# Cryptocurrencies and currency competition: has Hayek been too optimistic?

Marc Gronwald,* Yuan Zhao,†

October 1, 2018

**Abstract**

This paper contributes to the literature in two distinct ways. First, it empirically analyses the relationship between the prices of three major cryptocurrencies. The main finding can be summarised as follows: a strong relationship exists between prices of Bitcoin, Etherum, and Ripple. In addition, this relationship is found to vary over time. Finally, Bitcoin is the "dominant" currency in 2016-2017. Second, it discusses the obtained empirical results in the context of competition in currency. In light of the fact that Bitcoin is characterised by a number of undesirable properties, it is a reason for concern that Bitcoin has considerable influence on prices of other cryptocurrencies. In other words, it seems as if Hayek has been too optimistic: the outcome of the currency competition is not exactly what he has hoped for.

JEL Classification: C22, C32, B20, E50

Keywords: Cryptocurrencies, Currency competition, Granger causality, Spillover

*University of Aberdeen Business School, ifo Institute and CESifo. Address: University of Aberdeen Business School, Edward Wright Building, Dunbar Street, Aberdeen, AB24 3QY, United Kingdom. E-mail: mgronwald@abdn.ac.uk

†University of Aberdeen, Business School, E-mail: y.zhao@abdn.ac.uk

# 1 Introduction

The cryptocurrency Bitcoin emerged in 2000 based on a proposal by the anonymous creator Nakamoto (2009). Among the main motivation to create this digital currency was a considerable distrust in traditional financial market institutions  in particular commercial banks and hedge funds, but also central banks and other monetary authorities; at the time of the introduction of Bitcoin, the financial crisis just took place. It should be noted that Bitcoin is a private currency, created without any influence of those traditional institutions. Attention from the general public, however, Bitcoin only attracted around 2013/2014, in the wake of the first spectacular price movements. Over the years, various additional cryptocurrencies emerged; among the more important ones are Etherum and Ripple.

Academic interest in cryptocurrencies started around the same time Bitcoin exhibited the price movements referred to earlier, but in a way two separate streams of papers emerged: on the one hand, empirical researchers began analyzing price behavior of Bitcoin prices using conventional time series techniques. Epitomized by: On the other, the role of Bitcoin has been analyzed from a more political perspective: Weber discusses the legitimacy crisis of money, Dowd and Hutchinson (2015) emphatically state that the undeniable achievement of Bitcoin is that it demonstrates the practical possibility of fully decentralized monetary systems based on the principle of distributed trust rather than central authority. Many contributions to this second stream of papers are influenced by Hayeks (1976a, 1976b) proposals of private money and currency competition. Hayek (1976b) is concerned about political control of money in general and the nationalization of central banks in specific. Hayek (1976a) states that it remains unclear why the government should have the monopoly on creation of money and that currency competition has not been discussed. As a consequence, Hayek (1976a, 1976b) considers currency competition a way to stop inflation.

The aim of this paper is bridge the gap between these two perspectives. First, this paper conducts an empirical analysis of the relationship between a number of leading cryptocurrencies standard techniques such as Granger causality tests and volatility spillover models are applied. The results, second, will be used in order to test whether Hayeks (1976) optimism regarding currency competition was justified.

## 2 Cryptocurrencies, private money and currency competition

This section briefly summarizes the existing empirical literature on pricing of cryptocurrencies, followed by a discussion of recent contributions to the debate on private currencies and currency competition. A large number of contributions to this empirical literature is concerned with the volatility of Bitcoin, see e.g. Katsiampa (2017) and Cheah and Fry (2015), and many others. Cheah and Fry (2015) also analyse the existence of speculative bubbles. Finally, many study are concerned with informational efficiency of Bitcoin, see e.g. Urguhart (2016). Not many studies investigate the relationship between different cryptocurrencies; Corbet et al. (2018) form a notable exception in this regard.

The emergence of cryptocurrencies did not only spark this empirical research, it also reinvigorated the academic discussion of private money and currency competition. Hayek (1976a, 1976b) originally proposed that the creation of money should be taken out of the hand of nationalized central bank and that people should have the freedom to choose the currency they prefer. This proposal and any discussion of which necessarily had to stay on an academic, abstract level; only in the contact of the introduction of the European Currency Union this gained some practical relevance, see Dowd and Greenaway (1993). This now changed with the emergence of cryptocurrencies. Sanches (2016), for instance, discusses the inherent instability of private money. He shows that purely private monetary systems would inevitably collapse; however he introduces a government intervention that results in the global determinacy of equilibrium, which is a desirable property of any monetary system. What is more, Fernandez-Villaverde and Sanches (2016) use a model of privately issued currencies based on the Lagos-Wright framework and show that currency competition works in the sense that there exists an equilibrium in which price stability is consistent with competing private monies. For a recent non-technical discussion of this issue, see Sanches (2018).

## 3 Data and important features of cryptocurrencies

Apart from the enormous volatility Bitcoin prices are characterized by and concerns about a speculative bubble, Bitcoin has been criticized for a number of other reasons. First, according to

Nakamoto (2009), there is a fixed total supply of Bitcoin: not more than 21 million Bitcoins are ever going to be issued. Currently, about 17 million are in circulation; the number in circulation grows at a roughly constant rate. Yermack (2014) was among the first to emphasize that this would imply that if Bitcoin becomes wildly successful and displaces sovereign fiat currencies, it would exert a deflationary force on the economy since money supply would not increase in concert with economic growth. In addition, the process of generating new units, also referred to as mining, is extremely energy intensive; see e.g. de Vries (2018). In these regards Bitcoin is different from other cryptocurrencies such as Etherum and Ripple: While to date no hard cap on the total number of Etherum units has been imposed and the inflation seems to be changing from time to time, Ripple does not rely on the same energy intensive mining process like Bitcoin.

# 4 Results and discussion

This section contains a presentation as well as a discussion of the empirical results. We carry out some empirical tests on the volatility of the three largest cryptocurrencies, Bitcoin, Ethereum and Ripple. Figure 1 shows the market capitalisation of the largest three cryptocurrencies, including Bitcoin, Etherum, and Ripple. In this section, we will look into the conditional volatility, correlations, causal relationships, time variation on such relationships, and external factors that may affect the relationships.

- We model the conditional volatility for cryptocurrencies, by comparing different volatility models. We present the findings on Bitcoin as the baseline cryptocurrency. We examine the natural logarithm of the closing price ratio of consecutive days from 28 April 2013 to 24 Feb 2018. The daily return of Bitcoin index is 0.2435% with standard deviation of 0.04503. The returns are negative skewed and leptokurtosis. The p-value of the Jarqu-Bera test indicates that the returns deviate from a normal distribution. We also test there is significant ARCH effect in the returns of Bitcoin returns, suggesting the ARCH family models as the more appropriate specification to model. The unit root test from ADF, PP and KPSS test shows the return series from Bitcoin is stationary. The descriptive

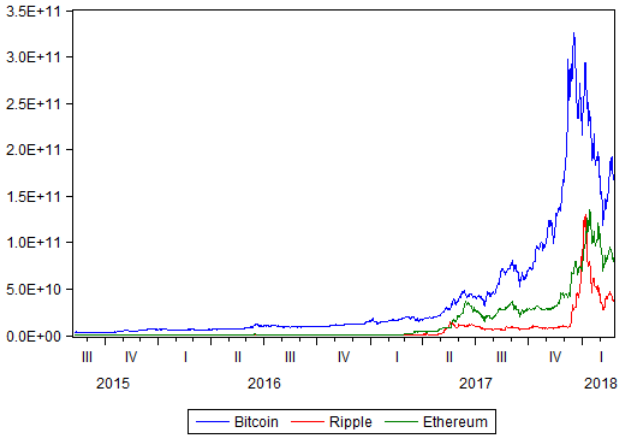


Figure 1: A Comparison of largest three cryptocurrencies.

Table 1: Descriptive statistics and unit root test of Bitcoin returns

| **Descriptive stats** | |
|---|---|
| Mean | 0.002435 |
| Median | 0.002045 |
| Maximum | 0.3575 |
| Minimum | -0.2662 |
| Std. Dev. | 0.04503 |
| Skewness | -0.1917 |
| Kurtosis | 11.0549 |
| Jarque-Bera | 4776.9130 |
| Observations | 1763 |
| **Unit root test** | |
| ADF test | -41.6905 |
| PP test | -41.8247 |
| KPSS test | 0.2537 |

statistics and unit root tests are presented as follows in Table 1.

We follow a similar approach to **?**, and conduct the likelihood ratio test on the GARCH model specifications, including AR(1)-GARCH(1,1), AR(1)-EGARCH(1,1), AR(1)-TGARCH(1,1), AR(1)-APARCH, AR(1)-CGARCH(1,1). And we find that the AR(1)-EGARCH(1,1) is the best specification based on the results of likelihood ratio test. We forecast the conditional volatility from this specification. Figure 2 shows the persistence and asymmetry in Bitcoin return volatility, especially around late 2013, the beginning of 2015, and the end of 2017.

- The contagion of spillover effects of multiple cryptocurrencies can be investigated using

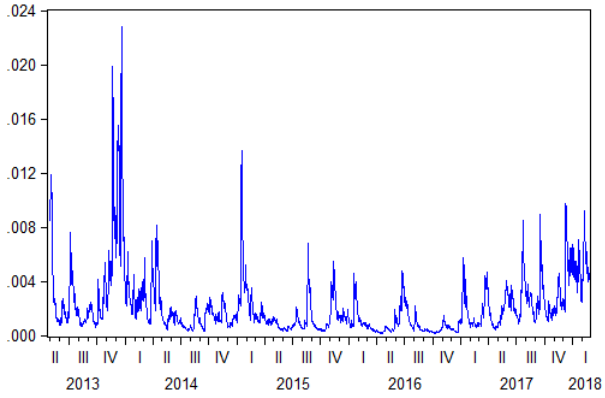


Figure 2: Conditional volatility of Bitcoin returns, Data Source: Coindesk.

trivariant-GARCH models. The following Figure 3 exhibits the covariance of each pair of cryptocurrencies. It is evident that the covariance between these three cryptocurrencies increases significantly around the recent one year compared to the initial one year. The covariance between Ripple and Ethereum is more sensitive to external economic conditions, implied by the more volatile fluctuations.

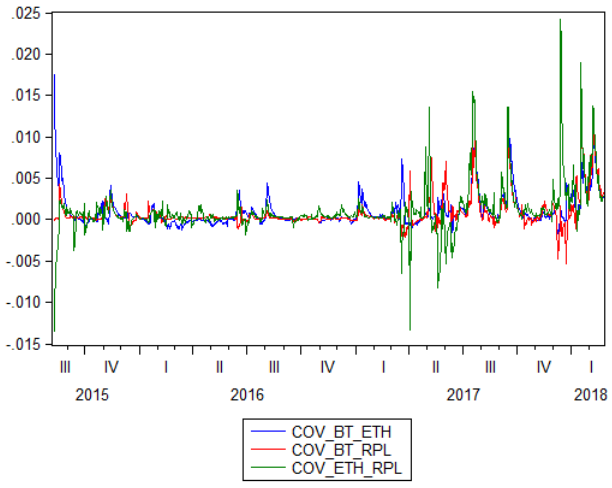


Figure 3: The covariance of largest three cryptocurrencies.

- According to Markowitz portfolio theory, an asset that is unrelated or even negatively correlated with another asset in the portfolio is characterised as hedging effective. Thus, it is worth looking into the correlation among the major cryptocurrencies in terms of

Table 2: Granger causality test of the largest three cryptocurrencies

| **Granger block exogeneity Wald test** | | |
|---|---|---|
| Dependent variable: Bitcoin | | |
| Excluded | Chi-sq | Prob. |
| Ethereum | 1.119537 | 0.5713 |
| Ripple | 10.46673 | 0.0053 |
| All | 12.08829 | 0.0167 |
| Dependent variable: Ethereum | | |
| Excluded | Chi-sq | Prob. |
| Bitcoin | 0.188579 | 0.91 |
| Ripple | 2.356285 | 0.3079 |
| All | 2.653052 | 0.6175 |
| Dependent variable: Ripple | | |
| Excluded | Chi-sq | Prob. |
| Bitcoin | 1.130565 | 0.5682 |
| Ethereum | 5.116094 | 0.0775 |
| All | 5.351787 | 0.2531 |

their roles on portfolio diversification. In this study, we utilise the Granger causality test and vector autoregressive (VAR) model, in order to investigate the short-term dynamic causal relationship between different pairwise cryptocurrencies. In Table 2, we present the findings for the short-run causality from different directions, on the null hypothesis of no short-term causal relationships. A p-value (Prob.) less than a predefined significance level (5%) indicates a rejection of the existence of a causal relationship. We find that under the condition of short-run exogenous economic shock, Ripple has a significant causal impact on the returns of Bitcoin. And Etherum has a causal relationship with Ripple. The direction of such causal relationship can be seen in Figure 4, by impulse response function. We find positive causal relationships from all directions.

- As indicated in the previous findings, cryptocurrencies have entered into a more dynamic market with more potential risks. Hence, we especially focus on the recent full year from 2016 to 2017, to examine the time variation of the causality. The following Figure 5 exhibits the covariance of each pair of cryptocurrencies, Table 3 shows the Granger causality of pairwise cryptocurrencies, and Figure 6 illustrates the directions of such causality, in the recent one year. We find that in the recent one year, Bitcoin dominates others by having an increasing covariance with the other two. There is a significantly positive causal relationship from Bitcoin to other currencies, which can be concluded according to the Granger block exogeneity Wald test p-value as 0.0386 and positive responses from

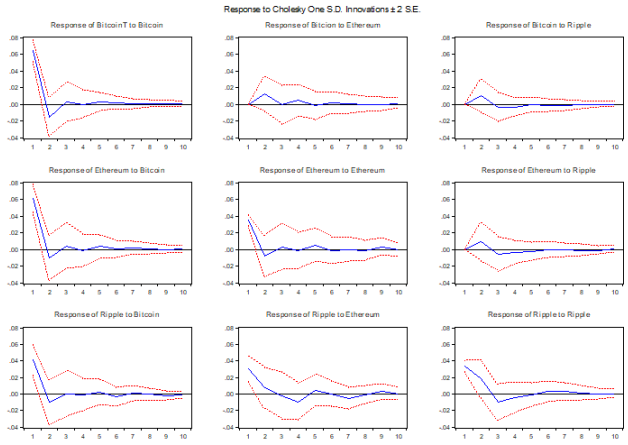


Figure 4: The Impulse Response Function of largest three cryptocurrencies.

Ethereum and Ripple.

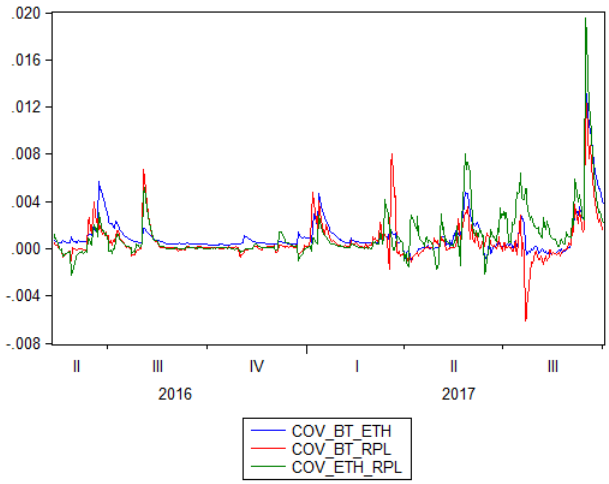


Figure 5: The covariance of largest three cryptocurrencies.

- Other external factors may also become sources affecting the market risk of cryptocurrencies. According to the review of financial literature, trading volume is a main factor affecting the risks and returns of financial assets. Therefore, we examine the causality of behavioural factors like trading volume on cryptocurrencies by implementing a VAR model and Granger causality test. Table 4 shows the causality of volume from these three currencies to their returns. We find that the trading volume of Ripple has a significant causal relationship over Bitcoin and Bitcoin volume. And the Bitcoin trading volume has

Table 3: Granger causality test of the largest three cryptocurrencies

| **Granger block exogeneity Wald test 2016-2017** | | |
|---|---|---|
| Dependent variable: Bitcoin | | |
| Excluded | Chi-sq | Prob. |
| Ripple | 3.1278 | 0.2093 |
| Ethereum | 0.8272 | 0.6613 |
| All | 3.6444 | 0.4563 |
| Dependent variable: Ethereum | | |
| Bitcoin | 6.5079 | 0.0386 |
| Ripple | 1.3257 | 0.5154 |
| All | 7.4076 | 0.1159 |
| Dependent variable: Ripple | | |
| Bitcoin | 1.5218 | 0.4672 |
| Ethereum | 0.7558 | 0.6853 |
| All | 3.0384 | 0.5514 |

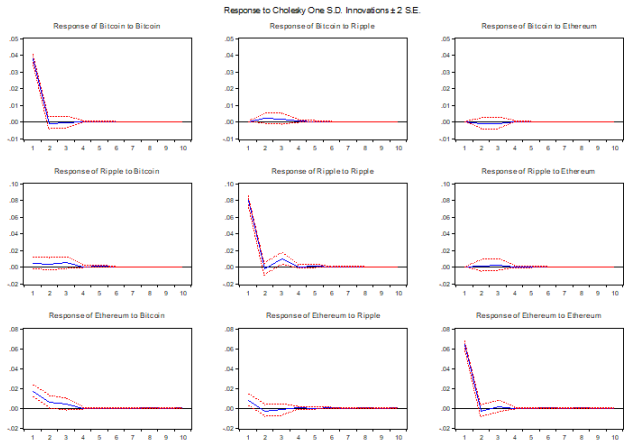


Figure 6: The Impulse Response Function of the largest three cryptocurrencies during 2016-2017.

the reverse causality over Ripple volume and Ethereum volume, which further confirms our inferences on the increasing impact of Bitcoin in the recent full year over others.

To summarize, Bitcoin seems to be dominant cryptocurrency, in particular in certain subsamples we consider. This perhaps just reflects that Bitcoin was the first cryptocurrency. It should be noted, however, that the analysis in this paper is descriptive and that the results of Granger causality tests must be interpreted with caution. Nevertheless, the problems associated with Bitcoin are obvious and are widely discussed in the literature; in particular the total limited supply which inevitably means that, in a Bitcoin economy, if the growth rate of the economy is different from the growth rate of money supply, there is either inflation or deflation. As stated above, Etherum does not have this feature.

Table 4: Granger causality test of the largest three cryptocurrencies return versus trading volume

| **Granger block exogeneity Wald test** | | |
|---|---|---|
| Dependent variable: Bitcoin | | |
| Excluded | Chi-sq | Prob. |
| Ethereum | 0.0787 | 0.9614 |
| Ripple | 4.6776 | 0.0964 |
| Bitcoin volume | 2.2668 | 0.3219 |
| Ethereum volume | 2.5613 | 0.2779 |
| Ripple volume | 6.5272 | 0.0383 |
| All | 17.6204 | 0.0617 |
| Dependent variable: Ethereum | | |
| Bitcoin | 4.8802 | 0.0872 |
| Ripple | 0.5197 | 0.7712 |
| Bitcoin volume | 3.4664 | 0.1767 |
| Ethereum volume | 1.1715 | 0.5567 |
| Ripple volume | 3.0683 | 0.2156 |
| All | 11.7578 | 0.3016 |
| Dependent variable: Ripple | | |
| Bitcoin | 2.0651 | 0.3561 |
| Ethereum | 1.0425 | 0.5938 |
| Bitcoin volume | 2.4065 | 0.3002 |
| Ethereum volume | 0.3773 | 0.8281 |
| Ripple volume | 2.2058 | 0.3319 |
| All | 10.4823 | 0.3992 |
| Dependent variable: Bitcoin volume | | |
| Bitcoin | 0.7594 | 0.6841 |
| Ethereum | 4.3616 | 0.1129 |
| Ripple | 0.2130 | 0.8990 |
| Ethereum volume | 4.4428 | 0.1085 |
| Ripple volume | 10.7419 | 0.0046 |
| All | 23.4696 | 0.0091 |
| Dependent variable: Ethereum volume | | |
| Bitcoin | 0.3634 | 0.8338 |
| Ethereum | 7.2534 | 0.0266 |
| Ripple | 0.4723 | 0.7897 |
| Bitcoin volume | 6.1108 | 0.0471 |
| Ripple volume | 2.6953 | 0.2598 |
| All | 21.2929 | 0.0191 |
| Dependent variable: Ripple volume | | |
| Bitcoin | 4.6771 | 0.0965 |
| Ethereum | 1.2313 | 0.5403 |
| Ripple | 5.8466 | 0.0538 |
| Bitcoin volume | 17.1896 | 0.0002 |
| Ethereum volume | 2.1749 | 0.3371 |
| All | 40.2409 | 0.0000 |

Perhaps Hayek would have hoped that Etherum would be the dominant currency, the currency people choose; or at least that Bitcoin does not dominate other currencies and, in a way, affect the general public view on cryptocurrencies and private money. As stated above, Hayek is very optimistic with regard to the outcome of a currency competition: people choose the currency they trust and this is one way to fight inflation. There always have been more skeptical voices, e.g. Dowd and Greenaway (1993) who state that We cannot explain currency-holding behavior only on the basis of their expected pecuniary return or more subjective factors like the amount of 'monetary stability' they are expected to deliver. They explain that network effects and switching cost also play a crucial role. Thus, even if people have the choice, the outcome might not necessarily desirable. Perhaps it is too early to conclude as it remains to be seen how the value of these currencies on the one hand and the relationship between these currencies on the other further develops. In any case, the emergence of cryptocurrencies allows one to study how people accept private money and, thus, also to analyse if Hayek has been too optimistic.

## 5 Literature


Cheah, E.-T. and J.Fry (2015), Speculative Bubbles in Bitcoin Markets? An Empirical Investigation into the Fundamental Value of Bitcoin, Economics Letters, 130, 32-36

Corbet, S., A.Meegan, C.Larkin, B.Lucey, and L.Yaroyava (2018), "Exploring the Dynamic Relationships between Cryptocurrencies and other Financial Assets", Economics Letters, 165, 28-34

De Vries, A. (2018), Bitcoins Growing Energy Problem, Joule, 2, 801-809

Dowd, K. and M.Hutchinson (2015), Bitcoin Will Bite the Dust, Cato Journal 35(2), 357-382

Dowd, K. and D.Greenaway (1993), Currency competition, Network Externalities and Switching Cost: Towards an Alternative View of Optimum Currency Areas, The Economic Journal, 103, 1180-1189

Fernandez-Villaverde, J., and D.Sanches (2016), Can currency competition work?, NBER Working Paper Series 22157

Hayek, F.A. (1976a), Denationalisation of Money, The Institute of Economic Affairs, London

Hayek, F.A. (1976b), Choice in Currency, The Institute of Economic Affairs, London

Katsiampa, P. (2017), Volatility Estimation for Bitcoin: A Comparison of GARCH Models, Economics Letters, 158, 3-6

Nakamoto, S. (2009), Bitcoin: A Peer-to-peer Electronic Cash System, available via www.bitcoin.com.

Sanches, D. (2016), On the Inherent Instability of Private Money, Review of Economic Dynamics, 20, 198-214

Sanches, D. (2018), Bitcoin vs. the Buck: Is Currency Competition a Good Thing?, Federal Reserve Bank of Philadelphia, 2018 Q2

Urquhart, A, (2016), The Inefficieny of Bitcoin, Economics Letters, 148, 80-82

Weber, B. (2016), Bitcoin and the Legitimacy Crisis of Money, Cambridge Journal of Economics, 40, 17-41