11/30/2022	4.40%	4.36%	18.60%	4.92%	3.22%





From the chart above, we know that the second half of November has more stable prices than those in the first half of November. There are no clear up and down trends, especially Bitcoin, Grid coin, and Peercoin.

Date	BTC	LTC	GRC	DOGE	PPC
1th vs 30th growth quantity	-3316.7	24.1705	-0.0015	-0.0357	-0.0716
1th vs 30th growth rate	-16.19%	43.85%	-21.45%	-25.05%	-14.50%

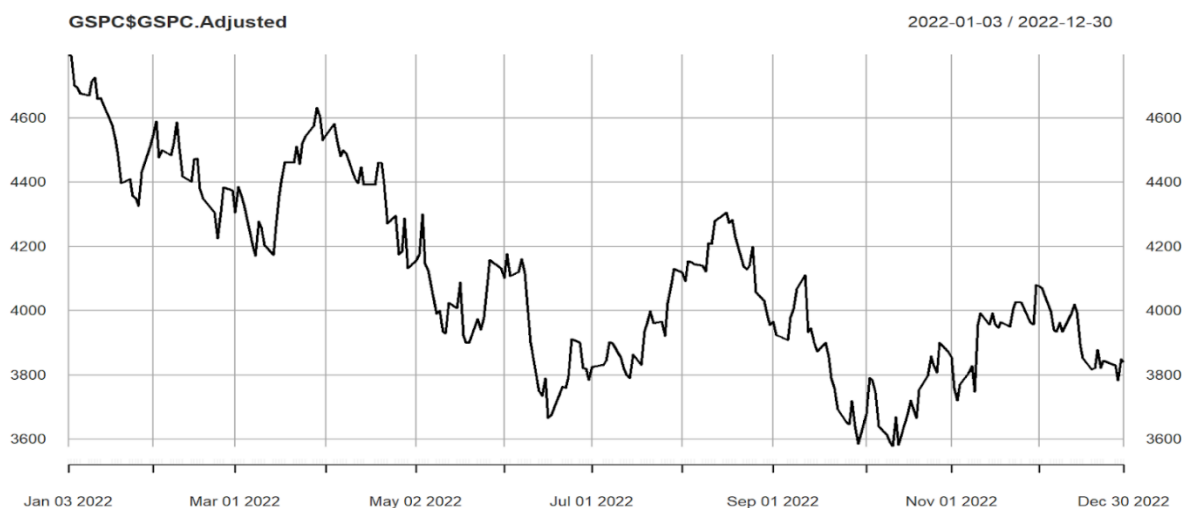
By comparing the first day and the last day of November, we are surprised these five cryptocurrencies have changed so much in these 30 days. The growth rate of Bitcoin has dropped by 16.19%, even though it is always stable in price.

7. Add S&P 500 index (^GSPC) from Yahoo Finance in the above analysis during time period from January 1, 2022 to December 31, 2022. Repeat the analysis in Questions 2 through 6 for the market index (S&P 500 index (^GSPC)). Your analysis should **include but not limited** to the following:

a) Compute the daily prices, daily returns, standard deviations for the market index (S&P 500 index (^GSPC)).

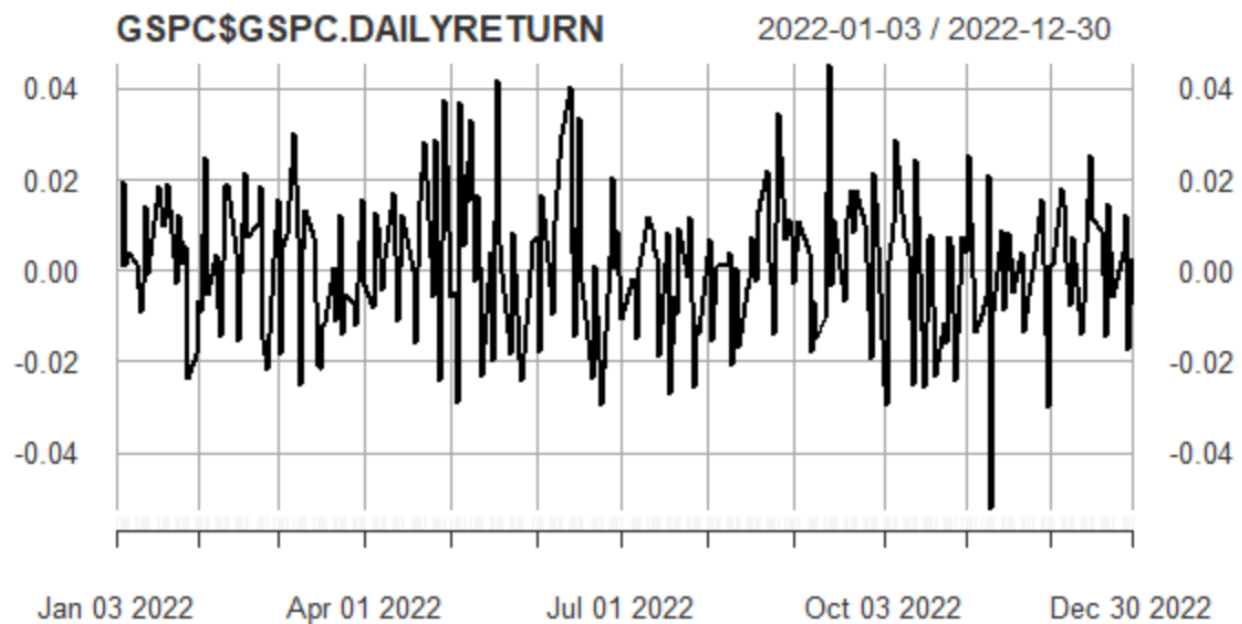
```
> head(GSPC)
```

```
      GSPC.Open GSPC.High GSPC.Low GSPC.Close GSPC.Volume
[1,]    4778.14    4796.64    4758.17    4796.56    3831020000
[2,]    4804.51    4818.62    4774.27    4793.54    4683170000
[3,]    4787.99    4797.70    4699.44    4700.58    4887960000
[4,]    4693.39    4725.01    4671.26    4696.05    4295280000
[5,]    4697.66    4707.95    4662.74    4677.03    4181510000
```



The highest price of SP500 in year 2022 is 4797 and the lowest is 3577. Median is 4027 and the average is 4099.

```
GSPC.Adjusted
Min.      :3577
1st Qu.   :3861
Median    :4027
Mean      :4099
3rd Qu.   :4339
Max.      :4797
```

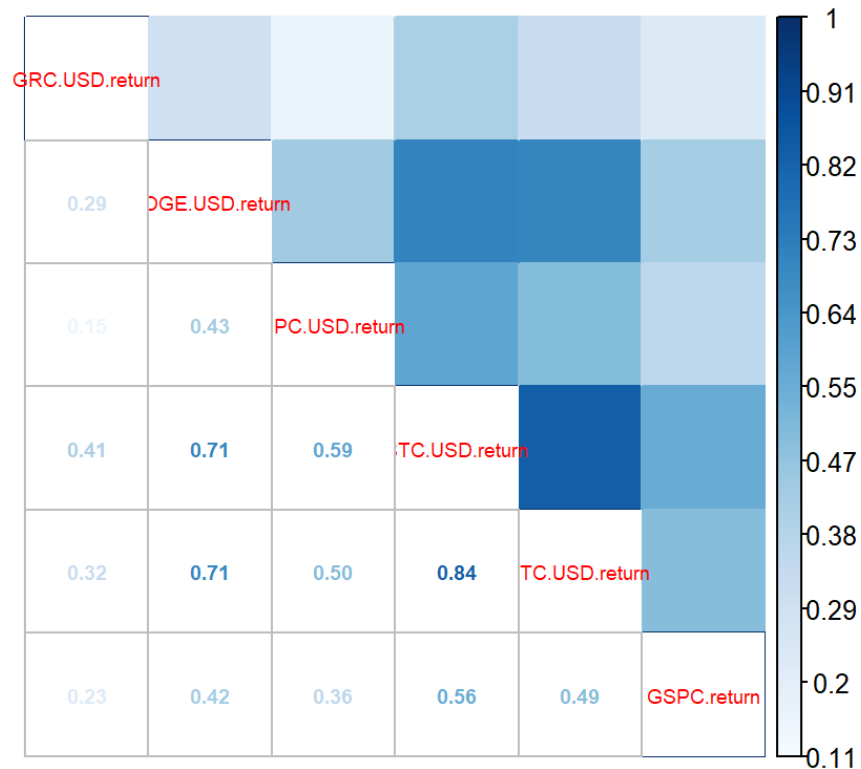


```
GSPC.Adjusted
Min.      :-0.0432366
1st Qu.   :-0.0100364
Median    :-0.0016088
Mean      :-0.0007739
3rd Qu.   : 0.0095052
Max.      : 0.0554345
```

The highest return of SP500 is 5.5% and the lowest is -4.3%. The average return is 0.07%.

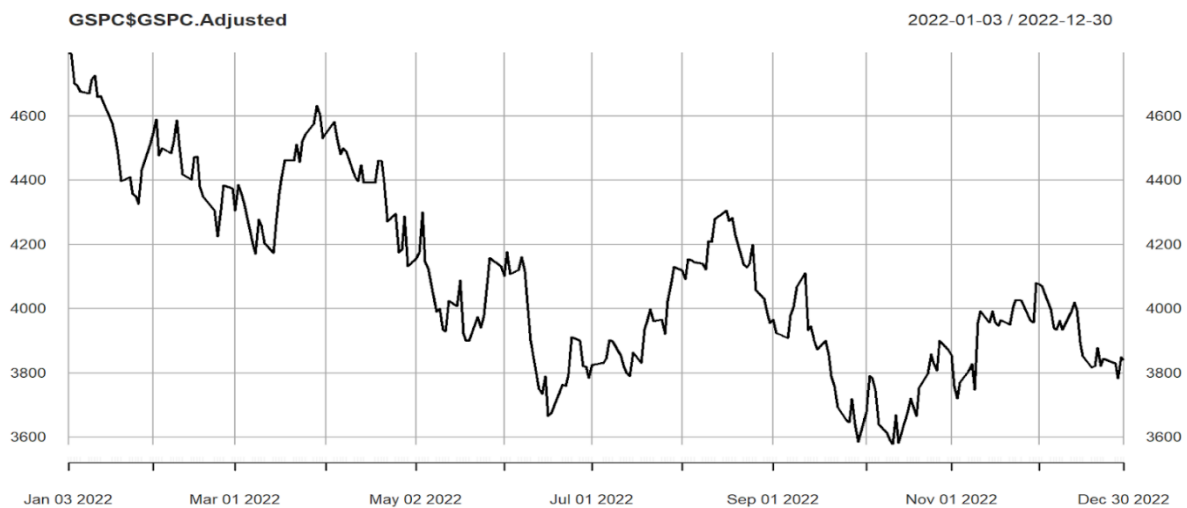
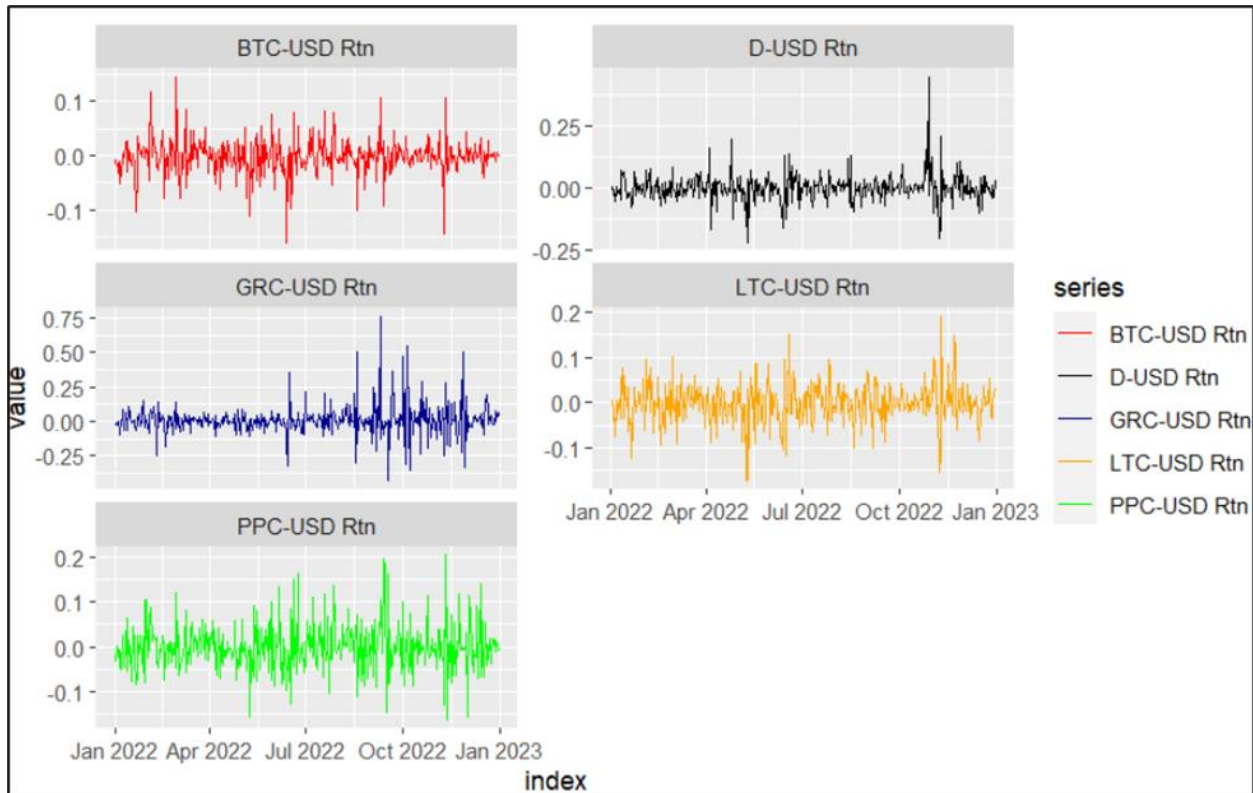
vars	n	mean	sd	median	trimmed	mad	min	max	range	skew	kurtosis	se
1	250	-0.0007739197	0.01525174	-0.001608806	-0.0007327539	0.01405321	-0.04323661	0.05543448	0.0986711	0.04971434	0.32221	0.0009646048

b) Recompute the correlation matrix by including the market index (S&P 500 index (^GSPC)).

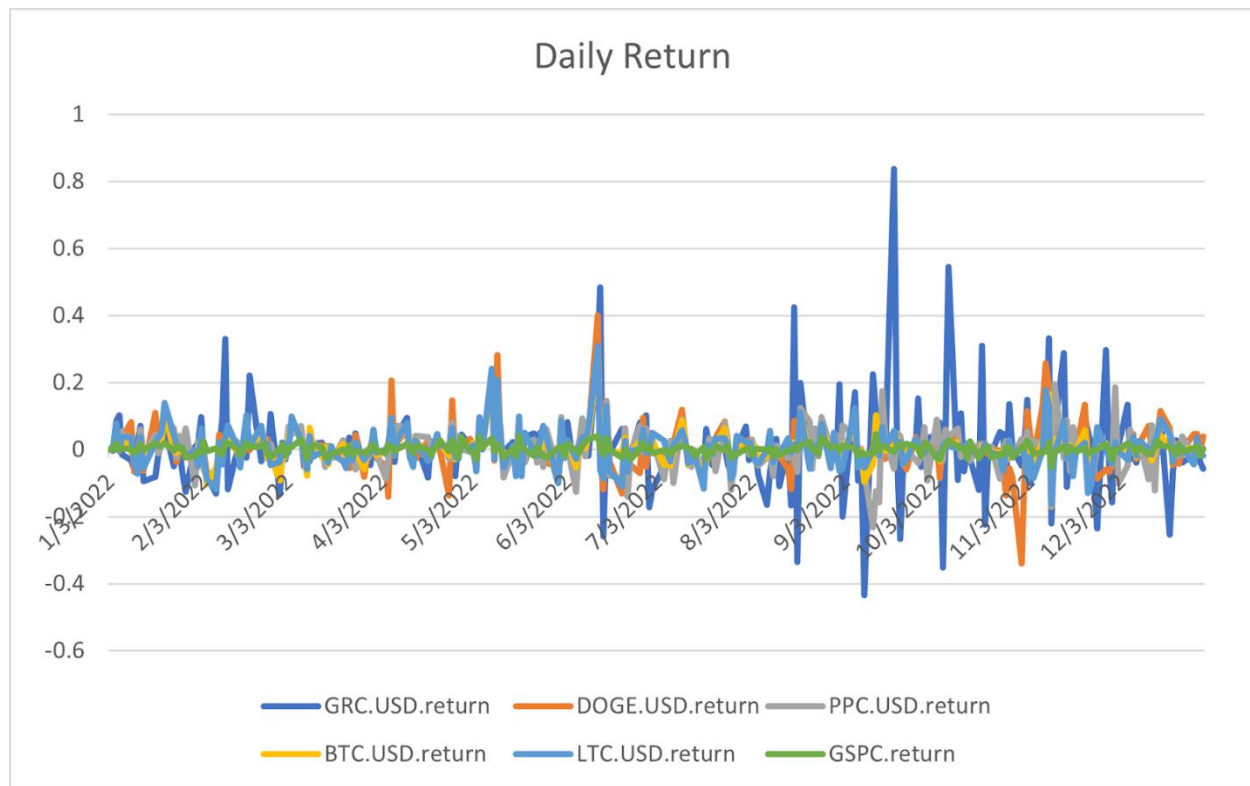


From the plot, GSPC has a relatively high correlation with Bitcoin. Gridcoin has a relatively high correlation with Bitcoin. Therefore, Gridcoin also has a high correlation with GSPC. Litecoin has the least correlation with Gridcoin. And all cryptocurrencies have a positive correlation with the market index.

c) How do the five cryptocurrencies' daily prices, daily returns, standard deviations compare with those of the market index (S&P 500 index (^GSPC)).



The daily price of SP500 shows a downward trend. Dogecoin has more volatility. Litecoin shows an upward trend.



Based on the daily return plot, we can see the return of Peercoin has the most volatility.

Compared to other cryptocurrencies.

	vars <dbl>	n <dbl>	mean <dbl>	sd <dbl>	median <dbl>	trimmed <dbl>	mad <dbl>	min <dbl>	max <dbl>	range <dbl>	skew <dbl>	kurtosis <dbl>	se <dbl>
Bitcoin	1	250	0	0.00	0	0	0.00	-0.01	0.01	0.02	0.33	1.61	0
Litecoin	2	250	0	0.02	0	0	0.01	-0.05	0.05	0.10	-0.10	0.52	0
Gridcoin	3	250	0	0.02	0	0	0.02	-0.09	0.05	0.14	-0.48	2.24	0
Dogecoin	4	250	0	0.01	0	0	0.01	-0.06	0.04	0.10	-0.75	1.94	0
Peercoin	5	250	0	0.02	0	0	0.02	-0.14	0.10	0.23	-0.76	6.24	0
GSPC	6	250	0	0.02	0	0	0.01	-0.04	0.06	0.10	0.05	0.32	0

d) How do the five cryptocurrencies react to the FTX failure compared to the market index (S&P 500 index (^GSPC)).

We can see after that FTX event happened on Nov.11th, SP500 experienced a rise compared to the five cryptocurrencies. Because correlation does not necessarily imply causation, it's possible that the up trend in the S&P 500 was not directly related to the failure of FTX or the addition of cryptocurrencies to a portfolio.

e) What can you conclude by including the market index (S&P 500 index (^GSPC)) into your analysis.

Though SP500 has a positive correlation with most cryptocurrencies, it still can play an important role to diversify the unsystematic risk when things like FTX happen.

8. What do you learn from the analysis from Part I of this project?

No matter in terms of the daily prices, daily returns, standard deviations or the daily prices, daily returns, standard deviations for the market index, Bitcoin price fluctuations are the smallest, so it can be concluded that people are more enthusiastic about Bitcoin than the other four cryptocurrencies. However, they are all heavily influenced by the news of the failure of FTX in mid-November 2022. Obviously, the S&P 500 is a very important index to study these crypto assets. It has a positive correlation with most cryptocurrencies, and it still can play an important role to diversify the unsystematic risk when things like FTX happen.

## **Part II: A Business Idea to be Implemented on the Blockchain**

9. Each group must propose a business idea. The business idea should be technically feasible for implementation via smart contracts on the Ethereum blockchain. Your business idea proposal must answer the following questions:

- a) Who are the target consumers for your business proposal?
- b) What is the closest existing competitor to your idea?
- c) Given the competitors, why would your target consumers prefer your business?
- d) Why deploy your idea on blockchain rather than in a centralized context?
- e) Explain how your business idea can be implemented on the Ethereum blockchain. Address all technical hurdles (e.g., Does the contract need to access information not stored on the blockchain? If so, how would it gain that access?).
- f) Is your business economically-viable for implementation on Ethereum?



g) Is your business economically-viable for implementation on any other blockchain?

Groups are encouraged to base their proposals on existing ideas by proposing improvements on promising existing ideas. Students are particularly encouraged to consider ideas in the realm of Decentralized Finance (DeFi) or Insurance. For a list of prominent ideas in the area of DeFi, students are encouraged to consult [www.defipulse.com](http://www.defipulse.com), which also provides additional links with details regarding each business.

## **Academic Link White Paper**

### **1. Abstract**

Academic Link is a functional upgrade to the Echo Link. Echo Link “is a blockchain network that connects students, education, and training institutions and industry participants.” Echo Link provides a decentralized platform that stores and transmits hashed and unalterable information provided by trusted authorities. It acts as the Web3 version of LinkedIn.

Echo Link White Paper:

[https://github.com/EchoLinkTech/EchoLinkService/blob/master/EchoLink\\_github.pdf](https://github.com/EchoLinkTech/EchoLinkService/blob/master/EchoLink_github.pdf)

Echo Link Official Website:

<https://www.echolink.info/>

Academic Link aims to utilize Echo Link’s network, enhance its verification process, and address the Skill & Experience Inflation issue.

### **2. Current Issues:**

#### **a. Inflated job market (Degrees, skills, and experiences)**

Without means to verify one’s claim of having certain skills and experience, it is entirely up to the employer to distinguish genuine candidates from others, not to mention identifying counterfeit degrees. This is forcing companies to run background checks, dedicate more resources to the interview and selection process, and rely on referral programs. An inflated job market is not only costly to the company but also unfair to genuine candidates because of intensified competition.

#### **b. Global Verification**

There were more than 940,000 international students from 224 countries in the U.S. alone in 2021. Almost all of them have submitted transcripts from universities or high schools in their home country during their application process. Considering the difference in the education system in different countries, this process is complicated, and it is also impossible for U.S. universities or employers to verify the validity of those transcripts.

### 3. Why Blockchain? (Question d)

- a. Consistent records and traceability
- b. Hard to manipulate or alter
- c. Open and borderless
- d. Community based verification
- e. Ownership of the record
- f. Minimized storage risk (Losing files, database issues)

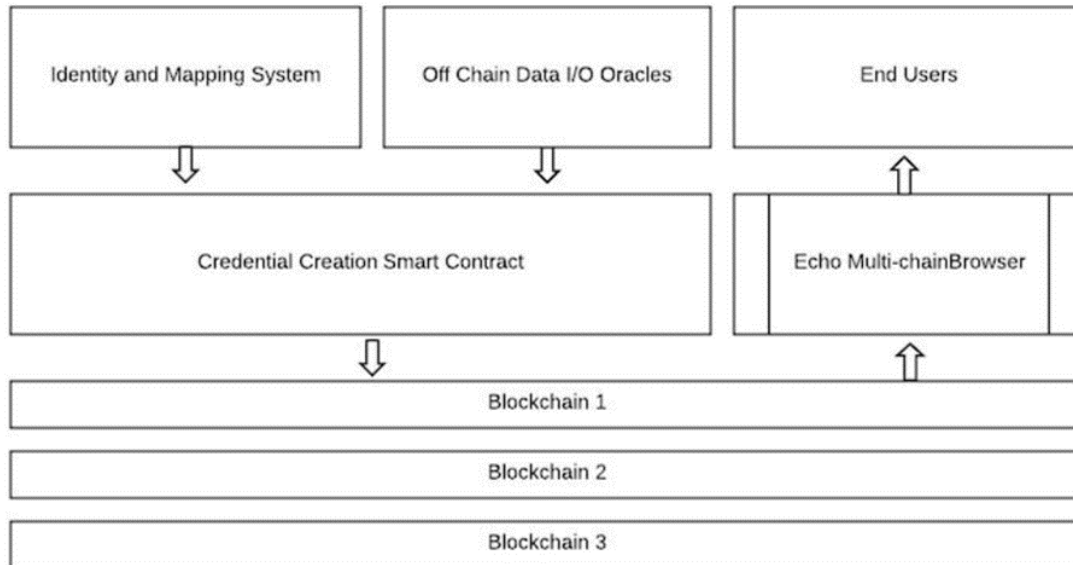
### 4. Target Consumers (Question a)

- a. **For Students**, Academic Link can store and validate their academic records and activities. Students will no longer need to request official transcripts or duplicate diplomas. Their skill & experiences are also more trustworthy to admission offices and potential employers.
- b. **For School Organizations and Academic Institutions**, Academic Link helps them eliminate imposters and protect the reputation of the school and its students. The school administration office can also use Academic Link to verify incoming students' records.
- c. **For Employers**, Academic Link can help them find desired talents with authenticated academic records, experiences, and skill sets.

### 5. What is Echo Link? (Question b)

Echo Link has four major components; They are:

- a. Digital Identity and Mapping System
- b. On-chain Credential Creation System
- c. Off-chain Data I/O System
- d. Multi-chain Data Browser for End Users



Echo Link’s identity and mapping system connects institutions with public accounts, and Oracles verifies the identity of the institution. The Verified institution accounts can issue credentials in batches through a smart contract. Along with personal information such as student names, photos, and transcripts, credentials are hashed, encrypted, and stored on the IPFS. The users, presumably employers, can browse individual information and query accounts with specific skills and degrees through Echo Multi-chain Browser.

## 6. Issues with Echo Link (Question c)

Echo Link built up a basic framework for a LinkedIn-like platform on the blockchain and addressed security and privacy issues with its encrypting document storage. The multi-chain browser allows users to view encrypted information and leaves room for improving compliance by updating its browsing system.

However, the following issue still exists:

### a. Skill & Experience Inflation

Mass-produced credentials in Echo Link are merely statements of facts that an individual undertook a certain program, obtained various grades, and acquired a degree in a specified area. These facts only take up a small portion of one’s resume, and their validity is less valued by employers. Individuals’ claims of certain experiences and possession of skills are more relevant in employers’ decision-making. However, Echo Link does not have the means to verify inaccurate and falsified claims on experience and skills, thus leaving the inflation issue unresolved.

### b. Account safety and validity

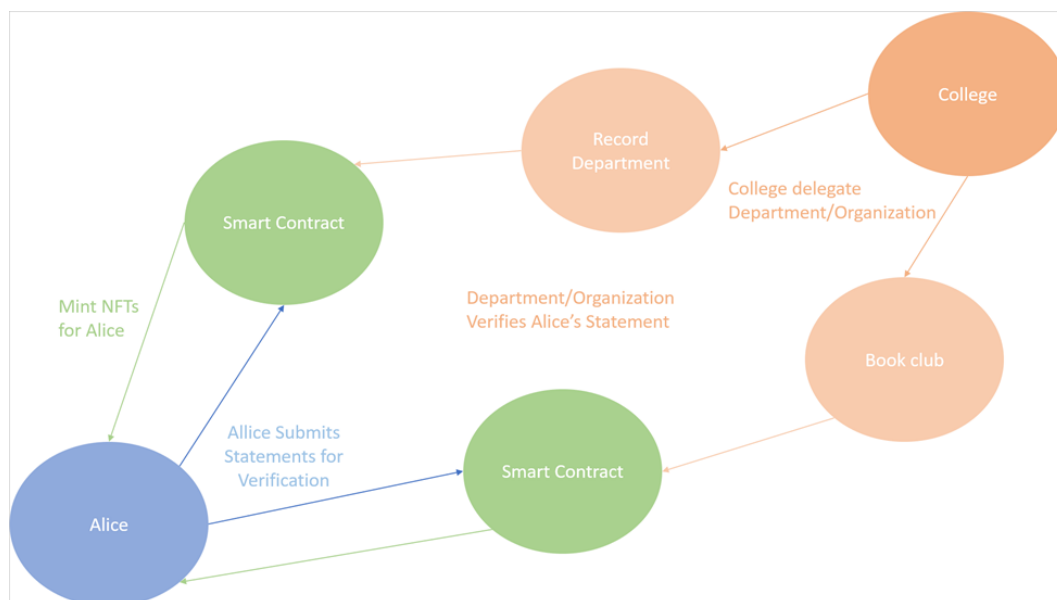
In Echo Link's white paper, it states: "The Echo Link System utilizes public keys (for example, Ethereum addresses) to identify entities in the Echo Link System. Each student is intended to hold a public key in the system. Each issuing organization will also have a public key (in other words, account) in the Echo Link System." The failure of FTX illustrated the risk of a one-key-for-all system. In the Echo Link System, institution accounts have the capability to issue credentials on a large scale. If an institution's private key is lost or worse, stolen, it can undermine the integrity of the institution's credentials, thus, the validity of the entire system.

Furthermore, there are many impostors of accredited institutions in both the real world and on the internet. Basing the institution verification system entirely on off-chain data I/O Oracles could allow impostors to penetrate the Echo Link and disrupt the system.

## 7. Academic Link's solution (Question e)

An overview of the system:

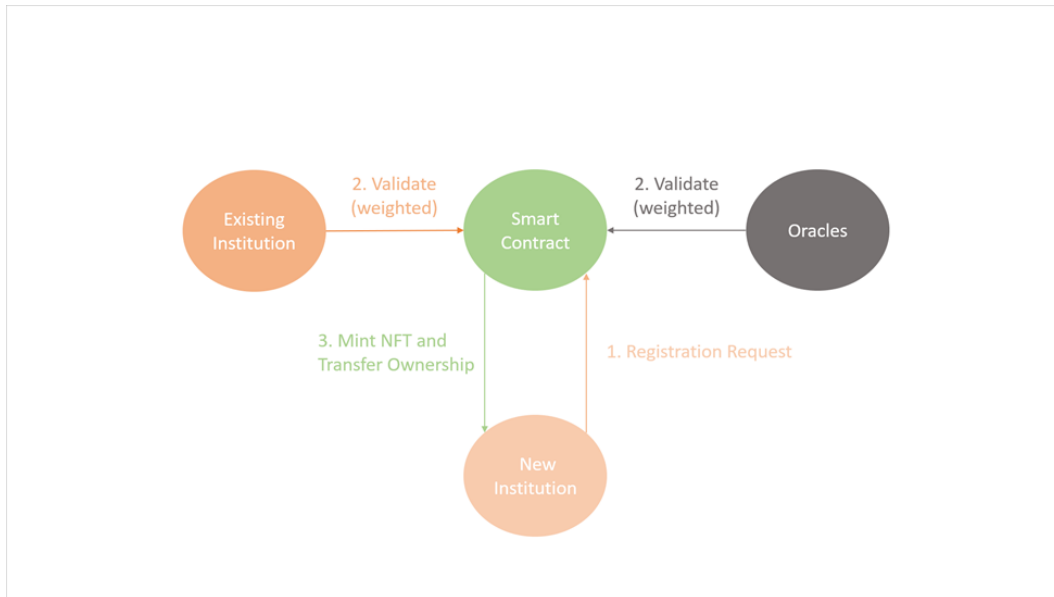
Academic Link intends to connect individuals with the organization at a highly granular level on the blockchain. People can write up skill & experience statements and have the corresponding (subsidiary) institution verified, providing creditable proof of their claims and dis-inflating of the job market. For example, Alice is a college student with a 4.0 GPA and an active member of the college book club. She hosted several book-reading sessions and illustrated excellent leadership in organizing the events. Through Academic Link, Alice can have the school's record-keeping organization validate her 4.0 GPA claim and upload her transcript. At the same time, Alice can also request the book club chairman, presumably who holds the book club's institution subsidiary account, verify her book club skills and experience. When an employer searches for candidates with leadership experience or a 4.0 GPA, Alice's verified skill & experience statement and her academic information will be available for view.



System Breakdown:

a. Weighted Institution Registration:

Instead of solely relying on Oracles, Academic Link proposes a weighted validation system including both the existing institution and Oracles. The registration is approved by the smart contract if more than a threshold of validations is reached. In the early stage, the smart contract should assign more weight to Oracles since the community is small and less representative. As the community grows, more weight is assigned to the existing institutions and their consensus because no one knows the industry better than the ones who operate within it. But it is crucial to maintain a minimum weight to Oracles preventing collusion among institutions.

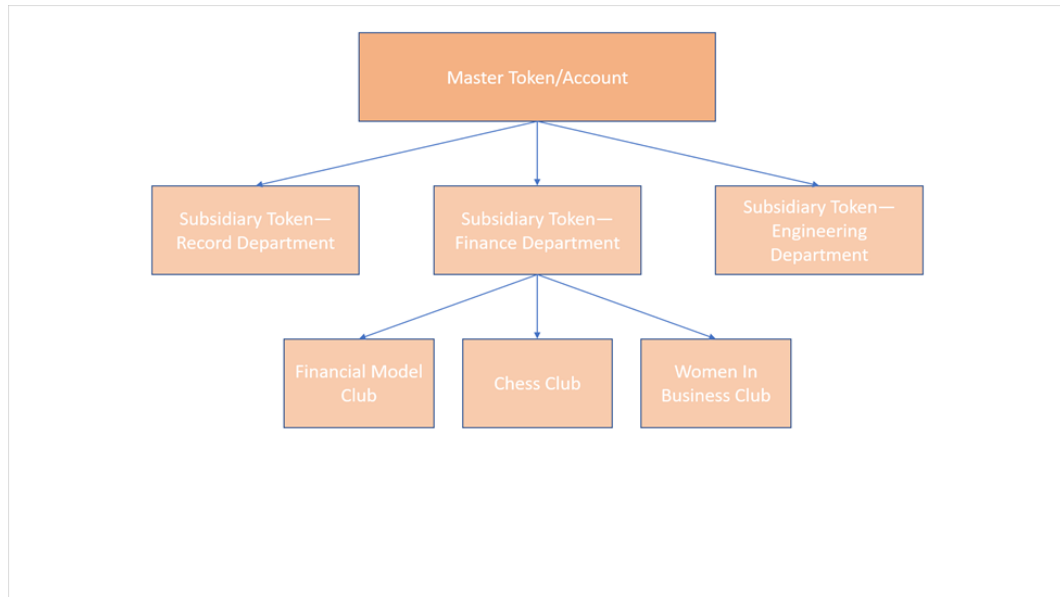


b. NFT systems:

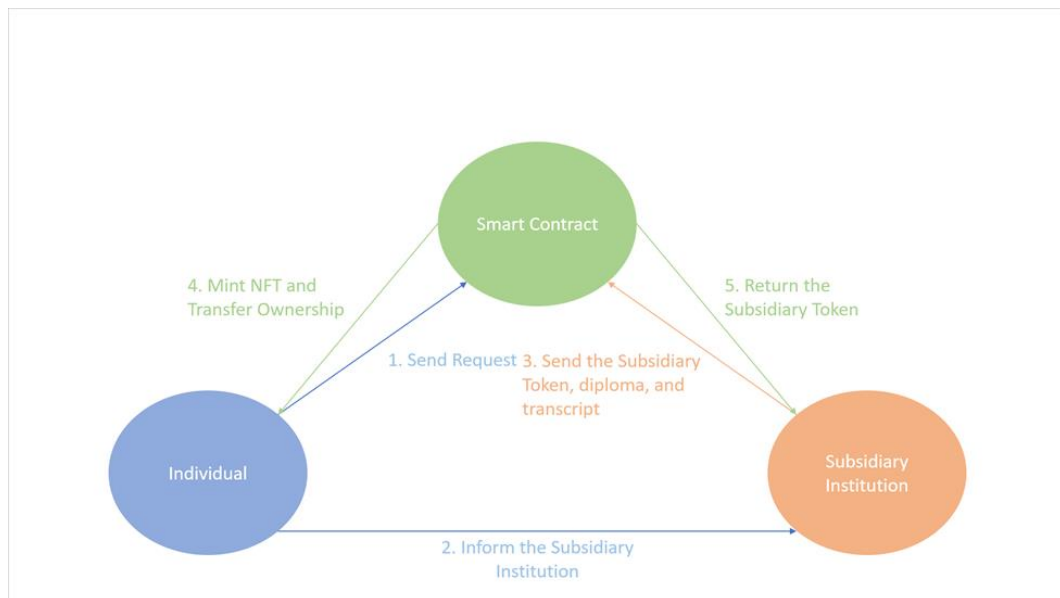
Academic Link proposes an NFT-based system for better trackability and management.

**For Institutions**, there are two kinds of Tokens: Master and subsidiary tokens.

The master tokens are proofs of validation and key to management. An account can only obtain a token through the weighted institution registration process. The token itself cannot perform degree, transcript, or experience validation, but it can delegate these functions to other accounts by creating subsidiary tokens with smart contracts.



**For Individuals,** they can have a wide range of NFTs representing their degrees and experiences statements. They make a request to the smart contract, and the corresponding subsidiary sends information along with its subsidiary token to the smart contract. The smart contract will hash all information into the NFT and transfer ownership of this NFT to the individual and return the subsidiary token.



c. Compliance control:

- I. All NFTs are non-transferable.
- II. All institutional NFTs expire at a preset time.
- III. There can only be one master token for each institution at any given time.

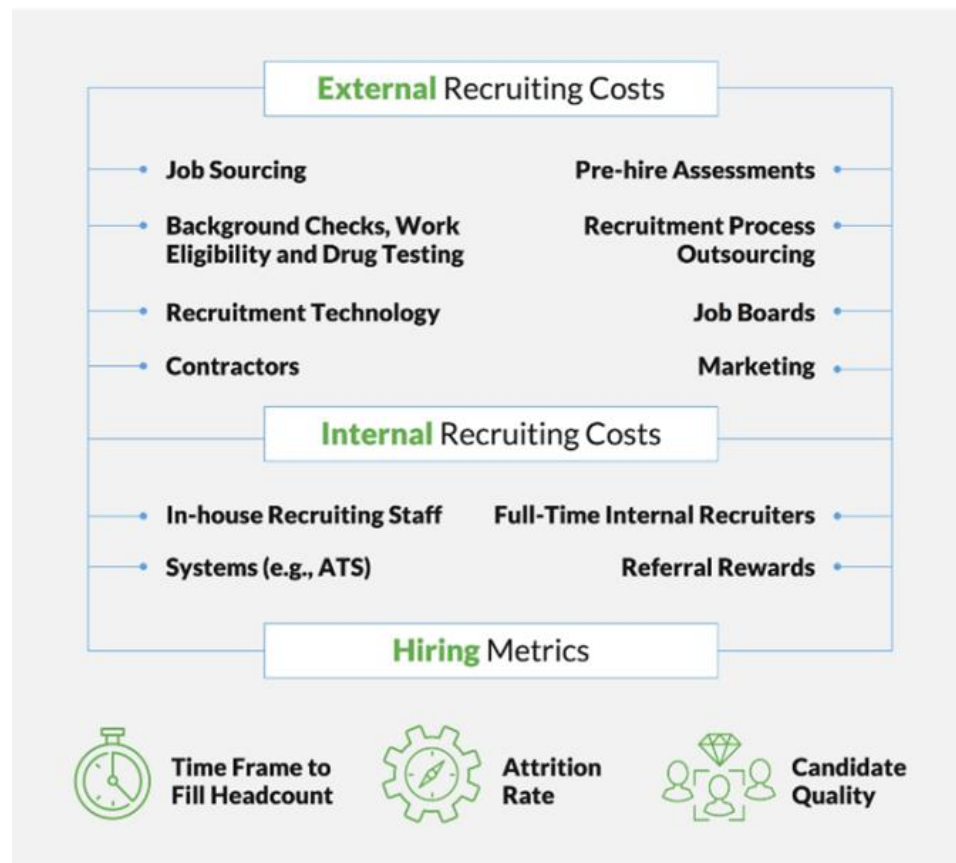
- IV. Any account can send its NFTs to a smart contract to burn it.
- V. The multichain browser can block compromised NFTs from being viewed by users.
- VI. Burning master tokens voids all subsidiary tokens.

The compliance system aims to provide room for human error and minimize damages from ill-intended action. For example, if the administrator of an institute's master token account suspects that the account's private key is compromised, the administrator can burn its master token by sending it to a special purpose smart contract and apply for a new one with a different account while not affecting already-minted NFTs. Alternatively, if the administrators lose their keys, they can wait for the tokens to expire and request a new one.

## 8. Costs & Benefits (Question f)

Cost of hiring:

Glassdoor research shows that the average U.S. employer spends about \$4,000 and 24 days to hire a new worker.



Despite the employer's investment in the hiring process, 74% of employers experienced hiring the wrong person for a position. Furthermore, the U.S. Department of Labor estimates that the average cost of a bad hiring decision is at least 30% of the individual's first-year expected earnings. Such a cost can be as high as \$15,000 for an employee with an annual income of \$50,000.

## Cost of Academic Link

### Gas fees:

The average gas fee for each Ethereum transaction is approximately \$1. Last year, the gas fee mostly remained below that level, with some exceptions. The highest fee occurred on May 1<sup>st</sup>, 2022, at \$23.82. Gas fees are subject to transaction volume and system scalability, which could bring uncertainty to the cost of using Academic Link. But as Ethereum moves to PoS, the volatility in price and cost of gas fees will decrease significantly. Furthermore, most verification processes are not time intensive. Thus, students and institutions can wait for the gas fee to drop if there is a sudden increase in demand on the blockchain.

### Minting NFTs:

Normally, there are several costs associated with NFTs, such as Gas fees, Listing Fees, and Account fees. However, Academic Link prohibits NFT trading because they represent individual experiences or institution verifications that specifically belong to individuals and organizations. Therefore, the cost of minting NFTs in Academic Link is mostly Gas fees.

It is estimated that each experience/degree NFT requires five transactions, which cost \$5 on the PoW Ethereum network on a normal day. This is still lower than what students typically pay for an official transcript.

### Institution verification & delegation:

Given that a university might have dozens of departments and hundreds of student organizations, the cost of delegation can become very high. Therefore, Academic Link will redirect some revenue from employer user fees to supplement institution delegation costs. However, a minimum cost is still required to ensure efficient use of the system.

### User fees:

Academic Link will charge employers (users) a fee for each query or charge a subscription fee. Such a fee should be lower than the \$35 per candidate pre-verification fee and reduce the probability of bad hires and associated costs.



	Employer	Students	Institutions
Current Cost	<ul style="list-style-type: none"> <li>Expensive and prolonged hiring process(\$4,000 and 24 days Average)</li> <li>Possible Bad hire</li> <li>Experience Verification difficulty (More rounds of interviews)</li> </ul>	<ul style="list-style-type: none"> <li>Increasingly competitive job market</li> <li>Distrust from employers</li> <li>Difficulty in proving education received in the home country to a foreign employer</li> <li>\$10-\$25 per official transcript or diploma</li> </ul>	<ul style="list-style-type: none"> <li>Reputation damage from counterfeit diploma</li> <li>Increasing the cost of career services to help students find jobs</li> <li>Hard to track how each organization/department contribute to student learning &amp; training</li> </ul>
Benefit from Academic Link	<ul style="list-style-type: none"> <li>Verified academic background, experience, and skills</li> <li>Easy query for candidates with a specific skill set</li> <li>Reduce the possibility of bad hire</li> </ul>	<ul style="list-style-type: none"> <li>Deflated job market</li> <li>Immutable records &amp; files</li> <li>Global transferability</li> </ul>	<ul style="list-style-type: none"> <li>Eliminate counterfeit diploma or experience claims</li> <li>Facilitates student employment</li> <li>Experience records detailed to each student without costs associated with record keep</li> </ul>
Cost of using Academic Link	<ul style="list-style-type: none"> <li>A small fee for each query or a subscription-based payment</li> </ul>	<ul style="list-style-type: none"> <li>Gas fee of \$5 per degree/experience</li> </ul>	<ul style="list-style-type: none"> <li>Gas fee of \$5 per Institution verification or organization delegation</li> </ul> <p>(Academic link will provide subsidies to institutions with more than ten organizations)</p>

## 9. System & Implementation (Question g)

Academic Link is best suited for Ethereum 2.0 for its higher scalability, lower transaction costs, and greater utility. But Academic Link can operate under the current Ethereum's PoW system with acceptable costs.

Academic Link can also work on other PoS networks, such as Polygon. Its gas fees are much lower than that of Ethereum and are currently at \$0,0005. However, it is crucial to take security into consideration since Academic Link relies on the trustworthiness of its network and the service it provides.

Lastly, it is unlikely for Academic Link to deploy its own blockchain because there will not be enough validators in the system, thus causing scalability and security issues.

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