Price Fluctuations and the Use of Bitcoin:

An Empirical Inquiry

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Abstract

Over recent years, interest has been growing in Bitcoin, an innovation which has the potential to play an important role in e-commerce and beyond. The aim of our paper is to provide a comprehensive empirical study of the payment and investment features of Bitcoin and their implications for the conduct of e-commerce. Since network externality theory suggests that the value of a network and its take-up are interlinked, we investigate both adoption and price formation. We discover that Bitcoin returns are driven primarily by its popularity, the sentiment expressed in newspaper reports on the cryptocurrency, and total number of transactions. The paper also reports on the first global survey of merchants who have adopted this technology and model the share of sales paid for with this alternative currency, using both ordinary and Tobit regressions. Our analysis examines how country, customer and company-specific characteristics interact with the proportion of sales attributed to Bitcoin. We find that company features, use of other payment methods, customers' knowledge about Bitcoin, as well as the size of both the official and unofficial economy are significant determinants. The results presented allow a better understanding of the practical and theoretical ramifications of this innovation.

Keywords: Bitcoin, cryptocurrency, online payments, technology adoption, electronic commerce, electronic money, empirical research, emerging technology, financial services

JEL Codes: E42, L81, O33

"The use of digital currencies such as Bitcoin, while not yet mainstream, is growing beyond the early enthusiasts. We expect this growth to continue and allowing people to use Bitcoin to purchase our products and services now allows us to be at the front edge of that trend."

Eric Lockard, Corporate Vice President of Universal Store at Microsoft

"Bitcoin is well suited for online transactions. It has no transaction fees and works well for international customers. Providing this convenience for the cult-following Bitcoin customer is the smart thing to do."

Patrick M. Byrne, Overstock.com, Chairman and CEO

E-commerce uses a range of payment methods that best suit the diverse preferences of consumers, the specifics of each transaction and the attributes of the product (H. Allen, 2003; Committee on Payment and Settlement Systems, 2012; Zhang & Li, 2006). A common feature of these payment systems is the presence of a trusted third party, who processes the transaction. Until recently, there was no widely-available equivalent to cash in e-commerce, even though the need for some form of electronic money to perform this role was clear, especially in the area of micro-payments (Chaum, 1983; Kauffman & Walden, 2001). Therefore, there was no possibility of non-reversible direct settlement between the parties to a transaction. This was pointed out in 2008 by Satoshi Nakamoto (a pseudonym for an individual or group of programmers) in a white paper entitled *'Bitcoin: A Peer-to-Peer Electronic Cash System'* (Nakamoto, 2008). The paper proposed a mechanism based on peer-to-peer networking, through which a payment system could eliminate financial intermediaries and allow users to make direct and (relatively) anonymous transactions via the Internet.

One of the important and original features of Bitcoin was that it provided a means of encouraging the take-up and use of the technology in its initial phase of development –

thereby overcoming the usual problems faced by other innovations (Committee on Payment and Settlement Systems, 2012; Hoehle, Scornavacca, & Huff, 2012; Rogers, 1983; Weber & Kauffman, 2011; Zhang & Li, 2006). This problem is particularly acute in the case of new payment systems, due to strong indirect network effects (Church, Gandal, & Krause, 2008; Schuh & Stavins, 2013; Stango, 2004) in a so-called two-sided market (Rochet & Tirole, 2003, 2006). The two-sidedness means that the simultaneous adoption is required by two groups of users in the network, namely customers making payments and merchants accepting them. Appropriate incentives, in particular financial, may be crucial to achieve critical mass for innovations in payment systems (Arango, Huynh, & Sabetti, 2011; Clemons, Croson, & Weber, 1996; Van Hove, 2001).[1] When Nakamoto's concept was implemented on January 3rd 2009, initial interest in Bitcoin was low. However, since the cryptocurrency possesses its own unit of value, which is tradable, possibilities for speculating on its price were created. This acted as a stimulus to interest early adopters, which is necessary for the take-off of any innovation (Rogers, 1983, p. 11). These new users, although they might only desire to make money from movements in the price, still are able to make payments using the cryptocurrency at any moment. They therefore contribute to the development of the network, and apropos the theory of network externalities (Economides, 1993; Katz & Shapiro, 1986) lead to the increase in its value, not least from the point of view of e-commerce vendors.

Since the start of regular trading of Bitcoin against the US dollar in July 2010[2], the number of transactions began to grow exponentially. From August 2010 to August 2014, the monthly number of transactions using Bitcoin increased 177-fold from 12,000 to 2.1 million, implying a compound annual growth rate of 265%. Market value, in US dollars, increased more than

[1] In traditional payment systems, such as credit cards and debit cards, incentives for consumers were provided by promotions and rewards programs (Ching & Hayashi, 2010; Schuh & Stavins, 2013). However, this requires initial financing from investors (Polasik, Wisniewski, & Lightfoot, 2012) – an option not available to the newly created cryptocurrency.

[2] The first Bitcoin stock market was launched in February 2010 and the first regular trading was introduced by Mt. Gox in July 2010.

27,000 times, reaching $6.3 billion, an annual growth of 1,184%.[3] The increase in value and high rate of return received by those engaged in the development of the Bitcoin network could be considered as one of the measures of success of the system (DeLone & McLean, 2004). This implies that Bitcoin has the potential to have a significant impact on the future conduct of online business.

As mentioned before, Bitcoin currently operates both as a payment system for electronic transactions as well as a cryptocurrency that enables investing, with the two being inextricably intertwined. This necessitates an empirical investigation that explores both aspects simultaneously. Therefore the aim of this paper is to be the first to provide a comprehensive study of both of these features and their implications for the conduct of e-commerce. Accordingly, we explore several fundamental questions: (i) What can vendors considering adopting Bitcoin expect, given their profile and the characteristics of the country in which they are based? (ii) For which payment methods is Bitcoin a complement and for which is it a substitute? (iii) How does media reporting on Bitcoin, be it enthusiastic or alarmist, affect the value of this cryptocurrency? (iv) What kind of fluctuations in Bitcoin prices can vendors expect, and what drives those fluctuations? (v) How should merchants organize their acceptance of Bitcoin when selling online?

To answer these questions, we conducted two parallel empirical studies, the first of which considers the determinants of Bitcoin returns. In the modelling process, we considered a very broad range of explanatory variables, which captured both the supply and drivers of demand. The popularity measures, including the number of Google searches using the word 'Bitcoin', as well as the number of English-language newspaper articles mentioning the same keyword, exerted a strong influence on returns. The tone of those articles was measured using computerized content analysis and was shown to be an important factor – a finding hitherto unreported in the literature. The number of transactions was also an important pricing

[3] Data calculated based on blockchain.info and coindesk.com.

consideration confirming that there is a strong link between the investment and payment functions of the cryptocurrency. This phenomenon can be rationalized through using the framework of network externality theory.

The second study focused on the use of Bitcoin in e-commerce. We explore the fraction of sales settled in Bitcoin, based on the results of the first-ever global survey of legal on-line vendors that have adopted it as a payment mechanism. An English-language questionnaire was distributed to the known population of vendors in April 2013. Of the just over 600 companies surveyed, 108 responded. Our results significantly broaden the knowledge about Bitcoin in that they reveal the determinants of its use in e-commerce, including both the characteristics of the seller, the market environment of the country in which the company is headquartered, and the use of alternative payment methods. The results showed that a greater share of sales through Bitcoin were achieved by start-ups and smaller companies in general, as well as by entities serving customers who had a better knowledge of this particular payment innovation. Another important result was that there was a greater share of Bitcoin payments in developing countries and those with a larger shadow economy. Furthermore, it was empirically demonstrated which payment methods Bitcoin is a substitute for, and which it is a supplement to. This has allowed us to formulate recommendations regarding adoption strategies.

To the best of our knowledge, this is the first academic paper that (*i*) jointly investigates the investment and payment aspects of Bitcoin using empirical methods, (*ii*) examines the e-commerce adopters of Bitcoin technology and (*iii*) assesses the impact of the number of Bitcoin transactions and the sentiment of media information on its value. The results are relevant for both existing and potential users of this cryptocurrency, and we believe that this work may help to inform e-commerce managers, as well as investors, regulators and public institutions.

The remainder of the paper is structured as follows. The next section provides an overview of the literature in the field of Bitcoin and identifies gaps in existing research. Section two defines Bitcoin, describes its system's mechanisms, provides more information about the market, elaborates on the challenges faced by the technology and discusses the theoretical background. Section three models the price formation process, while section four examines Bitcoin use in online payments, based on our own survey. Recommendations for managers, theoretical implications and conclusions follow.

1. Literature review

The rise of Bitcoin has implications for various fields, which demands a broad multidisciplinary framework for understanding this phenomenon. Bitcoin research has taken four main paths. The first discusses technological issues, including cryptographic problems, system security and vulnerability to attack (Eyal & Sirer, 2014; Feld, Schönfeld, & Werner, 2014). Within this literature, a large contingent is that of studies which analyze the transaction records held in the blockchain (Androulaki, Karame, Roeschlin, Scherer, & Capkun, 2013; Ober, Katzenbeisser, & Hamacher, 2013; Ron & Shamir, 2013, 2014). A second stream looks at public and legal issues, examining how Bitcoin is treated within different legal jurisdictions, including the treatment of tax liabilities arising from Bitcoin-related trades and investments, as well as anti-money laundering regulations (see, for instance, Bryans (2014), Christopher (2014), Stokes (2012), Tropina (2014)). These issues are of considerable practical importance for businesses and private individuals using Bitcoin, and also draw the attention of central banks and other public institutions (European Central Bank, 2012; HM Revenue & Customs, 2014; IRS, 2014; Segendorf, 2014; Velde, 2013). Moreover, Bitcoin, with its pseudo-anonymous and decentralized nature, raises concerns about new possibilities for tax evasion and financing illegal activities (Barratt, Ferris, & Winstock, 2014; Böhme, Christin, Edelman, & Moore, 2014; Ron & Shamir, 2014; Van Hout & Bingham, 2013). The third area relates to political (Karlstrøm, 2014), sociological (Maurer, Nelms, &

Swartz, 2013) and ethical (Angel & McCabe, 2014; Krugman, 2013) implications related to the emergence of Bitcoin and subsequent cryptocurrencies. In particular, libertarians see an opportunity in the decentralized nature of Bitcoin to gain freedom from surveillance by governments or financial institutions.

The fourth and final area of research concerns economic issues. This stream includes theoretical considerations as to whether Bitcoin performs the functions of money, some aspects of money supply and deflation (Evans, 2014; Segendorf, 2014; Selgin, 2014; Wang, 2014) and its investment potential (Brito, Shadab, & Castillo, 2014; Yermack, 2013). However, there is a noticeable lack of comprehensive empirical research in the field of Bitcoin economics. One notable exception is a study carried out by Garcia *et al*. (Garcia, Tessone, Mavrodiev, & Perony, 2014) which examined how the price of Bitcoin was related to general interest in it, measured by such an indicator as Google searches (a variable that we also use here). However, extant research thus far has not considered the sentiment of information in the media, such as whether reports about Bitcoin have a positive or negative tone, and the impact that this might have upon price. Additionally, the hypothesis of the interaction between the payment and investment functions of Bitcoin has not been considered empirically.

It is a little surprising that the primary application posited for Bitcoin - e-commerce - has not yet been subjected to rigorous scientific scrutiny, despite the fact that its use as an electronic payment system for transactions has many important consequences for information systems and distribution strategies via electronic channels. Most importantly, Bitcoin has not been analyzed as a substitute for older payment systems, even though their attributes differ markedly and are crucial for e-commerce businesses. This includes transaction costs (Chircu & Mahajan, 2006; Kaefer & Bendoly, 2004; Liang & Huang, 2000; Sung, 2006; Teo & Yu, 2005), as well as the distribution of risk and trust between traders and customers (Glover & Benbasat, 2011; Li, Pieńkowski, Van Moorsel, & Smith, 2012; Suh & Han, 2003). There is

also a dearth of studies that investigate the link between consumers' level of knowledge and their use of Bitcoin in e-commerce.

2. Understanding Bitcoin

2.1. Definition and Classification

We begin by defining what Bitcoin is and what qualities it possesses (Figure 1). As a starting point, we take the classification proposed by the European Central Bank (2012), which situates Bitcoin as unregulated digital money, which is a kind of virtual currency. To a certain extent it resembles electronic money, in particular, software money, which in contrast to hardware money, can be used on the Internet (Zähres, 2012). It also shares some common theoretical assumptions, such as those presented in the work of Chaum (1990, 1993) and Camp *et al.* (1995) (see (Kauffman & Walden, 2001)). It should be noted that, in contrast to electronic money, Bitcoin does not represent a pre-existing legal tender[4] (such as dollars or euros) and has its own value units. In this, it sits alongside other alternative currencies. However, it differs significantly from 'local currencies' (such as the Bristol Pound) which have parity with their country's official currency, guaranteed by the issuer. By using a decentralized ledger system, it is also unlike earlier virtual currencies, such as the Linden Dollar from the game *Second Life* or the Liberty Reserve digital currency (European Central Bank, 2012; Jin & Bolebruch, 2009). These systems are, just like regulated digital money, centralized with an institution authenticating transactions and controlling the money in issue. However, systems of this type can be compromised by, for example, a hacker attack, or closed by the authorities, as in the case of Liberty Reserve (Santora, Rashbaum, & Perlroth, 2013).

[4] Electronic money is treated as a surrogate legal tender in European Directive 2009/110/EC of the European Parliament and of the Council of 16 September 2009 on the taking up, pursuit and prudential supervision of the business of electronic money institutions amending Directives 2005/60/EC and 2006/48/EC and repealing Directive 2000/46/EC (Text with EEA relevance) (OJ L 267, 10.10.2009, p. 7-17).

Unlike earlier systems of digital money, be it e-money or virtual currencies, the importance of Bitcoin is that it is the first ever fully decentralized digital currency (Berentsen, 2014; Brito & Castillo, 2013). It is a virtual currency, but the use of peer-to-peer (P2P) networks and cybersecurity created a new sub-category: that of cyptocurrency (Berentsen, 2014; Bradbury, 2013). Within a couple of years of the launch of Bitcoin, 250 similar new cryptocurrencies were introduced (Segendorf, 2014) among which the most famous is probably Litecoin. The name cryptocurrency is justified because, in contrast to previous systems, cryptography is not limited to guaranteeing transaction security, but is also the very foundation for the philosophy of the currency. As noted by Karlstrøm (2014) common features of cryptocurrencies like Bitcoin are: (1) the money supply is controlled by an algorithm, the workings of which are in the public domain, and which is independent of central bank monetary policy; (2) verification of transactions is decentralized and non-hierarchical; (3) electronic wallets (in which the currency is stored) are not directly connected to the their respective owners by identity information. The last characteristic affords users a high level of anonymity, but contrary to popular belief, this is not total.

[Figure 1 about here]

The creator of Bitcoin described it as ‘a system for electronic transactions’ without suggesting that it should be a separate currency (Nakamoto, 2008). Yet it seems clear that Bitcoin is both a digital currency and a payment system. Accordingly, here we define Bitcoin as follows. It is the first cryptocurrency, a decentralized, pseudonymous, alternative digital currency, which is an integral part of the peer-to-peer payments system, based on a cryptographic protocol and using an algorithm to manage the supply of the currency.

2.2. Bitcoin System Mechanisms

Barber *et al.* (2012) and Moore (2013) argue that Nakamoto’s Bitcoin model drew upon work by David Chaum (1983) and of several other researchers (Back, 2002; Camenisch,

Hohenberger, & Lysyanskaya, 2005; Canard & Gouget, 2007; Dai, 1998; Okamoto, 1995). In planning to create a decentralized system of electronic payments without intermediaries, the challenge for Nakamoto was dealing with the hitherto unsolved problem of the same money being spent more than once (known as double-spending). In all previous electronic payment solutions, a trusted financial intermediary verified the accuracy of executed transactions (Everaere, Simplot-Ryl, & Traoré, 2011). The fundamental innovation in the Bitcoin system, which solved this problem, was the use of a public ledger which made all transactions visible (Evans, 2014).[5] The users of the system verify that the execution has been performed correctly. Decentralization was achieved by applying a peer-to-peer (P2P) communication model used previously in file-sharing protocols such as BitTorrent (Feld et al., 2014). Such systems are impossible to shut down by either the developers or a third party (Everaere et al., 2011). Also, once a transaction has been verified, it cannot be unwound – which is a positive for the one accepting the payment, but risky for the payer.

Bitcoin users employ 'wallets' – software that stores the necessary digital data, allows the generation of Bitcoin addresses and the management of balances of Bitcoin assigned to a specific address. Bitcoin addresses are comparable to a bank account, but operate differently in that other users know how much is in an account but do not know the identity of the holder. These addresses have public and private cryptographic keys assigned to them. The private key is used to authorize the transaction and, since it is effectively the only thing that gives ownership of a user's funds, should be protected. Bitcoin transactions are collected into 'blocks' by specialized users called 'miners'. With the help of dedicated software, they subsequently verify these blocks. Generating a block requires miners using their computational power to solve the cryptographic task of verifying the transaction (called 'proof of work'). Finding a block that contains the correct transaction typically occurs once every 10 minutes (Nakamoto, 2008). Information about this is communicated to all nodes of

[5] The transaction history is available at http://blockexplorer.com.

the Bitcoin network. Each new block contains a 'hash' of the previous block which guarantees that it follows it. As a result, the blocks are connected into a chain – the 'blockchain' – a public ledger that contains all the transactions ever executed in the system.

The incentive for miners to utilize their computing power to validate transactions is that they are rewarded for generating a block. This may be either in the form of transaction fees (paid for by particular users) or through the receipt of new Bitcoins issued by the system. This rewarding of miners through the latter scheme increases the supply of the cryptocurrency. The remuneration halves every four years – from the start of the system in 2009 to the end of 2012 the prize was 50 BTC[6], since 2013 this has been reduced to 25 BTC. The value of the reward is a tool to control the money supply with the maximum number Bitcoins that can be ever issued set at 21 million.[7] It will asymptotically approach the maximum, with 99% of the final supply estimated to be issued by 2032, and 100% by 2140 (Kroll, Davey, & Felten, 2013). The awards provide an incentive designed to support the early stage of the development of the system. As mining profits fall, it is expected that they will be replaced by transaction fees paid by users of the system (Nakamoto, 2008). As computing power increases, so does the difficulty of the cryptographic tasks. Miners group together in 'pools' that combine their computing power, increasing their chances of rewards.

Since any interested parties can view and analyze all the transactions recorded in the public ledger, Bitcoin is only pseudo-anonymous rather than totally anonymous (Brito & Castillo, 2013). Transactions can be tracked and traced to the IP address of the computer which sent the instructions. Moreover, if a Bitcoin address is disclosed, for example through a website, it may be possible to trace the flow of Bitcoins to and from a particular user, making them susceptible to hackers' attacks (Androulaki et al., 2013; Reid & Harrigan, 2013). There are

[6] Although there is no official classification within the ISO 4217 standard for currency designation for Bitcoin, the abbreviations BTC or XBT are used by traders and in publications, following the same three letter convention denoting other currencies.

[7] A Bitcoin can be divided into smaller units, down to 1 Satoshi which is equivalent to 0.00000001 of the original unit.

ways of maintaining anonymity, such as by carrying out transactions via the anonymizing network Tor (Dingledine, Mathewson, & Syverson, 2004) or using 'mixing services' that claim to obscure the address of users (Möser, Böhme, & Breuker, 2013), but even there they may still be analyzed (Christin, 2013). Thus, despite the furor over Bitcoin enabling anonymity, effectively most users' transactions are more transparent than those veiled in the secrecy of the traditional banking system. Additionally, while conventional banking restricts access to information to public institutions, the transparency of the Bitcoin system informationally empowers the citizen. However, while pseudo-anonymity may protect user information, it may also limit merchants' ability to collect information about their customers – an increasingly important part of targeted marketing communications (Piotrowicz & Cuthbertson, 2014).

2.3. The Bitcoin Market

Since Bitcoin is international and pseudo-anonymous, the number of users is difficult to estimate precisely (Segendorf, 2014). One way is to calculate the number of wallets: CoinDesk, one of the leading sources for Bitcoin news, estimated the number at 5.3 million in June 2014 – a seven-fold increase over July 2013.[8] However, since a user may have more than one wallet, and many wallets may be inactive, this estimate is likely to over-represent the number of users. If there are 2.9 billion users of the Internet worldwide[9], it is evident that the present holders of Bitcoins are widely dispersed and that the system may not have yet achieved critical mass (Evans, 2014; Grover, 2014).

The first purchase using Bitcoin was on May 22nd 2010 by Laszlo Hanyecz, a computer programmer from Florida, for two pizzas with the amount agreed at 10,000 Bitcoins (Bilton, 2013; Wallace, 2014; Yermack, 2013), which would be equivalent to $6.36 million on 1st July

[8] CoinDesk report: http://www.coindesk.com/state-of-bitcoin-q2-2014-report-expanding-bitcoin-economy/. Total wallets based on data from: Blockchain.info; MultiBit.org; Coinbase; Andreas Schildbach (Android Bitcoin Wallet developer) (accessed 26.07.2014).
[9] http://www.itu.int/en/ITU-D/Statistics/Documents/statistics/2014/ITU_Key_2005-2014_ICT_data.xls (accessed 02.10.2014).

2014. However, since then the network has been progressively expanding and now includes examples such US online retailer Overrstock.com, WordPress, Dell and Universal Store at Microsoft. Wikipedia accepts donations in Bitcoin, Google can work out a conversion rate for them, and PayPal will process Bitcoin payments for merchants (Mishkin, 2014).

Payment service providers play an important role in the development of the system such as Bitcoin. In traditional card payment systems, banks play a key role. However, in the e-commerce market the most success has been witnessed by non-bank payment service providers, such as PayPal. Their rise has been attributed to their innovations in handling the payment process, by providing a convenient interface, which motivated customers to shop online more frequently. In the case of Bitcoin, the seeming complexity of the arrangements needed to operate a cryptocurrency means that many companies have shied away from direct acceptance of payments. This has created a niche for start-ups that have specialized in servicing transactions on the behalf of vendors. These payment service providers add value because, apart from the transaction processing, they assume the risk associated with fluctuating values of the cryptocurrency and transfer domestic currency to merchants. The most famous providers are BitPay (Bryans, 2014) and Coinbase (Brito et al., 2014) and they are largely responsible for the rapid increase in the number of traders that accept Bitcoin. It is likely that innovations introduced by payment service providers will provide much of the impetus for the future growth of cryptocurrencies, just as PayPal helped drive online shopping.

Most people will not mine Bitcoins but buy them. They can be purchased directly from another user but the most convenient method is via 'exchange platforms'. They operate in real time and enable the trade of traditional currencies for Bitcoin and *vice versa* (European Central Bank, 2012). The platforms are a link between the Bitcoin system and the payment systems of individual countries. After the retail trade, this is the most significant contact area between the Bitcoin system and the real economy. The exchange platforms operate as closed

systems and the trading within is not registered on the blockchain. Currently, across the world, there are dozens of Bitcoin trading platforms. The largest are the Chinese OKCoin and BTC China, the English Bitstamp and the Bulgarian BTC-e, with the average daily turnover of these four platforms standing at approximately $42 million.[10] However, these platforms are not legally regulated and do not guarantee customer protection in the same way as regulated markets, making their use risky. The most notable example of the dangers for investors was perhaps the collapse of the Japanese Mt. Gox, which was one of the first Bitcoin online trading platforms and was the leader in this field for several years (Brito et al., 2014; Bryans, 2014). Although, at its peak in July 2011, the company claimed to carry out over 80% of transactions in the market for this cyptocurrency (Cawrey, 2013), by February 2014 it had filed for bankruptcy with losses reaching as much as 460 million dollars (McMillan, 2014). The cases of Mt. Gox and other failures of exchange platforms have resulted in calls for regulation. Such regulations, it has been argued, could be designed to simultaneously reduce the problem of money laundering and tax evasion (Bryans, 2014).

2.4. Bitcoin as a currency

Journalists, analysts and financial institutions often discuss the monetary value of Bitcoin (Ali, Berrdear, Clews, & Southgate, 2014; Blundell-Wignall, 2014; European Central Bank, 2012; Grover, 2014; Nathan, 2014). Bitcoin is not backed by any commodity or precious metal which would guarantee its value, and is therefore similar to other fiat currencies in operation today. Unlike other national currencies, however, Bitcoin is neither supported by legal guarantees of acceptance by the government, nor accepted for settling tax liabilities (Blundell-Wignall, 2014). Security for Bitcoin holders is based on trust in mathematical laws and faith in the technological solutions. For some users, owning Bitcoins is a means of expressing opposition to the traditional financial sector that lost their trust in the recent financial crisis (Bradbury, 2013).

[10] Based on statistics from http://bitcoincharts.com/markets/ (accessed 31.08.2014).

The value of Bitcoin against the dollar and other currencies is determined on the open market, in the same way as many national legal tenders (Brito & Castillo, 2013). Bitcoin has seen much higher volatility in its exchange rates compared to other world currencies and gold (Yermack, 2013), which may be down to the relative illiquidity of the Bitcoin market. Additionally, the possession of Bitcoin does not generate any cash flows, which means that there is no means of determining its fundamental value (Blundell-Wignall, 2014). Without such a benchmark, a sudden increase in price of Bitcoins cannot be labeled as a speculative bubble. However, some of the observed behavior of investors has appeared to fit the 'greater fool theory' in that their valuations of Bitcoin seemed based on a belief in a continued upward trajectory (Blundell-Wignall, 2014).

The fact that the supply of Bitcoins is relatively stable - the number of coins is asymptotically capped at 21 million and determined by a mathematical algorithm - suggests that some investors will hold it as a store of value, which diminishes its efficacy as a medium of exchange. Research from May 2012 indicated that up to 73% of addresses only receive Bitcoins and do not send them (Ron & Shamir, 2013). Ratcliff (2014) corroborates this in claiming that around 11% of Bitcoin have been held unused at addresses for more than 4 years, and 39% for more than a year.[11] This is consistent with Gresham-Copernicus' law (Krueger & Ha, 1995) stating that where there are two currencies in operation, the money seen as a better store of value will be hoarded and the inferior money will be used for transactions. But if belief in Bitcoins evaporates, this will be reversed and holders *en masse* will want to spend them quickly. Hoarding can lead to an increase in the purchasing power of the currency, which in turn carries the risk of triggering a deflationary spiral and recessionary tendencies, as noted by the (European Central Bank, 2012; Grinberg, 2012). A similar situation could be envisaged if the real growth rate surpasses the growth in money supply and the velocity of money is held constant (Böhme et al., 2014; Krugman, 2013).

[11] However, these numbers will also include users who have lost the keys to their wallets (Ron & Shamir, 2013).

As can be seen from the discussion above, Bitcoin could potentially have some influence on monetary policies of central banks, at least from a theoretical viewpoint. Taking this a step further, the significant replacement of national currencies by Bitcoin would imply reduction of the benefits derived from seigniorage (printing and minting new money) since in the Bitcoin economy these proceeds are captured by miners. This loss could potentially lead to fiscal distress. Secondly, the inability to print additional money in difficult circumstances makes operations of the lender-of-last resort much more challenging, putting fractional reserve banking at risk. Additionally, a predetermined money supply seriously erodes the possibility of conducting a countercyclical monetary policy. If prices and wages are sticky, attempts to counter deflationary pressures will be toothless, which could in turn lead to a recession and high levels of unemployment (see, for example, Azariadis & Stiglitz (1983)). If, on the other hand, prices and wages exhibit perfect flexibility, the economy would adjust quickly, but will have to bear the burden of high menu costs (Sheshinski & Weiss, 1977). The costs associated with frequent altering of nominal prices and renegotiation of labor contracts could indeed be non-trivial.

Concerns were also raised earlier with the emergence of electronic money (Bank for International Settlemets, 1996; European Central Bank, 1998; European Monetary Institute, 1994). This issue has continued to be explored but no consensus has emerged as to whether the risk is real (Bounie & Soriano, 2003; Freedman, 2000; Friedman, 1999, 2000; Goodhart, 2000; King, 1999; Tanaka, 1996). Ultimately, the influence of electronic money turned out to be negligible, primarily because of its low adoption, leaving only a potential threat to seigniorage (Boeschoten & Hebbink, 1996). Realistically, we should not expect Bitcoin to have a significant impact on the policies of central banks since, unlike electronic money, it is not a surrogate for legal tender and cannot be used for public finance or to settle tax debts.

Many of the fears related to the effect of Bitcoin on the macroeconomy may have been likewise exaggerated. At the moment the value of Bitcoins in circulation is miniscule

compared to world GDP and this innovation serves merely as a 'translational' rather than a 'functional' currency. Vendors usually fix their prices of goods and services in their national currency, and it is only the payment of an equivalent amount that is made using Bitcoin at the current exchange rate. We can therefore say that currently Bitcoin in e-commerce is used for settlement purposes. Prices of goods and services expressed in this cryptocurrency are perfectly elastic and therefore operation of this payment system is unlikely to generate additional nominal rigidities. This should significantly diminish any macroeconomic effects due to Bitcoin.

In the light of the above, it may be that a more promising approach is to consider Bitcoin as a payment system and to evaluate it through the lens of network economics. It is well-known that consumer utility increases with network size, which has been labeled in the literature as the "network externality" (Katz & Shapiro, 1985), the "network effect" (Liebowitz & Margolis, 1994), or "positive size externality" (Economides, 1993). It is easy to imagine that an individual's choice of payment instrument could be motivated by the prevalence of its acceptance in retail commerce. Similarly, merchants prioritize the installation of payment infrastructure for instruments that are already in wider use. The existence of a critical mass may thus be one of the factors promoting further adoption of payment innovations and this network effect has been observed for credit cards (Chakravorti, 2010) and bank transfers (Milne, 2006). As we outlined earlier, the network effect has been stimulated at an initial stage with Bitcoins acting as an investment vehicle to some early adopters. Since the purchase of goods and services is effectively an alternative means of redeeming a Bitcoin investment, every investor is a potential purchaser. This implies that it is not easy to separate investment and payment motives, and hence we analyze them jointly in this paper.

2.5. The Challenges to the Development of Bitcoin

Bitcoin can be considered safe since the cryptographic protocols have not been broken (Bryans, 2014). However, there are theoretical possibilities of disturbing its functioning. In

the ‘51% Attack’ scenario, a miner (or pool of miners) that obtains more than 50% of the computing power of the system would be able to change the current consensus over the operation of the currency and, as a result, enable double-spending or multiple use of their coins (Rosenfeld, 2014). This risk had been downplayed since it would require enormous computational power. In September 2014 the total computing capacity involved in mining Bitcoins was 10,000 times that of the 500 fastest computers in the world.[12] However, the risk is realistic, as in June 2014 the pool GHash.IO exceeded 50%. Its representatives assured the public that it will self-limit its share of computing power to 40%[13], but this merely demonstrates the possibility of a similar situation in the future.

The next problem is the security of stored Bitcoins. Hacking attacks are rife and aimed at all elements of the Bitcoin system infrastructure (Computer Fraud & Security, 2013): from merchants who accept Bitcoins, payment processors (Kastrenakes, 2013), providers of digital wallet services (D’Orazio, 2013) and trading platforms such as Mt. Gox (Decker & Wattenhofer, 2014) to wallets of individual users (Federal Bureau of Investigation, 2012). The dangers come from users’ lack of technical knowledge, as well as poor security used by some institutional participants in the system. The irreversibility of Bitcoin transactions makes losses practically impossible to recover. A detailed analysis of risks associated with the use of intermediaries is presented by Moore & Christin (Moore & Christin, 2013). Security is much stronger with ‘cold storage’ where private keys are saved on media that is not connected to the Internet, such as with USB drives or printed on paper.

The media often emphasizes how Bitcoin can be used for illegal activities (Brito & Castillo, 2013). There are concerns about the secretive purchase of illegal goods and the cross-border transfer of money either for money-laundering or to finance terrorism (Ron & Shamir, 2014; Tropina, 2014). Bitcoin was the normal means of settlement for the trade in illicit goods (such

[12] Calculations based on data from http://bitcoincharts.com and http://www.top500.org.
[13] https://ghash.io/ghashio_press_release.pdf.

as drugs, pornography and weapons) via online marketplaces such as the infamous Silk Road (Christin, 2013). On the other hand, due to the pseudo-anonymous character of the currency, detection of criminals is not impossible, as demonstrated by the closure of Silk Road in October 2013 and the prosecution of its founder. This was achieved through the analysis of publicly available transaction data (Ron & Shamir, 2013). Of course, traditional paper money is also used to finance illegal activities anonymously, yet there are no calls to ban it.

Another issue is that the legal status of Bitcoin, and its treatment by tax authorities, is not the same in different jurisdictions (Blundell-Wignall, 2014). Although most developed economies are reasonably relaxed about its appearance, some countries prohibit the holding and use of Bitcoins (such as Ecuador and Bolivia) and others impose restrictions (e.g. India and mainland China). Even where it is freely available and usable, the authorities take different positions on its status, typically classifying it as either equivalent to a foreign currency (Hartge-Hazelman, 2013), 'private money' (Clinch, 2013; HM Revenue & Customs, 2014), an asset or property (IRS, 2014), or outside the scope of existing legislation.

3. Bitcoin Price Formation

3.1. Data

In this section, our intention is to explore the under-researched question as to what influences the value of Bitcoin. To this end, we collect data on Bitcoin prices from CoinDesk and convert them into continuously compounded monthly returns. We suspected that these returns could be a function of popularity, itself connected to awareness. Two proxies for popularity have been developed here. The first is the percentage increase in the number of English language articles in the Nexis database which mention the word 'Bitcoin'. The second measure records the percentage increase in the number of searches for the keyword 'Bitcoin' relative to all Google searches. Both of these have been expressed as percentage changes rather than levels in order to avoid non-stationarity problems.

It needs to be mentioned however that interest in Bitcoin and the corresponding hike in news volume may also arise as a consequence of notable security breaches, collapses of Bitcoin exchanges or other scandals. In order to conduct a comprehensive analysis of the price formation, one needs not only to measure the information volume, but also distinguish whether the cryptocurrency is becoming increasingly famous or infamous. We intend to accomplish this goal by analyzing the sentiment of newspaper articles that mention the keyword 'Bitcoin'. We resort to using the recent developments in computational linguistics that allow for an objective measurement of the tone of textual documents. More specifically, for any given month, we collected all English language news items mentioning Bitcoin available in the Nexis database into a single text file. Subsequently, we used the thesauruses of words with positive and negative connotations developed by Henry (2008) to measure the sentiment inherent in the file. The positive thesaurus of Henry (2008) includes 105 words, while the negative wordlist has 85. These corpora have been developed specifically for the finance and accounting applications, which is appropriate for our work since we are modeling a financial variable. Subsequently, we programmed these thesauruses into computer-assisted text-analysis software called Diction. The software measured the frequency of both positive and negative words in the text files as per an average 500 words segment. Following Henry & Leone (2009), we construct a tone score for each document as a function of these frequencies: *Tone* = (Positive-Negative)/(Positive+Negative). By virtue of its construction, this index produces values falling within the (-1,+1) range. Henry & Leone (2009) document that their domain-specific wordlist outperforms more general alternatives in the accounting and finance contexts, as it mitigates the problem of polysemy (words with several meanings).

We also attempt to assess whether performance of Bitcoin depends on liquidity and collect data on the change in the total number of transactions in the blockchain. According to the network externality theory, the value of a network should be a positive function of its size and the number of transactions can be treated as a proxy for the number of users. Furthermore, to

capture the influence of changing money supply, we include a regressor measuring the increase in the total number of Bitcoins in circulation. Additionally, since Bitcoin can be viewed as a currency, we examine its relation to other foreign exchange rates. We focus on what are arguably the two most important currencies, namely the US dollar and the Euro. In order to be as comprehensive as possible, we analyzed the percentage changes in the broad trade-weighted indices. Since the trade between US and Eurozone is substantial and trade-weighting is applied, a strong negative correlation between our *USD* and *EUR* indices is present. We therefore do not bundle the *USD* and *EUR* explanatory variables into the same regression in order to avoid multicollinearity problems.

Lastly, we consider macroeconomic factors which have been previously shown to affect stock returns and bond risk premia (Asprem, 1989; Chen, Roll, & Ross, 1986; Ludvigson & Ng, 2009). We have selected aggregates that are available with monthly frequency and use OECD figures as proxies for the global economic climate. The study uses what are conventionally considered the three most important variables, namely growth in industrial production, unemployment and inflation. The exact definitions of the variables, together with their sources, are given in Table I.

[Table I about here]

[Figure II about here]

Figure II depicts the key indicators in our study and reveals some interesting regularities. Firstly, the exponential increases in the price of Bitcoin up to the end of 2013 were accompanied by growing transaction volume and interest in the technology. In early 2014 Google searches for Bitcoin began to drop, an omen of the subsequent price declines. Table II reports summary statics for the variables. Over the period under consideration, Bitcoin achieved much higher returns than other investment alternatives, such as stocks or bonds,

however it also suffered from much higher investment risk.[14] The popularity of this technology was growing rapidly, regardless of what measure we used, and this was corroborated by the increasing volume of transactions recorded. Overall, newspaper articles related to Bitcoin included more positive than negative words. The sample period witnessed appreciation of the US dollar and a slight depreciation of the Euro. This timeframe also includes an economic slowdown across much of the world, with slow growth, high unemployment and low inflation being recorded.

[Table II about here]

3.2. Empirical Results

Even though we have data on Bitcoin prices starting from July 2010, we are forced to dismiss the first few months in the series. During this initial period, there were no articles or Google searches based on the word 'Bitcoin', meaning that it was impossible to construct some of our variables. Also, at that time the market was nascent and illiquid. Consequently, our sample period commences in April 2011. The return regressions are presented in Table III. Panel A shows models including *Δln(Articles)* variable, while Panel B focuses on *Δln(Google)*.

One could argue that some of these regressions may suffer from an endogeneity and simultaneity problem. In our approach, we assume that popularity and media sentiment drive price changes – but it may be that the opposite is true. To counter this methodological difficulty, we employ an instrumental variable estimation in column (6) of the table. The popularity proxies and *Tone* are instrumented using exogenous variables, lagged endogenous variables, time trend, squared trend and *Δln(Cryptography)*. The last instrument measures the continuously compounded growth rate in the number of articles mentioning the word 'Cryptography' in the Nexis database.[15] It can be shown that such instrumentation is

[14] The standard deviation of monthly Bitcoin returns was 50.64%, while the standard deviation of the returns on the global stock market index MSCI World was only 4.11%.
[15] We assume that interest in Bitcoin will, at least to a certain extent, coincide with the interest in cryptography on which it relies.

equivalent to performing a 2SLS estimation of a simultaneous equation system with equations for Bitcoin returns, popularity proxy and *Tone.* Consequently, such specification should alleviate the endogeneity and simultaneity concerns. The R-squares from the instrumental regressions are reasonably high, leading us to believe that problems related to weak instruments will not occur.

[Table III about here]

The results in Table III indicate that popularity is a strong factor in determining Bitcoin returns, regardless of how it is defined and whether it is instrumented. A one per cent increase in the number of articles mentioning Bitcoin raises return by about 31 to 36 basis points. A similar jump in Google searches increases returns by about 53 to 62 basis points. *Tone* is statistically significant in most specifications and bears a positive coefficient, indicating that press articles undermining Bitcoin's reputation depress its price, while laudatory pieces lead to price inflation. The increase in transaction volume proves to be important, particularly in Panel A of the table. This result is consistent with the presence of network effect, in that the value of the network to the users increases in its size. Finally, the association between Bitcoin returns and fluctuations of major currencies, as well as global macroeconomic aggregates, is weak and statistically insignificant. We note that instrumentation does not alter our main conclusions obtained from our baseline regressions. The explanatory power of the models reported is quite high and can exceed a half, and the F-test for the joint significance of the regressors always rejects the null hypothesis of no influence. The Durbin-Watson statistics are close to 2, indicating that first-order residual autocorrelation is not a problem. We also performed Breusch-Godfrey tests[16] taking into account autocorrelations up to the tenth order and concluded that residual serial correlation is insignificant.

[16] These results are not reported in the tables, but can be obtained from the authors on request.

4. Bitcoin Usage in E-Commerce Payments

4.1. Data

In this section we present the results of an empirical investigation which is based on a survey of online vendors who declared that they accepted payment via the cryptocurrency Bitcoin in their e-business. This allowed us to explore what were the determinants of the Bitcoin-generated sales-fraction among legally-operating businesses that had adopted this payment method. There was a deliberate focus on legal business as it is the participation of such entities in the Bitcoin network that will popularize it and strengthen trust in the currency. Also, any analysis of traders that operate outside the law is likely to be highly unreliable, both because they are difficult to identify and, even if found, will be unlikely to voluntarily participate in such a survey (Van Hout & Bingham, 2013). To the best of our knowledge, this study is the first study that looks at the drivers of sales by vendors accepting Bitcoin. The only study that is tangentially related to ours was by Nicolas Christin (Christin, 2013), who examined the operation of Silk Road – an illegal online marketplace. Since Silk Road only accepted payment in Bitcoin, the focus of the study had to be different.

The analysis is based on a survey carried out by the authors in April 2013. The subjects were vendors who declared that they accepted Internet payments in Bitcoins for their traded goods, services provision or non-profit activities. The first phase of the study was the creation of a database of online vendors based on lists maintained in specialist forums.[17] From the initial 671 entities, verification of email addresses allowed us to remove outdated or inactive entries, limiting the test group to 603. Our assumption is that, at the time of its creation, the database included the majority of the population of legal enterprises that accepted Bitcoin and used English language. An invitation to complete an anonymous online questionnaire was sent to each entity. Non-responding potential participants were also sent a reminder of the invitation

[17] Services on the basis of which our database was built are: https://en.bitcoin.it/wiki/Trade, https://en.bitcoin.it/wiki/Donation-accepting_organizations_and_projects, https://bitcointalk.org/.

and a total of 108 usable responses from 35 countries were gathered. Table IV shows how the structure of the sample compares to the activity of the Bitcoin network (measured by nodes), categorized by country. The table suggests that our sample is broadly geographically representative.

[Table IV about here]

Table V contains the definitions of the variables that can be divided into two main groups. The first relates to the attributes of the company under investigation while the second covers characteristics of the country in which the company is headquartered. The first group of variables was created from the questionnaire items and can be divided into three areas. The first four variables – *Bitcoin_Sales*, *Size*, *Start_Up*, and *Physical_Location* – are related to characteristics of the entities that accept Bitcoin. *Bitcoin_Knowledge* – is the trader's evaluation of their customers' knowledge about Bitcoin. The next five – *Payment_Card*, *PayPal*, *Pay_by_Link*, *Cash*, and *Bank_Transfer* – are payment methods other than Bitcoin accepted by the entity. The country variables were formed from publicly available statistical data and describe the economic and business environment of the company. *lnGDP*, the natural logarithm of GDP per capita in US dollars is intended to indicate the level of economic development. *Shadow_Economy* captures the size of the shadow economy divided by the official GDP, times 100 and has been included since Bitcoin is widely perceived as a tool that facilitates illegal or undeclared activities. Each of these variables uses a measurement scale which is suitable for the item under consideration – further details are in Table V.

[Table V about here]

Summary statistics are presented in Table VI. They reveal interesting characteristics about the entities accepting Bitcoin. On average, the value of transactions carried out using Bitcoin was 31% of sales recorded in the sample. Just over half of the surveyed companies registered only

a small portion of sales (up to 10%) via Bitcoin. However, slightly more than a quarter of companies claimed that over 81% of their sales were conducted through this cryptocurrency. This group presumably includes organizations that have built their business model around the use of Bitcoin. 49% of observations in the sample were start-ups, here taken to be companies that have been established for less than three years. Only 23% of respondents were also 'bricks-and-mortar' traders, meaning that most of the sample specialized in Internet business. The sample was dominated by micro-enterprises, with 44% being sole traders, and 51% employing between 2 and 9 people – a distribution that is typical of most developed economies.[18]

[Table VI about here]

We consider other payment methods in e-commerce as they could be substitutes or complements to Bitcoin. Among our respondents, the most commonly available alternative was PayPal (64%), unsurprising given its popularity in e-commerce, particularly in the United States (Zhang & Li, 2006). The next most popular were bank transfers (44%), payment cards (39%) and cash-on-delivery (19%). Pay-By-Link was significantly less common (3%), as the coverage is only domestic and it has gained acceptance in only a few countries, such as Holland (Nijland & de Lange, 2013) and Poland (Kunkowski & Polasik, 2012). 18% of companies only accept Bitcoin and no other payment method. Customer knowledge, in the eyes of respondents, was mixed but with a median of 'rather good'.

The mean of GDP per capita for countries of origin of respondents was $42,900, with a median of $49,000. The geographical distribution is quite diverse, encompassing both developed and developing economies. With this in mind, we have tried to mitigate the problems arising from the presence of outliers by applying a log transformation of the variable. The average size of the shadow economy was around 15% of GDP. However, the

[18] For example, in the United States businesses employing up to 9 employees represent about 95% of all companies: (US Census Bureau, 2008, http://www.census.gov/econ/smallbus.html).

largest group of respondents came from the United States, for which the proportion was much lower at 8.6% of GDP. At the other end of the spectrum, this indicator for Thailand registered 50.6%.

4.2. Empirical Results

The empirical results are in Table VI which shows both the OLS and Tobit estimation approaches. The Tobit model is presented because the dependent variable representing the proportion of sales is both left- and right-censored. We included *Size* as an explanatory variable in only one specification of our model. Since the range of payment methods adopted may well be a function of size, we avoided bundling these variables together. In one of the regressions, the number of employees showed weak statistical significance. This may be due to some micro-firms are specialized in catering to the needs of specific customer segments, such as Bitcoin users. However, larger companies usually have a wider base of customers with different payment preferences. Consequently, the relative share of Bitcoin in their takings may naturally be lower. The factor that proved to have a strong, positive and significant impact on the fraction of sales with Bitcoin relates to the company being a start-up. This is likely to be because these start-ups are predominantly headquartered in developed countries and many such companies are innovative (Anokhin & Wincent, 2011). One could also suggest that start-ups have adopted Bitcoin as a form of advertising and a way to gain entrance into a new niche market. Further, it is possible that some of these companies were connected with the development of Bitcoin system and are specialized entities within its ecosystem. The physical location turned out to be an insignificant factor in explaining the underlying phenomenon.

The level of customers' knowledge of Bitcoin has a significant positive impact on the share of this cryptocurrency in vendors' sales. Since Bitcoin is an innovation that most people are unaware of, insufficient knowledge is one of the main barriers to its development. According

to Rogers (1983, p. 20) after an individual has been exposed to an innovation, the first step towards adoption is to actively seek information and knowledge about it.

[Table VII about here]

The study demonstrated that the existence of alternative payment methods in parallel to Bitcoin has an influence on consumer choice (Jonker, 2007; Zhang & Li, 2006). Three payment methods proved to have a negative impact on the regressant, the most notable of which was that of PayPal, which may be due to its popularity as a payment method among consumers (Worldpay, 2014). A lot of customers, facing a choice between Bitcoin and PayPal, will choose the familiar and established technology, although this distinction may erode in the future as PayPal integrates Bitcoin into its system (Mishkin, 2014). Similar reasons may explain the negative impact of payment cards. Payment through PayPal and credit cards is less risky for the customer as there is protection in the form of a charge-back procedures (Zhang & Li, 2006). Cash-on-delivery is often used by individuals, who may not even have a bank account or a payment card, and by those distrustful or ignorant of new technologies (F. Allen, Demirguc-Kunt, Klapper, & Peria, 2012). It is therefore expected that customers in this segment will be less interested in using Bitcoin.

Bank transfer was not a significant influence, suggesting that it is neither a substitute nor a complement to Bitcoin. The most intriguing finding was the positive association between Pay-By-Link and Bitcoin, which can be seen in the OLS estimation. Pay-By-Link is a mechanism based on bank transfers which allows the rapid execution of transactions, since it informs the seller immediately without waiting for the confirmation of fund transfer through the interbank payment system. Thus, Pay-By-Link is used primarily by those for whom fast completion of transactions is important, such as in the sale of IT services or on-line entertainment. Because Bitcoin also delivers fast online payments, it can be used for the same type of transactions as Pay-By-Link, and both payments are irreversible (unlike PayPal and

credit card transactions, where charge-back is possible). Also, both Pay-By-Link and Bitcoin have found a niche with digital enthusiasts seeking the latest 'new thing'. There are also cost factors – vendors pay high fees on PayPal and card payments[19] – so Pay-By-Link can be cheaper. For example, in the German system Sofort Banking, the fees are only 0.9% plus 0.25 Euro. Since accepting Bitcoin is also cheap, this suggests that cost-conscious traders may be inclined to simultaneously accept Pay-By-Link and Bitcoin. However, the use of Pay-By-Link is limited to domestic transactions, which means that this method is not a true substitute for Bitcoin when it comes to international trade. We would add that the results for Pay-By-Link should be interpreted with caution as only a small proportion of our respondents used this system and the variable fails to reach statistical significance in the more econometrically appropriate Tobit model.

Our empirical results show that the share of payments Bitcoin was significantly higher in countries with lower GDP per capita. The main reason is that developing countries have a general tendency to very high levels of cash utilization (Denecker, Sarvady, & Yip, 2009; Humphrey, Pulley, & Vesala, 1996; Weber & Kauffman, 2011). Historically, developing economies had large numbers of unbanked who are both unfamiliar with and unable to access traditional bank transfer systems (Schuh & Stavins, 2013). Demirgüç-Kunt & Klapper (2013) have observed a strong relationship between the popularity of bank accounts and payment cards, and per capita income. Since cards and bank transfers are so limited in their use, their applicability for e-commerce is similarly restricted, creating a potential niche for Bitcoin. Users can purchase Bitcoins without using the traditional banking infrastructure. They can purchase the coins from other individuals, dedicated Bitcoin ATMs, payment bureaus (such as at shops or petrol stations) or from non-bank payment providers. A good example of the

[19] According to Goldman Sachs (2014) the cost of accepting Bitcoin through a payment service provider is 1%, including the cost of protection against exchange rate volatility. Direct acceptance at the Bitcoin address of the store does not involve any fees. By comparison, the fees associated with card acceptance in e-commerce average about 2.9% of transaction value. PayPal fees in the UK, depending on the type of transaction, range between 1.4%+20 pence to 4.0% for international transactions (PayPal, 2014).

latter would be the M-Pesa system for transferring money via mobile phones. Additionally, many developing countries impose restrictions on foreign exchange or erect other barriers to international payments, which Bitcoin can overcome. Cross-border transactions may be further hindered by a lack of payment infrastructure, while foreign consumers may be cautious about forwarding their personal and credit card information. In such trades Bitcoin can be a very attractive option. Lastly, developing countries may pursue a less credible monetary policy, which will encourage citizens to look for alternatives to domestic currency.

Another factor is the larger shadow economies in many developing countries. Since GDP per capita and the relative size of the shadow economy are strongly negatively correlated, we do not include both variables in the same regression to avoid multicollinearity problems. Our results point to a positive association between the shadow economy and Bitcoin payments in e-commerce. Although our sample was drawn from legitimate business entities, a large shadow economy is associated with a broad range of dubious activities, such as tax evasion and money laundering (Schneider, 2012). As a result, people who are involved in such transgressions may come into possession of Bitcoins, which they then use to purchase goods and services.

Overall, our models fit the data well and can explain almost 65% of the variance of the dependent variable. It also can explain some of the general trends that will either inhibit or foster adoption of this technology. As a side-note, we would like to mention that we also collected information about the type of industry that our respondents were engaged in. This information, however, proved to have no statistical power to explain our dependent variable.[20]

[20] More detailed calculations can be obtained from the authors on request.

5. Practical and Theoretical Considerations

5.1. Managerial Implications

Our study provides practical guidance that may be valuable to e-commerce managers who are considering accepting Bitcoin payments.

a) Bitcoin can be treated as part of a marketing strategy. Due to press interest and the substantial level of Internet activity associated with Bitcoin, it may be possible to gain free media publicity. However, despite the overall positive tone of media coverage, there are articles that dwell on the negative connotations and any company should have a set of communication tools that can be used to allay and assuage consumer concerns.

b) Selecting an appropriate set of accepted payment methods is important in e-commerce. Factors that should be considered are: the cost of adoption and use, the risk of the transactions being reversed (chargeback), and the convenience to the customer. If vendors want low transaction costs and no chargeback, they should avoid credit cards, PayPal and cash on delivery (where the client may refuse the shipment). Pay-By-Link and Bitcoin are both cheap with irreversible transactions, but of the two, only Bitcoin payments can traverse national borders. Conversely, if a company is willing to accept higher costs and risks to improve to customer convenience (Zhang & Li, 2006), they should accept payment cards and PayPal, which customers in developed countries prefer. In such cases, Bitcoin provides only limited benefits but, if the vendor is looking to sell in developing countries with larger shadow economies, then accepting the cryptocurrency is a sensible option.

c) Managers should be aware that Bitcoin is not like other payment systems since it has its own unit of value, which is tradable, and historically has had very high volatility in its value. Vendors who are considering adopting it for e-commerce will need to choose between the following:

i. Keeping their own Bitcoin wallet. They can then accept payments directly, which will mean that they face no additional charge. Should they decide to keep them, they will become investors and bear the associated risk. Our study explicates what the important risk factors are. Acceptance without using an intermediary may also be associated with some legal and/or tax risks specific to a given country;

ii. Using the services of payment providers – the providers process the transactions and, in so doing, assume the risk associated with fluctuating values. The monies received by the vendor will be in their domestic currency, making accounting easier. Payment provides take a commission and invoice in the same way as payment card processers, although the fees are lower and there is no potential chargeback.

d) Our research has demonstrated that customers' knowledge about Bitcoin significantly influences its use. This highlights the importance of educational campaigns and it may be that this effect will apply even at a very local level.

5.2. Theoretical Considerations

As a result of our discussion of the problems in categorizing Bitcoin, we have suggested a new scheme of classifying money and money-like instruments. This was inspired by the report of the (European Central Bank, 2012; HM Revenue & Customs, 2014; IRS, 2014; Segendorf, 2014; Velde, 2013) and stresses the dual nature of Bitcoin currency and the fact that it integrates the P2P payment system, the cybercurrency and the mathematical mechanisms responsible for its functioning.

We have contemplated as to whether this cryptocurrency can exert a significant effect on the wider economy. It is doubtful that strong effects will materialize for a number of reasons. Firstly, governments are unlikely to abandon their national currencies, as this will lead to loss of seigniorage and cripple the operations of monetary policy. Secondly, the Bitcoin

ecosystem is still inchoate and therefore is unlikely to have any meaningful macroeconomic implications in the near future. Lastly, Bitcoin currently operates as a settlement rather than functional currency and should not introduce any additional nominal rigidities into the economy.

Since many macroeconomic theories have a limited usefulness in the context of our study, we have based our theoretical considerations on the theory of networks externalities and Rogers' concept of innovation diffusion. The combination of the two proved valuable in assessing the early success of Bitcoin, where we were able to observe how the fact that the cybercurrency was both an asset and a payment system enabled incentives to be granted to miners and speculators, encouraging early adoption and subsequent network development. This suggests that other innovators bringing radical alternatives to market should pay serious attention to the incentives needed to bring on board the necessary early-adopters.

Our research so far has illuminated some of the theoretical approaches to Bitcoin, but it has also opened up a number of areas to explore. We would suggest that the most valuable might be:

i. What is the potential for Bitcoin in cross-border transactions and its implications for international e-commerce (Gomez-Herrera, Martens, & Turlea, 2014)? The low transaction costs suggest that there are considerable possibilities in increasing transaction numbers, especially between countries that do not share a coherent and reliable payment infrastructure;
ii. How might Bitcoin affect financial inclusion (De Koker & Jentzsch, 2013; Diniz, Birochi, & Pozzebon, 2012; Kauffman & Riggins, 2012)? This is a serious global problem with many countries having a large swathe of their population unbanked. Bitcoin, potentially in allegiance with other non-banking transaction systems such as M-Pesa, may proffer solutions;

iii. What insights might be garnered from a more fine-grained analysis of different users? This could encompass, for example, new and old adopters, personal wealth and cultural differences.

6. Conclusions

This paper has endeavored to provide empirical evidence on the recent innovation Bitcoin, which can be considered as a new digital currency that is inextricably linked to a decentralized electronic payment system. The initial intention of its founder was that it could be an equivalent of cash that could be used in e-commerce. However, in addition to its payment function, it also acts as an investment asset. This dual nature has proved crucial to its success so far and our paper has investigated both of these functions, ensuring that we paid sufficient attention to their interconnection. While there has been much consideration of the technological and cryptographic angles, data on the economic aspects, especially its use as a payment mechanism in e-commerce, are scarce. Here, we have attempted to fill this void through examining Bitcoin's price formation and the drivers of its success with online merchants who accept it for payments. In doing so, we have identified both factors that are important for the promulgation of this technology and the value that market participants attach to it.

There is still no obvious theory delineating how Bitcoin should be priced since, by its very nature, it yields no dividends, cash flows or earnings. In the absence of obvious standard valuation approaches, we decided to use an exploratory empirical study instead. More specifically, the method employed here rests upon looking at both the supply-side and the factors that drive demand. Our results indicate that popularity of this cryptocurrency is one of the main factors driving the price. We observed that returns tend to be elevated whenever newspaper articles mention Bitcoin more frequently and whenever the number of people searching for it on Google increases. Moreover, the tone of newspaper articles also influences the value of Bitcoin - unfavorable mentions may have negative consequences, while

exhortatory pieces increase the price. There is also some indication that the demand arising from the transactional needs of users drives up prices which seems to confirm the link between the payment and investment functions of Bitcoin. At the same time, this technology is not well-integrated with traditional currency markets and the macroeconomy presumably because it is currently a relative newcomer.

We have also surveyed merchants who accept Bitcoin for online transactions and modeled the fraction of their sales attributed to this technology. One disquieting result of our research is that there is a positive relationship between Bitcoin payment activity and the size of the shadow economy. Furthermore, Bitcoin has a larger share of on-line vendors sales in countries with low GDP per capita, suggesting that it may both play a role in circumventing government restriction and provide a payment service to the unbanked. The results also demonstrate that Bitcoin interacts with other payment methods used in e-commerce. We find that PayPal, payment cards and cash-on-delivery are substitutes for Bitcoin, while Pay-By-Link appears to work as a complement. The results seem to indicate that share of sale with Bitcoin was higher for start-ups and smaller entities. A further key factor was customers' knowledge about this innovation – the more they knew, the more likely they were to engage with it. To some extent these findings reflect the incentives of vendors and customers to adopt this novel technology at an early stage in its genesis.

Indeed, it may be argued that Bitcoin has not yet reached critical mass (Grover, 2014). At the moment, it only appears viable as an alternative currency for online purchases since users are so widely dispersed. However, since Bitcoin was launched as a global solution, it was able to overcome many of the obstacles that obstructed preceding forms of electronic money, such as local standards, leading to a fissiparous market. (Kauffman & Walden, 2001; Stango, 2004). Even though Yermack (2013) concluded that Bitcoin is not fulfilling the functions of money, our research indicates that it can operate as a medium of exchange alongside other payment technologies. The network of entities that accept Bitcoin is expanding rapidly and there is a

burgeoning technical and business infrastructure that can ameliorate the problem of exchange rate volatility. It is worth noting that this helps confirm the re-intermediation process, which is observed in many market segments of e-commerce (Kauffman & Walden, 2001).

There are still many obstacles in the path ahead for Bitcoin, however. Perhaps the biggest is the legal status of the cryptocurrency, with some countries maintaining an outright ban, while others heavily restricting its use. Alongside this, there is considerable confusion as legislators attempt to determine its status for tax purposes – even within the EU countries there is no common approach. Our work highlights the importance of the shadow economy in driving Bitcoin use and should prompt authorities to consider how to restrain illegal activities facilitated by the cyptocurrency.

Time will tell as to whether the benefits will outweigh the shortcomings, and whether adoption will become widespread, or remain limited to narrow niches and the shadow economy. However, its emergence has created considerable interest among business communities and prompted a substantial new wave of cryptocurrencies inspired by Bitcoin. As a result, it can be argued that the arrival of Bitcoin has ensured that a number of concepts, such as decentralized electronic transactions, distributed public ledgers, management of payment systems and the supply of the currency through cryptographic algorithms have been included in the science and practice of information systems and finance.

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Figure I

Classification of Money

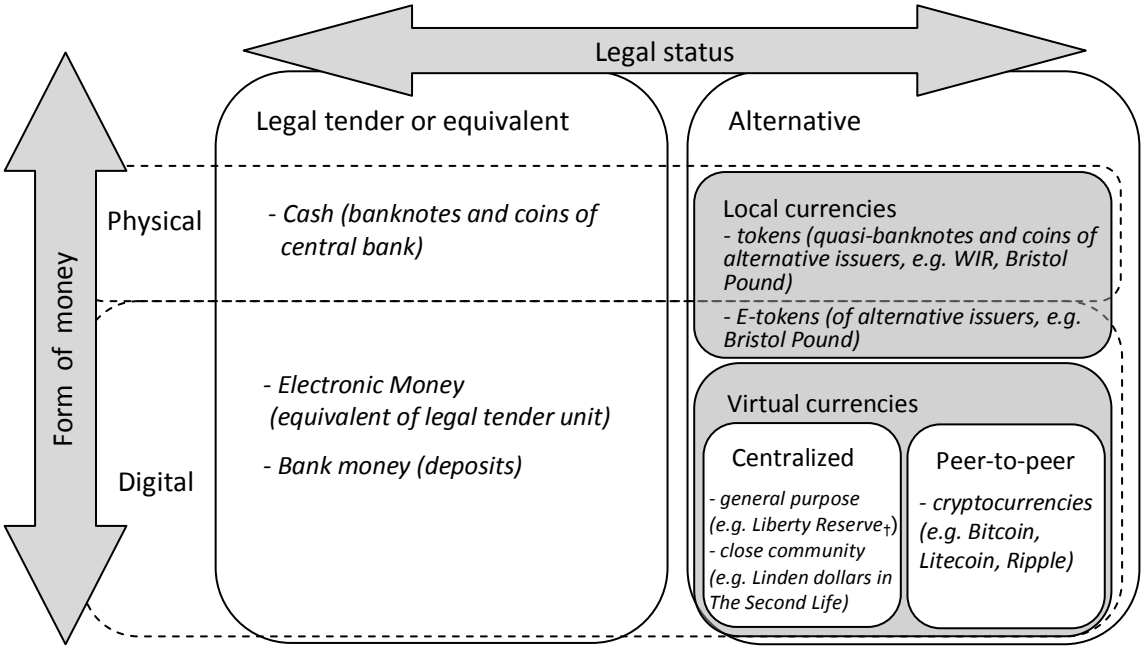
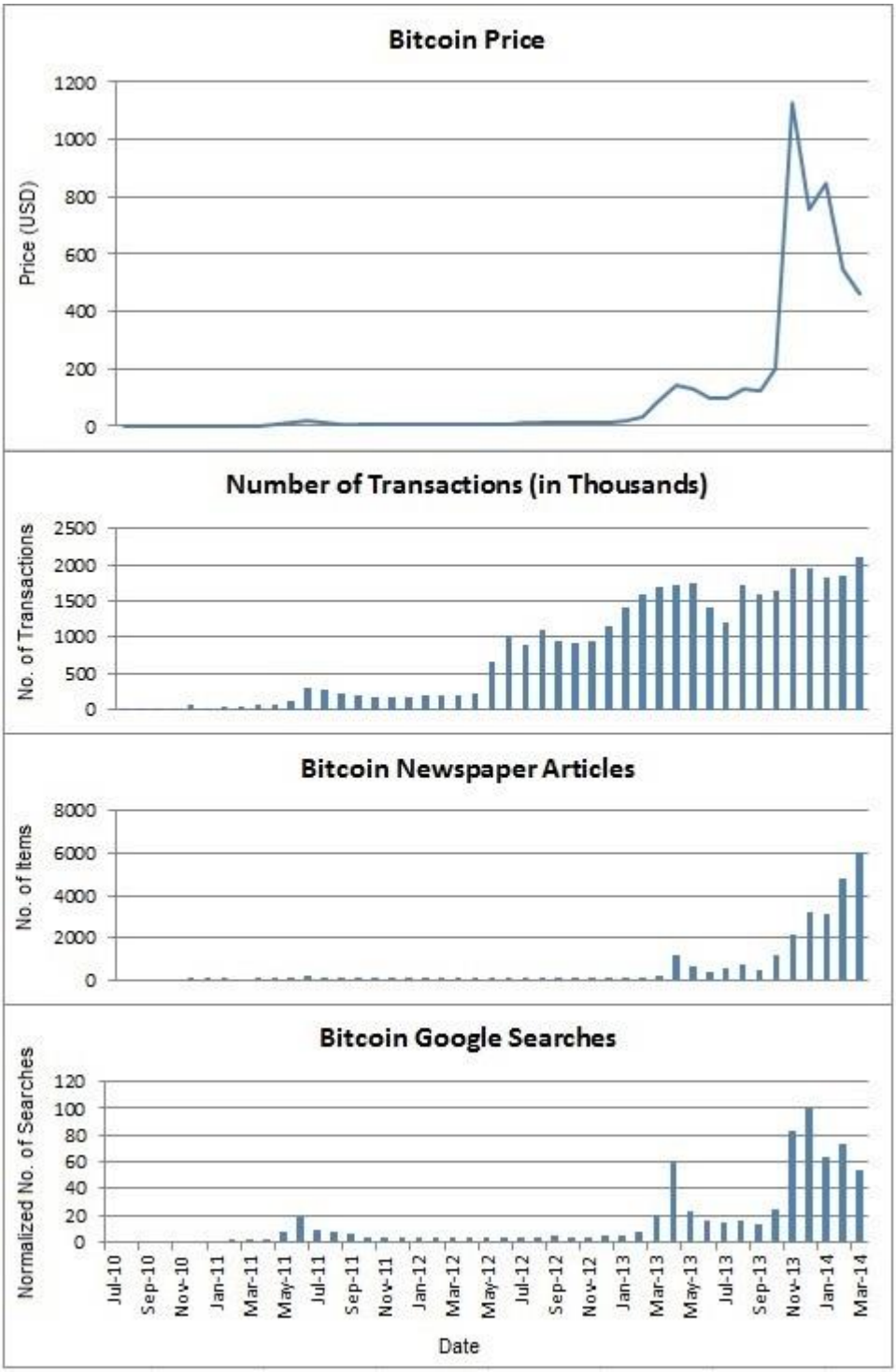


Figure II

Plots of Bitcoin-Related Variables



Note. The diagram plots the Bitcoin price sourced from CoinDesk, total number of Bitcoin transactions from DataMarket, number of English language articles in the Nexis database mentioning the keyword 'Bitcoin' and scaled number of 'Bitcoin' searches relative to overall number of Google searches. Number of transactions, articles and Google searches are recorded as monthly totals.

Table I

Definitions of the Variables Used in the Bitcoin Return Regressions

Variable	Definition	Source
Return_Bitcoin	Continuously compounded monthly return on Bitcoin denominated in US dollars.	CoinDesk
Δln(Articles)	Percentage increase in the number of English language news articles mentioning the word "Bitcoin" in the Nexis database relative to previous month. The count includes newswires and non-business news.	Nexis
Δln(Google)	Percentage increase in the number of searches for the keyword 'Bitcoin' relative to the total number of Google searches. The search data in levels has been scaled, so the observation recording the highest value is equivalent to 100 on a 0-100 measurement scale.	Google Trends
Tone	For any given month, all English language news items mentioning the word "Bitcoin" in the Nexis database were collected into one text file. The frequency of positive and negative words in these text files was measured with reference to Henry's (2008) thesauruses. The *Tone* variable is a function of these frequencies, namely (positive-negative)/(positive+negative).	Nexis
ΔTransactions	Increase in the total number of Bitcoin transactions relative to previous month (in millions).	DataMarket
ΔSupply	Increase in the total number of Bitcoins in circulation relative to previous month (in millions).	DataMarket
USD	Continuously compounded percentage growth rate in the US dollar broad index (FED), which measures a weighted average of foreign exchange values of the dollar against currencies of the US major trading partners.	Datastream
EUR	Continuously compounded percentage growth rate in the trade weighted Euro index (BoE).	Datastream
Ind_Prod_Growth	OECD industrial production growth (previous period, seasonally adjusted).	OECD, Key Short-Term Economic Indicators
Unemployment	OECD harmonized unemployment rate (all persons, seasonally adjusted).	OECD, Key Short-Term Economic Indicators
Inflation	OECD inflation in consumer prices (previous period, all items).	OECD, Key Short-Term Economic Indicators

Table II

Summary Statistics for the Variables Appearing in Bitcoin Return Models

Variable	Mean	Standard Deviation	25th Percentile	Median	75th Percentile
Return_Bitcoin	17.7123%	50.6418%	-10.6354%	7.7998%	40.5553%
Δln(Articles)	24.1667%	79.3778%	-32.2464%	27.0632%	70.3082%
Δln(Google)	11.0805%	56.7867%	-23.0186%	0.0000%	23.9278%
Tone	0.3624	0.3460	0.1657	0.3866	0.5972
ΔTransactions	0.0561	0.1754	-0.0272	0.0093	0.1771
ΔSupply	0.1885	0.0596	0.1326	0.2069	0.2313
USD	0.1757%	1.6978%	-0.7101%	-0.0758%	0.9082%
EUR	-0.0175%	1.7614%	-1.4273%	0.3901%	1.2862%
Ind_Prod_Growth	0.1618%	0.4526%	-0.1000%	0.1500%	0.4750%
Unemployment	7.8857%	0.1240%	7.9000%	7.9000%	7.9500%
Inflation	0.1583%	0.2034%	0.0000%	0.1000%	0.3000%

Note. Variable definitions are given in Table I. All variables run from April 2011 to March 2014, with the exception of *Unemployment* which ends in February 2014 and *Ind_Prod_Growth* which ends in January 2014.

Table III

Determinants of Bitcoin Returns

Panel A. Regressions Including the *Δln(Articles)* Variable						
	(1)	(2)	(3)	(4)	(5)	(6)
Intercept	-0.0178 *(0.0864)*	-0.1486 *(0.2424)*	-0.0488 *(0.0867)*	-0.5503 *(0.0846)*	0.2610 *(5.2137)*	-0.1382 *(0.1003)*
Δln(Articles)	0.3592*** *(0.0835)*	0.3422*** *(0.0847)*	0.3379*** *(0.0822)*	0.3482*** *(0.0861)*	0.3123*** *(0.0838)*	
Δln(Articles)_Instrumented						0.3852*** *(0.0844)*
Tone	0.2982* *(0.1506)*	0.2797** *(0.1368)*	0.2753* *(0.1464)*	0.2821* *(0.1475)*	0.1650 *(0.1701)*	
Tone_Instrumented						0.4624* *(0.2504)*
ΔTransactions		0.8282** *(0.3813)*	0.8592** *(0.3816)*	0.8169** *(0.3897)*	1.0157** *(0.4399)*	0.9163* *(0.4493)*
ΔSupply		0.5051 *(1.1956)*				
USD			-2.1182 *(4.0991)*			
EUR				0.1721 *(3.5473)*		
Ind_Prod_Growth					25.0425 *(18.4995)*	
Unemployment					-4.0796 *(65.6296)*	
Inflation					26.2630 *(35.0820)*	
R-squared	0.3168	0.4000	0.4012	0.3966	0.4750	0.4079
Adj. R-squared	0.2754	0.3226	0.3239	0.3187	0.3583	0.3467
F-statistic	7.6501	5.1662	5.1915	5.0936	4.0711	6.6610
Prob(F-statistic)	0.0019	0.0026	0.0026	0.0028	0.0049	0.0015
Durbin-Watson	1.7828	1.7340	1.7546	1.7352	1.7953	1.9898

Panel B. Regressions Including the *Δln(Google)* Variable

	(1)	(2)	(3)	(4)	(5)	(6)
Intercept	-0.0169	-0.0421	-0.0216	-0.0418	-1.1792	-0.1542
	(0.0997)	*(0.2177)*	*(0.1037)*	*(0.0920)*	*(4.3793)*	*(0.0983)*
Δln(Google)	0.6223***	0.5879***	0.5777***	0.5956***	0.5295***	
	(0.1259)	*(0.1311)*	*(0.1224)*	*(0.1145)*	*(0.1196)*	
Δln(Google)_Instrumented						0.5878***
						(0.1186)
Tone	0.3450**	0.3286**	0.3257**	0.3726***	0.2615	
	(0.1425)	*(0.1420)*	*(0.1478)*	*(0.1336)*	*(0.1740)*	
Tone_Instrumented						0.5834**
						(0.2548)
ΔTransactions		0.3410	0.4228*	0.3262	0.4865	0.4009
		(0.2291)	*(0.2258)*	*(0.2354)*	*(0.3377)*	*(0.3803)*
ΔSupply		0.0840				
		(1.2548)				
USD			-3.9777			
			(4.7826)			
EUR				2.4276		
				(3.3446)		
Ind_Prod_Growth					14.2249	
					(13.5913)	
Unemployment					14.3046	
					(55.3027)	
Inflation					30.2439	
					(46.7752)	
R-squared	0.4791	0.4916	0.5085	0.4978	0.5157	0.4502
Adj. R-squared	0.4475	0.4260	0.4450	0.4330	0.4080	0.3933
F-statistic	15.1760	7.4932	8.0166	7.6808	4.7908	7.9146
Prob(F-statistic)	0.0000	0.0002	0.0001	0.0002	0.0019	0.0005
Durbin-Watson	1.9623	1.8893	1.9785	1.9191	1.8542	2.0572

Note. Panel A of this table presents regressions linking Bitcoin returns with a set of explanatory variables including *Δln(Articles)*, while Panel B focuses on regressions incorporating *Δln(Google)*. Variable definitions are given in Table I. All regressions are estimated using monthly data from April 2011 to March 2014. Regressions including *Ind_Prod_Growth* variable end in Jan 2014. Models labeled (6) include two instrumented variables as regressors. Exogenous variables, lagged endogenous variables, time trend, squared trend and the continuously compounded growth rate in the number of articles mentioning the word 'Cryptography' in the Nexis database have been used as instruments. White (1980) heteroskedasticity-consistent standard errors are shown in parentheses. *, ** and *** represent statistical significance at 10%, 5% and 1%, respectively.

Table IV

Activity of Bitcoin Network Activity by Country Compared to the Sample Structure

Country (TOP-5 by Nodes)	Percentage of Bitcoin Nodes (September 2014)	Percentage of Respondents (April 2013)
USA	39%	34%
Germany	8%	11%
United Kingdom	7%	7%
France	6%	1%
Canada	5%	3%

Source: Data on 'Percentage of respondents' originates from our survey conducted in April 2013, while the data 'Percentage of Bitcoin Nodes' comes from The Bitcoin Foundation https://getaddr.bitnodes.io/ (last accessed September 2013). Bitcoin nodes are points on the network that hold the core client together with a copy of the complete blockchain. Most nodes are held by miners who need access to the blockchain in order to create new blocks and who are obliged to store the full history of transactions.

Table V

Definitions of Variables Constructed from the Survey

Variable	Definition
Company-Specific Variables	
Bitcoin_Sales	This variable records responses to the following questionnaire item: 'What is the fraction of sales value conducted via Bitcoin?' This question was multiple choice and specified 7 intervals ranging from 0% to 81-100%. For the purposes of our calculations we have taken the midpoint of the interval selected and expressed the data in percentage points.
Size	Number of employees working for the company. Records represent midpoints of 5 different intervals.
Start-Up	Dummy variable indicating companies established less than 3 years ago.
Bitcoin_Kowledge	Variable recording responses to the following question: 'How would you rate the knowledge of your customers regarding Bitcoin?' on a 4-point scale ranging from 1) Very poor to 4) Very good.
Physical_Location	Dummy variable indicating whether the company is conducting sales in a physical location (e.g. shop, office, service outlet).
Payment_Card	Dummy variable for the acceptance of payment cards (debit, credit) by the company.
PayPal	Dummy variable for the acceptance of PayPal payments.
Pay_by_Link	Dummy variable for the acceptance of payments via Pay-By-Link.
Cash	Dummy variable for companies accepting the 'cash-on-delivery' payment method.
Bank_Transfer	Dummy variable for companies accepting bank transfers from their customers.
Country-Specific Variables	
lnGDP	Natural logarithm of GDP per capita expressed in current US dollars for the country in which the company is headquartered. The data was taken from World Economic Outlook Database compiled by IMF.
Shadow_Economy	Size of the shadow economy (in % of official GDP) estimated for the country in which the company is headquartered. This data has been sourced from the Appendix of Schneider (2012).

Table VI

Summary Statistics for the Survey Variables

Variable	Number of Observations	Mean	Standard Deviation	25th Percentile	Median	75th Percentile
Company-Specific Variables						
Bitcoin_Sales	101	30.6931	37.1351	5.0000	5.0000	90.0000
Size	100	8.2000	34.9973	1.0000	6.0000	6.0000
Start-Up	108	0.4907	0.5022	0.0000	0.0000	1.0000
Physical_Location	108	0.2315	0.4237	0.0000	0.0000	0.0000
Bitcoin_Kowledge	101	2.3366	1.0225	1.0000	3.0000	3.0000
Payment_Card	108	0.3889	0.4898	0.0000	0.0000	1.0000
PayPal	108	0.6389	0.4826	0.0000	1.0000	1.0000
Pay_by_Link	108	0.0278	0.1651	0.0000	0.0000	0.0000
Cash	108	0.1944	0.3976	0.0000	0.0000	0.0000
Bank_Transfer	108	0.4352	0.4981	0.0000	0.0000	1.0000
Country-Specific Variables						
lnGDP	101	10.5220	0.6584	10.5808	10.8004	10.8781
Shadow_Economy	99	14.9667	8.7401	8.6000	12.5000	16.0000

Note. Variable definitions are shown in Table IV.

Table VII

Modeling the Fraction of Sales Conducted via Bitcoin

Panel A. Results of OLS Estimation				
	(1)	(2)	(3)	(4)
Intercept	-15.8611**	13.7449	154.1301***	1.8429
	(7.5235)	*(10.7200)*	*(28.9745)*	*(11.4494)*
Size	-0.0461*			
	(0.0258)			
Start-Up	30.9588***	22.4614***	20.1376***	19.5028***
	(6.5274)	*(6.3029)*	*(6.0898)*	*(6.3316)*
Physical_Location	-5.7005			
	(6.6917)			
Bitcoin_Kowledge	14.1837***	12.0883***	13.8861***	12.7528***
	(3.4209)	*(2.6929)*	*(2.4916)*	*(2.4782)*
Payment_Card		-14.1959**	-14.4356**	-15.1790**
		(5.9802)	*(5.9930)*	*(6.0155)*
PayPal		-25.4845***	-23.9468***	-25.3335***
		(5.9797)	*(5.7469)*	*(5.6758)*
Pay_by_Link		23.3874**	23.3628**	23.4049*
		(9.2047)	*(11.1243)*	*(12.2232)*
Cash		-17.4715**	-15.9047**	-15.0971**
		(6.9065)	*(6.3367)*	*(6.9229)*
Bank_Transfer		3.9960	-1.1811	-2.1165
		(6.6462)	*(6.0943)*	*(6.6552)*
lnGDP			-13.6480***	
			(2.8853)	
Shadow_Economy				0.8220***
				(0.2272)
R-squared	0.4257	0.5866	0.6499	0.6443
Adj. R-squared	0.3992	0.5540	0.6165	0.6096
F-statistic	16.1190	18.0375	19.4895	18.5637
Prob (F-statistic)	0.0000	0.0000	0.0000	0.0000

Panel B. Results of Tobit Estimation

	(1)	(2)	(3)	(4)
Intercept	-47.1749***	1.0252	250.9073***	-16.8294
	(15.2608)	*(14.5427)*	*(67.6949)*	*(15.7426)*
Size	-0.0383			
	(0.1296)			
Start-Up	49.5839***	34.8684***	30.6624***	29.6082***
	(10.1324)	*(8.3885)*	*(8.0697)*	*(8.0095)*
Physical_Location	-4.1224			
	(12.2988)			
Bitcoin_Kowledge	24.1768***	19.9666***	23.3836***	20.9831***
	(5.3218)	*(4.1189)*	*(4.0981)*	*(3.9384)*
Payment_Card		-16.5761**	-16.6151**	-17.1115**
		(8.0730)	*(7.7814)*	*(7.7229)*
PayPal		-40.2662***	-39.2853***	-39.9375***
		(8.4360)	*(8.0740)*	*(7.9508)*
Pay_by_Link		35.3557	30.1452	28.6266
		(23.2584)	*(20.9575)*	*(20.8604)*
Cash		-24.1125**	-22.8749**	-21.9174**
		(10.8759)	*(10.6846)*	*(10.5038)*
Bank_Transfer		7.0298	-3.8868	-3.7186
		(8.9304)	*(8.9462)*	*(8.7575)*
lnGDP			-24.0992***	
			(6.3971)	
Shadow_Economy				1.3259***
				(0.4807)
Log likelihood	-309.1620	-314.5538	-287.0383	-286.9478
Left censored obs [%]	14.1304	14.4330	15.0538	15.3846
Right censored obs [%]	27.1739	25.7732	26.8817	25.2747

Note. This table presents regressions linking the percentage of sales conducted via Bitcoin to a range of explanatory variables. Panel A reports OLS results, while Panel B provides estimates of a Tobit model left censored at 0 and right censored at 90. Variable definitions are given in Table IV. Standard errors of parameter estimates are given in parentheses and those reported in Panel A were estimated using White (1980) heteroskedasticity-consistent method. *, ** and *** represent statistical significance at 10%, 5% and 1%, respectively.

Appendix: Bitcoin acceptance and usage questionnaire

The study is conducted by the [ ] University in [ ]. The aim of the research is to understand the acceptance and usage of Bitcoin. Furthermore, an important issue is to identify the key factors determining the development of virtual currencies and their ability to compete with traditional means of payment.

Your answers will help to expand the scientific knowledge about the virtual currency. We strongly believe that the results of the research will contribute to the dynamic development of the virtual currency market.

It will take about **10 minutes** to answer the questions. Anonymity of the participants is guaranteed and identification of the responses from individual participants is impossible.

Does your company accept Bitcoin? Please choose only one of the following:

a) Yes
b) We do not accept, but we are planning to within 6 months
c) We were accepting but we have stopped
d) We do not accept and we do not plan to
e) I have never heard about it

How many employees does your company have? Please choose only one of the following:

f) 1
g) 2-9
h) 10-49
i) 50-249
j) 250 and more

In which country is your company located? Please write your answer here: _____

Does your company also have a traditional point of sale (shop, office, service point)? Please choose only one of the following:

a) Yes
b) No

How long has your company performed sales over the Internet? Please choose only one of the following:

a) Less than 1 year
b) Between 1 and 3 years
c) Between 3 and 5 years
d) Between 5 and 10 years
e) More than 10 years

What types of products/services do you offer over the Internet?

a) Hosting services/cloud computing
b) Programming services
c) Cryptographic services
d) Design services/art
e) Advertising and marketing services
f) Gambling
g) Automotive
h) Electronics/photography/household appliances
i) Entertainment (games, music, books and multimedia)
j) Clothing/gifts
k) Sport/tourism
l) Health/beauty
m) Non-profit
n) Other

Which payment methods (apart from Bitcoin) does your company accept? Please choose all that apply:

a) Payment card (credit card, debit card)
b) PayPal
c) Pay-By-Link (quick online interface for bank transfer)
d) Cash on delivery
e) Bank transfer
f) SMS/MMS premium payment
g) Other

What percentage of your value of sales is realized in Bitcoin:

a) 0%
b) 1-10%
c) 11-20%
d) 21-40%
e) 41-60%
f) 61-80%
g) 81-100%

How do you rate your customers' knowledge of Bitcoin? Please choose only one of the following:

a) Very good
b) Rather good
c) Rather poor
d) Very poor
