

Analysis of return correlation dynamics between traditional and crypto assets during boom-and-bust cycles

MSc. in Applied Information and Data Science
Time Series Analysis in Finance

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1 Introduction

Harry Markowitz once said that “diversification is the only free lunch in investing”. In the first five months of 2022, global equities and fixed income experienced a severe downturn, mainly caused by a combination of rising inflation and interest rates, the Ukraine conflict, fresh lockdowns in China and overall pessimism around growth and earnings outlook. In this environment achieving high diversification within the traditional asset classes (e.g., stocks, bonds, or commodities) is often not enough to avoid steep losses. The lunch may be free but the ingredients for a good meal are quite hard to find right now! Alternative asset classes could potentially help investors drive diversification in their portfolio. Being one of the fastest growing (and most controversial) alternative assets, crypto has now been on investors’ radar for many years and its effect on portfolio diversification has been a topic of extensive research. At the core of this discussion lies the concept of correlation between assets classes which is also a cornerstone of Markowitz’s “modern portfolio theory”. In theory, the value (and returns) of crypto assets should be intrinsically bound to the degree of adoption of the underlying cryptocurrency and thus be isolated from the external market dynamics. This theory has however collided with the reality of these currencies turning into investment objects. As such, it is critical to assess their diversification properties in order to make informed investment decisions. This paper aims at providing additional perspective on the correlation between crypto and traditional assets and thus offering guidance around potential diversification effects of crypto assets when added to a portfolio of traditional assets classes. The main objective of this paper is the analysis of the behavior of historical return correlation between crypto and traditional assets during market expansions and contractions.

2 Literature Review

One of the earliest papers to analyze the return correlation of a crypto asset with traditional and other alternative investment classes was Brière et al. in 2015 [1]. The paper concluded that over the period under consideration, Bitcoin (the only crypto asset analyzed in the paper) had exceptionally high average return and volatility and its correlation with other assets was remarkably low. Spanning tests conducted in the paper confirmed that BTC investment offered significant diversification benefits and its addition to a well-diversified portfolio might improve the risk-return trade-off. This rosy view around the diversification benefits of crypto assets has been disputed by several subsequent authors. In particular, the covid pandemic proved to be a turning point in this discussion. The market downturn that followed the outbreak of the virus in the US in March 2020 put the theory of diversification through crypto assets to a test. The analysis of crypto’s diversification benefits was conducted by numerous authors including Allen (2022) [2], Maasoumi and Wu (2021) [3], Kristoufek (2020) [4], Conlon et al. (2020) [5], Lahmiri and Bekiros (2020) [6], and Grobys (2021) [7]. The result from these studies was a resounding contradiction to Brière et al. In fact, they showed that the main cryptocurrencies did not provide a strong portfolio diversification tool in the context of the covid crisis.

3 Selection of Benchmarks, Periods and Key Metrics

3.1 Benchmarks

For our analysis we selected a range of investment objects to represent wider asset classes. On the traditional assets side, we analyzed the S&P 500 (Ticker: ^GSPC) as a proxy for equities, the iShares Core U.S. Aggregate Bond ETF (Ticker: AGG) to represent fixed income and the price of Gold in USD (Ticker: GC=F). As for crypto assets, we considered Bitcoin (Ticker: BTC-USD) and Ethereum (Ticker: ETH-USD), the two largest crypto assets per market capitalization as our benchmark.

3.2 Period

The period considered for our analysis spans from January 2018 to May 2015. Reason for this selection, besides the data availability for Ethereum, is the inclusion of multiple boom-bust cycles like the market slumps of 2018, the covid crisis and the current market downturn as well as the post 2018 growth period and the sharp recovery from covid.

3.3 Key Metrics

In our paper we initially considered several attributes of the investment objects analyzed (e.g. mean, standard deviations etc.) for descriptive statistic purposes. We then narrowed our focus on two key metrics that represent the

core of our analysis: correlation and beta.

Correlation is extremely important in the context of portfolio risk management and portfolio selection. In fact, as the following formula shows, the risk (i.e. standard deviation) of a portfolio is highly dependent on the degree of correlation between the assets in the portfolio.

$$\sigma_p = \sqrt{\sigma_p^2} = \sqrt{\sum_{i=1}^N \sum_{j=1}^N w_i w_j \sigma_i \sigma_j \rho_{ij}} = \sqrt{\sum_{i=1}^N w_i^2 \sigma_i^2 + \sum_{i=1}^N \sum_{i \neq j}^N w_i w_j \sigma_i \sigma_j \rho_{ij}} \quad (3.1)$$

In this paper we will only consider the Pearson correlation which assumes normal distributions, there are however other correlation measures like Kendall and Spearman correlation which for simplicity reason will be excluded from the scope of this paper.

The second key statistical metric for our analysis is beta. From a statistical point of view Beta is the slope of the linear regression between the market and an individual asset. In other words, it measures the volatility of an individual asset compared to the systematic risk of the entire market. Mathematically Beta is defined by following formula:

$$\beta = \frac{\text{cov}(R_e, R_m)}{\text{var}(R_m)} \quad (3.2)$$

Where R_e is the return on an individual stock, R_m the return on the overall market.

In our analysis we will utilize the concept of dual betas instead of the traditional beta. In fact, traditional beta expresses the level of risk assuming that an investment's gains will be the same on days that the market rises as its loss will be on days when that it falls. On the other hand, dual betas represent two independent betas. The first, upside beta, is calculated to reflect upside risk while the other, downside beta, is calculated to reflect downside risk [8].

4 Descriptive statistics

In this section we conducted an exercise of descriptive statistics for the assets considered. Our objective was to gain a better understanding of the data, the shape of the assets' distributions, their stationarity found in appendix C and time series of log returns over the selected period. For the latter refer to appendix A.

4.1 Statistical attributes of traditional and crypto assets

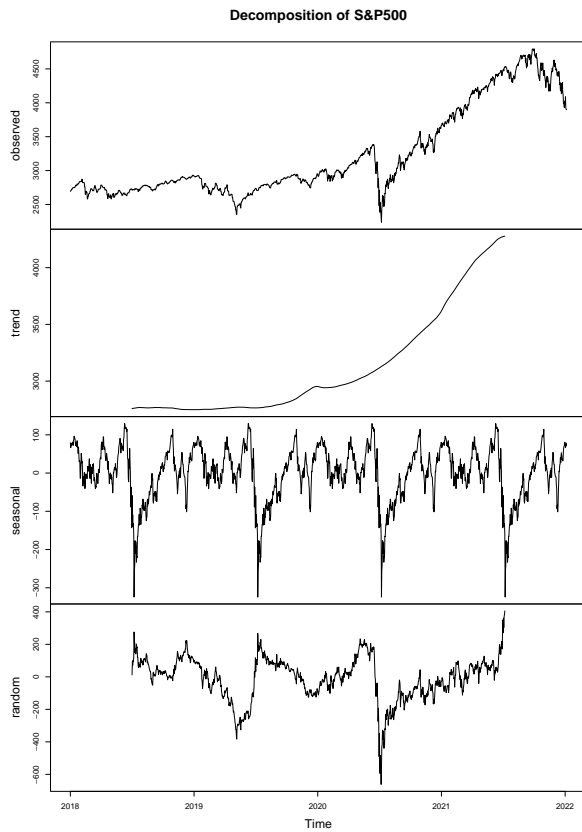
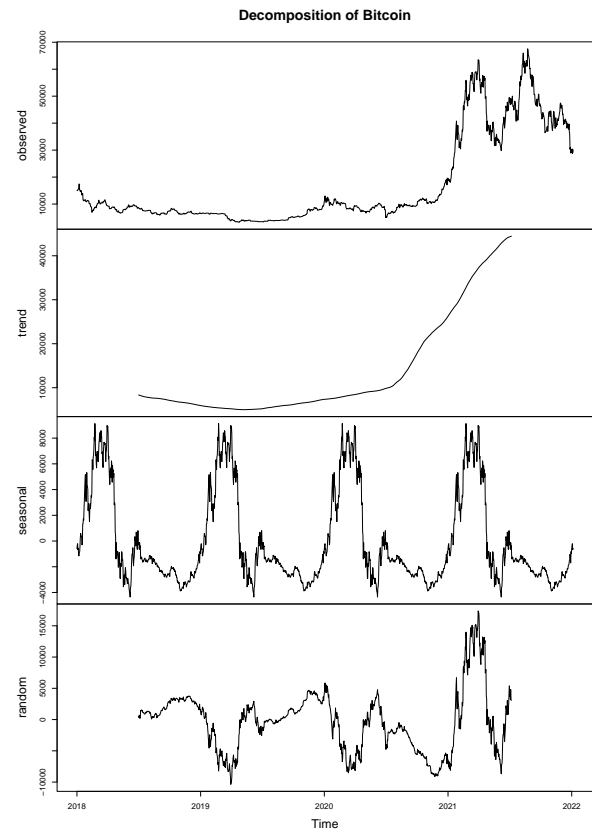
The following table shows a range of selected statistical attributes for the assets considered in this paper. Here it's worth pointing out, even though not particular surprising, the higher standard deviation of the crypto assets, which are broadly known for their high volatility. This is also reflected in the minimum and maximum values observed for the two assets during the period in scope.

Table 4.1: *Descriptive statistics of the assets*

	S&P500	AGG	Gold	BTC	ETH
Mean	2.524771e-04	3.132228e-05	2.308032e-04	4.558319e-04	5.439970e-04
Stan. Dev	0.012	0.003	0.008	0.041	0.053
Maximum	0.090	0.023	0.058	0.203	0.344
Minimum	-0.128	-0.041	-0.051	-0.465	-0.551
Skewness	-1.090	-3.484	-0.294	-1.180	-0.884
Kurtosis	24.414	65.431	11.019	17.811	15.159

4.2 Decomposition

Furthermore, we performed a decomposition of the assets analyzed with a particular focus on their seasonality which was observable in all assets except gold. See below a decomposition of the S&P 500 and Bitcoin. Decomposition for the other assets can be found in appendix B.

Figure 4.1: *Decomposition of S&P500*Figure 4.2: *Decomposition of Bitcoin*

5 Correlation and Beta analysis

5.1 Long-run static correlation

The first step of our analysis focuses on establishing the “long-run” average correlation between the log returns of the assets in scope which we calculated for the entire period taken into consideration (January 2018 – May 2022).

Table 5.1: *Return correlation between January 2018 and May 2022*

	S&P500	AGG	Gold	BTC-USD	ETH-USD
S&P500	1.000	0.058	0.046	0.263	0.286
AGG	0.058	1.000	0.252	0.140	0.125
Gold	0.046	0.252	1.000	0.109	0.102
BTC-USD	0.263	0.140	0.109	1.000	0.801
ETH-USD	0.286	0.125	0.102	0.801	1.000

What this analysis shows is a relatively low correlation coefficients between crypto assets and traditional asset classes during this period. In addition to that, we can observe a very high correlation within the crypto asset class (i.e. between Ethereum and Bitcoin).

5.2 Rolling Correlation

To gain a better understanding of the development of correlation coefficients over time we examined the 60-day rolling correlation for the assets in scope. The following graph shows the rolling correlation between Bitcoin and the S&P 500 (please refer to appendix D for the graph of the other asset classes). From this graph is visible that the correlation between Bitcoin and the S&P 500 is highly volatile, non-stationary and does not seem to follow a clear pattern.

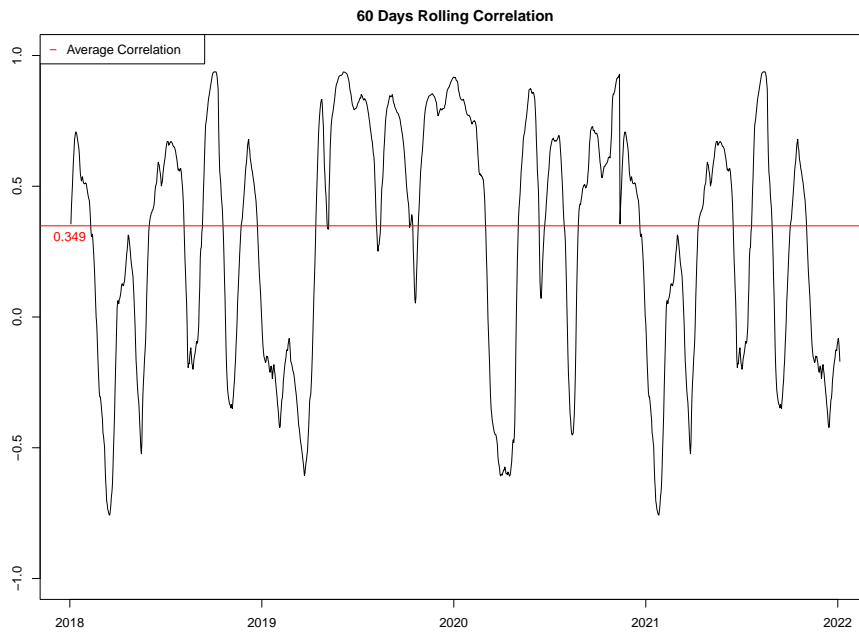


Figure 5.1: 60 Days Rolling Correlation S&P500 and Bitcoin

We proceed to investigate whether the spikes in correlation between Bitcoin to the S&P can be connected to a specific state of the market (e.g. market expansion or market contraction). In other words, does Bitcoin's returns behave differently depending on whether the market experience a contraction or an expansion?

To gain initial insights into this question, we juxtaposed the rolling correlation depicted above to the time series of the S&P 500. Here we can notice that some of the highest correlation levels between the two were reached during market downturns especially at the beginning of the covid pandemic and at the beginning of the market downswing of 2022. The corresponding graphs can be found in appendix D

In order to obtain analytical proofs for the insight we gained from the graphical analysis conducted above, we dissected the S&P 500 (used as proxy for the entire market) and selected periods of contractions and expansions to analyze in more granularity and corroborate the fact that crypto seems to show a very high degree of correlation during market downturns.

5.3 Return correlation in market expansions

We first analyzed the correlation between our assets during market expansion. To do so, we selected following periods:

- 26.12.2018 - 12.02.2020
- 24.03.2020 - 31.12.2021

The first period (26.12.18 – 12.02.20) was selected to represent the market expansion after the downturn of 2018. This expansions was mainly driven by a booming tech sector, easy monetary policy and tax cuts rolled out by the Trump administration. The S&P 500 return over this period equals 36%.

The following table 5.2 shows the correlation matrix of all the observed assets over this period. This analysis highlights that the correlation between crypto and traditional assets is generally low and even negative for the S&P 500.

Table 5.2: Return correlation between 26.12.18 and 12.02.20

	S&P500	AGG	Gold	BTC-USD	ETH-USD
S&P500	1.000	-0.344	-0.276	-0.120	-0.028
AGG	-0.344	1.000	0.510	0.011	0.010
Gold	-0.276	0.510	1.000	0.217	0.113
BTC-USD	-0.120	0.011	0.217	1.000	0.803
ETH-USD	-0.028	0.010	0.113	0.803	1.000

The second period considered spans from 24.03.2020 to 31.12.2021. This was selected to capture the strong recovery

after the downturn caused by the outbreak of the covid 19 pandemic in the US. The S&P 500 grew over 95% during this period.

From the updated correlation matrix, we can observe that the correlation between crypto and traditional assets is generally low and clearly below average levels as shown in table 5.1.

Table 5.3: *Return correlation between 24.03.20 and 31.12.21*

	S&P500	AGG	Gold	BTC-USD	ETH-USD
S&P500	1.000	0.100	0.131	0.243	0.232
AGG	0.100	1.000	0.261	0.047	0.067
Gold	0.131	0.261	1.000	0.093	0.122
BTC-USD	0.243	0.047	0.093	1.000	0.755
ETH-USD	0.232	0.067	0.122	0.755	1.000

5.4 Return correlation in market contractions

We proceed with the analysis of the correlation of the observed assets during periods of market contractions. In this context, we analyzed following timeframes:

- 20.02.2020 - 23.03.2020
- 28.03.2022 - 20.05.2022

The first period analyzed extends from 20.02.2018 to 23.03.2020. This coincides with the outburst of the covid 19 pandemic in the US that had profound ripple effects on the market. The S&P 500 plunged around 29% during this period.

The correlation matrix reveals a significant increase of correlation level for crypto assets to traditional asset classes. These are, in case of the S&P 500, more than twice as high as the long-run average correlation and more than three times as high for bonds. Although the correlation of crypto to gold drastically increased compared to its average, it remains anchored at a relatively low level. This is not the case for Stocks and bonds with the former showing a correlation coefficient of 0.65 to Ethereum and the latter 0.53 to Bitcoin. Additionally, we can observe that during this period Bitcoin and Ethereum are very strongly correlated (0.98) thus neutralizing the diversification effect within crypto investments.

Table 5.4: *Return correlation between 20.02.20 and 23.03.20*

	S&P500	AGG	Gold	BTC-USD	ETH-USD
S&P500	1.000	0.114	0.064	0.596	0.650
AGG	0.114	1.000	0.265	0.533	0.499
Gold	0.064	0.265	1.000	0.260	0.209
BTC-USD	0.596	0.533	0.260	1.000	0.984
ETH-USD	0.650	0.499	0.209	0.984	1.000

The second period considered start on 28.03.2022 and ends on 20.05.22. This period reflects the market downturn caused by a combination of macroeconomic and geopolitical factors like rising inflation and interest rates as well as the war in Ukraine and covid outbreaks in China . The market contracted 15% during this period.

The correlation matrix points to extremely high correlation level between crypto and the S&P 500 which represent an almost threefold increase compared to the long-run average correlation. The very high correlation level of 0.72 and 0.73 for Bitcoin and Ethereum respectively show that diversification benefits of an equity portfolio through crypto would have been extremely marginal during this period. Slightly different results can be observed for bonds and Gold. Although bonds experienced a steep downturn during this period, the daily dynamics in this asset class were mainly driven by the inflation level thus explaining the comparatively low correlation to crypto. The same is true for Gold which, given its "safe haven" status, was influenced especially by geopolitical development and commodities specific dynamics. Table 4.5: Return correlation between

Table 5.5: *Return correlation between 28.03.22 and 20.05.22*

	S&P500	AGG	Gold	BTC-USD	ETH-USD
S&P500	1.000	0.127	-0.207	0.720	0.732
AGG	0.127	1.000	0.019	0.078	-0.011
Gold	-0.207	0.019	1.000	0.005	-0.033
BTC-USD	0.720	0.078	0.005	1.000	0.940
ETH-USD	0.732	-0.011	-0.033	0.940	1.000

5.5 Betas

Finally, we analyzed the dual betas for the period in scope. The values of the dual betas below confirm the conclusion drawn from the previous graphical and analytical analysis. In fact, the betas of crypto to the S&P 500 are relatively low during market upswings and almost double during market downswing. As showed previously a similar pattern cannot be confirmed for Bonds and Gold.

Table 5.6: *Up- and Downbetas for BTC and ETH with S&P500, AGG and Gold as the market*

	S&P500		AGG		Gold	
	up	down	up	down	up	down
BTC	0.62	1.173	1.616	3.201	0.824	0.216
ETH	0.857	1.598	0.49	3.856	0.807	0.337

6 Conclusion

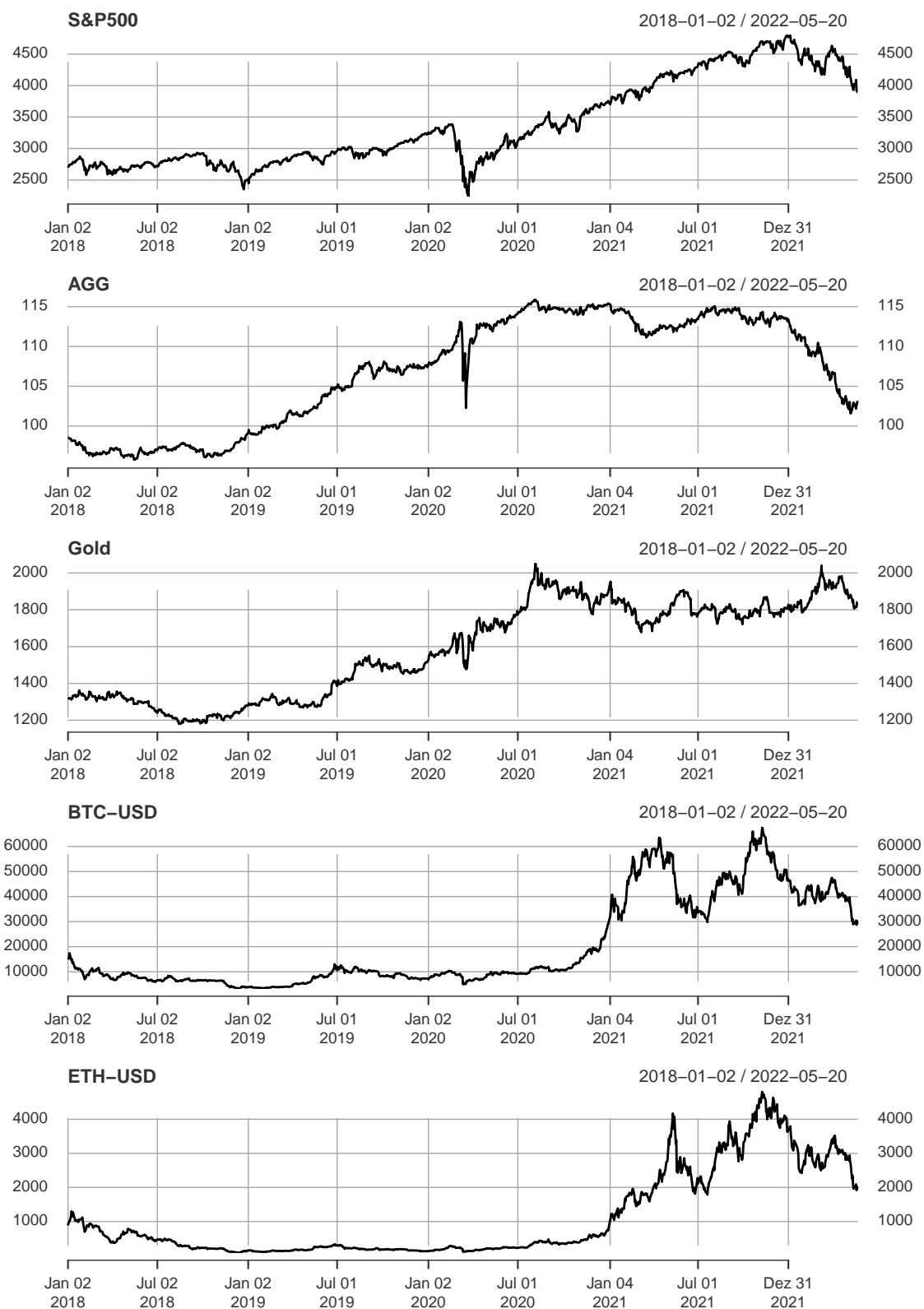
The objective of our paper was to analyze the correlation dynamics between crypto and traditional assets as well as understanding potential behavioral patterns during periods of market expansion and contraction. The literature available on this topic delivers conflicting results which on one side point to positive diversification effects of crypto thanks to its lower correlation and on the other to the increase in correlation during the covid-driven market downturn and thus to lower diversification benefits. From the graphical analysis of the correlation between crypto and traditional assets, we noticed that the spike in correlation coefficients in crypto seems to coincide with periods of market downturn. This intuition was confirmed through our analytical research. Our results show low correlation coefficients and betas between crypto and S&P 500 during market expansion and very high correlation and betas during market contraction. A clear pattern could not be identified for the relationship between crypto and bonds or gold. Therefore, equity investors can consider crypto as their fair-weather friend: it will help you drive diversification as long as the market is in an upward trend but, as soon as things get tough, it will turn the back on you!

References

- [1] BRIÈRE, Marie ; OOSTERLINCK, Kim ; SZAFARZ, Ariane: Virtual currency, tangible return: Portfolio diversification with bitcoin. In: *Journal of Asset Management* 16 (2015), November, Nr. 6, 365–373. <http://dx.doi.org/10.1057/jam.2015.5>. – DOI 10.1057/jam.2015.5. – ISSN 1479–179X
- [2] ALLEN, David E.: Cryptocurrencies, Diversification and the COVID-19 Pandemic. In: *Journal of Risk and Financial Management* 15 (2022), Nr. 3. <http://dx.doi.org/10.3390/jrfm15030103>. – DOI 10.3390/jrfm15030103. – ISSN 1911–8074
- [3] MAASOUMI, Esfandiar ; WU, Xi: Contrasting Cryptocurrencies with Other Assets: Full Distributions and the COVID Impact. In: *Journal of Risk and Financial Management* 14 (2021), Nr. 9. <http://dx.doi.org/10.3390/jrfm14090440>. – DOI 10.3390/jrfm14090440. – ISSN 1911–8074
- [4] KRISTOUFEK, Ladislav: Grandpa, Grandpa, Tell Me the One About Bitcoin Being a Safe Haven: New Evidence From the COVID-19 Pandemic. In: *Frontiers in Physics* 8 (2020). <http://dx.doi.org/10.3389/fphy.2020.00296>. – DOI 10.3389/fphy.2020.00296. – ISSN 2296–424X
- [5] CONLON, Thomas ; CORBET, Shaen ; MCGEE, Richard J.: Are cryptocurrencies a safe haven for equity markets? An international perspective from the COVID-19 pandemic. In: *Research in International Business and Finance* 54 (2020), 101248. <http://dx.doi.org/https://doi.org/10.1016/j.ribaf.2020.101248>. – DOI <https://doi.org/10.1016/j.ribaf.2020.101248>. – ISSN 0275–5319
- [6] LAHMIRI, Salim ; BEKIROU, Stelios: The impact of COVID-19 pandemic upon stability and sequential irregularity of equity and cryptocurrency markets. In: *Chaos, Solitons & Fractals* 138 (2020), 109936. <http://dx.doi.org/https://doi.org/10.1016/j.chaos.2020.109936>. – DOI <https://doi.org/10.1016/j.chaos.2020.109936>. – ISSN 0960–0779
- [7] GROBYS, Klaus: When Bitcoin has the flu: on Bitcoin's performance to hedge equity risk in the early wake of the COVID-19 outbreak. In: *Applied Economics Letters* 28 (2021), Nr. 10, 860–865. <http://dx.doi.org/10.1080/13504851.2020.1784380>. – DOI 10.1080/13504851.2020.1784380. – Publisher: Routledge _eprint: <https://doi.org/10.1080/13504851.2020.1784380>
- [8] KIRAN, Pande: *Dual-Beta - The Smart Investor's Most Valuable Tool | Seeking Alpha*. <https://seekingalpha.com/article/1578622-dual-beta-the-smart-investors-most-valuable-tool>, <https://seekingalpha.com/article/1578622-dual-beta-the-smart-investors-most-valuable-tool>.
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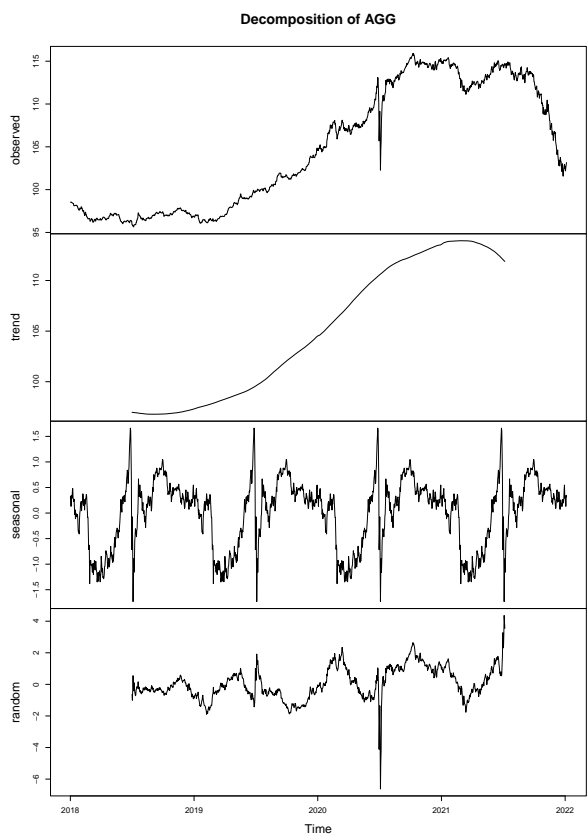
Appendix

A

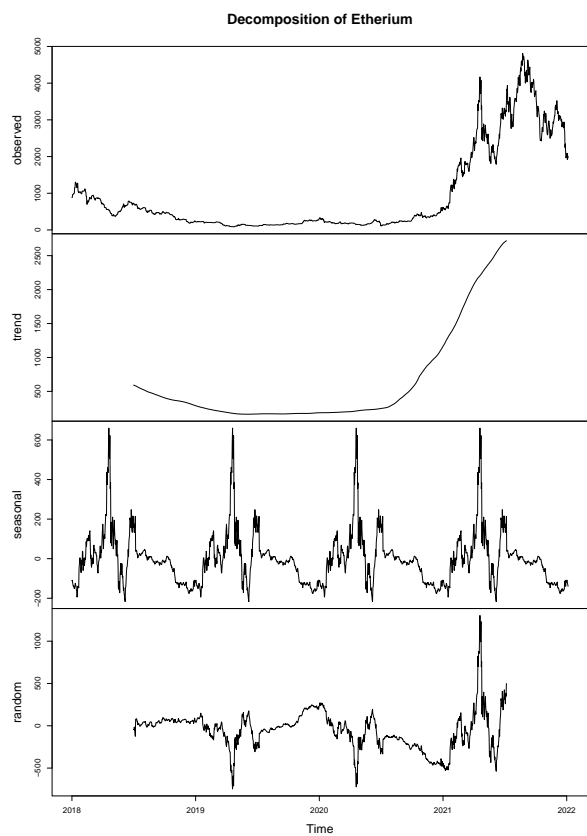


Time series of the five assets

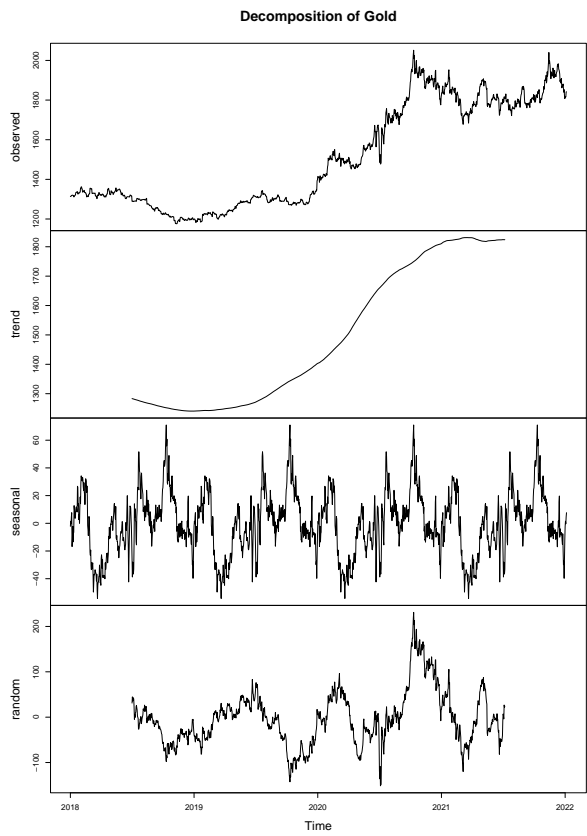
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Decomposition of AGG

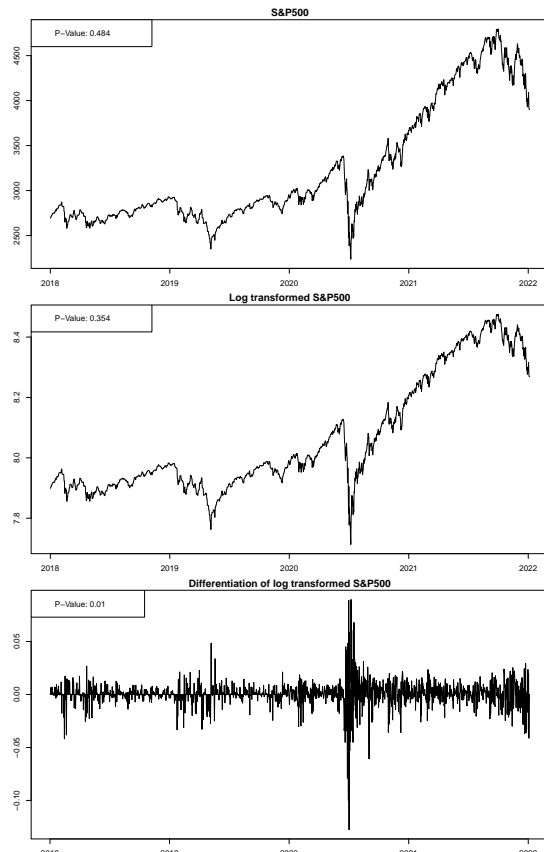


Decomposition of Ethereum

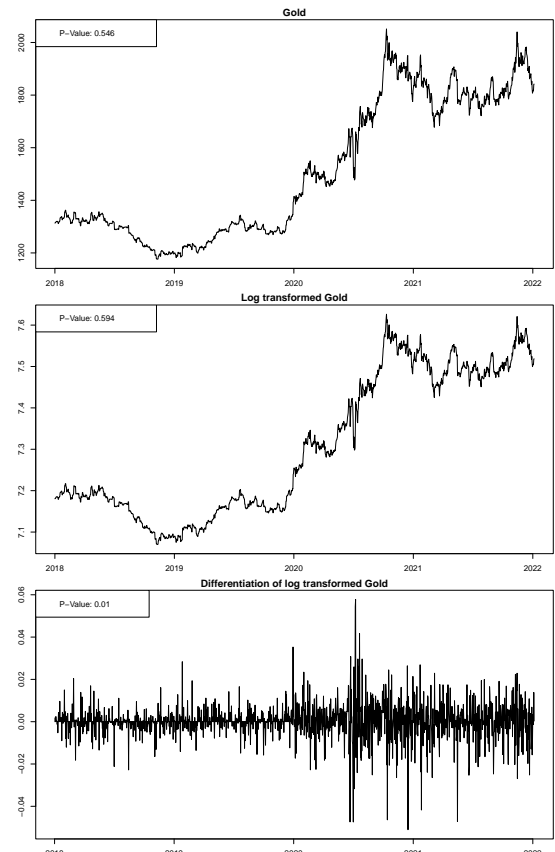


Decomposition of Gold

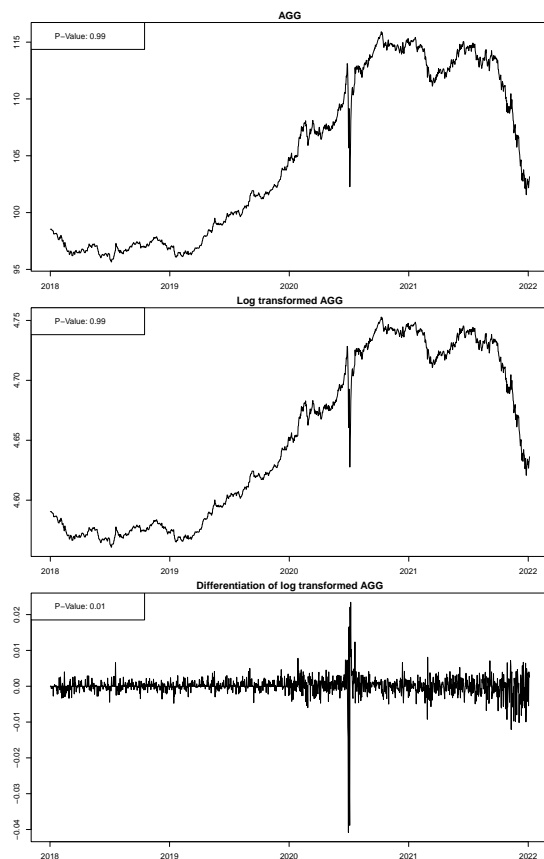
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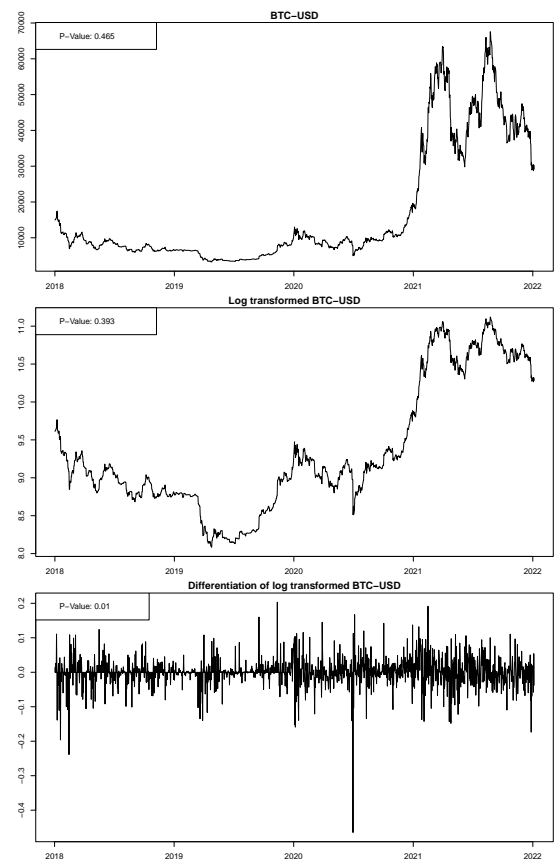
P-values of S&P500 before and after transformation



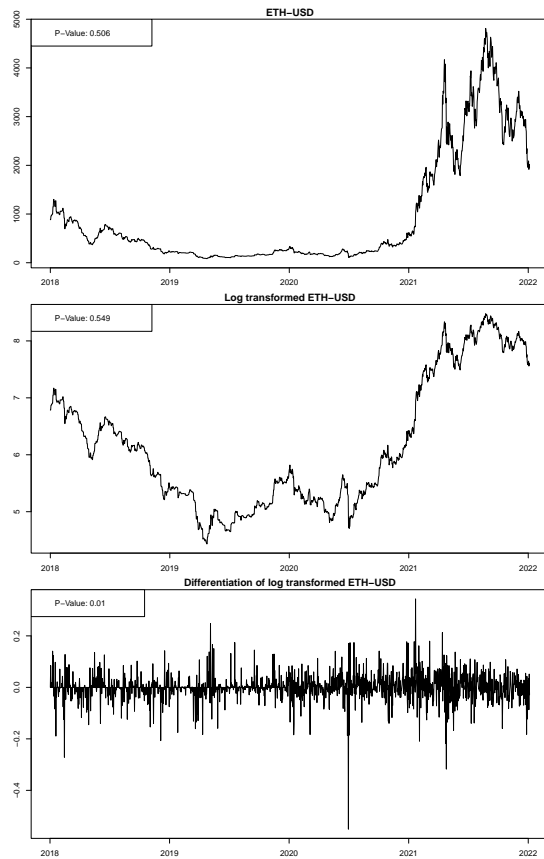
P-values of Gold before and after transformation



P-values of AGG before and after transformation

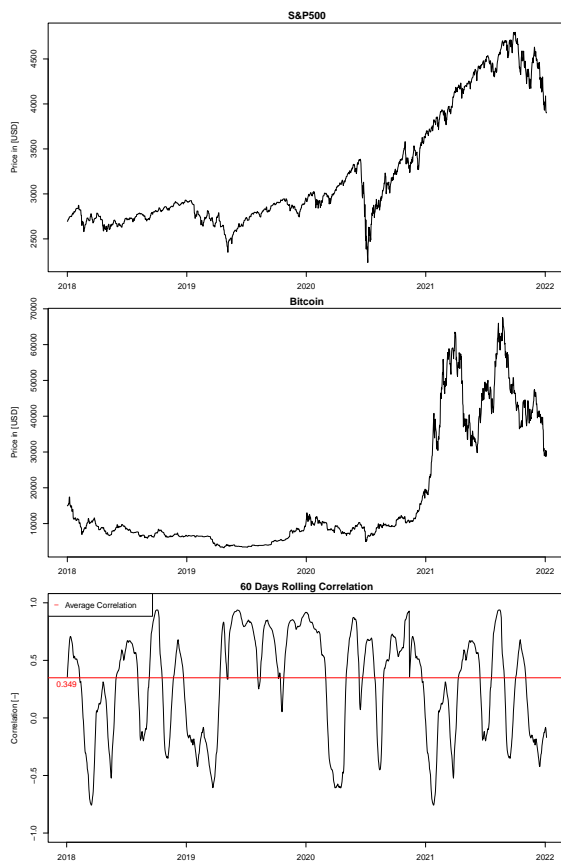


P-values of Bitcoin before and after transformation

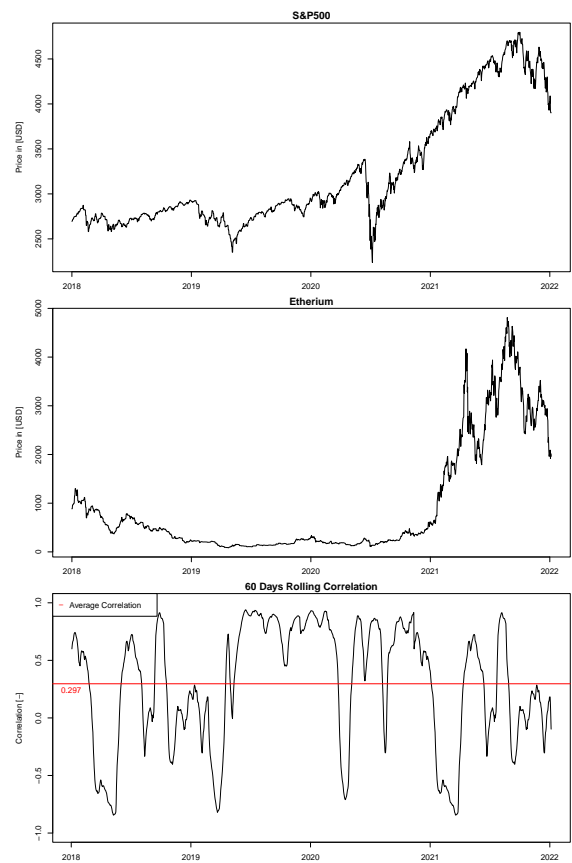


P-values of Ethereum before and after transformation

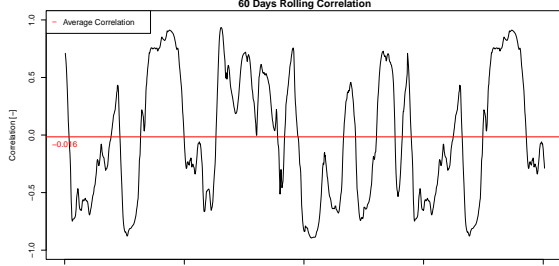
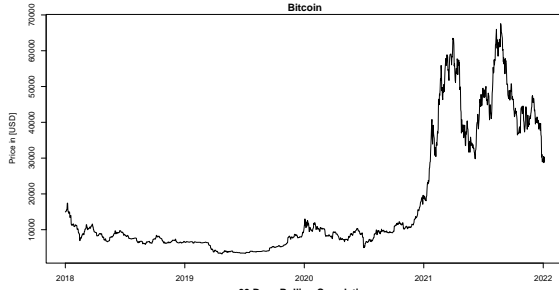
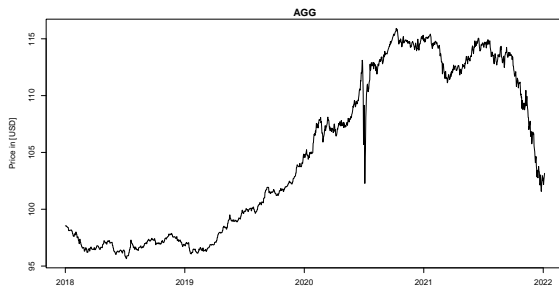
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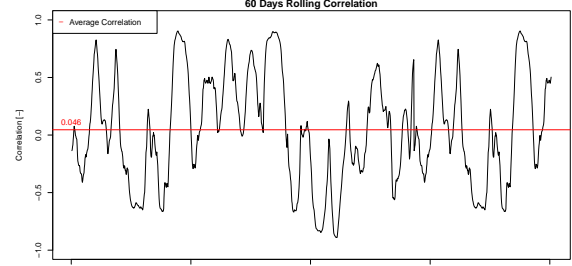
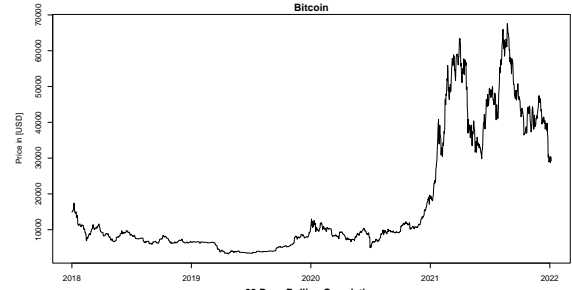
60 Days Rolling Correlation S&P500 and Bitcoin



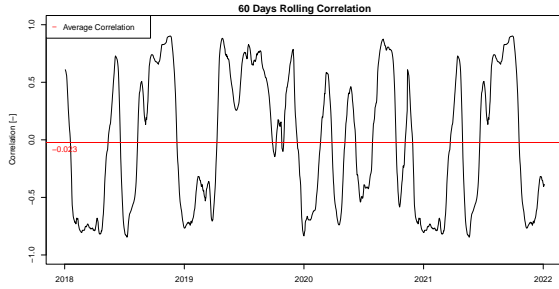
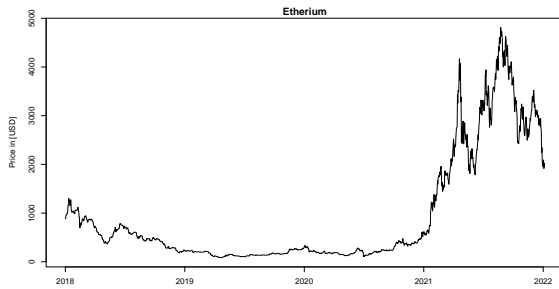
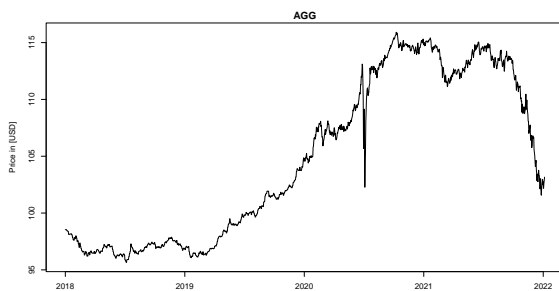
60 Days Rolling Correlation S&P500 and Ethereum



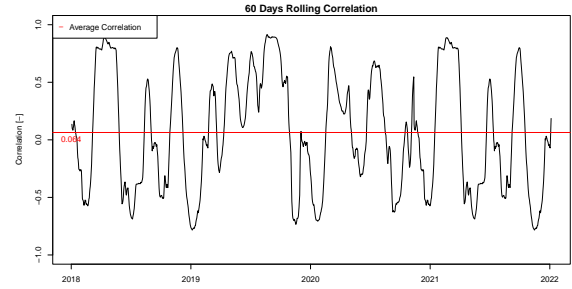
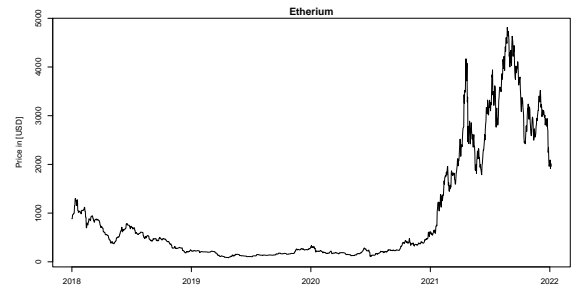
60 Days Rolling Correlation AGG and Bitcoin



60 Days Rolling Correlation Gold and Bitcoin



60 Days Rolling Correlation AGG and Ethereum



60 Days Rolling Correlation Gold and Ethereum