Grupo de Pesquisa em
Gestão e Planejamento Econômico-Financeiro
Universidade Federal do Rio de Janeiro – UFRJ

Is bitcoin a currency or a technology?

Reilly S. White, Yorgos D. Marinakis, and Steven T. Walsh

Textos para Discussão

No. 5 – março, 2018.

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Título

Is bitcoin a currency or a technology?

Autores

Reilly S. White, Yorgos D. Marinakis, and Steven T. Walsh *

*Anderson School of Management – University of New Mexico.

Resumo: Criptomoedas, como bitcoin, têm fascinado tanto especialistas em tecnologia como investidores nos últimos anos. Algumas características do bitcoin são bastante conhecidas atualmente. Mas uma questão fundamental permanece: É o bitcoin uma moeda ou uma tecnologia? Esta lacuna científica pode ser resolvida, até certo ponto, pela comparação do comportamento do bitcoin com outros instrumentos. Este trabalho é relevante para aqueles interessados em estudos interdisciplinares sobre moedas, criptomoedas, e tecnologias emergentes, e também para os que se interessam pelas fronteiras da regulação.

Palavras-chave: Criptomoedas, bitcoin, investimentos, difusão tecnológica.

Abstract: Cryptocurrencies such as bitcoin have fascinated technologists and investors alike in recent years. Some aspects of bitcoin are now familiar. But a fundamental question remains unasked: is bitcoin a currency or a technology? This research gap can be closed somewhat by comparing the behavior of bitcoin to other instruments. The present study is relevant to those engaging in interdisciplinary studies involving currencies, cryptocurrencies, and emerging technologies; and to those studying the frontiers of regulation.

Key-words: Cryptocurrency; bitcoin; Investments; technology diffusion.

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Reilly S. White, Yorgos D. Marinakis, and Steven T. Walsh

reillywhite@unm.edu, ymarinak@unm.edu, and swalsh91@comcast.net

Anderson School of Management

University of New Mexico

Albuquerque, New Mexico 87131

Abstract

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Keywords:

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À l'aurore, armés d'une ardente patience, nous entrerons aux splendides Villes

In the dawn, armed with a burning patience, we shall enter the splendid cities.

Arthur Rimbaud, *A Season in Hell: Farewell*

Introduction

Cryptocurrencies such as bitcoin have fascinated technologists and investors alike in recent years. Blockchains have been heralded as the harbinger of the new economy (Swan 2015) and as a great financial disruptor (Peters and Panayi, 2016). Bitcoin itself straddles the space between blockchains and applications, between currency and technology. Once the nascent tender of the black market, bitcoin amassed a market capitalization of over $300 Billion by late 2017. Yet, few academic investigations into the nature of its value have been conducted. In this paper, we address the source of bitcoin's value and its relevance as both a technology and investment.

Some aspects of bitcoin are now familiar. Researchers have well-investigated the (exchange) value of bitcoin (Hayes 2016, Chan et al. 2017, Li and Wang 2017, Wang and Vergne 2017a, 2017b) and its relation to banking (Eyal 2017, Piazza 2017). Some have conjectured on its potential social implications (Alcantara and Dick 2017, Scott et al. 2017). The possible social impacts of bitcoin have been compared to those of Potosí Silver (Zimmer 2017). Others have studied bitcoin's network effects (Gandal and Halaburda 2016, Luther 2016). Future improvements to the technology have already been proposed (Bonneau et al. 2015). Bitcoin has been studied as a market singularity (Dallyn 2017) and the market for cryptocurrencies received an evaluation (White 2015).

But a fundamental question remains unasked: is bitcoin a currency or a technology? This question is relevant because it is a prerequisite to the question of whether bitcoin should be regulated as a currency or as a technology. This regulatory issue sharpens as bitcoin's value appreciates and begins to look like a speculative bubble.

This research gap can be closed somewhat by comparing the behavior of bitcoin to other instruments. What currencies (or other financial instruments) does it resemble? What technologies does it resemble? Is bitcoin diffusing like a product (by environmental learning, or by cultural transmission), or is it diffusing like a currency?

The present study is relevant to those engaging in interdisciplinary studies involving currencies, cryptocurrencies, and emerging technologies; and to those studying the frontiers of regulation.

Theoretical Background

Currencies form a crucial part of our modern economic environment, but this has not always been the case. As an innovation, currency grew out of inefficiencies in the bartering system presented since the earliest stages of human development. Smith (1776) saw currencies as a means for improving liquidity in a *quid pro quo* barter system: trade between a butcher and brewer was only possible if they each had something the other wanted. Money, on the other hand, was a common store of value that could be used to purchase anything anybody wanted. Currency was born to fill this niche. As discussed in Kivotaki (1989), the most important factor

in determining if something can act as a currency is simple: are there enough economic agents that *believe* it can?

The earliest currencies utilized materials with a widely understood intrinsic store of value. Cowry shells were used as currency prior to 1000 B.C. (Yang 2011). Standardized coinage utilizing electrum, an alloy of gold and silver, was minted in the Mediterranean states of Aegina and Lydia in the decades following 700 B.C. (Kagan, 1982). Trade quickly flourished with the introduction of coinage. For nearly two thousand years, currency was transacted units of traditionally valuable metals: gold, silver, and bronze. Paper currency, present in global commerce for the last thousand years, was often stabilized only when supported by one of these metals.

The establishment of the modern gold standard in the 19th century did much to standardize global currency regimes (Bordo 2003). However, wars, depressions, and economic shocks of the 20th century exposed its substantial limitations. After World War II, the Bretton Woods Agreement declared the U.S. Dollar to be solely convertible to gold at $35 per ounce, in turn tethering all other currencies to the dollar. The suspension of dollar convertibility to gold in 1971 established the current modern 'free floating' *fiat* system. The gold standard allowed for decades of low inflation and exchange rate volatility (Bordo 2003), but was incapable of keeping up with varying monetary demand and the high level of global fiscal discipline required.

In our current system, most of our monetary supply is not held as currency, but created through lending (McLeay et. al. 2014). For example, the $1.6 trillion of US Currency currently in circulation (Federal Reserve 2017) is a fraction of the $15.3 trillion of monetary stock redeemable on demand (MZM 2017). Commercial banks issue new loans, in effect creating money by crediting the borrower with a bank deposit equal to the size of the loan. Likewise, repaying these loans destroys money. Central banks can control monetary policy at the national level by setting the interest rate on reserves, encouraging or restraining lending by banks. In turn, this has pronounced effects on inflation, employment, and investment across an economic area.

Cryptocurrencies as Currencies

Much of the initial scholarly research on bitcoin was based on the assumption that it was an emerging currency. Many technical researchers assume bitcoin to be a currency *ipso facto* by virtue of its existence, and find cause for improvement in its definition of decentralization (Gervais et. al. 2014). Early on it was convincingly demonstrated that bitcoin failed most of the basic functions of all currencies (Yermack 2013): at the time, it lacked substantial transaction value and was a poor store of value. In this paper, we investigate whether this is still the case today.

The contemporary case for free-floating currencies (Friedman 1953) holds that nation states can preserve monetary independence and avoid disruptive economic shocks that occur when a peg is adjusted for value. The novelty of cryptocurrencies is that they are truly supranational: digital, decentralized and independent of national interest. Combined with its finite supply, it has characteristics of gold, being fungible and available universally. This also presents its greatest obstacle for widespread adoption. Successful decentralized currencies like bitcoin currently offer little incentive to be adopted by national governments, since they offer little in the way of monetary policy control. Likewise, widespread adoption of cryptocurrencies could undermine the effectiveness central banks, making legal restrictions surrounding their adoption more likely.

The greatest hurdle in establishing any currency is credibility as a means for exchange. In this sense, bitcoin has improved dramatically in the last year. Daily transaction value has increased to roughly $5 Billion dollars a day in December 2017 from roughly $200 Million a year ago (Blockchain 2017), while the number of daily transactions has increased more modestly from 270,000 to roughly 400,000 in the same period (Bitcoin 2017). Compared to other currencies in the $5 Trillion daily foreign exchange market, the value transacted by bitcoin approximates the daily turnover of minor currencies such as the Hungarian Forint or Indonesian Rupiah (BIS 2017).

Money serves three functions (Ali et. al. 2014): it offers a store of value, a medium of exchange, and lastly, a unit of account. Many objects can be stores of value for an individual, such as real estate, collectibles, or art. Mediums of exchange require at least two parties to coordinate their valuation, and this is a hurdle bitcoin passes easily. However, units of account require that many people use a currency across many different transactions (Woodford 2003). Central Banks' primary role is controlling that unit of account. For bitcoin, this is a harder hurdle to pass. While spot transactions and (as of November 2017) future markets exist for bitcoin, using it in day-to-day society requires another medium of exchange. We cannot, as of yet, take out mortgages exclusively in bitcoin or invest exclusively in investments and markets denominated in bitcoin. To be paid bitcoin wages, you must first get an employer to convert their native currency's money into bitcoin – a process that would be identical if they requested their employer pay them in smartphones, golf balls, or any other non-currency item. In this light, the startup costs for digital currencies are immense.

These non-mutually exclusive questions attempt to resolve the nature of bitcoin as an investment. If bitcoin is a currency, does it behave like one? Further, if it actually represents a separate asset class, what sort of assets offer the closest proxies to bitcoin? Last, the rapid appreciation in the value of bitcoin over the last year has generated substantial interest by investors. We further investigate whether bitcoin is a 'bubble', defined here as the unsustainable increase in asset prices that precedes a price collapse.

Methods

Bitcoin as Currency

Since the unraveling of the Bretton Woods system in 1971, the last four decades have seen the rise of sometimes volatile free-floating currencies. With over four decades of ample currency data, we propose that bitcoin should superficially resemble one of the existing currencies during the early stages of its economic development. We examine 18,937 USD-based monthly currency pairs since 1977 and compare them to bitcoin's monthly changes in value between 2010 and 2016. Running correlations were computed using 77 months of bitcoin values. Currencies with insufficient time data were dropped, and the resulting currency pairs were sorted by correlation. Data was obtained from the PACIFIC Exchange Rate Service at the University of British Columbia Sauder School of Business (Columbia 2017).

Bitcoin as Asset Class

If bitcoin fails our currency test, is it possible that it represents an entirely new asset class? Many investment organizations have been marketing cryptocurrencies as a unique investment product

(Burniske and White, 2017). Bitcoin is mainly uncorrelated with major asset classes and used as a primarily speculative tool (Baur et al. 2017). Bitcoin is primarily driven by demand of investors for an alternative investment vehicle, making it a unique (if separate) asset class (Glaser et. al. 2014). Bitcoin has been compared to a limited number of other asset classes (Brière et. al. 2015, Wu and Pandey 2014).

In our investigation, we expand our correlation matrix to include 32 different currencies, indices, and other investments to offer the most thorough and effective comparison of bitcoin to date in academic literature. We also sort our data into three time periods: 2010-2016, the full breadth of bitcoin's history; 2013-2016, the more recent period where bitcoin had a total market capitalization greater than $500 million; and the 2015-2016 period of rapid appreciation. Data ends at December 31, 2016, the most recent data available on WRDS CRSP service.

Despite bitcoin's most recent classification and acceptance as a commodity, it resembles none of the other major commodities (Business Insider 2017). Indeed, bitcoin throughout its history is inversely correlated to gold, silver, and oil. In the most recent period (2015-2016), bitcoin is positively correlated to silver and gold, but still strongly negatively correlated to oil prices.

Bitcoin also fails to correlate well with major currencies. It has always been negatively correlated to the five major currencies studied, but in the most recent period of appreciation, the negative correlation to the British Pound and Chinese Yuan has been profound. bitcoin, similar to cryptocurrencies in general, behaves as a *contra-currency* relative to other entities. It moves in ways and magnitudes that are effectively opposite the major currencies.

Most consistently, bitcoin has been most correlated to *bxysm*, the CBOE S&P 500 2% OTM BuyWrite Index, and *bxmd*, the CBOE S&P 500 30-Delta BuyWrite Index, both options indices. Furthering the view of some academic experts that view cryptocurrencies as a de-facto haven for speculators, the movement and expansion of bitcoin has resembled the high growth and volatility found in derivatives market. The underlying options measured by the BuyWrite index are used as a portfolio enhancement strategy to improve returns and reduce risk (CBOE 2017).

We next examine whether bitcoin would be similarly effective in a portfolio of securities to improve performance and reduce risk. For the period of 2014-2017, we calculated the 1-year and 3-year monthly Betas on bitcoin. Beta measures the relative risk-to-return relationship between a security and the overall market in a diversified portfolio. Market risk has a Beta of 1; riskier securities have higher Betas. To further examine the relative reward-for-risk ratio, we also compute the Sharpe Ratio, defined by the following originally derived from Sharpe (1966):

$$S_p = \frac{\overline{R_p} - \overline{R_f}}{\sigma_p}$$

The Sharpe Ratio is defined as $\overline{R_p}$, the mean return of the portfolio and $\overline{R_f}$, the mean return on three-month U.S. treasury bills (here, the risk-free rate of interest), divided by σ_p the standard deviation of portfolio returns. The $\overline{R_p} - \overline{R_f}$ return is also described (see Morningstar, 2005; "Standard Deviation and Sharpe Ratio", *Morningstar Methodology Paper*. https://gladmainnew.morningstar.com/directhelp/Methodology_StDev_Sharpe.pdf) as the average monthly excess return:

$$\overline{R_e} = \frac{1}{n}\sum_{i=1}^{n}(R_i - RF_i)$$

Where $\overline{R_e}$ is the average excess return of the portfolio, computed monthly; R_i is the return of the portfolio in month I, and RF_i is the return of the risk-free benchmark. In our example, we calculate the Sharpe Ratio for bitcoin as a portfolio; usually, this statistic would not be tested for individual stocks, but given the role and dominance of bitcoin as the *ipso facto* representative of the cryptocurrency asset class, we find it potentially useful for investors. This reward-for-risk ratio is then annualized to provide consistency, and demonstrates the returns of bitcoin when controlling for total risk (standard deviation). The higher the Sharpe Ratio, the better; values greater than 1 are considered desirable for investors.

Bitcoin as Bubble

Is bitcoin a bubble? As early as Cheah and Fry (2015), convincing arguments have been made over the speculative nature of bitcoin investments from an asset pricing perspective. The question remains a difficult and complex one, as bubbles require a concise definition. Here, we borrow the definition famously used by Case and Shiller (2003) that a 'Bubble'

> *"refers to a situation in which excessive public expectations of future price increases cause prices to be temporarily elevated."*

Measuring bubbles can be difficult and mathematically complex. Jarrow et. al. (2011) created an effective model at measuring bubbles in internet stocks during the 1998-2001 technology bubble, and Stöckl et. al. (2010) provide a thorough analysis of widely accepted bubble-measuring techniques in experimental asset pricing literature. These papers provide a great analytical framework for a future paper on cryptocurrencies, but the extant models are far from decisive. Urquhart (2016) builds evidence to demonstrate that bitcoin's pricing inefficiencies contribute to (often) incorrect valuation, providing the groundwork for speculative bubbles.

Does bitcoin meet this definition? One way of examining bitcoin is to consider its growth in valuation relative to other speculative assets. For example, Garber (1989) details the mania surrounding the Dutch Tulip Bubble. Introduced from the Ottoman Empire in the 16th century, tulips were a desirable luxury commodity that appreciated rapidly from 1634-1637, eventually exceeding the price of some luxury houses in Amsterdam before crashing abruptly in 1637. Thompson (2007) considers it a by-product of an inefficient futures market rather than a true bubble, but it remains an often-cited example of early and unsupported rises (and falls) of asset prices.

The South Sea Bubble of 1720 surrounded the South Sea Company, a joint-stock firm first established to consolidate British debt and then granted a trade monopoly with South America (Garber 1990). Shares in the company were in high demand by investors, who saw the foreign trade value to be profoundly significant. The tenfold increase in the value of stock in 1720 from 100£ to nearly 1000£ per share followed widespread interest across British society. While the broad economics of trade with the South Sea remained sound, the arrival of fraudulent competitors and the passing of the regulatory Bubble Act of June 1720 produced a liquidity crisis in the market as investors grew disenchanted (Garber 1990). The price quickly collapsed to 150£ by autumn, costing many investors a fortune – including famously Sir Isaac Newton.

The third (and most modern) bubble proxy we examine in the technology bubble and collapse of 1998-2001. Driven by the promise of computer technology, technology stocks rose five-fold between 1997-2000 (Griffin et. al., 2011). Many technology firms failed (notably Pets.com and Webvan), while many others saw precipitous declines in stock prices. Priceline (PCLN) saw prices surge to nearly $1000 per share in April 1999 before falling to below $10 per share in

December 2000. Cisco Systems, Inc. (CSCO) saw prices fall from $80 per share to below $14 in nearly the same period.

We compared bitcoin's appreciation through November 2017 to these three bubbles. Data for the Dutch Tulip Crisis was obtained from Thompson (2007) and Garber (1989); the South Sea Bubble utilized Garber (1990) and data from the Yale International Center for Finance South Seas Bubble 1720 Project. Data for Cisco Systems was obtained from daily stock data accessible from the WRDS CRSP database. We examine the price appreciation and collapse over a 30-month period with a common baseline of 100 during the first month of available data (Yale 2017).

Bitcoin as Technology

To construct a diffusion curve, bitcoin data were compiled from the Blockchain.info website (Blockchain 2017). The Richards model was then fit to the bitcoin data. The benefit of the Richards model is that it is a flexible, four-parameter model, and is able to fit the full range of sigmoidal shapes. The Richards model was introduced in 1959 in the context of plant growth (Richards 1959). It was recently applied to technology diffusion data (Marinakis 2012). The model has been modified and reparameterized by several researchers. As modified by Sugden et al. (1981), the model is:

$$W_t = W^{\infty}[1-(1-m)\exp[-k(t-T^{\infty})/m^{m/(1-m)}]]^{1/(1-m)}$$

where W_t is the weight or growth at time t, W^{∞} is the asymptotic weight, k is the maximum relative growth rate per unit time, T^{∞} is the time to asymptote, and m is a shape parameter with the property that $m^{1/(1-m)}$ is the relative weight at time T^{∞}. In application to the present study, W^{∞} is the asymptotic number of publications, k signifies the maximum diffusion per unit time relative to the number of publications, T^{∞} is the time to asymptote, and m is a shape parameter.

To construct a working hypothesis for how currencies diffuse, net circulation (diffusion) of the euro was graphed. If the diffusion was r-shaped, then it occurred through environmental learning (individual learning); if the diffusion was s-shaped, then it occurred through cultural transmission (Henrich 2001). All large-scale diffusion of technology-based products occurs through cultural transmission because it traces out s-shaped curves. Euro diffusion data was obtained from the European Central Bank website (ECB 2017).

Results

Bitcoin as Currency

In Panel A, we present an overview of the currencies ranked by their highest correlation to bitcoin. *End Period* marks the last month in the 77-month correlation period. For simplicity, adjacent months from the same currency pair with slightly lower correlations were omitted from the table. For example, the *End Period* Nov 2003 CNY/USD correlation was 0.920, but it was omitted from the table for being representative of the same economic period and circumstances. We define adjacent periods as occurring within six months of the period of maximum or minimum correlation in Table 1. We note surprisingly high correlations between several historical currencies and bitcoin: the Malaysian Ringgit through October 2004, the Bermudan Dollar through March 2011. While the directional variation of these currencies was similar (all

demonstrated extended periods of appreciation), the magnitudes of the currency changes were substantially lower than the substantial month-on-month volatility associated with bitcoin.

Similarly, Panel B ranks the least correlated currencies to bitcoin since 1977. Particularly with regards to the Hungarian Lempira and Russian Ruble, the 77-month periods coincided with substantial declines in the currencies value relative to the dollar. The vast majority of currencies most and least correlated to bitcoin are usually are developing currencies in times of substantial economic and political volatility.

Although these results are interesting, the correlations not only do not imply causation, but in many cases are the links are spurious. Long-term currency appreciation has been seen in other currencies. However, bitcoin's magnitude of appreciation has no precedence in the history of modern currency valuation.

Table 1: Bitcoin Correlation to Major USD Currency Pairs, 1977-2016

Using a database of 77 months of bitcoin returns from 2010 to 2016, we compared these results to 18,937 USD-based global currency pairs from 1977-2016. Running correlations for all currency pairs were calculated against Bitcoin in 77-month periods; correlations with less than 77 months of history were omitted. Panel A includes the 15 highest correlated currencies to Bitcoin; Panel B includes the 15 currencies with the lowest correlation. *End Period* refers to the end of the 77-month correlation window. For simplicity, currency pairs that were recurring within one year were omitted.

Panel A: Currencies Ranked by Highest Correlation to Bitcoin, 1977-2016

Rank	*Currency Pair*	*Currency*	*End Period*	*Correlation*
1	MYR/USD	Malaysian Ringgit	Oct 2004	0.944
2	CNY/USD	Chinese Yuan	Oct 2003	0.923
3	BMD/USD	Bermudan Dollar	Mar 2011	0.911
4	BBD/USD	Barbadian Dollar	Mar 2011	0.899
5	CNY/USD	Chinese Yuan	Jun 2001	0.877
6	NZD/USD	New Zealand Dollar	May 2015	0.831
7	JPY/USD	Japanese Yen	Nov 1991	0.810
8	KRW/USD	Korean Won	May 2015	0.809
9	TWD/USD	Taiwan New Dollar	Jun 1993	0.770
10	KRW/USD	Korean Won	May 2004	0.764
11	HKD/USD	Hong Kong Dollar	Apr 1997	0.762
12	ITL/USD	Italian Lira	Nov 1991	0.749
13	DEM/USD	German Mark	Nov 1991	0.748
14	CHF/USD	Swiss Franc	Aug 1991	0.747
15	FRF/USD	French Franc	Aug 1991	0.742

Panel B: Currencies Ranked by Lowest Correlation to Bitcoin, 1977-2016

Rank	*Currency Pair*	*Currency*	*End Period*	*Correlation*
1	HNL/USD	Honduran Lempira	Mar 2011	-0.953
2	HKD/USD	Hong Kong Dollar	Jul 1989	-0.924
3	BMD/USD	Bermudan Dollar	Sep 2006	-0.916
4	MYR/USD	Malaysian Ringgit	Oct 2003	-0.900
5	RUB/USD	Russian Ruble	Oct 2004	-0.883
6	BBD/USD	Barbadian Dollar	Jul 2012	-0.882
7	CNY/USD	Chinese Yuan	Feb 2000	-0.876
8	ARS/USD	Argentine Peso	Feb 2008	-0.869
9	TTD/USD	Trinidad & Tobago D	Sep 2002	-0.832
10	TRY/USD	Turkish Lira	Apr 2007	-0.812
11	ISK/USD	Icelandic Króna	Sep 2014	-0.808
12	PEN/USD	Peruvian Sol	Dec 2004	-0.801
13	ITL/USD	Italian Lira	Nov 1998	-0.780
14	BGN/USD	Bulgarian Lev	Mar 2003	-0.770
15	MYR/USD	Malaysian Ringgit	May 2005	-0.747

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13	DEM/USD	German Mark	Nov 1991	0.748
14	CHF/USD	Swiss Franc	Aug 1991	0.747
15	FRF/USD	French Franc	Aug 1991	0.742

Panel B: Currencies Ranked by Lowest Correlation to Bitcoin, 1977-2016

Rank	***Currency Pair***	***Currency***	***End Period***	***Correlation***
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Bitcoin as Asset Class

Results are displayed in Table 2. Major currencies are highlighted in green and commodities are highlighted in yellow. Rolling Betas and Sharpe Ratios using monthly data from January 2014 to November 2017 are below in Figure 5.

Figure 5: Rolling 1-year Betas, 3-year Betas, and Sharpe Ratios for bitcoin from 2014-2017

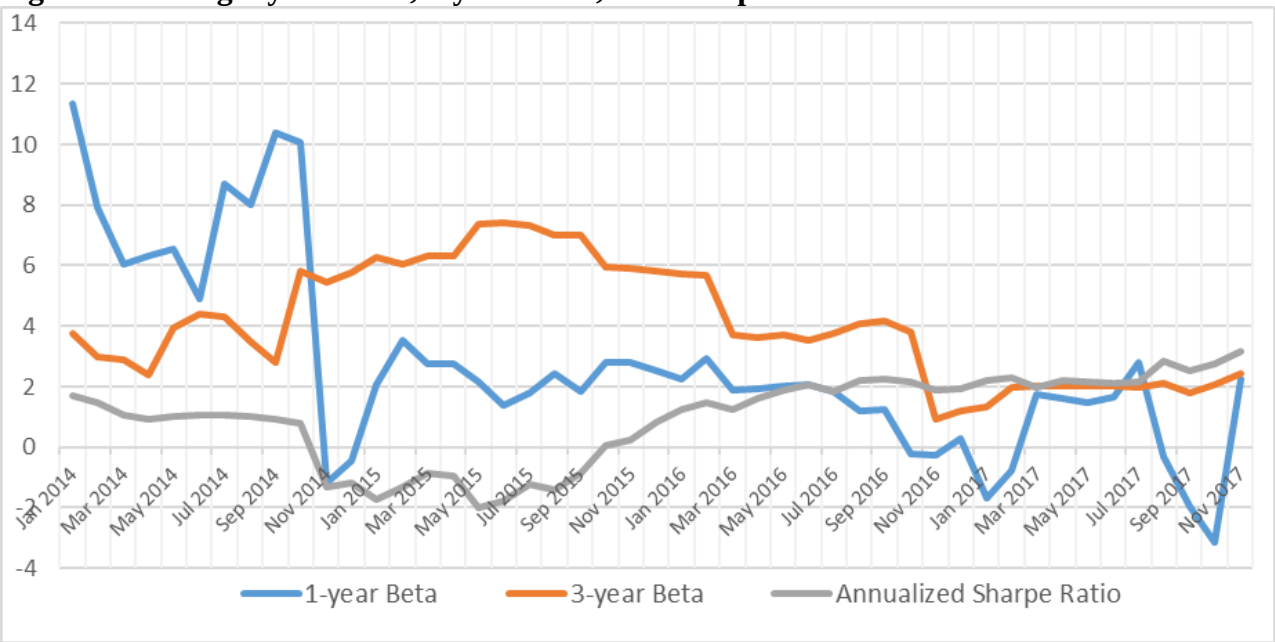


Table 2: Bitcoin Correlation Table Between Bitcoin and Major Market Indicators

In this table, we show the correlation of Bitcoin prices with major market indicators in three different time periods ending on December 31, 2016. The first period begins on August 17th, 2010 when data became available; the second period begins on March 13, 2013, the week when Bitcoin achieved a market capitalization of $500 Million; the third beings on January 1, 2015. For visibility, widely held currencies are highlighted in green and commodoties are highlighted in yellow.

	Key	**August 17, 2010 - December 31, 2016**			**March 13, 2013 - December 31, 2016**			**January 1, 2015 - December 31, 2016**		
Symbol	**Description**		Correlation	Significance		Correlation	Significance		Correlation	Significance
bfly	CBOE S&P 500 Iron Butterfly Index	**bitcoin**	**1.000**	**0.000**	**bitcoin**	**1.000**	**0.000**	**bitcoin**	**1.000**	**0.000**
bitcoin	Bitcoin	bxysm	0.805	0.000	bxysm	0.516	0.000	bxmd	0.873	0.000
bnd	US Aggregate Bonds	bxmd	0.802	0.000	cmbo	0.487	0.000	putsm	0.870	-0.018
bndx	International Bonds	cmbo	0.800	0.000	bxmd	0.486	0.000	cllz	0.847	0.000
bxmd	CBOE S&P 500 30-Delta BuyWrite Index	cllz	0.799	0.000	cllz	0.470	0.000	cmbo	0.818	0.000
bxmsm	CBOE S&P 500 BuyWrite Index	sptr	0.795	0.000	putsm	0.463	0.000	bxmsm	0.814	0.000
bxysm	CBOE S&P 500 2% OTM BuyWrite Index	spy	0.793	0.000	bxmsm	0.456	0.000	xlk	0.798	-0.008
cll	CBOE S&P 500 95-110 Collar Index	spxsm	0.793	0.000	xlk	0.407	-0.944	bxysm	0.775	0.000
cllz	CBOE S&P 500 Zero-Cost Put Spread Collar	putsm	0.791	0.000	sptr	0.406	0.000	sptr	0.738	0.000
cmbo	CBOE S&P 500 Covered Combo Index	bxmsm	0.789	0.000	spy	0.398	0.000	bndx	0.728	0.000
cndr	CBOE S&P 500 Iron Condor Index	pput	0.787	0.000	spxsm	0.398	0.000	spxsm	0.570	0.000
cyb	Chinese Yuan	xlk	0.777	0.000	pput	0.356	0.000	spy	0.565	0.000
euo	UltraShort Euro	cll	0.766	0.000	cll	0.295	0.000	bfly	0.484	0.000
fxb	British Pounds	nfo	0.705	0.000	bfly	0.238	0.000	slv	0.462	0.000
fxe	Euro	shy	0.491	0.000	bndx	0.231	-0.002	gld	0.403	0.000
gld	Gold	uup	0.363	0.000	nfo	0.199	0.000	mub	0.351	-0.621
jnk	Junk Bonds	euo	0.267	0.000	mub	0.140	-0.003	pput	0.237	0.000
mub	Munincipal Bonds	mub	0.258	0.000	shy	0.134	-0.009	bnd	0.167	0.000
nfo	Investor Sentiment	bndx	0.231	0.000	bnd	0.003	0.000	uup	0.135	0.000
pput	CBOE S&P 500 5% Put Protection Index	bnd	-0.235	0.000	fxe	-0.014	0.000	euo	0.069	0.000
putsm	CBOE S&P 500 PutWrite Index	cndr	-0.284	0.000	uup	-0.024	-0.365	shy	0.031	0.000
shy	Short Term Treasuries	jnk	-0.292	0.000	euo	-0.039	0.000	nfo	-0.036	0.000
slv	Silver	vxosm	-0.401	0.000	udn	-0.042	-0.758	cll	-0.150	0.000
sptr	S&P 500® Total Return	vix	-0.408	0.000	slv	-0.060	-0.003	vix	-0.281	0.000
spxsm	S&P 500®	fxb	-0.411	0.000	gld	-0.072	-0.196	vxosm	-0.322	0.000
spy	S&P 500	fxe	-0.441	0.000	cndr	-0.104	-0.024	jnk	-0.414	0.000
udn	US Dollar Bear	cyb	-0.459	0.000	jnk	-0.121	-0.120	fxe	-0.452	0.000
uso	Crude Oil	uso	-0.516	0.000	uso	-0.136	-0.606	udn	-0.474	0.000
uup	US Dollar	udn	-0.522	0.000	vix	-0.196	0.000	cndr	-0.555	0.000
vix	Volatility	bfly	-0.561	0.000	fxb	-0.213	-0.401	uso	-0.700	-0.033
vxosm	CBOE S&P 100 Volatility Index	gld	-0.643	0.000	vxosm	-0.244	0.000	cyb	-0.808	-0.575
xlk	SPDR Tech Sector ETF	slv	-0.674	0.000	cyb	-0.487	0.000	fxb	-0.919	-0.272

One year Betas, computed with monthly data, were highly volatile: bitcoin reported betas greater than 10 as late as November 2014 and below zero (indicating an opposite risk correlation to the market) several times in 2017. The 3-year betas were demonstrably more consistent and mathematically appropriate. For much of 2015, bitcoin's high beta values were nearly unprecedented, even when compared to other mid-cap and large-cap equity securities. However, by late 2016, bitcoin's beta dropped to around 2: effectively a higher-than-average risk security, but not significantly riskier than some stocks frequently held by investment managers in portfolios (for comparison, as of December 2017, AMD reported a beta of 2.44 and Brazilian energy firm Petrobras 2.41). From a beta standpoint, bitcoin has been a broadly investible commodity since the beginning of 2017.

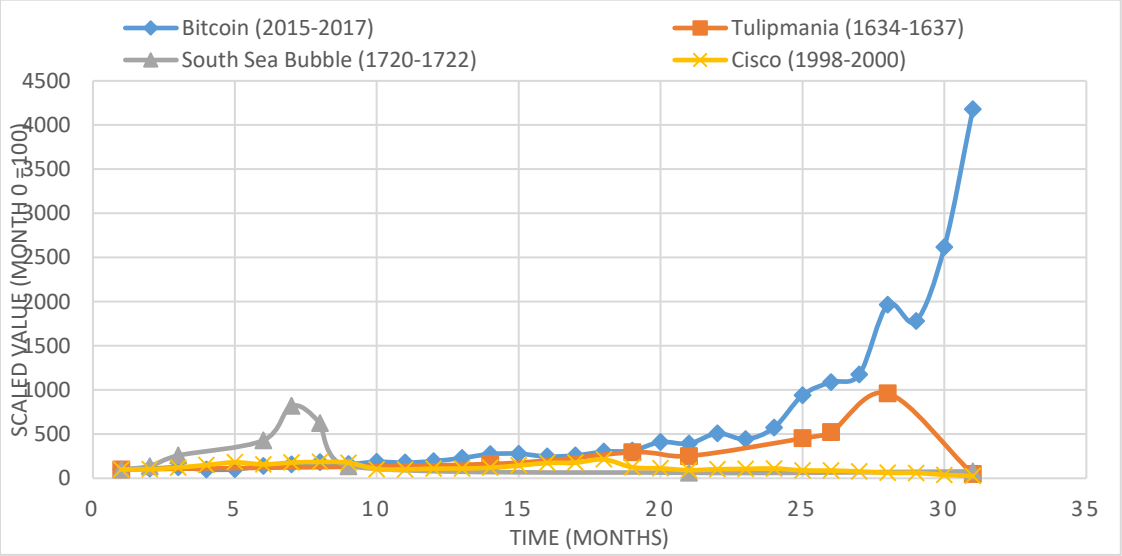
In calculating the Sharpe Ratio, our results were broadly similar. Bitcoin's annualized Sharpe Ratio languished until early 2016 when it approached and exceed a value of 2, making it a potentially desirable asset from a reward-for-risk perspective. Not only did it exceed the market risk free rate substantially, total volatility (relative to its return) was at manageable levels for high returns. In this respect, it resembles a high-risk, high-return asset highly correlated to derivative indices and inversely correlated to major currencies. Further, the improvement of its portfolio metrics corresponded to the beginning of its rapid appreciation in 2017, suggesting a predictive framework exists for determining cryptocurrency value.

Bitcoin as Bubble

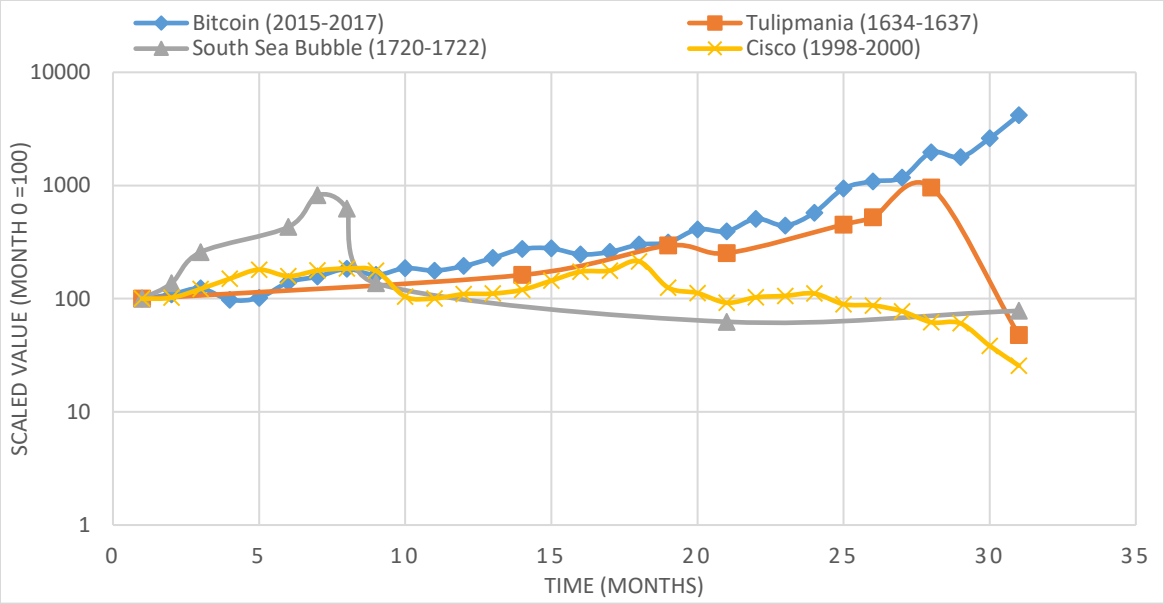
Results are displayed in real and logarithmic terms in Figure 6 below:

Figure 6: 30 Months of Asset Price Bubble Valuations

Panel A: Actual Values with Month 0=100.



Panel B: Logarithmic Values with Month 0=100.



Bitcoin as Technology

The Richards model was fit to the total number of bitcoin data (Figure 7, Tables 3a, 3b), and to the bitcoin blockchain size data (Figure 8, Tables 4a, 4b). The clean fit of s-shaped curves is visually obvious, and in addition the fits were statistically significant. The Richards model was also fit by inspection to the average bitcoin block size data (Figure 9, Table 5), because the data was too noisy to obtain a statistically significant fit. It is notable that bitcoin minting is scheduled to terminate at 21m bitcoins, but the forecast shows that minting will asymptote at 18.5m bitcoins. Bitcoin minting closely reaches its asymptote somewhere between 2000 and 3000 days after its initial introduction. Average bitcoin block size reaches its asymptote after 4000 days. Bitcoin blockchain size reaches its asymptote well after 5000 days.

In addition, the diffusion curve of the euro is distinctly r-shaped rather than sigmoidal (Figure 10). Per Henrich (2001), this result suggests the working hypothesis that all currencies diffuse through environmental (individual) learning. Further initial currency offerings will need to be examined to validate this hypothesis.

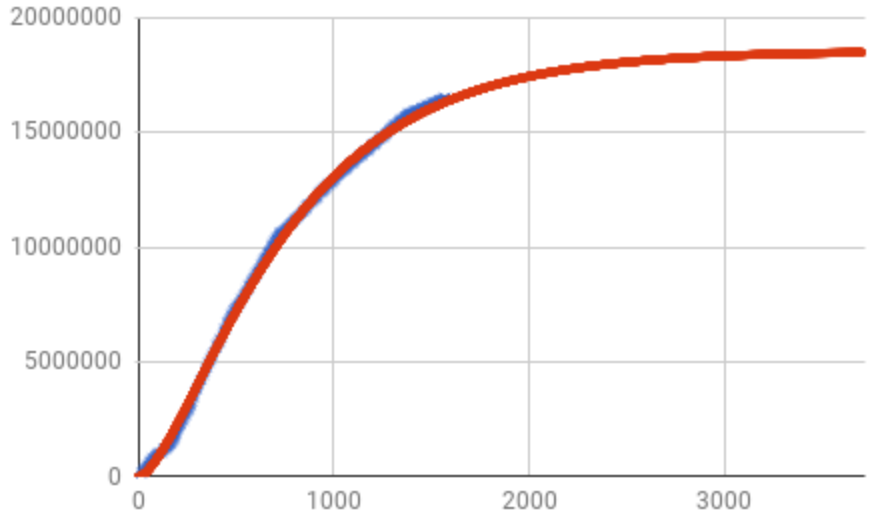


Figure 7. Total number of bitcoins that have already been mined. Shorter line shows data (Blockchain 2017), day 1 to 1573. Longer line shows model, day 1 to 3700.

Parameter	Estimate	Approx. Std. Error	Approx. 95% Confidence limits	
m	0.3909	0.00963	0.3720	0.4098
w	18532501	53748.1	18427075	18637927
t	165.6	7.2245	151.4	179.7
k	0.00165	0.000017	0.00162	0.00169

Table 3a. Richards model parameters for the data sets of the total number of bitcoins.

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	1.932E17	4.83E16	1495759	<.0001
Error	1569	5.067E13	3.229E10		
Uncorrected Total	1573	1.933E17			

Table 3b. Richards model goodness-of-fit for the total number of bitcoins.

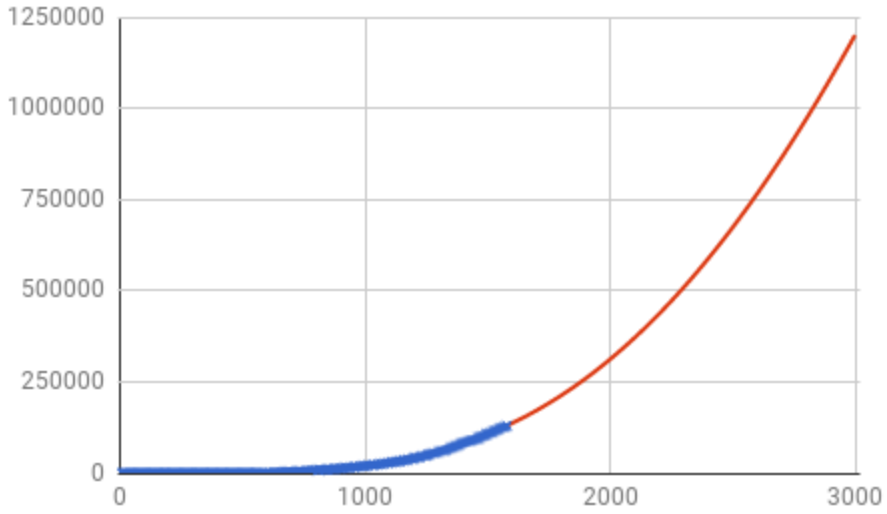


Figure 8. Bitcoin blockchain size, or the total size of all block headers and transactions not including database indexes. Shorter line shows data (Blockchain 2017), day 1 to 1582. Longer line shows model, day 1 to 3000.

Parameter	Estimate	Approx. Std. Error	Approx. 95% Confidence limits	
m	8.03E-01	0.0440	0.7163	0.8889
w	15496657	18928304	-2.163E7	52623910
t	5179.5	1994.5	1267.3	9091.7
k	0.000304	0.000154	1.676E-6	0.000606

Table 4a. Richards model parameters for the bitcoin blockchain size.

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	3.001E12	7.502E11	223094	<.0001
Error	1569	5.3098E9	3362749		
Uncorrected Total	1573	3.006E12			

Table 4b. Richards model goodness-of-fit for the bitcoin blockchain size.

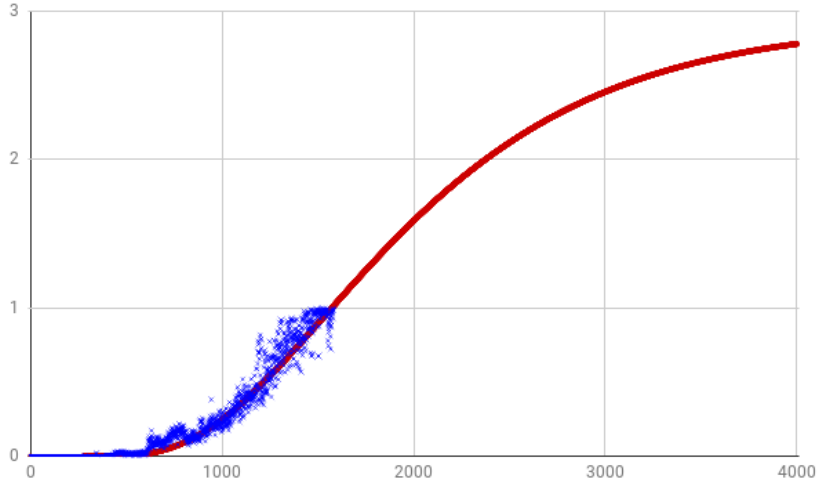


Figure 9. Average bitcoin block size. The x's show the data (Blockchain 2017), day 1 to 1582. The line shows the model, day 1 to 4000.

Parameter	Estimate
m	7.80E-01
w	2.93E+00
t	1500
k	1.20E-03

Table 5. Richards model parameters for the average bitcoin block size.

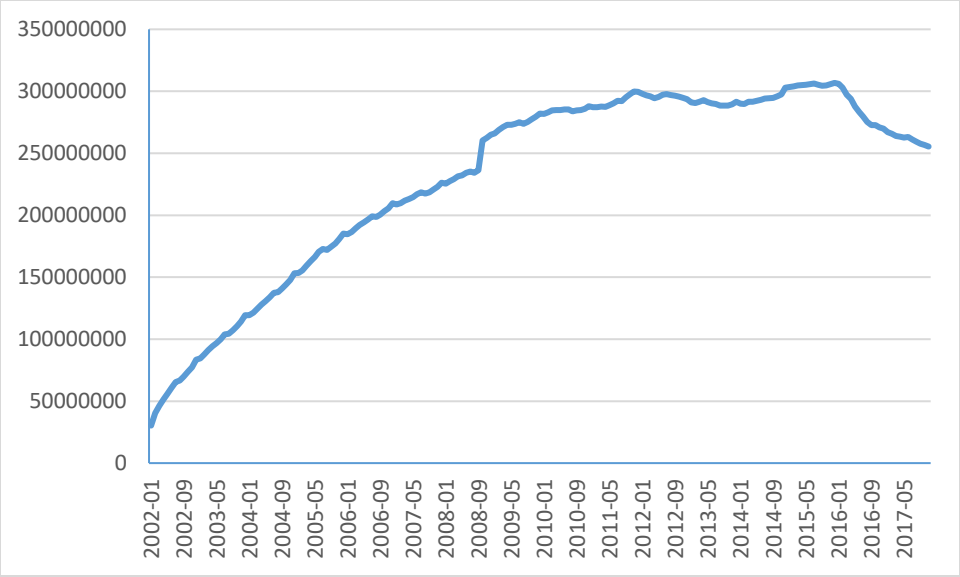


Figure 10. Diffusion (net circulation) of the euro.

Discussion

We find evidence to suggest that the diffusion of bitcoin can be modelled by the sigmoidal Richards function. Combined with the finding that the diffusion of the euro traced out an r-shaped curve rather than a sigmoidal curve, these results suggest that bitcoin is diffusing like a technology rather than like a currency. The application of abductive reasoning suggests that bitcoin is a technology rather than a currency.

As a currency, bitcoin also fails as a unit of account despite its rapidly appreciating physical and transactional value. It has a strong case for being the largest representative of an entirely new cryptocurrency asset class. Yet, the high correlation of bitcoin to derivative indices suggests significant speculative elements in its valuation, making absolute economic valuation difficult. At the same time, its inverse correlation to major currencies and competitive risk/return characteristics make it a viable portfolio investment. Expansion of the options, futures, and greater arbitrage between exchanges will improve both market liquidity and pricing in the future.

We also find that bitcoin behaves like an emerging asset class with high persistent correlations to derivative indices and an inverse relationship to major currencies. In fact bitcoin behaves unlike any national currency has behaved over at least the last 40 years. The return-for-risk profile has improved substantially since 2015, making bitcoin potentially appealing as a portfolio investment. However, its resemblance to several historical asset price bubbles poses substantial risks going forward.

When compared to other widely-accepted bubbles, bitcoin exceeds all others in length and magnitude. The rapid appreciation of bitcoin, particularly in 2017, has been unpresented when compared to price increases among historical assets. This does not necessarily lead to a valuation market, since bitcoin certainly possesses some underlying transactional economic value in parallel markets. However, even among economically viable entities: the South Sea Company in the 18th century or Cisco in the 21st century – substantial price collapses followed periods of

rapid appreciation. Applying the Case and Shiller (2003) definition, it appears bitcoin does indeed suffer from a hazard of great expectations to its future price. Historically, this has been an unsustainable position for such assets. While the collapse of cryptocurrency prices could be severe (as during the technology bubble of 1997-2001), the resulting market will be healthier and more grounded in rational economic value. The market will also determine which of the emerging cryptocurrencies possess the greatest value in the future blockchain economy. Bitcoin's true valuation lies between its basest role as black market tender and its aspiration to be a globally recognized alternative currency.

Conclusion

We find that bitcoin closely follows a sigmoidal Richards function in its diffusion and blockchain size. Further, we correlated bitcoin against major currencies in the last four decades. While bitcoin resembled some emerging market currencies through long, sustained appreciation, the magnitude of bitcoin's appreciation has been unprecedented. Contrary to its common classification as a commodity, bitcoin remains most closely related to option indices and inversely correlated to major currencies. Last, we find the bitcoin's rapid asset appreciation has exceeded the most prominently studied historical bubbles of the last three hundred years, posing substantial hazards in the near future for investors and technologists alike.

The present study contributes to the theory of currencies in part by clarifying what is not a currency. It contributes to the theory of cryptocurrencies by empirically classifying the behavior of a leading cryptocurrency. It contributes to the theory of technology by applying technology diffusion theory to a hybrid techno-financial instrument.

We have many unanswered questions about bitcoin that present many future avenues for research. Valuation models for cryptocurrencies are nearly absent from literature, and their development would help clarify many of the valuation fundamentals that remain unknown. In our research, we found that lower bitcoin betas and higher Sharpe ratios corresponded with the beginning of bitcoin's rapid recognition as a viable investment commodity in 2017. Identifying and predicting these characteristics would be useful for investors during the transition period from a closely-held niche technology to highly valued asset class. We are just beginning to grasp the implications of blockchain technology and cryptocurrency. Significant work must be accomplished before the potential of these technologies are realized.

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