To the Moon? On the Relentless Rise of Cryptoassets and Their (Dis)Function as Money

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Abstract
Cryptoassets are highly controversial, risky, speculative assets that exhibit wild volatility. In 2021 Bitcoin reached several all-time highs, growing more than 400% year-on-year, while Dogecoin increased by more than 20,000% year-on-year. In this paper, we propose two research hypotheses. The first, whether cryptoassets could function as money, we judge to remain invalid due to their intrinsic volatility. However, we found some evidence to suggest that Bitcoin and Ether could be maturing, as they moved more closely with the market than during previous price rallies. The second hypothesis, whether cryptoassets could function as investment assets, we show to be valid. To do so, we explored the likely drivers behind the 2021 market rally. Next, we used portfolio theory to show that adding even small quantities of cryptoassets to traditional portfolios of equities and bonds improves the overall performance of the portfolio. Also, we found that all cryptoassets exhibited large abnormal returns, further evidencing their exceptional nature. Ultimately, besides the value of cryptoassets for improving the portfolio risk-return trade-off, the real (if any) value of cryptoassets might come from their inherent innovative nature.

Keywords
Cryptoassets; cryptocurrencies; Bitcoin; Ether; Dogecoin; portfolio management.

Introduction

Money has taken different forms through the ages; examples range from cowry shells in West Africa to large copper plates (*riksdaler*) in early Sweden or strings of coins in China. These various forms of money share three functions: (1) store of value – value is maintained over time, even if sometimes not perfectly e.g. when increasing inflation erodes purchasing power, (2) unit of account – value can be measured in economic transactions, and (3) medium of exchange – accepted widely as a method of payment.

Cryptoassets are highly controversial risky speculative assets that do not function well as money. This is because they do not perform well as a store of value given their wild volatility, but neither as means of payments given low acceptance levels by merchants. In 2021 Bitcoin reached several all-time highs, growing more than 400% year-on-year. Other cryptoassets have also followed suit, with e.g., Dogecoin increasing 20,000%

year-on-year. However, this paper will not discuss stablecoins, a new class of cryptoassets that aim to peg themselves to the value of fiat currencies.

Furthermore, cryptoassets have been increasingly correlated with the value of traditional financial instruments, particularly during times of lower volatility. With the US Dollar at its lowest since spring 2018 and the developing COVID-19 crisis, cryptoassets may be increasingly used as a hedging instrument. We hypothesize that portfolios that include cryptoassets may outperform those which do not. Even if investors appear to lose money on their cryptoasset investments on most days, significant gains that offset these losses are possible, and they could materialize when least expected.

Using public data on cryptoasset, stock, and bond prices, and according to Markowitz (1952), we show cryptoassets outperformed the market between 2015 and 2021, which suggests they could make a good addition to investment portfolios. Our paper extends the body of existing research by analyzing data until April 2021. Our findings are in line with Plantakis (2020), Briere (2015) and Eisl (2015) in that adding small proportions of cryptoassets to diverse portfolios could improve the overall outcome of the portfolio.

Literature review

Function of money

The role of Bitcoin and other cryptoassets has long been debated. Cryptoasset enthusiasts were quick to declare the obsolescence of centralized finance (Nakamoto, 2008). However, Atzori (2015) advocated for the role of the state as a necessary central point of coordination in society. Following our definition of money in the introduction, we test the hypothesis of whether cryptoassets perform well as money.

Firstly, cryptoassets are highly volatile and thus are incompatible with storing value. There have been times when their value appeared to have normalized but severe daily swings (both upwards and downwards) of more than 10% have been common, alongside yearly changes in value in the order of thousands of percentage points – Dogecoin being an extreme example. Secondly, at the time of writing, cryptoassets did not perform well as a medium of exchange. While the adoption of cryptoassets has continued to increase, cryptoassets are not widely accepted as means of payment. Hett (2008) discusses their use in the context of financing terrorism, which further exacerbates concerns about cryptoassets' use.

Nevertheless, cryptoassets do function well as a unit of account. In fact, they function better than other forms of fiat money in this respect. Given that cryptoassets are first and foremost digital assets, they can be divided down to 8 decimal places (compared to 2 in the case of most fiat money). This could be beneficial for the financial system, as, according to Berentsen et al. (2002) the divisibility of money could increase innovation by enabling micropayments, which could revolutionize pay-for-use services.

Overall, cryptoassets do not score very highly when assessed against the criteria that measure how well they function as money, rendering our first hypothesis invalid. The remainder of our paper will focus on our second research hypothesis – whether cryptoassets could function well as investment assets instead.

Drivers of cryptoassets price movements in 2021

In 2021 Bitcoin reached several all-time highs, growing by more than 400% since 2020 (Coindesk, 2021), followed by other cryptoassets with more impressive increases, such as Dogecoin's 20,000% since 2020 (Coindesk, 2021). We believe the following to be likely drivers of cryptoassets' price movements in the first half of 2021: (1) increased institutional demand; (2) upswing from speculative retail investments and (3) increased interest by regulatory authorities.

First, institutional demand has increased in 2021, with more companies either buying cryptoassets directly or offering additional cryptoassets services to their customers. For example, Phillips (2021) shows that several institutions have been accumulating Bitcoin since 2020. Further, Dhamodharan (2021) outlines how major payment service providers are planning to start supporting cryptoassets on their networks. We believe such developments could help cryptoassets further climb on the adoption curve.

Second, the early 2021 price movements coincided with an upswing from speculative retail investments. Thus, cryptoassets are increasingly moving into the cultural mainstream, fueled by increased media coverage and celebrity endorsements. Dogecoin is proof of the power of such endorsements. Having started as a joke, the market capitalization of Dogecoin exceeded $80bn in May 2021, when its price rose by more than 20,000% year-on-year. Further, cryptoassets with a fixed supply, such as Bitcoin, could act as a hedge against inflation because no entity (e.g., the central bank) could unilaterally devalue them by creating more. After the onset of the COVID-19 pandemic, many policymakers deployed quantitative easing programs to jump-start economies, increasing the total quantity of money in the economy, which could increase inflation.

Third, several countries and authorities e.g., European Commission (2020) launched initiatives to regulate cryptoassets, which might further legitimize their use. Further, a few firms that offer cryptoasset-related services (e.g., payments – Revolut in Lithuania, custody – Anchorage Bank in the USA) were authorized as banks thus potentially increasing the links between cryptoassets and traditional financial markets.

Modern portfolio theory

The foundations of modern portfolio theory (MPT) were laid out in 1952, with Markowitz's seminal paper on the principles that should guide investors for optimally selecting assets (Markowitz, 1992). Since then, it fundamentally transformed the world of investments and has represented inspiration for all future developments in the field of asset pricing, reinventing these principles to incorporate new findings based on sophisticated modeling and empirical observation (Rubinstein, 2002). MPT offers the conceptual framework for constructing portfolios of assets based on two main

instruments, i.e., the expected return of an investment in those assets and the risk associated with an investment, which is combined with investors' risk aversion to lead to the "optimal" allocation within the portfolio; this is the well-known normative mean-variance analysis (Markowitz & Todd, 2000). The most important off-spring of the mean-variance framework is the asset pricing theory, developed since the 1960s by William Sharpe in the form of the Capital Asset Pricing Model – CAPM (Sharpe, 1963; 1964), a positive theory that makes assumptions about how investors behave, instead of how they should behave, as indicated by MPT. Thus, the relationship between the expected return of any investment and the systematic or market risk it bears was encapsulated in the famous "beta" coefficient.

CAPM changes investors' focus from the total risk of an asset or portfolio to its systematic component, and postulates that only higher levels of systematic risk will be compensated by higher expected returns and not higher levels of total risk. Over time, alterations and improvements have been proposed to these models so that they better suit a more complex financial and investment environment (Fama and French, 2015). Additionally, extensions of the CAPM have been proposed, such as the intertemporal CAMP of Merton (1974), or the international CAPM that includes risk premiums for currency risk (Solnik, 1974; Stulz, 1981).

The application of these models has been limitless. Their direct use for portfolio management has been straightforward and various tools that measure portfolio performance have been invented over time. Among them, the Sharpe ratio, a measure that considers the excess return over the risk-free rate divided by the total risk of an asset (Sharpe, 1996), and Jensen's measure or alpha, which is the average return on investment above or below the CAPM-predicted one (Jensen, 1968), are, by far, the most well-known and used in the investment management industry.

The precepts of MPT have proven sufficiently robust to the emergence of newer types of assets, with different patterns of prices and returns compared to those available in financial markets. Examples include financial derivatives and, more recently, cryptoassets. Liu and Pan (2003), Quigley (2006), and Hsuku (2017) demonstrated that financial derivatives contracts consistently improve portfolio performance and allow active investors to exploit the time-varying opportunity set available. Cryptoassets' exceptional returns over the last two decades have given rise to speculative investments, despite the overwhelming evidence of their exceptional volatility. Research on how cryptoassets may be used to improve portfolios' risk-return trade-offs has also followed. Results indicate that, as in the case of derivatives, adding cryptoassets to existing portfolios generates considerably higher risk-adjusted returns (Andrianto & Diputra, 2017; Kajtazi & Moro, 2019; Platanakis & Urquhart, 2020).

However, MPT has its limits and one of the most important is the considerable evidence of non-normality in return distributions, a finding pioneered by Peiro (1999) and Cont (2001), and continued by Premaratne and Bera (2005), or Adcock et al. (2015), etc. More recently, portfolio optimization models that consider the higher moments of returns' distributions, i.e., skewness and kurtosis, have also been advanced – see Fabozzi et al. (2006), Harvey et al. (2010), or Mhiri and Prigent (2010).

Data and methodology

We begin by considering a portfolio comprising of Standard and Poor's 500 (S&P 500) and Bloomberg Barclays Aggregate Bond Index (the Agg), in equal parts. The former is a free-float, weighted measurement stock market index of 500 of the largest companies listed on stock exchanges in the US. The latter is a broad-based fixed-income index used as a benchmark to measure the relative performance of US bonds. Both the data from S&P500 and the Agg were obtained from Reuters.

We selected three cryptoassets to analyze – Bitcoin (BTC), Ether (ETH), and Dogecoin (DOGE). All cryptoassets' prices are in USD and were obtained from Coindesk. Finally, we added gold to our analysis, primarily to act as a comparison with cryptoassets. The price of gold is in USD per troy ounce and was obtained from the Federal Reserve Economic Data (FRED). Similar approaches to constructing portfolios including cryptoassets, i.e., portfolios that consist of equity, bonds, and cryptoassets, have been proposed in the literature – see, for example, Corbet et al. (2018), Kajtazi and Moro (2019) or Platanakis and Urquhart (2020). Also, gold was considered in the portfolio management literature as a "safe haven" for equity and bond portfolios (Baur & Lucey, 2010; Bredin et al., 2015) and recent approaches have contrasted the properties of bitcoin versus gold for portfolio performance improvement (Urquhart & Zhang, 2019; Henriques & Sadorsky, 2018).

We considered daily returns from cryptoassets investments, which we defined as the growth rate of the investment, where P_t is the price of Bitcoin (B) at time t

$$R_{t+1}^{B} = \frac{P_{t+1} - P_t}{P_t} \qquad (1)$$

To judge the value of cryptoassets as investment, we calculated the Sharpe Ratio for Bitcoin, Ether, and Dogecoin

$$Sharpe\ Ratio = \frac{E[R] - RFR}{\sigma} \qquad (2)$$

where $E[R]$ is the expected return R, RFR the US Risk-Free Rate obtained from the FRED, given that all our data sources are linked to the US Dollar and σ the standard deviation of daily returns. Further, according to CAPM, for any asset with return R, the expected return on the asset should equal the risk-free rate RFR plus the $Beta$ multiplied by the market risk premium, namely RFR-adjusted expected return. We expressed this as

$$E[R_i] = RFR + \beta(E[R_M] - RFR) \qquad (3)$$

$$\text{where } \beta = \frac{Cov(R_i, R_M)}{Var(R_M)} \qquad (4)$$

and R_i is the return on an asset i and $E[R_M]$ is the expected return on the market portfolio M. Beta (β) is well-known as the coefficient of systematic or market risk.

We also calculated $alpha$ or abnormal returns for our cryptoassets and gold. These are returns over a period that were higher than the return generated by the asset's benchmark (S&P 500). According to CAPM, abnormal returns should net out over time.

$$\alpha_i = E[R_i] - (RFR + \beta(E[R_M] - RFR)) \quad (5)$$

We stored the daily values for all our chosen assets in an SQLite database and we implemented our calculations using the Python programming language. We used the well-known powerful libraries Pandas and NumPy, which come equipped with a wide array of mathematical and statistical functions, such as calculating percentage changes, means, and variances. Additionally, for computing Sharpe ratios we made use of the FinQuant open-source library. When calculating the various cryptoassets' alpha and beta values, we split the time series for the cryptoasset in a 30-day rolling window.

Similarly, for our portfolio analysis, we split the data in 30-day rolling windows and then created a portfolio where the cryptoasset was given a variable weighing between 1 and 99%, with the S&P 500 and Agg taking equal halves of the remaining allocation. Varying the cryptoassets' weighting allowed us to explore the relationship between a portfolio's cryptoasset contents and its performance parameters, such as expected returns, volatility as beta, and Sharpe ratio. To this end, we apply Markowitz (1952) mean-variance framework whereby the return on a portfolio is defined by

$$R_p = \sum_{i=1}^{n} w_i R_i \quad (6)$$

where R_p is the portfolio return, R_i is the returns of individual assets included in the portfolio, w_i is the corresponding weights of these individual assets, and n is the number of assets included in the portfolio.

Since we use volatility as defined by the beta coefficient, to capture the systematic risk of our portfolios, instead of standard deviation (as in the mean-variance framework), we calculate the betas of our portfolios as the weighted average of the betas of individual assets included in the portfolios:

$$\beta_p = \sum_{i=1}^{n} w_i \beta_i \quad (7)$$

where β_p is portfolio beta, β_I am the beta of individual assets in the portfolio, and w_i and n are defined above.

The alphas for our portfolios have been calculated similarly to alphas for cryptoassets and gold, using the portfolios' betas instead of individual assets betas. We used daily values between 26th October 2015 and 26th April 2021, with the only exception of Dogecoin, for which data was only available starting 25th March 2019.

Results and discussion

Cryptoassets market – a brief overview

The total market capitalization of cryptoassets nearly reached $1tn during the previous bull market of 2018 and has remained relatively stable at around $200bn during 2019 and most of 2020 (Coinmarketcap, 2021). However, cryptoassets started rallying in 2021 with a total market capitalization exceeding $2tn. While large, Figure 1 puts this into perspective: as of May 2021, the market capitalization of cryptoassets was almost equal to Italy's GDP, but half the market capitalization of Gold and a fraction of the US stock market's capitalization.

Figure 1. The market capitalization of cryptoassets compared to other markets
(Authors' analysis using data from the World Bank, International Monetary Fund, Federal Reserve Board, Reuters, and Coinmarketcap)

Figure 2 shows the number of active Bitcoin addresses, which has historically been a good indicator of its price. Indeed, on many occasions, the number of active addresses started to increase before Bitcoin's price did. This chart also suggests that the value of individual Bitcoin transactions has, on average, been steadily increasing since 2020, while the number of transactions was largely stationary. This might indicate that Bitcoin has been maturing, with larger value transactions ultimately influencing its price.

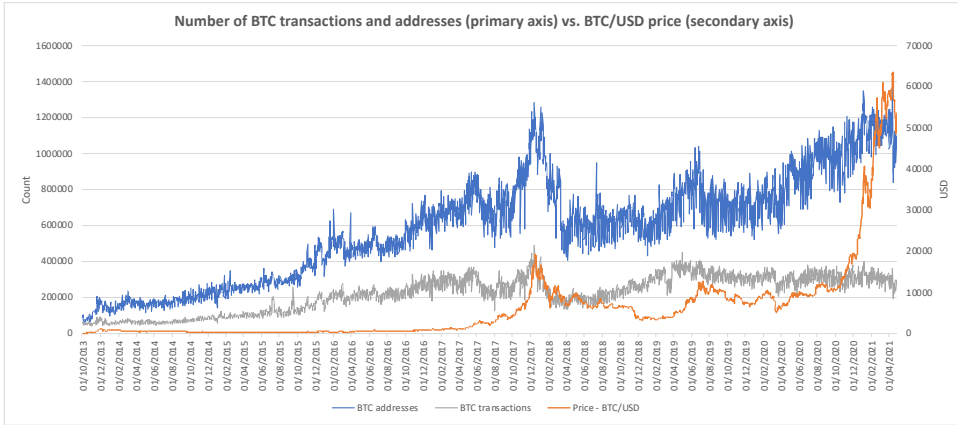

Figure 2. BTC number of transactions vs. active addresses vs. USD price *(glassnode.com)*

We examined the same charts for Ether and we see that active addresses historically tracked its price closely and started increasing before Ether's price did. Figure 3 shows that the 2021 Ether price rally was very different from the previous one with values of individual transactions remaining low, for the most part. Unlike Bitcoin, which is essentially just an alternative payment system, Ethereum, Ether's underlying platform, supports running "smart contracts" that allow customers to specify intricate details of complex contracts they might wish to enter. Since "smart contracts" require Ether-based fees to be paid, this could be a reason why the median Ether transaction value remained low compared to that of Bitcoin – users run a multitude of relatively inexpensive "smart contracts".

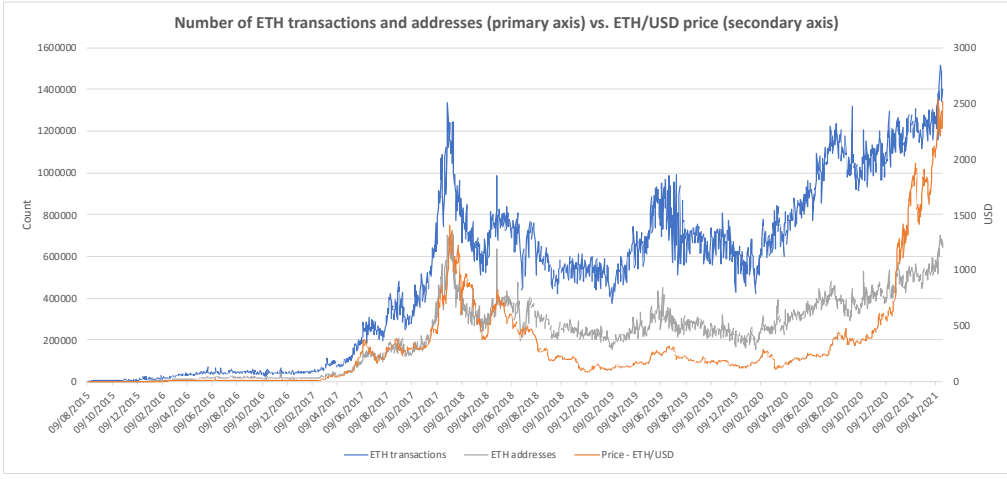

Figure 3. ETH number of transactions vs. active addresses vs. USD price.
(glassnode.com)

Dogecoin has been behaving very differently from Bitcoin, Ether, and most other cryptoassets. Originally created as a joke, Dogecoin's value grew dramatically in 2021, likely driven by celebrity endorsements. None of the relationships described above between the price, volume, active addresses, and median transaction values appear to

hold for Dogecoin. This is a cautionary tale that the cryptoassets market is unpredictable and not always subject to traditional analysis.

Unlike Bitcoin and Ether, active addresses have not been a good indicator for Dogecoin's price (Figure 4), which remained relatively stable (and low) until 2021. Further, unlike Bitcoin and Ether, the number of Dogecoin transactions appeared relatively stable during both 2017 and 2021 price rallies, with a small number of outliers. However, the value of individual Dogecoin transactions appears to vary wildly.

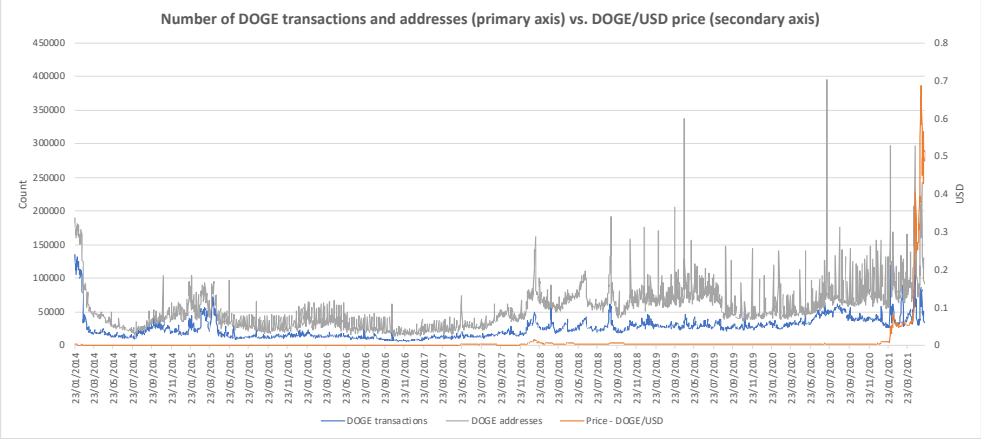

Figure 4. Dogecoin number of transactions vs. active addresses and USD price. *(coinmetrics.io)*

Cryptoassets as investment opportunities

We will now discuss our quantitative results, obtained according to the methodology set out in Section 3.

Starting with our baseline portfolio of 50% S&P 500 and 50% The Agg, we created four additional portfolios which contain equal parts of S&P 500 and The Agg and added one of Bitcoin, Ether, Dogecoin, and Gold, respectively. To better understand the impact of adding cryptoassets to our four portfolios we varied the amount of Bitcoin, Ether, Dogecoin, and Gold respectively, using the following splits: 1%, 10%, 25%, 50%, 75%, 90%, and 99%, with equal parts of S&P 500 and the Agg representing the rest of the allocation.

Our analysis found that varying the amount of a specific cryptoasset within a single portfolio did not have a significant impact on annualized returns or Sharpe Ratios. However, we observed significant differences between portfolios which were likely due to the intrinsic volatility of the specific cryptoassets added, as well as the extent to which these were moving alongside the broader market. The rest of the discussion covers four "middle" portfolios comprising 50% one of Bitcoin, Ether, Dogecoin, and Gold respectively, and 50% equal parts of S&P 500 and The Agg. Unsurprisingly, the

portfolio containing gold is tracing our baseline more closely than those containing cryptoassets.

Figure 5 shows the annualized percent returns of our four portfolios comprising of 50% Bitcoin, Ether, Dogecoin, and Gold respectively, with the other 50% of each portfolio comprising of equal parts of S&P 500 and the Agg. These are mapped against our baseline. Dogecoin's 2021 rally is evident from the chart, the returns of the portfolio containing it far exceeding those of other cryptoassets. Also, cryptoassets' returns oscillate wildly and while investors might have lost money every day for an extended period, these losses may have been recovered through some substantial outliers.

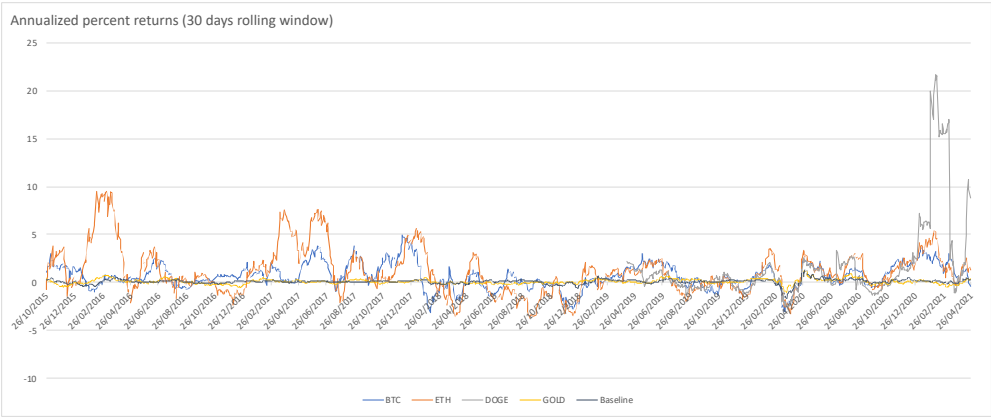

Figure 5. Annualized percent returns of our four portfolios compared to the baseline (30 days rolling window)
(Authors' analysis)

Figure 6 shows the betas for our portfolios. Negative betas suggest that investments moved in the opposite direction from the market, while positive betas are associated with portfolio return moving in the same direction as the market. Portfolios comprising of cryptoassets exhibit large negative betas. The most notable result is a negative beta of -19 for the portfolio containing Dogecoin in January 2021, but betas close to -10 e.g., for the portfolio containing Ether, have not been unusual in the past. Further, the chart shows that despite popular belief that cryptoassets aim to disrupt traditional financial markets, they can display large positive betas over relatively long periods (e.g., most of 2017 and 2018 as well as part of 2020), which implies that overall market and economy performance is reflected in cryptoassets performance.

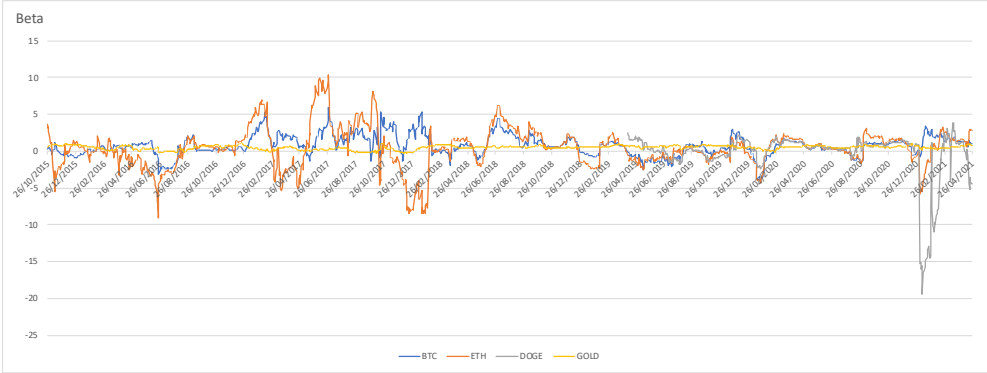

Figure 6. Portfolios' Beta
(Authors' analysis)

Figure 7 shows the Sharpe Ratio for our four portfolios described above, which exhibited mixed behavior. In 2021 adding any of the cryptoassets to our benchmark portfolio performed better than simply adding gold. Based on the Sharpe Ratio alone, the theory suggests against investing in cryptoassets when faced with a safer alternative, given the higher variance of the resulting portfolio.

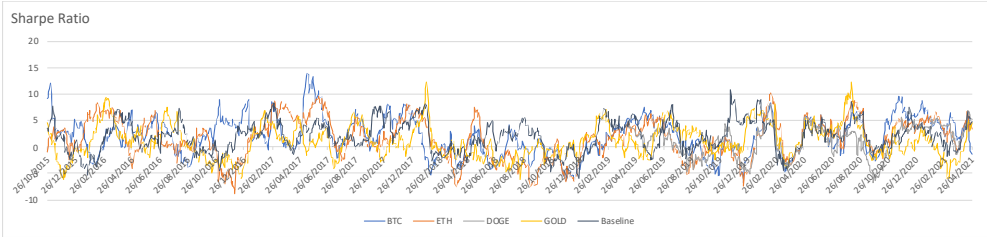

Figure 7. Sharpe Ratio of our four portfolios compared to the baseline
(Authors' analysis)

We will now discuss the alphas of our portfolios (Figure 8), or their ability to "beat" the market. Alpha is a measure of abnormal returns, stemming from the idea that markets are efficient, and so assets or portfolios cannot systematically exceed the market. The performance of the Dogecoin portfolio far exceeded expectations in 2021, with a maximum alpha of 8%. While this is a significant outlier, the chart shows that alphas between 3-10% either positive or negative, were not uncommon across portfolios containing cryptoassets.

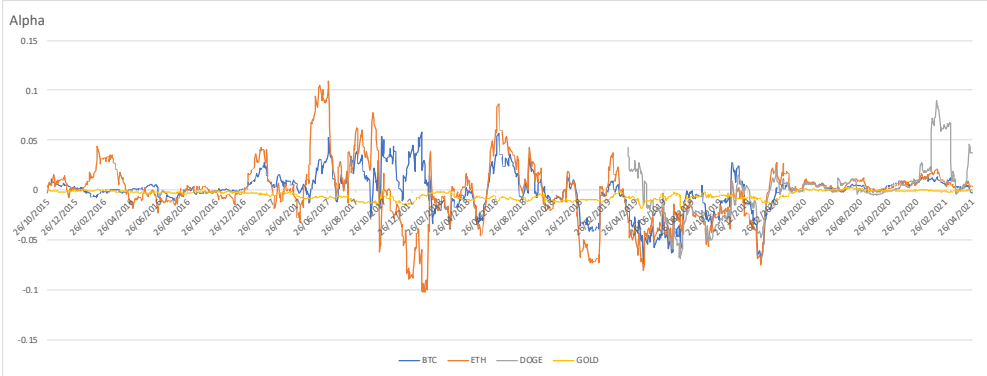

Figure 8. Portfolios' Alphas
(Authors' analysis)

According to CAPM, investors should seek the highest Sharpe Ratio of the total portfolio, and not of the individual assets in the portfolio. Therefore, when analyzing individual assets, the *alpha* could be a more meaningful measure. In the case of cryptoassets, they do frequently exhibit sizeable *alphas*. Furthermore, including an asset with a positive *alpha* within a portfolio that already has a high Sharpe Ratio will, in theory, further increase the latter.

Conclusions

The prices of cryptoassets have been rising sharply in 2021 after stabilizing following the crash of 2018. Active addresses (users) have grown, and prices have been rising with them. All three cryptoassets we analyzed, Bitcoin, Ether, and Dogecoin, showcased high negative betas and high positive alphas, especially during 2021. While cryptoassets are outliers compared to traditional markets, Dogecoin has been an outlier amongst cryptoassets in 2021 with a 20,000% price increase year on year. Despite some maturing in recent years, cryptoassets, by and large, continue to fail on two of the three criteria that define the function of money which might hinder their wider adoption as money. This invalidates our first research hypothesis, whether cryptoassets function well as money.

Portfolios that included cryptoassets outperformed our benchmark portfolio comprising of equal parts of stocks and bonds. This validates our second research hypothesis, whether cryptoassets could function as investment assets. The cryptoassets we analyzed exhibited large negative *betas*, further showcasing their speculative nature. Further, all cryptoassets exhibited large abnormal returns, which suggests that *alpha* might be a better-suited measure for performance than *beta* in the case of cryptoassets. However, returns are likely inflated by survivorship bias – we have considered three cryptoassets perceived to be successful whereas many thousands have failed.

Finally, irrespective of the results discussed above, it might be the case that the real value (if any) of cryptoassets does not come from their performance as investment assets, but instead from the inherent innovation they bring to the market. Indeed,

beyond Bitcoin which continues to dominate the market, we witnessed dramatic shifts in the cryptoasset landscape in recent years, as more players entered the space and new services emerged.

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