Cryptocurrency Analysis – A Survey of Recent Academic Literature

Abstract

The conventional autoregression tools of econometrics have been used to estimate correlations between log-returns (or prices) of cryptocurrencies and traditional assets, and characterise their variance behaviour. From these, confident suggestions have been made that cryptocurrencies are suitable tools for diversifying portfolios, due to their low correlation with traditional assets such as stocks, bonds, currencies, and commodities. These low correlations may be explained by Ciaian *et al.* [1], whose analysis suggests that consumer demand, market development, and speculation are the long-term determinants of Bitcoin (BTC) price, rather than global macro and financial econometric indicators. Their analysis also provided a basis for estimating cryptocurrency value, based on transaction volume and circulation velocity. Further, their subsequent analysis of the relationship between bitcoin and other cryptocurrency prices estimated that most them were correlated with Bitcoin in the short term, but few were over longer time frames – possibly due to their individual market development, suggesting an important role for studying their fundamentals. [2]

Less confidence has been expressed in their suitability for hedging risks of traditional assets, though there were some indications, especially for energy commodities such as oil. Additionally, several commentators suggested that Bitcoin demand has increased during adverse economic events such as the Cyprus banking crisis [3], and dramatic central bank actions such as India's demonetization campaign. [4] Indeed, Damordaran has expressed his belief that Bitcoin, and other cryptocurrencies, have taken the role of gold for some people. [5] Finally, Marie Brière, Head of Investor Research, Asset Management of Crédit Agricole and Societé Génerale (AMUNDI), summarised her view of the potential of cryptocurrencies for portfolio diversification as follows:

> *Including even a small proportion of BTCs in a well-diversified portfolio may dramatically improve risk-return characteristics. Overall, our key message is that virtual currencies deserve to be taken seriously by financial analysts.* [6]

Summary of academic positions

Perhaps the most fundamentally interesting question researchers can ask is "what determines cryptocurrency and asset prices?" Ciaian *et al.*, in the service of the European Commission and Catholic University Leuven, examined models of BTC price formation for the period from 2009 to 2015. [1] These models were based on earlier work on currencies under the gold standard [7], where currency supply and demand were equated to form the classical equation of exchange:

$$P^B = \frac{PG}{VB}$$

Where P^B is the Bitcoin price in dollar, P is the general price level of goods and services, G is the size of the Bitcoin economy, V is the velocity of Bitcoin circulation, B is the supply of Bitcoins.

Typically, this model assumes that demand is purely from the volume of transactions conducted using the currency, rather than some independent demand for the currency such as from asset price speculation. i.e. Value is determined by the currency's use in transactions, and how the currency is held or spent by its holders. This model was transformed to a regression model, and specific variants were formulated to test different hypothesis. Factors such as estimates of BTC demand (transaction rate, new address generation rate) and velocity of circulation (via days destroyed) were included, and extensions were made to include regression terms for investor attractiveness/interest (number of internet views and posts etc.) and macro-financial indicators (stock and commodity prices). The models were considered over two periods: before and after September 2013, when the BTC price crash began. They found that price formation is most likely driven by bitcoin market development, consumer demand, and speculation, rather than global macro-financial development (correlations with traditional assets), with the trend being stronger in the post-crash time period. This indicates that bitcoin returns may continue to offer low correlations with traditional asset classes, and emphasises the role of transaction activity estimates in valuing cryptocurrencies.

Ciaian *et al.* then examined correlations between BTC and other cryptocurrency prices, from 07/2012 to 10/2016, using Autoregressive Distributed Lag (ARDL) models. [2] They estimated that cryptocurrency prices were often significantly correlated with BTC price in the short-run, but generally not in the long-run. This may support the view that BTC market development supports emergence of other cryptocurrencies, with them becoming largely independent as they develop, due to their long-term price formation being more dependent on individual market development. The cryptocurrencies are typically weakly correlated with traditional assets over longer terms, with some, such as DASH coin, displaying negative correlations with indicators such as gold price and the 10-Year Treasury Constant Maturity Rate. Additionally, they estimated that BTC and Alt100 alt-coin index[1] prices were correlated with the gold price over the long term.

[1] http://alt19.com/marketindexes.html

The most current, and perhaps pertinent, econometric research has been conducted at Humboldt University (Berlin, Germany) and at various Singaporean institutes, who collaborated on a cryptocurrency portfolio index (CRIX)[2], and analysed its properties and relationships to other assets. [8-10] Most recently, Chuen *et al.* [9] found that member cryptocurrency log-returns displayed low correlation with traditional assets (typically < 0.05), over the period 11 August, 2014 to 27 March, 2017, which persisted when subjected to Dynamic Conditional Correlation (DCC) modelling of return quantiles. These low correlations were consistent with previous CRIX publications. [10] Further, several cryptocurrencies displayed small negative correlations with traditional assets. Most notably and strongly, BTC and CRIX with oil returns, possibly suggesting hedging potential. Additionally, CRIX had some positive correlation with gold in higher return quantiles. Due to the differing analytical methods employed, and time frames considered, in these publications, more detailed investigation of asset return correlations and characteristics is recommended.

Correlations between the CRIX member currencies' returns were examined by Elendner *et al.* [10], who found that BTC aside, most had fairly low correlations, typically < 0.2. They characterised these as lower than typical for correlations between stocks traded on public exchanges.

Portfolio analyses from Trimborn *et al.* [11] and Chuen *et al.* [9] suggested that addition of cryptocurrencies could improve risk/return behaviour when combined with stock indices or traditional asset portfolios. Chuen *et al.* noted that the CRIX index has not demonstrated as much utility for the mean-variance investor, nor statistical confidence of its improvement of the tangency portfolio. The former is probably due to CRIX's limited sample period, as BTC does not display this drawback. The latter result demands further investigation, which is already strongly recommended given the limited analysis available.

Earlier work established BTC's potential for diversification and portfolio enhancement. Marie Brière, Head of Investor Research at Asset Management of Crédit Agricole and Societé Génerale (AMUNDI), examined it from 07/2010 to 12/2013, finding log-returns weakly correlated (< 0.1) with traditional assets, except for gold (0.14), and portfolio risk/return curves and Sharpe ratios improved by its addition. [6] She also noted its possible role as a safe-haven investment. Similarly, Eisl *et al.* [12] found that BTC should be included in an optimum portfolio constructed from a Conditional Value-at-Risk framework, over the period 2010 to 2015.

Several researchers have examined BTC for its hedging potential, often looking for correlations with gold. Generally, researchers have applied GARCH or DCC models to BTC log-returns or price, and sought negative correlations with traditional assets. Alternatively, two studies have applied wavelet coherence analysis to examine correlations over time-scale as well as asset class or return quantile.

The earliest study came from Kristoufek [13], who used wavelet coherence analysis to analyse correlations, over various time frames, between BTC price and potential drivers such as transaction and exchange volumes, gold price, and the Cleveland Federal Reserve's Financial Stress Index (CFSI) for the period 9/2011 to 2/2014. Trade-Exchange ratio (transaction volume to exchange trading volume) was quite strongly correlated with bitcoin price over longer time periods, though not with statistical significance at the 5% level. This may suggest that price increases as BTC is used more for transactions relative to speculation and investment, supporting Ciaian *et al.*'s [1] hypothesis that market

[2] http://crix.hu-berlin.de/

development drives BTC price. BTC price was not generally correlated with CFSI scores, but was positively correlated, over medium time frames, during the Cyprus banking crisis in early 2012. In this period and time frame the wavelet phase indicates that price was led by CFSI score. This suggests that BTC may be a safe haven during adverse economic events or dramatic central bank actions, though not generally.

Caution must be exercised when interpreting these analyses however: the CFSI only monitors US economic indicators, the time frame of analysis is narrow and limited to early periods in BTC's development, and the method of analysis is limited to pairs of variables, without further statistical analysis described – critical for proper calculation of statistical significance when more than two variables in total are considered for correlation with BTC price. Future use of this technique should be extended over the entire BTC price history, with more appropriate indicators of financial risk as variables, and appropriate statistical analysis of p-values to compensate for the many statistical "experiments" carried out.

Dhyrberg [14] used GARCH analysis, derived from previous work examining gold as a hedge against the US dollar [15], to examine log BTC price correlations with log FTSE index, and logarithms of the USD-GBP and USD-EUR exchange rates, from 07/2010 to 05/2015. Very small negative correlations to the FTSE index, and stronger negative correlations (~ -0.175) to the USD-GBP exchange, were found. None were statistically significant for $p < 0.10$, and no indication was given that p-values compensated for the use of separate models for each variable.

Bouri *et al.* [16] adapted the DCC based analysis method of Ratner and Chiu [17] to examine log-return correlations between BTC and traditional assets over the period 06/2011 to 10/2015, with further analysis of the contribution of extreme movement quantiles (1%, 5%, 10%) to the correlation. The analysis sought assets for which BTC was either uncorrelated or negatively correlated, particularly during times of stress, as represented by the lowest return quantiles. BTC was weakly (positively) correlated with most assets, and displayed negative correlation with some Asian stock indices. This negative correlation was maintained for the 10% quantile. This was also observed with oil at 10% but not overall. Most observations were significant at $p < 0.01$, though not all. This analysis, as with that from Chuen *et al.* [9], would be worth repeating over more recent time periods.

Another DCC based article from Bouri *et al.* [18] analysed correlations between BTC log-returns and composite, energy, and non-energy commodities indices from 06/2010 to 10/2015. This period included the BTC price crash of late 2013, and the oil price crash of 2014. As expected, weak correlations (< 0.03) were found between BTC and commodity returns for the entire period, and both before and after the BTC price crash. Before the BTC crash, and overall, negative correlations between BTC and energy commodities returns were displayed. These persisted across the 1, 5, and 10% quantiles, though were only statistically significant ($p < 0.05$) for the constant and 1% quantile terms. They were also observed for the composite commodities index. Due to overlap with the persisting effects of the 2013 BTC crash, negative correlation with oil was not observed after 12/2013 – the period including the oil price crash. With the evolving nature of the BTC market, further analysis of subsequent adverse oil price events is recommended for gauging BTC hedging ability for energy commodities.

Finally, Bouri *et al.* [19] constructed a global volatility index (WVIX), and used a wavelet based analysis combined with quantile regression to examine BTC return correlation with global market volatility. They claimed that BTC may

have reacted positively to extremes of uncertainty over shorter time periods. Caution should be exercised when considering these results however, as the opposite trend was observed with other conditions.

Discussion

To date, most published work has been limited to Bitcoin, though in the past year research on other cryptocurrencies has begun to appear. The work on Bitcoin has primarily focussed on log-return correlations with traditional assets and macro-financial indicators, with these correlation estimates being uniformly low. Correlations between cryptocurrencies were also relatively low, particularly over longer periods. Additionally, Ciaian *et al.* [1] focussed on BTC pricing models, concluding that consumer demand, market development, and speculation were the long-term price determinants.

Ciaian *et al.*'s 2016 publication [1] raised two important issues: firstly, they noted that structural breaks in BTC price may occur, and analyses need to take them into account. The price crash of 2013 is the obvious example, but other events such as currency "forks", and payment technology upgrades (such as the impending Lightning Network adoption) may precipitate breaks too. These econometric regime changes, combined with increasing market adoption and development, mean that analyses will need to be kept up to date, with emphasis on best modelling the behaviour of the current regime. Rolling 12-month, six-month, or shorter, correlations may be appropriate.

Secondly, any analysis is only as good as the data it's based on, and many variables needed to be estimated for a pricing model. All studies in this field must strive to use the most representative and accurate data possible – whether it be combined exchange data for prices and returns, estimates of global financial uncertainty, cryptocurrency transaction volume, or circulation velocity. The latter cryptocurrency properties require particular attention, due to the peculiar nature of cryptocurrency use – a high proportion of transactions are the result of single users moving funds from one wallet to another, which does not represent economic activity. This so called "self-churn" may have a large effect on velocity and transaction volume estimates. [20, 21]

Several studies have sought to answer whether BTC can act as a safe-haven, or hedge, against uncertainty or negative returns from traditional assets. The strongest results here are the consistently low estimations of correlations between BTC returns and those from traditional assets, suggesting that BTC may not be as affected by a downturn in those assets, or an increase in global perception of risk or volatility. Low correlations have also been observed, in a few recent studies, for other cryptocurrencies. In depth treatment of them remains elusive though.

Less certain is whether BTC or other cryptocurrencies can act as strong hedges against downturns in other assets. Typically, researchers have sought negative correlations with traditional asset returns. Though some indications have been observed over certain time scales or movement quantiles, consistent hedging of this sort has yet to be demonstrated. Additionally, there has been some indication of BTC price and returns correlation with economic volatility and stress, but these have been limited to certain combinations of time-scale, quantile, and specific time period. Comprehensive studies that compare cryptocurrency hedging properties to gold, the Swiss Franc, and other traditional safe-haven assets, would be of considerable value, particularly so if they include examination of periods of adverse economic events, and asset price downturns. Despite claims that BTC demand and returns have increased during adverse economic events such as the Cyprus banking crisis [3], and dramatic central bank actions such as India's demonetization campaign [4], hedging and safe-haven abilities of cryptocurrencies have yet to be confirmed. Nevertheless, prominent commentators, such as Damordaran, have expressed a belief that BTC and other cryptocurrencies have taken the role of gold for some people. [5]

Despite the various studies of econometric properties, robust portfolio analysis is not currently publicly available. A comprehensive analysis of cryptocurrencies, building to relevant portfolio analysis should be a goal for the field.

Finally, it must be emphasised that conclusions about the econometric and investment properties of cryptocurrencies should be the result of consistent studies using the same data, conducted over appropriate and relevant time periods, where statistical methods that compensate for the totality of statistical experiments conducted in these studies are applied.

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