This is a preprint draft of a paper accepted (22 January 2019) for publication in International Review of Financial Analysis in 2019.

DOI of the published version: 10.1016/j.irfa.2019.01.006

The Drivers of Bitcoin Demand: A Short and Long-Run Analysis

Luis P. de la Horra [a,1], Gabriel de la Fuente [a], Javier Perote [b]

[a] University of Valladolid, Spain

[b] University of Salamanca, Spain

[1] Corresponding author: Business & Economics School. Department of Financial Economics and Accounting. Address: Avda. Valle Esgueva, 6. 47011, Valladolid (Spain). E-mail: luispablo.horra@uva.es. Phone: +34 606782986.

The Drivers of Bitcoin Demand: A Short and Long-Run Analysis

Luis P. de la Horra [a,2], Gabriel de la Fuente [a], Javier Perote [b]

[a] University of Valladolid, Spain

[b] University of Salamanca, Spain

Abstract

Since 2010, Bitcoin has shown high price volatility, spurring a debate regarding the underlying reasons that lead economic agents to demand it. This paper analyzes the demand for Bitcoin in order to determine whether it stems from Bitcoin's utility as a medium of exchange, a speculative asset, or as a safe-haven commodity. We examine Bitcoin from a monetary-theory perspective and build a demand model that explores both the long-term and short-term relationships among variables. Our findings show that Bitcoin behaves as a speculative asset in the short term. In the long term, however, speculation does not seem to influence demand for Bitcoin. Instead, demand might be driven by expectations regarding Bitcoin's future utility as a medium of exchange.

JEL Classification: C51, E41, E42, E50

Keywords**:** Bitcoin demand; medium of exchange; speculative asset; safe haven; Bitcoin standard

Acknowledgements: We gratefully acknowledge the Spanish Ministry of Economics and Competitiveness for its funding, under research projects ECO2017-84864-P and ECO2016-75631-P. We are also grateful to *Blockchair.com* for providing useful data for our research.

[2] Corresponding author: Business & Economics School. Department of Financial Economics and Accounting. Address: Avda. Valle Esgueva, 6. 47011, Valladolid (Spain). E-mail: luispablo.horra@uva.es. Phone: +34 606782986.

The Drivers of Bitcoin Demand: A Short and Long-Run Analysis

Abstract

Since 2010, Bitcoin has shown high price volatility, spurring a debate regarding the underlying reasons that lead economic agents to demand it. This paper analyzes the demand for Bitcoin in order to determine whether it stems from Bitcoin's utility as a medium of exchange, a speculative asset, or as a safe-haven commodity. We examine Bitcoin from a monetary-theory perspective and build a demand model that explores both the long-term and short-term relationships among variables. Our findings show that Bitcoin behaves as a speculative asset in the short term. In the long term, however, speculation does not seem to influence demand for Bitcoin. Instead, demand might be driven by expectations regarding Bitcoin's future utility as a medium of exchange.

JEL Classification: C51, E41, E42, E50

Keywords: Bitcoin demand; medium of exchange; speculative asset; safe haven; Bitcoin standard

1. Introduction

The 2008 financial crisis exposed central banks' failure to implement policies aimed at providing economic stability. Loose monetary policies undertaken in the early 2000s by the Federal Reserve and the European Central Bank contributed to creating massive asset bubbles in the United States and the Eurozone, bringing about economic uncertainty and instability on a global scale (Allen and Carletti, 2010; Bordo and Lane, 2013). In Europe, the crisis was accompanied by solvency problems in the banking sector, which sparked mistrust towards the financial industry and its ability to perform some of its core functions in market economies.

In this atmosphere of widespread uncertainty, Bitcoin emerged as a new form of digital money and payment infrastructure that enables users to make peer-to-peer transactions without the intervention of financial intermediaries (Nakamoto, 2008). Bitcoin works in a decentralized manner by regulating itself through the incentives created by the protocol. All transactions are validated by other users in the network (so-called *miners*) and recorded on a blockchain, a public ledger that can be accessed (but not modified) by Bitcoin users. This solves the double-spending problem and prevents potential fraudulent practices without the need for intermediaries or central authorities (Dwyer, 2015).

Bitcoin has become a worldwide phenomenon, encouraging the creation of new currencies based on the same technology. Several stages can be identified in the evolution of Bitcoin. The first available price dates to August 17, 2010. Due to its potential as a digital currency as well as expectations of short-term capital gains, demand for Bitcoin soon skyrocketed, causing its price to increase by a factor of 100 between April 13, 2011 and April 1, 2013. Over the following years, prices continued to increase, surpassing the threshold of $1,000 on November 28, 2013 and $10,000 on December 1, 2017, when it reached, what is to date, its peak price. Since then, the price of Bitcoin has decreased dramatically, losing 80% of its value since peaking in December 17, 2017[1]. However, Bitcoin price formation has not been stable. On the contrary, it has shown high price volatility since its inception. Stavis (2018) identifies thirteen price corrections of at least 30% between January 2012 and August 2018. This seems to question its feasibility as a medium of exchange, supporting the idea of Bitcoin as a speculative asset or, to a lesser

[1] This number has been calculated by comparing the price on December 17, 2017 (highest historical price) with the price on November 26, 2018. Data have been retrieved from Quandl.com.

extent, a safe-haven commodity, which has gained in importance to the detriment of its original conception as a currency.

The purpose of this paper is to elucidate whether Bitcoin is demanded as a medium of exchange, a speculative asset, or as a safe-haven commodity. In order to carry out this task, we first provide a theoretical analysis that places Bitcoin within the framework of monetary theory. Consistent with our theoretical foundations, we build and test an empirical model to explore the factors influencing demand for Bitcoin.

Our research is framed within the recent branch of literature that deals with the economic aspects of Bitcoin. From an economic-theory perspective, the pioneering studies were those of Dwyer (2015) and Selgin (2015). Dwyer provides a general introduction to the economics of Bitcoin, whereas Selgin explores Bitcoin through the lens of monetary theory. White (2015a) undertakes a multidimensional analysis of Bitcoin and other cryptocurrencies, emphasizing their similarities and differences with fiat money. By means of a monetary model, Hendrickson et al. (2016) analyze the conditions under which Bitcoin could coexist with central-bank money. Finally, Weber (2016) explores a hypothetical scenario with Bitcoin as the world reserve currency and compares this monetary arrangement with the Classical Gold Standard.

Nonetheless, a substantial majority of the published papers on the economics of Bitcoin address the issue from an empirical perspective. We identify four major themes in the literature. First, the possible existence of bubbles in the Bitcoin market has been the subject matter of papers such as Cheah and Fry (2015), Corbet et al. (2018b), and Fry (2018). A second theme in the literature is the analysis of Bitcoin and other cryptocurrencies from a portfolio perspective. In this respect, Brière et al. (2015) conclude that Bitcoin improves the Sharpe ratio of a well-diversified portfolio, whereas Corbet et al. (2018c) show the diversification benefits of the three major cryptocurrencies, especially in the short term. Platanakis and Urquhart (2018) also find diversification benefits after analyzing Bitcoin in the context of a stock-bond portfolio. The analysis of Bitcoin price formation and efficiency is a third major topic in the literature. Bouoiyour and Selmi (2015), Ciaian et al. (2016) and Kristoufek (2015) explore the underlying factors influencing the price of Bitcoin, whereas Urquhart (2016) and Takaishi and Adachi (2018) focus on Bitcoin price inefficiencies.

Our paper can be placed within a fourth branch of literature that examines the financial nature of Bitcoin as a currency, a speculative asset or a safe-haven commodity. Glaser et al. (2014) contribute to the asset-currency debate by looking at whether investors are interested in Bitcoin as a speculative asset or as a currency. Blau (2018) examines Bitcoin's volatility in order to ascertain whether this results from speculative trading, which would point in the direction of Bitcoin as a speculative investment vehicle. Finally, Bouri et al. (2017) assesses the safe-haven properties of Bitcoin.

Baur et al. (2018b) is particularly relevant for our research as it examines the question of whether Bitcoin is an asset or medium of exchange by using three complementary methodologies. First, the authors analyze the risk-return characteristics of Bitcoin and compare them with those of other assets through a correlation matrix. Second, a regression analysis of Bitcoin returns on stock returns is performed to explore the safe-haven properties of Bitcoin. Finally, they classify Bitcoin users into six user types and analyze the total balances and wallet characteristics of each user type. The authors conclude that Bitcoin lacks the safe-haven properties usually associated with gold and has very limited use as a currency, being held mainly as a speculative investment.

Our paper differs from Baur et al. (2018b) in that it analyzes the financial nature of Bitcoin through a demand model, contributing to the existing literature in several ways. First, the existence of bubbles in Bitcoin markets suggests there might be discrepancies between the determinants of Bitcoin demand in the long and short term. Thus, we use an error correction model to analyze the short-run dynamics of the demand for Bitcoin and compare them with demand in the long term. Second, our model incorporates price volatility as an explanatory variable to elucidate whether Bitcoin is demanded as a speculative vehicle. Third, two variables widely used in the money demand literature (interest rates and income) are included in our model to test whether demand for Bitcoin stems from its utility as a currency.

Our results suggest that Bitcoin is demanded as a speculative asset, albeit only in the short term. In the long term, however, speculation does not seem to play an important role in shaping demand for Bitcoin. Neither is Bitcoin demanded as a safe haven or a means of payment. We conclude that expectations concerning its future utility as a medium of exchange might be the key factor driving demand for Bitcoin today.

The remainder of the paper is structured as follows. Section 2 analyzes Bitcoin from a monetary-theory perspective. Section 3 undertakes an empirical analysis in order to elucidate the factors shaping the demand for Bitcoin. Section 4 provides a detailed discussion of the results, distinguishing between long-term and short-term relationships among variables. Section 5 is dedicated to the conclusions and future lines of research.

2. The Economics of Bitcoin

The emergence of Bitcoin is the result of an entrepreneurial effort aimed at facilitating transactions among economic agents. In this sense, Bitcoin fits in well with the evolutionary theory of money as explained by Menger (2009). According to this theory, money emerged spontaneously due to the limitations that bartering in all its forms imposed on market transactions. The flaws of bartering were traditionally overcome using precious metals. Unlike other commodities, precious metals possess certain characteristics that qualify them as suitable media of exchange (Rallo, 2017). First, precious metals do not deteriorate easily over time, making them efficient stores of value. In addition, they can be utilized as universal units of account because of their divisibility and fungibility. Finally, precious metals are highly-demanded economic goods with a relatively-stable exchange value and high tradability, an attribute that Menger (2009) referred to as *saleableness*.

In the same way as precious metals were turned into media of exchange by economic agents who realized that gold or silver helped overcome market coordination inefficiencies, Bitcoin was born to optimize the way in which transactions are conducted, partly eliminating the need for financial intermediaries, lowering transaction costs and freeing up resources that can be used more productively in other parts of the economy.[2]

2.1. Bitcoin and the Functions of Money

Money has traditionally performed three basic functions: as a medium of exchange, a store of value, and as a unit of account (Jevons, 1876).[3] To what extent does Bitcoin fulfill these three functions? Even though an increasing number of multinational corporations accept Bitcoin payments, Bitcoin is not universally accepted as a medium of exchange (Chokun, 2018). In 2017, the average number of trade transactions per day (transactions involving sending and receiving bitcoins, which could be considered a proxy for real-economy transactions) was 277,000, a 23% increase compared to 2016.[4] Yet this represents a negligible fraction of all the cash and non-cash transactions that took place globally in 2017. In addition, available evidence indicates that most Bitcoin transactions

[2] On the other hand, verification of new transactions and, thus, production of new bitcoins consumes vast amounts of energy. Therefore, while it is true that it reduces transaction costs for users, in aggregate terms, the net social benefit derived from the use of Bitcoin might be negative due to growing energy costs.

[3] Jevons (1876) adds a fourth function: *standard of deferred payment*, which allows economic agents to settle debts using a common standard.

[4] Own calculations based on data from www.quandl.com.

are carried out through online exchanges, not between Bitcoin addresses. The daily trade-exchange ratio, which relates trade volume and exchange volume, averaged 0.29 in 2017.[5] This number suggests that, on average, seven out of ten daily transactions are related to currency-exchange speculation, and only three to trade.

Yermack (2013) points to its lack of liquidity to question the feasibility of Bitcoin as a medium of exchange. Similarly, after undertaking an analysis of Bitcoin liquidity for the period 2014-2015, Loi (2017) concludes that Bitcoin is less liquid than stocks. Despite the initial lack of liquidity that new currencies tend to experience, Bitcoin bid-ask spreads have significantly decreased since 2015. In 2017, Coinbase, the most traded Bitcoin exchange, offered a daily average bid-ask spread for the pair Bitcoin/USD of 0.022604$, 43% lower than in 2015.[6] Bitcoin liquidity has therefore increased considerably over the last few years notwithstanding the fact that Bitcoin/USD spreads are still substantially higher than those of the most traded currency pairs.

As a store of value, Bitcoin has evidenced serious flaws due to its inherent price instability. Baur et al. (2018a) show that the standard deviation of Bitcoin daily returns between 2010 and 2017 widely exceeds that of stock indices, forex pairs, or commodities. Bitcoin prices are even more volatile than most single stock prices. Amazon's stock volatility in the above period was three times lower than Bitcoin's: 1.96% compared to 5.88%. In annualized terms, Bitcoin's volatility came to 112% compared to Amazon's 31%.[7]

Yermack (2013) also raises concerns about the security of the digital wallets where bitcoins are stored. These concerns are grounded upon several episodes of digital

[5] Own calculations based on data from www.quandl.com.
[6] Own calculations based on data from www.bitcoinity.org.
[7] Own calculations based on data from Yahoo Finance.

thefts that have taken place since the emergence of Bitcoin in 2009 (Redman, 2017). If digital wallets are not safe, he argues, Bitcoin's ability to store value is severely undermined. Although real, these security shortcomings do not pose a threat to the long-term viability of Bitcoin. First, Bitcoin wallets are varied and not all of them can be accessed online (Naware, 2016). Hardware or paper wallets are valid alternatives to online wallets. These alternatives do not imply sharing information with intermediary companies offering wallet services. Furthermore, third-party insurance might help mitigate any risk derived from security issues with online wallets. Insurance firms would charge a premium dependent upon several factors: the reputation of digital wallet businesses and insurance holders, the amount insured, etc.[8]

Bitcoin meets the unit-of-account function, albeit only in part. On the one hand, Bitcoin is infinitely divisible (although not fungible) and can be used as a numerical measurement unit (Bal, 2014). However, it does not facilitate price comparisons due to its high volatility. Economic agents see themselves compelled to convert Bitcoin prices into fiat money when comparing the price of goods and services. Thus, Bitcoin is scarcely used as a unit of account. Volatility affects the functioning of Bitcoin as a unit of account in a second manner: it increases businesses' *menu costs*. If business owners priced their goods and services in bitcoins, they would incur high price-changing costs because of Bitcoin's extremely volatile relative price in terms of goods and services.

[8] Yermack (2013: 14) objects to this type of insurance since "it forces the customer to bear the cost of evaluating the security (financial and otherwise) of both the wallet company and the insurance company". However, this argument is essentially flawed for two reasons. First, information costs would be negligible since rating businesses would emerge to take advantage of a potential market gap, reducing information asymmetries to a minimum. More importantly, it would exert a positive influence by disciplining wallet companies: only those businesses with a strong reputation in security issues would be insured, attracting the vast majority of customers to the detriment of low-reputation firms.

Our analysis reveals that Bitcoin scarcely fulfills the functions of money. For the time being, it has not become a universally accepted medium of exchange. In addition, its high volatility makes it an unreliable store of value and an inadequate unit of account.

2.2. The Macroeconomics of Bitcoin

Assessment of Bitcoin as an instrument in the process of being monetized must include a detailed analysis from the lens of monetary policy. Given the absence of empirical evidence (Bitcoin has not been adopted as a reserve currency by any country), we conduct a theoretical analysis of how monetary policy would be implemented under a hypothetical Bitcoin Standard.

A Bitcoin Standard refers to a monetary arrangement in which Bitcoin would be utilized as high-powered money by a group of countries. Bitcoin would back the issuance of paper currencies by central banks as well as deposits and other financial instruments issued by commercial banks and other financial institutions. We assume that, under a Bitcoin Standard, fractional-reserve banking would continue to exist, enabling financial intermediaries to expand the money supply by maintaining only a fraction of their liabilities in Bitcoin reserves.

Unlike fiat money, Bitcoin's monetary base is pre-programmed to grow at a predictable, decreasing rate that will reach zero in 2140. Bitcoin inelastic supply entails advantages and disadvantages. The recent history of monetary institutions suggests that a currency shielded against supply manipulations heralds a significant step towards fulfilling monetary stability. The twentieth century is plagued with episodes of hyperinflation brought about by the action of central banks printing their way out of economic crises (Hanke and Krus, 2013).

In addition, Bitcoin fixed supply solves a classic problem of private fiat monies (Selgin, 2015). The irredeemable nature of fiduciary money creates an incentive for private money issuers to expand the money supply. Since money always trades above its fundamental value (Williamson, 2011) and production costs are negligible, private money issuers would be incentivized to make short-term profits by printing increasing quantities of notes. Hayek (1976) points out that financial institutions would issue the right amount of money to maintain the purchasing power of their currencies for reputational purposes. Yet Fisher (1986) explains that the short-term incentives to expand the money supply would lead to the depreciation of private fiat currencies until their value equaled the production cost of the notes. In other words, competing private fiat currencies would inevitably result in a paper standard.

Despite its fiduciary nature, Bitcoin's algorithmically-determined monetary base makes supply manipulations impossible. Nonetheless, this differential advantage that Bitcoin possesses over fiat money might also pose a problem in terms of macroeconomic stability. An inelastic money supply may be harmful for the economy, especially in the aftermath of an aggregate demand shock (Selgin, 1997; Horwitz, 2000). Economic and financial crises often lead to a decline in the velocity of circulation, understood as the number of times a monetary unit changes hands over a period of time. This decline in velocity results from economic agents engaging in fewer transactions in the real economy. In other words, the demand for real money balances increases as nominal spending goes down due to uncertainty over the future of the economy. Aggregate demand for goods and services thus collapses (i.e., the demand for money skyrockets). As a result, in supply and demand terms, the demand curve would need to shift downwards via a lower price level to reach a new equilibrium.

However, prices tend to be *sticky* under certain circumstances. Whereas prices quickly adjust downwardly following increases in productivity, the situation is markedly different when the adjustment needs to be made in the aftermath of a sharp decline in nominal spending (Selgin, 2017). In this situation, price stickiness will likely result in monetary or demand-side deflation, defined as a general decline in the price level due to a decrease in the velocity of circulation or the money stock (Bagus, 2015).[9] The effects of demand-side deflation are potentially disastrous as evidenced by the Great Depression: the failure of the Federal Reserve to offset the steep decline in the money stock in the early 1930s brought on the worst economic crisis of the twentieth century (Friedman and Schwartz, 1971). The equation of exchange indicates that, when faced with sticky prices, a decrease in the velocity of circulation or money supply should be offset by an increase in the money stock in order to keep nominal spending stable and avoid monetary deflation (Selgin, 2017).

Due to its inflexible supply, however, monetary authorities under a Bitcoin Standard would be incapable of compensating potential changes in velocity, destabilizing nominal GDP and thus causing instability at a macroeconomic level (Selgin, 2015). Selgin suggests that this problem would be partly solved under a free banking system with Bitcoin used as high-powered money.[10] This would provide banks with certain leeway to adjust their reserve requirements and issue their own notes in response to changes in the demand for money. Although theoretically possible, Selgin acknowledges that such a monetary arrangement is unrealistic; hence, the need for a currency whose monetary base can be adjusted with changes in velocity.

[9] Productivity increases bring about a different kind of deflation: price or supply-side deflation (Bagus, 2015).

[10] However, some problems would remain. For instance, increased demand for outside money (in our case, Bitcoin) would make it difficult to accommodate changes in velocity (Selgin, 2015).

A Bitcoin Standard resembles the Classical Gold Standard in several ways. First, both impose constraints on the discretion of central banks in relation to money supply management, although in different ways. During the Classical Gold Standard period, the monetary base was controlled by market forces: an increase in the value of gold created an incentive for entrepreneurs to invest more resources in gold mining, expanding the supply of gold; and vice versa, a decrease in the value of gold pushed entrepreneurs out of the gold market, reducing its supply (White, 2015b). Under a Bitcoin Standard, neither the market nor a discretionary authority would control Bitcoin supply. This has an important implication for Bitcoin's potential as reserve currency: since its relative price in terms of goods, services and other currencies would be determined exclusively by changes in demand for it, Bitcoin would inevitably be subject to constant fluctuations, making it a deficient medium of exchange and a poor store of value (Selgin, 2015).

Under the Classical Gold Standard, central banks were able to conduct monetary policy via interest rates. Yet their capacity to do so was limited by gold arbitrage: a country that lowered interest rates over an extensive period of time experienced gold outflows in favor of higher-rate countries, forcing the former to raise interest rates in order to avoid running out of gold reserves (Weber, 2016). This mechanism prevented large interest-rate differentials among countries. In contrast, a Bitcoin Standard would not allow countries to conduct independent monetary policies because Bitcoin arbitrage would be costless (Weber, 2016). The cost of gold arbitrage (essentially shipping and insurance) provided central banks with certain flexibility to adapt their interest-rate policy to the economic juncture of the country, a flexibility they would lack were Bitcoin to become the world reserve currency.

2.3. *The Financial Nature of Bitcoin: Commodity, Asset or Currency?*

Throughout history, a vast amount of monies and money substitutes have been employed as media of exchange (Angel and McCabe, 2015). Bitcoin pioneered a new form of (digital) money that self-regulates in a decentralized manner, allowing for secured transactions thanks to the use of cryptographic encryption. The innovative design of Bitcoin has led economists to disagree upon its financial nature.

Bitcoin was originally devised as a medium of exchange, i.e., a digital currency that facilitates peer-to-peer transactions. Yet, due to its inherent flaws as a medium of exchange, Bitcoin is hardly used as such (Baur et al., 2018b; Glaser et al., 2014). Selgin (2015) points out that Bitcoin shares characteristics with two types of high-powered money: fiat money and commodity money. On the one hand, Bitcoin resembles commodity monies insofar as its supply is limited by design and possesses a growing marginal production cost (as opposed to fiat money, whose supply is potentially unlimited due to near-zero marginal production costs). On the other hand, Bitcoin is a purely fiduciary medium of exchange: its non-monetary value is zero.[11] Because of its dual nature, Selgin coined the term *synthetic* commodity money to refer to Bitcoin.

The analysis of Bitcoin as a particular type of commodity relies upon the evolutionary theory of money. When gold was in the process of being monetized, economic agents increased their demand for gold because of its utility to acquire goods and services in the market (Bagus, 2015). As a result, the price of gold started to increase gradually until it stabilized, giving birth to a new form of money. Bitcoin seems to be going through a similar monetization process, which would explain the massive price

[11] White (2015) suggests that Bitcoin could have non-monetary value derived from its affinity demand, i.e., those who demand Bitcoin because it cannot be manipulated by governments or central banks. This implies that, even if economic agents ceased to use it as a medium of exchange or speculative asset, its price floor would be above zero.

increase over the last few years. Its volatility is thus the result of uncertainty derived from the possibility that Bitcoin becomes a widely-used medium of exchange at some point in the future. This makes Bitcoin a short-term, speculative asset: as long as there are investors willing to bet on or against Bitcoin's capacity to become money for at least a fraction of the world population, its price will continue to fluctuate in an unpredictable manner. The idea of Bitcoin as a commodity in the process of being monetized would also explain why, unlike gold, Bitcoin does not act as a safe haven (Baur et al., 2018b; Bouri et al., 2017; Klein et al., 2018).

To what extent does Bitcoin fit into the category of financial asset? The fundamental value of a financial asset is driven by the future cash flows it is expected to generate (Damodaran, 2017). Since Bitcoin does not generate any income streams, it does not possess a fundamental value in the same way stocks or bonds do. Following this reasoning, fiat currencies would not be considered financial assets either as they do not generate income. Yet the fundamental value of fiat currencies is not zero, which implies that economic agents derive some non-income benefits from holding them, namely, fiat currencies facilitate the payment of taxes and provide economic agents with liquidity. Similarly, Bitcoin possesses a non-monetary yield: it allows for black-market transactions and tax evasion (Cochrane, 2017). Thus, as long as it yields utility to its users, Bitcoin can be argued to possess some fundamental or intrinsic value, which would qualify it as a financial asset.

The literature examining the existence of bubbles in cryptocurrency markets provides meaningful insights on the fundamental value of Bitcoin. According to Diba and Grossman (1988), a bubble exists when the price of an asset diverges persistently from fundamentals. This implies that, in order to experience price bubbles, a financial asset needs to possess some kind of fundamental value from which to deviate. Cheah and Fry

(2015) find evidence of Bitcoin exhibiting speculative bubble behavior, concluding that its fundamental value is zero. Similarly, Baek and Elbeck (2015) show that fundamental economic factors do not influence Bitcoin returns. Yet the literature is not homogenous in this respect. Corbet et al. (2018b) draw upon three fundamental variables to identify bubbles in the price of Bitcoin since 2009: blockchain position, hashrate and liquidity. They find that fundamentals drive Bitcoin prices, although only during short periods of time.

It should be noted that these three categories (currency, commodity and financial asset) are not mutually exclusive. For instance, gold is a commodity that was once used as the world reserve currency and is today considered a safe-haven asset by many investors. In the same way, Bitcoin might be perceived and thus employed by investors for different purposes. Elucidating which factors determine the demand for Bitcoin would help us establish why Bitcoin is demanded by economic agents: as a medium of exchange, a speculative asset, or as a safe-haven commodity.

3. Hypotheses Development and Demand Model

The extensive literature on money demand shows that demand for a widely-used currency depends essentially upon three variables: income, price level, and interest rates (e.g., Friedman, 1956; Keynes, 1973). Income and price level are both positively related to money demand: if either income or prices increase, more money will be needed to undertake transactions. As a result, the number of transactions should also be positively related to money demand. In contrast, interest rates are inversely related to money demand as these represent the opportunity cost of holding money balances. In addition, the equation of exchange suggests that there should be an inverse relationship between demand for money and velocity of circulation:

$$M_D = \frac{P \, x \, Y}{V} \quad (1)$$

where M_D is the demand for money; P represents price level; Y is the number of goods and services produced in an economy; and V the velocity of money, which is defined as the speed at which money changes hands.

If demand for Bitcoin stems from its use as money, we conjecture that the following hypotheses should hold.

H1. Aggregate income is positively related to the demand for Bitcoin.

H2. The number of transactions in the Bitcoin economy is positively related to the demand for Bitcoin.

H3. The price level is positive related to the demand for Bitcoin.

H4. Interest rates are negatively related to the demand for Bitcoin.

H5. Velocity of circulation is negatively related to the demand for Bitcoin.

The existence of price bubbles in Bitcoin markets seems to support the narrative of Bitcoin as a speculative asset since bubbles tend to be driven by speculative behavior (Cheah and Fry, 2015; Corbet et al., 2018b; Fry, 2018). The speculative nature of Bitcoin finds support in Baur et al. (2018a), who identify asymmetries in the way Bitcoin volatility behaves in response to positive and negative shocks, with positive shocks bringing about higher volatility than negative ones. This implies that Bitcoin investors respond to potential short-term capital gains or losses in a speculative manner, i.e., increasing or decreasing their exposure to Bitcoin considerably. Were Bitcoin to be perceived by investors as a speculative asset, we would expect volatility to affect the demand for Bitcoin. Accordingly, we state our sixth hypothesis.

H6. Volatility exerts an influence on the demand for Bitcoin.

Gold has traditionally been considered a safe haven both for equities (Baur and McDermott, 2010) and the US dollar (Ciner et al*.,* 2013). It has served as a refuge asset in times of economic downturns and inflationary pressures. Inasmuch as Bitcoin resembles a (synthetic) commodity, it could be an alternative to gold as safe haven. Yet the evidence so far suggests that Bitcoin lacks the safe-haven properties of gold (Baur et al*.,* 2018b; Bouri et al*.,* 2017; Klein et al., 2018). If investors were to demand Bitcoin as a safe haven, Bitcoin and gold would behave as complementary goods: their respective demand would increase (decrease) in parallel in times of crises (economic growth). Accordingly, we posit our last hypothesis.

H7. The price of gold is positively related to the demand for Bitcoin.

In order to test the above hypotheses, we propose the following demand model:

$$BTD_t = \beta_0 + \beta_1 BTS_t + \beta_2 BTV_t + \beta_3 BTSize_t + \beta_4 BTPL_t + \beta_5 VOL_t + \beta_6 GOLD_t + \beta_7 R_t + \beta_8 Y_t + u_t \qquad (2)$$

where BTD represents demand for Bitcoin; BTS is the supply of Bitcoin;[12] BTV refers to the velocity of circulation (**H5**); $BTSize$ is the size of the Bitcoin economy (**H2**); and $BTPL$ represents the price level of the global economy (**H3**). These four variables are included in the model developed by Ciaian et al. (2016), which we complete by adding four more variables. First, we include a variable (VOL) that allows us to measure the impact of price volatility on Bitcoin demand (**H6**). Second, we use the price of gold ($GOLD$) to analyze the safe-haven properties of Bitcoin (**H7**). Finally, two more variables are introduced to determine whether investors hold Bitcoin as a medium of exchange.

[12] We include the supply of Bitcoin for a correct specification of the model. Since we are proxying demand using price, omitting Bitcoin supply could lead to model misspecification.

First, an interest rate (R) is included to measure the opportunity cost of holding Bitcoin (**H4**). Second, we add an income variable (Y) to elucidate whether demand for Bitcoin grows with the economy (**H1**).

4. Empirical Analysis

4.1. Variable Construction

For our model, we use daily data between 17 August 2010 and 28 February 2018, obtained from four sources: Quandl, Yahoo Finance, The St. Louis Fed, and Blockchair.[13] For variables that do not have prices every day of the year (Bitcoin trades 365 days a year), the last available price is used to fill in the missing values.

Our empirical analysis faces a significant challenge with regard to how demand for Bitcoin is measured. When analyzing money demand, a monetary aggregate is utilized to proxy demand for either nominal or real money balances. Since financial institutions do not offer financial instruments backed by Bitcoin, the only monetary aggregate available is its monetary base, i.e., the number of Bitcoins in circulation, which constitutes a significant limitation in the study of demand for Bitcoin. The problem with the monetary base stems from the fact that it is perfectly inelastic or not responsive to shifts in demand. Consequently, the number of bitcoins in circulation is exogenous, which implies that demand cannot be measured using the monetary base. We need to draw upon a different proxy that accurately reflects changes in demand.

Following Buchholz et al. (2012), we find the price of Bitcoin to be a reliable proxy for its demand due precisely to Bitcoin's inelastic supply. Asset prices are

[13] All Bitcoin data come from https://www.quandl.com/ except for the variable Bitcoin Days Destroyed, which has been retrieved from https://blockchair.com/. Gold prices and the EUR/USD exchange rate have been obtained from https://fred.stlouisfed.org/. Finally, MSCI World Index prices come from https://finance.yahoo.com.

determined by the interaction of supply and demand. Since Bitcoin's long-term supply is immutable, all price movements will be the result of changes in demand. Figure 1 illustrates how, under perfectly inelastic supply, demand shifts are translated into price changes at a rate that directly depends on the elasticity of demand. Let Bitcoin demand be $D = D(P, Q)$. Changes in demand can be expressed as $dD = \frac{dD}{dP}dP + \frac{dD}{dQ}dQ$. Under a perfectly inelastic supply (i.e., $dQ = 0$), demand shifts directly determine price variation: $dP = \frac{dP}{dD}dD$. Hence, price can be considered a reliable proxy for demand.

[Insert Figure 1 here]

The supply of Bitcoin is measured through the number of bitcoins in circulation. Velocity is proxied using Bitcoin Days Destroyed, which is calculated by multiplying the number of bitcoins in a transaction by the number of days those coins were last spent (Smith, 2018). We proxy the size of the Bitcoin economy by drawing upon the number of transactions per day. We follow Ciaian et al. (2016) by using the EUR/US exchange rate to measure the price level of the global economy.[14]

London Bullion Market gold prices are used as a proxy for the price of gold (Kristoufek, 2015; Bouoiyour and Selmi, 2015). The yield of the 3-month US Treasury Bill approximates the opportunity cost of holding Bitcoin as a medium of exchange (Dreger and Wolters, 2010). As for the scale variable, the literature on money demand suggests the use of real GDP (e.g., Anderson et al., 2017; Serletis and Gogas, 2014). Yet the fact that we are dealing with daily data poses a problem when working with GDP. To

[14] Ciaian et al (2016: 1806) justify the use of the EUR/USD exchange rate as the price level of the global economy as follows: "We use the exchange rate between the US dollar and euro, because in our data Bitcoin price is denominated in US dollars. For example, if the US dollar would appreciate against euro, most likely it would also appreciate against the Bitcoin. Consequently, an increase in the exchange rate between euro and the US dollar would lead to a decrease in the amount of US dollars that have to be paid for one Bitcoin, which decreases its price."

overcome this issue, we use the MSCI World Index given that stock market indices are highly correlated with real income (Chaudhuri and Smiles, 2006).

To capture the impact of volatility on Bitcoin demand, we have built a GJR-GARCH model (Baur et al., 2018a; Glosten 1993). This variant adds an extra term to account for potential asymmetries (Brooks, 2008). The conditional variance of a GJR-GARCH is given by

$$\sigma_t^2 = \alpha_1 + \alpha_2 u_{t-1}^2 + \alpha_3 \sigma_{t-1}^2 + \alpha_4 u_{t-1}^2 I_{t-1} \quad (3)$$

where $u_{t-1}^2 I_{t-1}$ represents the asymmetric term.

To confirm the appropriateness of this GARCH model to describe the variance of the error term, the following conditions must hold: $\alpha_1 > 0$, $\alpha_2 \geq 0$ and $\alpha_2 + \alpha_4 \geq 0$. A negative sign in α_4 would suggest that positive shocks bring about higher volatility in the following period than negative shocks of the same sign. The estimated values of σ_t^2 constitute the variable of volatility that will be included in our Bitcoin demand model (Buchholz et al., 2012). Table 1 shows the estimation of an AR(1) for the conditional mean and a GJR-GARCH (1,1) model for the conditional variance of Bitcoin prices. Results support the choice of model, exhibiting a high persistence of variances as usually found in most financial variables.

[Insert Table 1 here]

4.2. Methodology and Results

According to time-series theory, the stationarity of the variables must be analyzed before modeling the dynamics of the series (Granger and Newbold, 1974). Table 2 presents the results of the Augmented Dickey-Fuller (ADF) test for all series. The ADF test reveals that only three variables are I(0) at a 5% significance level: BTS, BTV and VOL. The other variables are I(1) (i.e., stationary in first differences).

[Insert Table 2 here]

When dealing with I(1) and I(0) variables, the Bound Testing Methodology developed by Pesaran and Shin (1999) and Pesaran et al. (2001) represents a valid approach to test for cointegration. This methodology, which has previously been applied to study Bitcoin (Bouoiyour and Selmi, 2015; Ciaian, 2016), establishes that an error correction model (ECM) can be formulated provided that variables are cointegrated and thus that a long run relation exists. Cointegration analysis, which is presented in Table 3 (Model 1), suggests that variables are cointegrated at a 1% significance level.[15] Results are based on the following specification, where the error correction term appears in a disaggregated manner:

$$\Delta BTD_t = \alpha + \beta' \Delta BTD_{t-k} + \gamma' \Delta X_t + \delta' \Delta X_{t-k} + [\theta_1 BTD_{t-1} + \theta_2 BTS_{t-1} + \theta_3 BTV_{t-1} + \theta_4 BTSize_{t-1} + \theta_5 BTPL_{t-1} + \theta_6 VOL_{t-1} + \theta_7 GOLD_t + \theta_8 R_{t-1} + \theta_9 Y_{t-1}] + u_t \quad (4)$$

where ΔBTD_t is Bitcoin demand in first differences; ΔBTD_{t-k} represents a vector of first k lagged endogenous variables; ΔX_t is a vector of independent variables in first differences; ΔX_{t-k} is a vector of first k lagged independent variables; the expression in brackets captures the error correction term; and u_t a white noise random variable.

Therefore, the Engle-Granger two-step procedure can be used to disentangle the long-term and short-term equilibrium models (Engle and Granger, 1987)[16]. In a first

[15] Values for the F-test are tabulated in Pesaran et al. (2001).

[16] The fact that variables are cointegrated suggests that there might be a deviation from long-run equilibrium in the short term. Thus, we need to analyze the determinants of demand for Bitcoin both in the short and long term.

stage, we perform an OLS regression to obtain the long-term relationships among variables:

$$BTD_t = \beta_0 + \beta_1 BTS_t + \beta_2 BTV_t + \beta_3 BTSize_t + \beta_4 BTPL_t + \beta_5 VOL_t + \beta_6 GOLD_t + \beta_7 R_t + \beta_8 Y_t + e_t \quad (5)$$

Results can be found in Table 3 (Model 2). This model explains 97.6% of changes in demand for Bitcoin. All variables are significant at a 1% level except for BTV and VOL.

In a second stage, we estimate the short-run dynamics by means of the following ECM, which is analogous to that in equation (3):

$$\Delta BTD_t = \alpha + \beta \Delta BTD_{t-k} + \gamma \Delta X_t + \delta \Delta X_{t-k} + \alpha \hat{e}_{t-1} + u_t \quad (6)$$

where $\hat{e}_{t-1}$ is the aggregated error correction term, built using the lagged residuals of the OLS estimation in equation (5), and where α represents the speed of adjustment of the model towards long-term equilibrium. Table 3 (Model 3) shows the results of the estimated model. The overall significance suggests that the model accurately explains the dynamics of Bitcoin demand. All variables are statistically significant at a 10% level or less, except for ΔBTS_t and ΔBTS_{t-1}. The coefficient of the error correction term indicates that 1.41% of disequilibrium is corrected every day.

[Insert Table 3 here]

4.3. Robustness checks

In this section, we test the robustness of our results. First, we re-estimate our model removing weekends and holidays from the data. In order to do so, we follow the same steps as above. We first generate a volatility variable by formulating a GJR-GARCH (1,1) model. The results, which can be found in Table 4, are similar to those in our original GARCH model. This suggests that the removal of weekends and holidays from our data does not change the conditional variance estimates. We then analyze the stationarity of the variables. As expected, we find no changes when compared to our original estimations. Table 5 shows that all variables follow I(1) processes except BTS, BTV, and VOL, which are found to be stationary in levels.

[Insert Table 4 here]

[Insert Table 5 here]

The next step is to test for cointegration using the Bound Testing Methodology. Results indicate that variables are cointegrated at a 1% significance level (Table 6, model 4). The F-Statistic suggests that the degree of cointegration is even higher than in our original model. We finally estimate the long-term and short-term equilibrium models. As shown in Table 6 (model 5), the long-run relationships hardly vary in terms of economic and statistical significance. Regarding the short-run model, some differences in the dynamic structure are identified, leading to apparently faster adjustment (Table 6, model 6). Nevertheless, this effect is only caused by the shorter series employed and does not affect the significance of the variables involved in the short run model. Overall, our results seem robust to the exclusion of weekends and holidays from our data.

[Insert Table 6 here]

A second robustness test involves analyzing the evolution of relationships among variables over time. Figure 2 illustrates the recursive coefficient estimates for the whole sample. Coefficients seem remarkably stable, especially after 2012 when Bitcoin began to attract public attention. The exception is the coefficient of the three-month U.S Treasury Bill yield (R), which did not stabilize until 2016. Figure 3, which shows the recursive p-values, indicates that the statistical significance of variables hardly changes after 2013, except for R, which becomes non-significant at a 10% level between

September 2016 and January 2017; and BTV, which becomes statistically significant at a 10% level during some sub-periods of the sample.

[Insert Figure 2 here]

[Insert Figure 3 here]

Interestingly, the coefficients remain fairly stable over the period when the late 2017 bubble formed and then burst[17]. To further confirm this point, we re-estimate our model excluding data after the bubble burst (Table 7). Results are similar to those in our original model, suggesting that our estimations are robust despite the major slump in demand that took place in late 2017.

[Insert Table 7 here]

5. Discussion

5.1. Long-term equilibrium

Our model explains 97.6% of moves in the demand for Bitcoin. All the variables are found to be statistically significant except for velocity (BTV) and volatility (VOL). In addition, all the variables are economically significant with the exception of BTV. [18] The number of Bitcoin transactions ($BTSize$), a proxy for the size of the Bitcoin economy, plays an important role in shaping demand for Bitcoin: a 1% increase in the number of transactions leads to a 0.49% increase in Bitcoin prices. This result, which is in line Ciaian et al. (2016), seems to confirm **H2**: more transactions require the use of an increasing number of bitcoins, which in turn spurs demand for Bitcoin.

[17] According to Stavis (2018), the formation period goes from 12 November 2017 to 17 December 2017. Therefore, we consider the latter as the date when the correction started (i.e., when the bubble burst).
[18] Ziliak and McCloskey (2004) stress the importance of distinguishing between economic and statistical significance.

However, not all Bitcoin transactions are related to the real economy, since some of them may just be transactions between accounts belonging to the same person. As pointed out by Smith (2018: 2), transactions may not be a good indicator of the use of Bitcoin to purchase goods and services in the real economy. Luckily, Bitcoin Days Destroyed, the proxy utilized to measure the velocity of Bitcoin BTV, corrects for this shortcoming by lending greater weight to "less frequently circulating coins". The fact that BTV is neither statistically nor economically significant at a 10% level suggests that demand for Bitcoin does not stem from its use as a medium of exchange.[19] This result also serves to reject **H5**, which conjectures a statistically significant and negative relationship between velocity and Bitcoin demand.

Price level ($BTPL$), measured through the EUR/USD exchange rate, seems a key factor in explaining demand for Bitcoin as suggested by its positive and significant influence, which appears to support **H3.** This is in line with the literature on money demand: a positive variation in price level increases the demand for money in nominal terms (Friedman, 1956). Yet the sharp increase in Bitcoin demand over the last few years might suggest a different explanation, namely a simple correlation between supply and demand for Bitcoin. The strong economic significance of $BTPL$ (a 1% increase in $BTPL$ leads to an 11% rise in Bitcoin demand) supports the second interpretation: the large coefficient would be due to the strong increase in demand for Bitcoin over the last few years. Otherwise, the increase would be roughly proportional.

We can confidently reject **H6** since VOL does not seem to affect demand for Bitcoin. This result might indicate that, in the long run, demand is driven by fundamentals, in other words by its future utility as a medium of exchange. Nevertheless,

[19] This result goes in line with Ciaian et al. (2016).

this should not rule out the hypothesis of Bitcoin as a speculative asset in the short term as suggested by the literature on bubbles in cryptocurrency markets (e.g., Cheah and Fry, 2015). The negative and significant coefficient of gold prices ($GOLD$), used as a proxy to evaluate the safe-haven properties of Bitcoin, can be used to reject **H7**. Were Bitcoin to be perceived by investors as a safe haven, it would correlate positively with the price of gold.

The yield of the three-month U.S. Treasury Bill (R) exerts a positive and significant influence on Bitcoin demand. This result leads us to reject **H4**: long-term demand for Bitcoin does not respond inversely to changes in short-term interest rates, which contradicts the empirical literature on money demand (e.g., Dreger and Wolters, 2010; Anderson et al., 2017). If Bitcoin were demanded as money, the yield of a short-term, liquid asset would represent its opportunity cost (i.e., the amount of interest lost by keeping one's wealth in cash) and the sign would thus be negative. Finally, the MSCI World Index (Y), a proxy for GDP, exercises a positive and significant influence on the demand for Bitcoin: a 1% rise in Y increases demand by 3.9%. Even though this positive relationship lends support to **H1**, the size of the coefficient does not fit in with previous empirical evidence: income elasticities (increased demand for money due to a rise in income) tend to range between 0.4 to 1.6 (Knell and Stix, 2005).

Three corollaries may be drawn from our long-run model. First, the coefficients and signs of the two variables used to analyze Bitcoin from a money-demand perspective (namely, a short-term interest rate and a proxy for real income) seem to question Bitcoin's use as a medium of exchange, a result also found in Baur et al. (2018b). Second, the fact that volatility is not a factor influencing long-term demand for Bitcoin suggests that, even though Bitcoin does not seem to be demanded as a medium of exchange today, it is seen to possess future utility as such. Lastly, Bitcoin is not demanded as a safe haven, as suggested by its negative correlation with gold. This result coincides with that obtained by Baur et al. (2018b), Klein et al. (2018) or Kristoufek, (2015).

5.2. Short-term Dynamics

In the short term, the picture differs substantially.[20] Five variables of our long-term model do not play any significant role in the short-run demand for Bitcoin: ΔY, $\Delta BTPL$, ΔR, ΔBTV and $\Delta GOLD$. This divergence reveals that demand for Bitcoin is driven by differing forces depending upon the time horizon considered. Whereas the non-statistical significance of ΔY, $\Delta BTPL$, ΔR and ΔBTV leads us to reject the notion that short-term demand for Bitcoin results from its utility as a currency (**H1, H3, H4 and H5** respectively)**,** $\Delta GOLD$ suggests that Bitcoin is not demanded as safe haven in the short term (**H7**)**.**

Previous variations in the demand for Bitcoin (BTD) exert an economically and statistically significant influence on increments today, reflecting the dynamic behavior of Bitcoin demand. Nonetheless, signs vary. Whereas a 1% increase in ΔBTD_{t-1} results in an 11.7% increase in the ΔBTD, a 1% increase in ΔBTD_{t-2} brings about a 6.5% decrease in ΔBTD, which points to the speculative nature of Bitcoin in the short term. Intuitively, the positive and significant coefficients of $\Delta BTSize$ and $\Delta BTSize_{t-1}$ suggest there is short-term demand for Bitcoin as a medium of exchange, a result that seems to confirm **H2**. Yet, as shown in the long-run model, this result may prove misleading. Again, we turn to Bitcoin Days Destroyed to elucidate whether Bitcoin is demanded for transaction purposes in the short term. Since ΔBTV does not affect the demand for Bitcoin, we can thus conclude that the use of Bitcoin as a medium of exchange in the short term is

[20] It should be noted that the short-run model is in differences. Thus, the following analysis deals with increments (Δ) in the demand for Bitcoin.

negligible. The non-significance of the two proxies used to analyze the medium-of-exchange demand for Bitcoin (ΔR and ΔY) seems to support this conclusion.

As shown by ΔVOL and its lags, past volatility variations influence changes in the demand for Bitcoin, which reveals the significant short-term impact of volatility on Bitcoin demand **(H6).** The response of Bitcoin demand to moves in volatility seems to indicate that speculation is the main reason why Bitcoin is demanded in the short term. This conclusion is in line with findings provided by Baek and Elbeck (2015), Baur et al. (2018b) or Bouoiyour and Selmi (2015). In addition, ΔVOL, ΔVOL_{t-2} and ΔVOL_{t-4} exert a negative influence on demand for Bitcoin, suggesting that price works as a reliable approximation for demand: an increase in volatility leads to a decrease in the speculative demand for Bitcoin. Finally, the model moves towards long-term equilibrium relatively quickly: 1.4% of disequilibrium is corrected every day.

In a nutshell, our model strongly supports the hypothesis of Bitcoin as a speculative asset, ruling out other motives for demanding Bitcoin in the short term.

6. Conclusion

Bitcoin has attracted a lot of attention due mainly to the drastic price surge it has experienced over the last few years. This increase in prices has been accompanied by a huge rise in volatility, which has fueled a debate about the financial nature of Bitcoin. In this paper, we explore whether the increasing demand for Bitcoin results from its utility as a medium of exchange, a speculative asset or as a safe-haven commodity. We first scrutinize the economics of Bitcoin from a monetary-theory perspective, evidencing its shortcomings as a currency since it fails to adequately fulfill the functions of money. In addition, we theorize about the possibility of Bitcoin becoming a world reserve currency, pointing out that its inelastic supply is an insurmountable obstacle in the attainment of macroeconomic stability.

In a second part, we perform an empirical analysis of the factors influencing demand for Bitcoin in order to shed light on its financial nature as a medium of exchange, safe-haven commodity, or speculative asset. Our findings suggest that speculation fuels the demand for Bitcoin in the short term, which seems to confirm the idea of Bitcoin as a speculative vehicle. In the long term, however, speculation does not play a role in shaping demand for Bitcoin, which might indicate that demand is driven by expectations about its future utility as a medium of exchange.

The main limitation of our analysis is linked to the use of Bitcoin price as a proxy for demand. Even though the justification finds support in supply and demand theory as well as in previous literature, the choice of price as the dependent variable hinders the comparison of our model with money demand models, which have traditionally used monetary aggregates to measure the demand for money. A second limitation may be found in the limited use of Bitcoin as a medium of exchange nowadays. Since Bitcoin is still in the process of being monetized, the factors determining its demand might differ from those of consolidated currencies. Extrapolating variables from money demand literature to analyze its demand as a medium of exchange might thus produce misleading results.

Because cryptocurrencies are still a relatively-new field of study, the years ahead are expected to witness the emergence of fresh research that broadens our knowledge of the field. One potential line of research might involve exploring non-volatile, supply-elastic cryptocurrencies (so-called *Stable Coins*), which would help to shed light on the inherent drawbacks of supply-inelastic digital forms of money like Bitcoin.

References

Allen, F., & Carletti, E. (2010). An Overview of the Crisis: Causes, Consequences, and Solutions. *International Review of Finance*, *10*(1), 1–26. https://doi.org/10.1111/j.1468-2443.2009.01103.x.

Anderson, R. G., Bordo, M., & Duca, J. V. (2017). Money and velocity during financial crises: From the great depression to the great recession. *Journal of Economic Dynamics and Control*, *81*(January 2010), 32–49. https://doi.org/10.1016/j.jedc.2017.03.014.

Angel, J. J., & McCabe, D. (2015). The Ethics of Payments: Paper, Plastic, or Bitcoin? *Journal of Business Ethics*, *132*(3), 603–611. https://doi.org/10.1007/s10551-014-2354-x.

Baek, C., & Elbeck, M. (2015). Bitcoins as an investment or speculative vehicle? A first look. *Applied Economics Letters*, *22*(1), 30–34. https://doi.org/10.1080/13504851.2014.916379.

Bagus, P., (2015). *In Defense of Deflation*. Springer. https://doi.org/10.1007/978-3-319-13428-4.

Bal, A. (2014). Should Virtual Currency Be Subject to Income Tax? Available at SSRN: https://ssrn.com/abstract=2438451.

Baur, D. G., Dimpfl, T., & Kuck, K. (2018a). Bitcoin, gold and the US dollar – A replication and extension. *Finance Research Letters*, *25*, 103–110. https://doi.org/10.1016/J.FRL.2017.10.012.

Baur, D. G., Hong, K., & Lee, A. D. (2018b). Bitcoin: Medium of exchange or speculative assets? *Journal of International Financial Markets, Institutions and Money*, *54*, 177–189. https://doi.org/10.1016/J.INTFIN.2017.12.004.

Baur, D. G., & McDermott, T. K. (2010). Is gold a safe haven? International evidence. *Journal of Banking and Finance*, *34*(8), 1886–1898. https://doi.org/10.1016/j.jbankfin.2009.12.008.

Blau, B. M. (2018). Price dynamics and speculative trading in Bitcoin. *Research in International Business and Finance*, *43*(September 2016), 15–21. https://doi.org/10.1016/j.ribaf.2017.07.183.

Bordo, M. D., & Landon-Lane, J. (2013). Does expansionary monetary policy cause asset price booms? some historical and empirical evidence. *Journal Economía Chilena (The Chilean Economy)*, *16*(2), 04-52.

Bouoiyour, J., & Selmi, R. (2015). What does Bitcoin look like? *Annals of Economics and Finance*, *16*(2), 449–492.

Bouri, E., Molnár, P., Azzi, G., Roubaud, D., & Hagfors, L. I. (2017). On the hedge and safe haven properties of Bitcoin: Is it really more than a diversifier? *Finance Research Letters*, *20*, 192–198. https://doi.org/10.1016/J.FRL.2016.09.025.

Brière, M., Oosterlinck, K., & Szafarz, A. (2015). Virtual currency, tangible return: Portfolio diversification with bitcoin. *Journal of Asset Management*, *16*(6), 365–373. https://doi.org/10.1057/jam.2015.5.

Brooks, C. (2008). *Introductory Econometrics for Finance* (2nd ed). Cambridge: Cambridge University Press.

Buchholz, M., Delaney, J., Warren, J., Parker, J. (2012). Bits and bets. Information, price volatility, and demand for Bitcoin. Available at https://www.reed.edu/economics/parker/s12/312/finalproj/Bitcoin.pdf.

Ciaian, P., Rajcaniova, M., & Kancs, d'Artis. (2016). The economics of Bitcoin price formation. *Applied Economics*, *48*(19), 1799–1815. https://doi.org/10.1080/00036846.2015.1109038.

Chaudhuri, K., & Smiles, S. (2004). Stock market and aggregate economic activity: evidence from Australia. *Applied Financial Economics*, *14*(2), 121–129. https://doi.org/10.1080/0960310042000176399.

Cheah, E.-T., & Fry, J. (2015). Speculative bubbles in Bitcoin markets? An empirical investigation into the fundamental value of Bitcoin. *Economics Letters*, *130*, 32–36. https://doi.org/10.1016/J.ECONLET.2015.02.02.

Ciner, C., Gurdgiev, C., & Lucey, B. M. (2013). Hedges and safe havens: An examination of stocks, bonds, gold, oil and exchange rates. *International Review of Financial Analysis*, *29*, 202–211. https://doi.org/10.1016/j.irfa.2012.12.001.

Chokun, J. (2018). Who Accepts Bitcoins as Payment? List of Companies. Available at https://99bitcoins.com/who-accepts-bitcoins-payment-companies-stores-take-bitcoins/.

Cochrane, J. H., 2017. Bitcoin and Bubbles. Available at https://johnhcochrane.blogspot.com/2017/11/bitcoin-and-bubbles.html.

Corbet, S., Lucey, B., Urquhart, A., & Yarovaya, L. (2018a). Cryptocurrencies as a financial asset: A systematic analysis. *International Review of Financial Analysis*. https://doi.org/10.1016/J.IRFA.2018.09.003.

Corbet, S., Lucey, B., & Yarovaya, L. (2018b). Datestamping the Bitcoin and Ethereum bubbles. *Finance Research Letters*, *26*, 81–88. https://doi.org/10.1016/j.frl.2017.12.006.

Corbet, S., Meegan, A., Larkin, C., Lucey, B., & Yarovaya, L. (2018c). Exploring the dynamic relationships between cryptocurrencies and other financial assets. *Economics Letters*, 165, 28–34. https://doi.org/10.1016/J.ECONLET.2018.01.004.

Damodaran, A., 2017. The Bitcoin Boom: Asset, Currency, Commodity or Collectible? Available at http://aswathdamodaran.blogspot.com.es/2017/10/the-bitcoin-boom-asset-currency.html.

Diba, B. T., & Grossman, H. I. (1988). Explosive Rational Bubbles in Stock Prices? *The American Economic Review*, Vol. 78, No. 3 (Jun., 1988), pp. 520-530. https://doi.org/10.2307/1809149.

Dreger, C., & Wolters, J. (2010). Investigating M3 money demand in the euro area. *Journal of International Money and Finance*, *29*(1), 111–122. https://doi.org/10.1016/j.jimonfin.2009.02.002.

Dwyer, G. P. (2015). The economics of Bitcoin and similar private digital currencies. *Journal of Financial Stability*, *17*, 81–91. https://doi.org/10.1016/j.jfs.2014.11.006.

Engle, R. F., & Granger, C. W. J. (1987). Co-Integration and Error Correction: Representation, Estimation, and Testing. *Econometrica*, *55*(2), 251. https://doi.org/10.2307/1913236.

Fischer, S. (1986). Friedman versus Hayek on private money: Review essay. *Journal of Monetary Economics, 17*, 433–439. https://doi.org/10.1016/0304-3932(86)90067-X.

Friedman, M. (1956). *Studies in the quantity theory of money* (Vol. 561). Chicago: University of Chicago Press.

Friedman, M., & Schwartz, A. J. (1971). *A Monetary history of the United States, 1867-*

1960. New Jersey: Princeton University Press.

Fry, J. (2018). Booms, busts and heavy-tails: The story of Bitcoin and cryptocurrency markets? *Economics Letters*, *171*, 225–229. https://doi.org/10.1016/J.ECONLET.2018.08.008.

Glaser, F., Zimmermann, K., Haferkorn, M., Weber, M. C., & Siering, M. (2014, April 15). Bitcoin - Asset or Currency? Revealing Users' Hidden Intentions. Available at SSRN: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=242524.

Glosten, L. R., Jagannathan, R., & Runkle, D. E. (1993). On the Relation between the Expected Value and the Volatility of the Nominal Excess Return on Stocks. *The Journal of Finance*, *48*(5), 1779. https://doi.org/10.2307/2329067.

Granger, C. W. J., & Newbold, P. (1974). Spurious regressions in econometrics. *Journal of Econometrics*, *2*(2), 111–120. https://doi.org/10.1016/0304-4076(74)90034-7.

Hanke, S.H., Krus, N. (2012). World Hyperinflations. *Cato Journal*. Available at https://object.cato.org/sites/cato.org/files/pubs/pdf/workingpaper-8_1.pdf.

Hayek, F. A. von. (1976). *The Denationalization of Money: An Analysis of the Theory and Practice of Concurrent Currencies*. London: Institute of Economic Affairs.

Hendrickson, J. R., Hogan, T. L., & Luther, W. J. (2016). The Political Economy of Bitcoin. *Economic Inquiry*, *54*(2), 925–939. https://doi.org/10.1111/ecin.1229.

Horwitz, S. (2000). *Microfoundations and macroeconomics: An Austrian perspective.* London: Routledge.

Jevons W. S. (1876). *Money and the Mechanism of Exchange*. New York: D. Appleton and Co. Available at http://oll.libertyfund.org/titles/318.

Keynes, J. M. (1973). *The collected writings of John Maynard Keynes. Volume VII, The general theory of employment, interest and money*. London: MacMillan.

Klein, T., Pham Thu, H., & Walther, T. (2018). Bitcoin is not the New Gold – A comparison of volatility, correlation, and portfolio performance. *International Review of Financial Analysis*, *59*, 105–116. https://doi.org/10.1016/J.IRFA.2018.07.010.

Knell, M., & Stix, H. (2005). The Income Elasticity of Money Demand: A Meta-Analysis of Empirical Results*. *Journal of Economic Surveys*, *19*(3), 513–533. https://doi.org/10.1111/j.0950-0804.2005.00257.x.

Kristoufek, L. (2015). What Are the Main Drivers of the Bitcoin Price? Evidence from Wavelet Coherence Analysis. *PLoS One, 10,* e0123923. https://doi.org/10.1371/journal.pone.0123923.

Loi, H. (2017). The Liquidity of Bitcoin. *International Journal of Economics and Finance*, *10*(1), 13. https://doi.org/10.5539/ijef.v10n1p13.

Menger, C. (2009). *On the Origins of Money*. Auburn: Ludwig von Mises Institute. Available at https://mises.org/library/origins-money-0.

Nakamoto, S. (2008). Bitcoin: A Peer-to-peer Electronic Cash System. Available at http://bitcoing.org/bitcoin.pdf.

Naware, A.M. (2016). Bitcoin: Its Advantages and Security Threats. *International Journal of Advanced Research in Computer Engineering & Technology*, *5*, 2278–1323. Available at http://ijarcet.org/wp-content/uploads/IJARCET-VOL-5-ISSUE-6-1732-1735.pdf.

Pesaran, M.H., Shin, Y. (1999). An Autoregressive Distributed-Lag Modelling Approach to Cointegration Analysis. In Strom, S. (Ed.), *Econometrics and Economic Theory in the*

20th Century (pp. 371–413). Cambridge: Cambridge University Press. https://doi.org/10.1017/CCOL521633230.011.

Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics*, *16*(3), 289–326. https://doi.org/10.1002/jae.616.

Platanakis, E., & Urquhart, A. (2018). Should Investors Include Bitcoin in Their Portfolios? A Portfolio Theory Approach. Available at SSRN: https://doi.org/10.2139/ssrn.321532.

Rallo, J.R. (2017). *Contra la Teoría Monetaria Moderna*. Barcelona: Deusto.

Redman, J. (2017). The Bitcoin Exchange Thefts You May Have Forgotten. Available at https://news.bitcoin.com/bitcoin-exchange-thefts-forgotten/.

Selgin, G. (1997). *Less than Zero: The Case for a Falling Price Level in a Growing Economy*. London: Institute of Economic Affairs.

Selgin, G. (2015). Synthetic commodity money. *Journal of Financial Stability*, *17*, 92–99. https://doi.org/https://doi.org/10.1016/j.jfs.2014.07.002.

Selgin, G. (2017). Stable prices or stable spending? Available at https://www.alt-m.org/category/monetary-policy-primer/.

Serletis, A., & Gogas, P. (2014). Divisia Monetary Aggregates, the Great Ratios, and Classical Money Demand Functions. *Journal of Money, Credit and Banking*, *46*(1), 229–241. https://doi.org/10.1111/jmcb.12103.

Smith, R. D. (2018). Bitcoin Average Dormancy: A Measure of Turnover and Trading Activity. Available at http://arxiv.org/abs/1712.10287.

Stavis, S. (2018). From Bear to Bull, a Look into the Cycle of Bitcoin Prices. Available at https://hackernoon.com/from-bear-to-bull-a-peek-into-the-price-cycle-of-bitcoin-96ff25045743.

Takaishi, T., & Adachi, T. (2018). Taylor effect in Bitcoin time series. *Economics Letters*, *172*, 5–7. https://doi.org/10.1016/J.ECONLET.2018.07.046.

Urquhart, A. (2016). The inefficiency of Bitcoin. *Economics Letters*, *148*, 80–82. https://doi.org/10.1016/J.ECONLET.2016.09.019.

Weber, W.E. (2016). A Bitcoin Standard: Lessons from the Gold Standard. *Bank of Canada.* Available at https://www.banqueducanada.ca/wp-content/uploads/2015/12/bitcoin-standard-lessons.pdf.

White, L.H. (2015a). The market for cryptocurrencies. *Cato Journal, 35,* 383–402. Available at https://object.cato.org/sites/cato.org/files/serials/files/cato-journal/2015/5/cj-v35n2-13.pdf.

White, L. H. (2015b). The merits and feasibility of returning to a commodity standard. *Journal of Financial Stability*, *17*, 59–64. https://doi.org/10.1016/j.jfs.2015.03.003.

Williamson, S. (2011). Bitcoin. New Monetarism. Available at http://newmonetarism.blogspot.com.es/2011/06/bitcoin.html.

Yermack, D. (2015). Is Bitcoin a Real Currency? In David K.C. Lee (Ed.), *The Handbook of Digital Currency* (pp. 31-44). Elsevier.

Ziliak, S. T., & McCloskey, D. N. (2004). Size matters: the standard error of regressions in the American Economic Review. *The Journal of Socio-Economics*, *33*(5), 527–546. https://doi.org/10.1016/J.SOCEC.2004.09.024.

Table 1: GJR-GARCH (1,1)

	Bitcoin (log) price
Mean equation	
Constant	5.012***
	(30.4237)
AR(1)	1.003***
	(6854.567)
Variance equation	
Constant	4.24E-05***
	(13.4427)
u_{t-1}^2	0.375***
	(20.9901)
$u_{t-1}^2 I_{t-1}$	- 0.169***
	(-8.4155)
σ_{t-1}^2	0.789***
	(199.3616)

The dependent variable of the mean equation is the price of Bitcoin in logarithmic form. The mean equation includes a first-order autoregressive term to eliminate autocorrelation (*z*-statistics in parentheses). *** denotes significance at a 1% level.

Table 2: Augmented Dickey-Fuller Test

Variables	Specification	T-Statistic	Stationary (1-α = 5%)
BTD	Trend and intercept, Schwarz Criterion	-2.5327	No
BTS	Trend and intercept, Schwarz Criterion	-6.0647***	Yes
BTV	Trend and intercept, Schwarz Criterion	-9.6415***	Yes
BTSize	Trend and intercept, Schwarz Criterion	-3.2365*	No
BTPL	Trend and intercept, Schwarz Criterion	-1.9718	No
VOL	Intercept, Schwarz Criterion	-14.2526***	Yes
GOLD	Trend and intercept, Schwarz Criterion	-2.6365	No
R	Trend and intercept, Schwarz Criterion	2.3067	No
Y	Trend and intercept, Schwarz Criterion	-2.5877	No

***, **, * denote statistical significance at a 1%, 5%, and 10% level respectively. All variables are introduced in logarithmic form except for *R* (the three-month U.S. Treasury Bill) and *VOL* (volatility). *BTD* represents the demand for Bitcoin; *BTS* is the supply; *BTV* is Bitcoin velocity; *BTSize* is the number of transactions per day; *BTPL* is the price level; *GOLD* is the price of gold; and *Y* is the price of the MSCI World Index.

Table 3: Results

	Model 1 Cointegration-Test Model	**Model 2** Long-Run Equilibrium	**Model 3** Short-Run Dynamics
	Δ*BTD*	*BTD*	Δ*BTD*
Δ*BTD*(-1)	0.1051*** (2.7258)	-	0.1169*** (3.1298)
Δ*BTD*(-2)	-0.0323 (-0.8426)	-	-0.0658* (-1.8277)
Δ*BTD*(-5)	0.0521** (2.2988)	-	0.0605** (2.4760)
Δ*BTD*(-6)	0.0741*** (3.3747)	-	0.0691*** (3.2046)
Δ*BTS*	27.4578 (1.4280)	-	28.8601 (1.4280)
Δ*BTS*(-1)	-28.7831 (-1.4686)	-	-25.7053 (-1.4456)
Δ*BTSize*	0.0247*** (3.2520)	-	0.0232*** (3.4853)
Δ*BTSize*(-2)	0.0130** (2.0610)	-	0.0146** (2.0610)
Δ*VOL*	-2.1936*** (-6.0263)	-	-2.0764*** (-4.6349)
Δ*VOL*(-1)	0.7972** (2.5657)	-	0.7458** (2.0119)
Δ*VOL*(-2)	-	-	-0.6611* (-1.8323)
Δ*VOL*(-4)	-	-	-0.3509* (-1.9255)
Δ*BTPL*(-1)	-0.0140*** (-3.9907)	-	-
BTD(-1)	-0.014*** (-3.9907)	-	-
BTS(-1)	0.0022 (0.0604)	-	-
BTV(-1)	0.0019 (0.8926)	-	-
BTSize(-1)	0.0112** (2.1365)	-	-
BTPL(-1)	0.1674*** (3.9899)	-	-
VOL(-1)	-0.4366*** (-3.7702)	-	-
GOLD(-1)	-0.0386 (-1.4798)	-	-
R(-1)	0.0172** (2.146)	-	-
Y(-1)	0.0637** (2.0576)	-	-
ê(-1)	-	-	-0.0141*** (-3.7566)
BTS	-	3.6913*** (6.3157)	-
BTV	-	0.0371 (1.5649)	-
BTSize	-	0.4956*** (4.7683)	-
BTPL	-	11.0127***	-

		(28.5080)	
VOL	-	0.8263 (0.6505)	-
GOLD	-	-1.1466*** (-2.6665)	-
R	-	0.7672*** (7.6430)	-
Y	-	3.9057*** (9.3936)	-
C	-0.0973 (-0.1874)	-69.1169*** (-9.7391)	-0.0019 (-1.1035)
F-Statistic (model)	19.4298***	13969.18***	26.6973***
Adjusted R-Squared	-	0.976	-
Breusch-Godfrey Serial Correlation LM Test (F-Stat.)	2.0457 (Not autocorrelated)	14228.93*** (Autocorrelated)	1.2257 (Not autocorrelated)
White's Heteroskedasticity Test (F-Stat.)	3.5259*** (Heteroskedastic)	87.4986*** (Heteroskedastic)	4.0716*** (Heteroskedastic)
Observations	2723	2746	2723
F-Statistic (cointegration test)	4.737	-	-
Relevant critical value (unrestricted intercept, no trend, k=8, α= 1)	4.10	-	-

T-statistics in parentheses. ***, **, * denote statistical significance at a 1%, 5%, and 10% level respectively. All variables are introduced in logarithmic form except for *R* (the yield of the three-month U.S. Treasury Bill) and *VOL* (volatility). *BTD* represents the demand for Bitcoin; *BTS* is the supply; *BTV* is Bitcoin velocity; *BTSize* is the number of transactions per day; *BTPL* is the price level; *GOLD* is the price of gold; and *Y* is the price of the MSCI World Index. The variance-covariance matrix has been estimated using the Newey-West estimator to overcome autocorrelation and heteroskedasticity issues. In models 1 and 3, the lag length has been selected using the Schwarz criterion.

Table 4: GJR-GARCH (1,1) (no weekends and holidays)

	Bitcoin (log) price
Mean equation	
Constant	5.143***
	(33.4760)
AR(1)	1.005***
	(4684.602)
Variance equation	
Constant	0.00015***
	(15.1566)
u_{t-1}^2	0.4790***
	(14.6253)
$u_{t-1}^2 I_{t-1}$	- 0.2091***
	(-6.1758)
σ_{t-1}^2	0.6989***
	(72.54)

The dependent variable of the mean equation is the price of Bitcoin in logarithmic form. The mean equation includes a first-order autoregressive term to eliminate autocorrelation (*z*-statistics in parentheses). *** denotes significance at a 1% level.

Table 5: Augmented Dickey-Fuller Test (no weekends and holidays)

Variables	Specification	T-Statistic	Stationary (1-α = 5%)
BTD	Trend and intercept, Schwarz Criterion	-2.5218	No
BTS	Trend and intercept, Schwarz Criterion	-5.2894***	Yes
BTV	Trend and intercept, Schwarz Criterion	-9.3097***	Yes
BTSize	Trend and intercept, Schwarz Criterion	-2.7777	No
BTPL	Trend and intercept, Schwarz Criterion	-1.9715	No
VOL	Intercept, Schwarz Criterion	-17.8719***	Yes
GOLD	Trend and intercept, Schwarz Criterion	-2.6416	No
R	Trend and intercept, Schwarz Criterion	2.2834	No
Y	Trend and intercept, Schwarz Criterion	-2.5904	No

***, **, * denote statistical significance at a 1%, 5%, and 10% level respectively. All variables are introduced in logarithmic form except for *R* (the three-month U.S. Treasury Bill) and *VOL* (volatility). *BTD* represents the demand for Bitcoin; *BTS* is the supply; *BTV* is Bitcoin velocity; *BTSize* is the number of transactions per day; *BTPL* is the price level; *GOLD* is the price of gold; and *Y* is the price of the MSCI World Index.

Table 6: Results (no weekends and holidays)

	Model 3 Cointegration-Test Model	**Model 4** Long-Run Equilibrium	**Model 5** Short-Run Dynamics
	ΔBTD	BTD	ΔBTD
$\Delta BTD(-4)$	0.0613**	-	0.0994***
	(2.5705)		(3.8273)
$\Delta BTS(-1)$	-	-	-19.7273*
			(-1.9342)
$\Delta BTS(-6)$	-	-	21.5155**
			(2.0015)
ΔBTV	0.0075**	-	-
	(2.2069)		
$\Delta BTV(-1)$	-0.0102**	-	-
	(-1.9848)		
$\Delta BTV(-2)$	-0.01074**	-	-
	(-2.0397)		
$\Delta BTV(-3)$	-0.0122***	-	-
	(-2.9031)		
$\Delta BTV(-4)$	-0.0074	-	-
	(-1.5891)		
$\Delta BTV(-5)$	-0.0075**	-	-
	(-2.1175)		
$\Delta BTV(-6)$	-0.0073**	-	-
	(-2.3208)		
$\Delta BTV(-7)$	-0.0052**	-	-
	(-2.1757)		
$\Delta BTSize$	0.026***	-	0.0272***
	(2.6457)		(3.46)
$\Delta BTSize(-2)$	0.0175***	-	0.0133**
	(2.6468)		(1.9779)
ΔVOL	-1.3499***	-	-1.1955***
	(-4.5525)		(-3.4633)
$\Delta VOL(-3)$	-	-	-0.2850*
			(-1.7358)
$\Delta VOL(-5)$	-	-	-0.2319*
			(-1.8242)
$BTD(-1)$	-0.0213***	-	-
	(-4.3173)		
$BTS(-1)$	0.0072	-	-
	(0.1358)		
$BTV(-1)$	0.0019***	-	-
	(3.2287)		
$BTsize(-1)$	0.0106	-	-
	(1.4305)		
$BTPL(-1)$	0.2273***	-	-
	(3.8392)		
$VOL(-1)$	-0.3776***	-	-
	(-4.6154)		
$GOLD(-1)$	-0.0511	-	-
	(-1.3740)		
$R(-1)$	0.0136	-	-
	(1.0813)		
$Y(-1)$	0.1001**	-	-
	(2.3434)		
$\hat{e}(-1)$	-	-	-0.0197***
			(-3.7719)
BTS	-	3.4847***	-
		(5.51)	
BTV	-	0.0316	-

		(1.1882)	
BTSize	-	0.5396*** (4.8437)	-
BTPL	-	10.9817*** (26.2473)	-
VOL	-	0.5126 (0.4595)	-
GOLD	-	-1.1466** (-2.4188)	-
R	-	0.7752*** (7.1140)	-
Y	-	3.9138*** (8.6031)	-
C	-0.4492 (-0.6755)	-66.1851*** (-8.6995)	0.0038* (1.9482)
F-Statistic (model)	12.7254***	10074***	24.2920***
Adjusted R-Squared	-	0.9764	-
Breusch-Godfrey Serial Correlation LM Test (F-Stat.)	5.1449*** (Autocorrelated)	7494.29*** (Autocorrelated)	7.6501*** (Autocorrelated)
White's Heteroskedasticity Test (F-Stat.)	3.2837*** (Heteroskedastic)	58.8014*** (Heteroskedastic)	2.5184*** (Heteroskedastic)
Observations	1938	1960	1936
F-Statistic (cointegration test)	6.7130	-	-
Relevant critical value (unrestricted intercept, no trend, k=8, α= 1)	4.10	-	-

T-statistics in parentheses. ***, **, * denote statistical significance at a 1%, 5%, and 10% level respectively. The variance-covariance matrix has been estimated using the Newey-West estimator to overcome autocorrelation and heteroskedasticity issues. The lag length has been selected using the Schwarz criterion.

Table 7: Long-Run Equilibrium Model (Period 8/17/2010 – 12/17/2017)

	BTD
BTS	3.7566***
	(6.27)
BTV	0.03167
	(1.5011)
BTSize	0.4822***
	(4.5438)
BTPL	11.009***
	(28.0235)
VOL	0.8467
	(0.6631)
GOLD	-1.1377***
	(-2.6213)
R	0.7598***
	(7.0224)
Y	3.9025***
	(9.2442)
C	-70.0771***
	(-9.7103)
F-Statistic (model)	12695.64***
Adjusted R-Squared	0.974364
Breusch-Godfrey Serial Correlation LM Test (F-Stat.)	14358.35*** (Autocorrelated)
White's Heteroskedasticity Test (F-Stat.)	86.6106*** (Heteroskedastic)
Observations	2673

T-statistics in parentheses. ***, **, * denote statistical significance at a 1%, 5%, and 10% level respectively. The variance-covariance matrix has been estimated using the Newey-West estimator to overcome autocorrelation and heteroskedasticity issues

Figure 1 – Interaction between supply and demand in Bitcoin markets

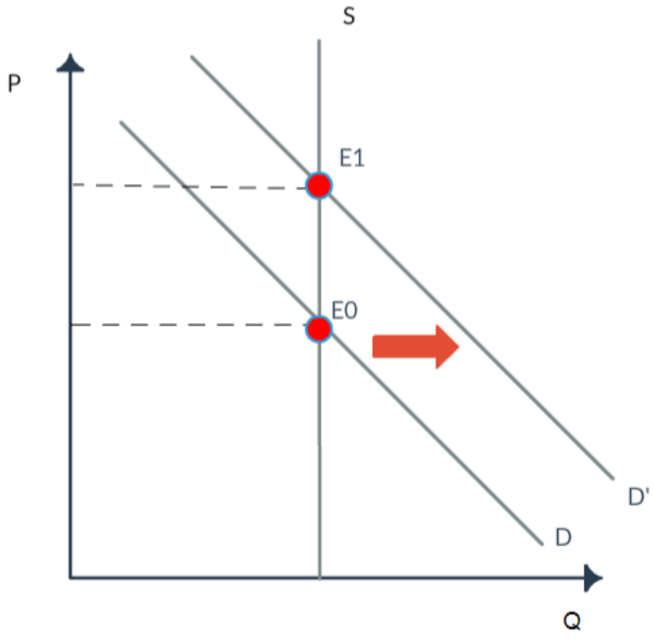

Figure 2 – Recursive coefficients

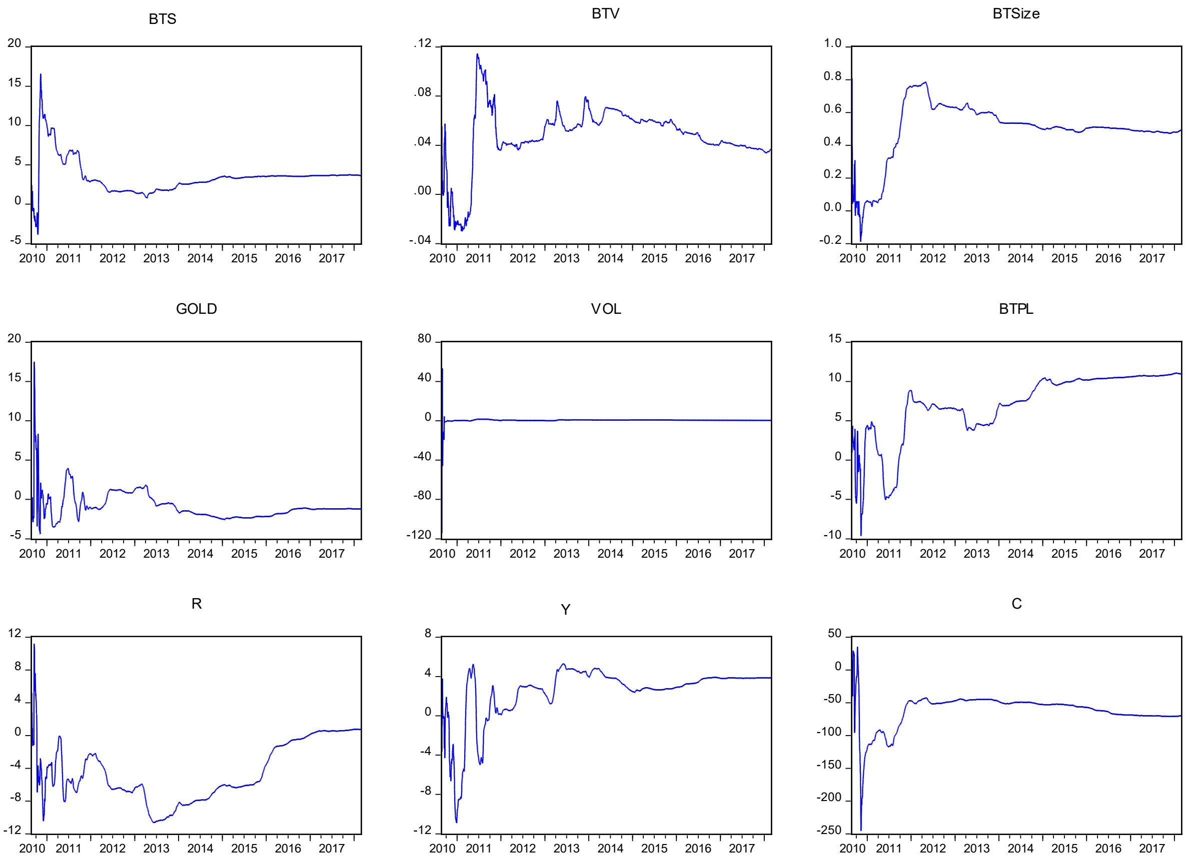

Figure 3 – Recursive p-values