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Assessing the viability of bitcoin as a currency and an alternative investment

Gustav Niblaeus
21249@student.hhs.se

Caroline Nylund
22005@student.hhs.se

Abstract: Intrigued by bitcoin's exceptional value development and media attention, we assess its viability as a currency and an alternative investment. First, we perform a statistical analysis of historical financial data on bitcoin and compare with traditional currencies, commodities and securities. Second, we analyse the relationship between bitcoin's value development and investor sentiment, using the largest online bitcoin forum as proxy. Third, we conduct interviews with industry experts to deepen the analysis. We conclude that bitcoin seems to exhibit features more similar to an alternative asset than a traditional currency. However, whether bitcoin will function as a currency or an alternative investment going forward depends on conflicting forces; it seems that the features that make bitcoin an attractive investment are also the factors that impede the functionality of bitcoin as a currency, and vice versa. In either case, the societal and user value introduced by bitcoin holds promise for its future viability.

Keywords: alternative investment, bitcoin, BTC, cryptocurrency, sentiment analysis

Tutor: Michael Halling

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1 Introduction

In this thesis, we assess the viability of bitcoin as a currency and an alternative investment. To examine this we perform a statistical analysis of historical financial data and investor sentiment, and analyse qualitative data collected through interviews with industry experts.

The statistical analysis of historical financial data comprises a comparison between bitcoin and selected benchmarks including traditional currencies, commodities, stocks and bonds. First, we assess the attractiveness of bitcoin as a currency and an alternative investment by comparing its return, risk and risk-adjusted return to those of the benchmark variables. Second, we proceed to examine the risk in more detail since bitcoin has a unique risk profile, which has implications on both the investment decision and on bitcoin's functionality as a currency and an alternative investment. To apply appropriate risk measures, we test for normality in the return distribution and find deviations, which lead us to apply historical Value-at-Risk. Third, we examine the tails of bitcoin's return distribution, since it is important to understand its exposure to extreme events. We are also interested in examining how bitcoin correlates with the benchmark variables in order to further assess its behaviour, and to understand whether it introduces any diversification and hedging possibilities. Finally, we perform a sentiment analysis, since bitcoin's exposure to extreme events suggests that its value development has not only been driven by rational investment decisions, but possibly also by investor sentiment. To deepen the analysis and gain an objective understanding of possible future scenarios for bitcoin, we also analyse qualitative data collected through interviews with seven industry experts with different backgrounds.

We find that bitcoin has substantially higher risk and return than any of our benchmark variables and that it outperforms all traditional currencies in terms of risk-adjusted return. Further, bitcoin has extensive tail risk, which however seems to be compensated for by extreme positive events. Overall, bitcoin could thus be attractive for investors with low risk aversion. We also find that bitcoin offers diversification benefits since it lacks correlation with any of our benchmark variables. Another interesting result is that bitcoin's value development seems to be closely related to general attention, which suggests that it does not derive from rational investment decisions. From the qualitative analysis, we find that the benefits introduced by bitcoin, especially the underlying technology, are too large to ignore.

We conclude that bitcoin seems to exhibit features more similar to an alternative asset than a traditional currency. There seem to be conflicting forces in whether it will function as a currency or alternative investment going forward, but in either case, the societal and user value introduced by bitcoin holds promise for its future viability.

1.1 Motivation

Bitcoin has gone from being a frenzy among high tech societies and gradually gaining attention, to becoming widely discussed in media and public. The phenomenon has engaged people from all around the world, and many prominent individuals have expressed opinions. Among these are;

“While these types of innovations may pose risks related to law enforcement and supervisory matters, there are also areas in which they may hold long-term promise”
(Alan Blinder, Vice Chairman of the FED)

“I think [bitcoin] is a technical tour de force.” (Bill Gates, Founder of Microsoft)

“The Bitcoin phenomenon seems to fit the basic definition of a speculative bubble — that is, a special kind of fad, a mania for holding an asset in expectation of its appreciation.”
(Robert J Shiller, Nobel Laureate in Economics)

Recent events such as the shut-down of the largest bitcoin exchange Mt. Gox (February 2014), the vice chairman of the Bitcoin Foundation, Charlie Shrem, being charged for money laundering by funnelling cash to Silk Road, an illicit online drug bazaar (January 2014) and FBI shutting down Silk Road, (October 2013) have directed additional attention to bitcoin (Figure 1).

Although the research on electronic cash and cryptography has evolved in recent decades, research on bitcoin and cryptocurrencies is a whole new research area and previous research is thus limited. While the research mainly seems to cover technical or macroeconomic aspects, it lacks a financial perspective which we aim to contribute with.

1.2 Research focus

Bitcoin was introduced as electronic cash, and has been described as for example a currency, a commodity and various types of financial assets. In an attempt to clarify the confusion and to assess whether bitcoin is feasible as an asset class for investment, we aim to answer the research question:

Does bitcoin have the potential to become a viable currency and an alternative investment?

By examining this research question, we aim to investigate whether bitcoin fulfils any function, or if the recent hype is a social phenomenon in response to the mythical founder, and the fact that it has made people overnight multi-millionaires.

It should be clarified that bitcoin is a digital cryptocurrency, which is to be distinguished from a virtual currency. Digital cryptocurrencies differ in the transaction feature of exchanging money for real goods and services, and are thus not limited to online circulation. Further, Bitcoin with a capital “B” refers to the network while bitcoin with a lower-case “b” refers to the unit of the network. Hereinafter, the unit bitcoin will be referred to as BTC.

1.3 Key features of bitcoin

BTC was first introduced on February 11, 2009, when the anonymous founder Satoshi Nakamoto posted a link to his research paper describing Bitcoin with the following comment:

“I’ve developed a new open source P2P e-cash system called Bitcoin. It’s completely decentralized, with no central server or trusted parties, because everything is based on crypto proof instead of trust. Give it a try...” (Satoshi Nakamoto, February 11, 2009)

This came to be the start of what could potentially become a new era of digital currencies. Since 2009 several cryptocurrencies such as Namecoin, Litecoin, Peercoin and Mastercoin have been launched. However, the idea of digital currencies and electronic cash can be derived from 1982, when researcher David Chaum introduced his ideas of digital cash and blind signatures.

BTC is a decentralized digital currency, based on a peer-to-peer (P2P) network. The underlying software, Bitcoin, is a free, open-source protocol meaning that the network is collectively organized as opposed to fiat money, which is controlled and issued by a central authority. Bitcoin enables instant P2P transactions i.e. directly between network users, without any third party intervention, as well as worldwide payments and low transaction fees.

Since the introduction in 2009, the protocol has been viewed, monitored, reported and improved by the network which has the authority to modify the protocol by majority consent. Since BTC is not controlled by any central authority, the money supply and the transactions are instead controlled by the network itself, by so called miners. Mining is the process in which new BTC are realised. To control the supply and thus the value, the underlying protocol makes mining progressively more difficult.

Miners confirm transactions by including them in the block chain, a public record of all BTC transactions which serves to verify transactions and prevent double-spending. A transaction is basically a transfer between two Bitcoin addresses, i.e. digital wallets in which BTC are held. The wallet is personal and has a unique address to which a private key is assigned. The key constitutes a secret piece of data that confirms the ownership and thus the spending right through a cryptographic signature. By using this signature a transfer can be completed. Since the Bitcoin address is not transparently linked to any individual, and thus a level of anonymity can be achieved, BTC has been used in illegal transactions. Further, transaction fees constitute a reward to the miners for their service to confirm the transactions and thus to create incentive to maintain the network.

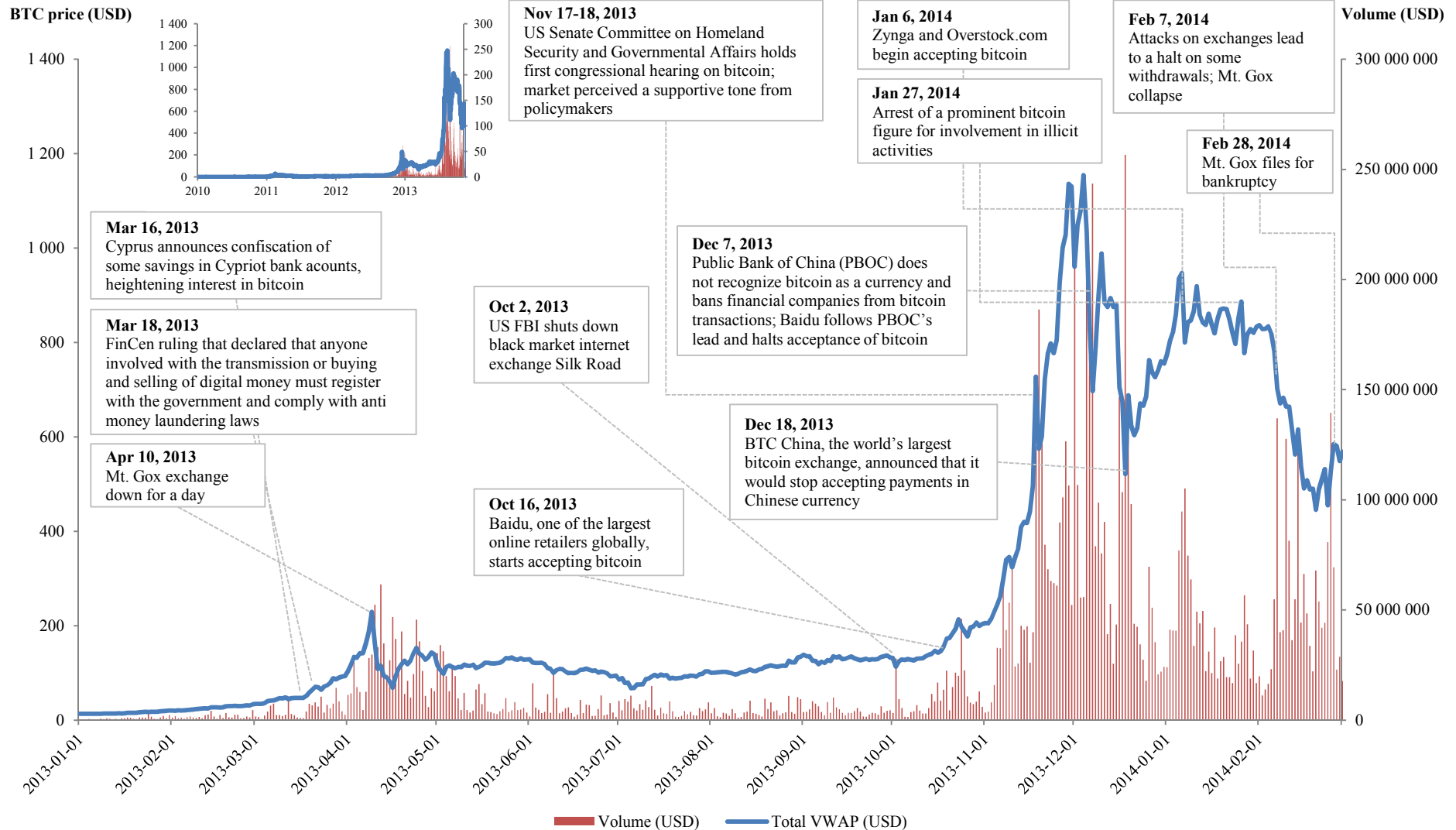
The BTC economy is limited to around 21 million BTC with a predictable increase of supply until it is fully realized in year 2140. The value of BTC is not pegged to, or derived from, any underlying fundamentals but is determined by supply and demand. BTC can be exchanged for fiat money on specific exchanges including Bitstamp, BTC-e and Safello.

The BTC landscape, including companies providing infrastructure, middleware and applications, is under development. In parallel, an increasing amount of retailers start accepting BTC as payment even though the use of BTC as medium of exchange is still very limited. In addition, legal authorities around the world are developing regulatory frameworks.

FIGURE 1

BTC price and volume

This graph shows the volume-weighted price of BTC and volume traded from January 1, 2013 – February 28, 2014



2 Previous research

2.1 Literature review on bitcoin

While Bitcoin has received considerable attention in the literature, most of the academic research is focused on the technical aspects of the underlying protocol. There is also a substantial amount of research on the regulatory and legal aspects of BTC and other cryptocurrencies. However, research on the value development of BTC is limited to only a few articles.

Yermack (2013) examines the historical trading behaviour of BTC to see whether it behaves like a traditional currency. He compares the volatility of the BTC/USD exchange rate to the volatilities of the exchange rates of the Euro, Yen, British Pound, and Swiss Franc as well as the price of gold, and finds that the volatility of the BTC exchange rate is significantly higher than any other currency and gold. Further, Yermack (2013) studies the movement of BTC to other currencies, as well as to the gold price and finds that the BTC/USD exchange rate exhibits almost zero correlation with the other exchange rates or with the price of gold.

Yermack (2013) concludes that BTC fails to conform to the classical properties of a currency. It does not behave like a currency at all, but rather resembles a highly speculative investment like the internet stocks of the late 1990s. Since it lacks correlation with other currencies and gold, it is ineffective as a risk management tool, which is a common use for currencies.

Kristoufek (2013) studies the relationship between the BTC/USD exchange rate and search queries on Google and Wikipedia, where the search queries serve as a proxy for investors' sentiment. He finds a strong and statistically significant correlation between the BTC price and search queries on both Google and Wikipedia. A crucial disadvantage of Kristoufek's method, which he also recognises in the paper, is the fact that it does not distinguish between positive and negative interest in BTC. The investor sentiment proxy variables are simply the number of searches on Google per week and number of daily page views on Wikipedia respectively.

Hanley (2013) analyses the features of BTC from a more theoretical and highly critical view. He argues that Bitcoin's developers combine technical implementation proficiency with ignorance of currency and banking fundamentals; that there are several fundamental errors with BTC as a currency. According to Hanley, the asymptotic limit of the number of BTC at 21 million is one major flaw. For BTC to become a major currency, the valuation of each BTC

would have to increase by several hundred times. No rational player would use BTC for spending purposes if such a value development is expected. Hence, the limited number of BTC increases the incentive to hoard, which further decreases the credibility of BTC supporting actual commerce. Consequently, the valuation of BTC will always be determined by speculation rather than by utility for spending, according to Hanley. He further argues that with BTC, reserve banking is impossible. Since BTC are unique and cannot be duplicated, it is impossible to create new money by issuing a loan. Hence, a bank can only issue loans in BTC corresponding to the exact same amount that it has in deposits.

Hanley brings forward several other arguments against the viability of BTC and concludes that, contrary to what the developers of BTC intended, it cannot be a significant disruptive force to financial markets.

Barber et al. (2012) investigate the underlying reasons for the success of BTC compared to other crypto- or digital currencies, and also how BTC could become a long-lived stable currency. Among the key success factors of BTC, they mention the fact that BTC has a completely decentralized architecture, without any single trusted entity. Further, they argue that the Bitcoin ecosystem is ingeniously designed, and ensures that users have economic incentives to participate in the mining and transaction verification process. The predictable money supply also provides incentives for early adopters – the earlier in the game, the cheaper the mining. Other advantages are the open-source nature of the Bitcoin protocol, which has created a flourishing ecosystem surrounding BTC, as well as the low transaction fees, which is attractive in micropayments.

While the predictable money supply is mentioned as an advantage, Barber et al. argue that the upper limit is one of the key structural problems with BTC. This limit results in what Barber et al. call a deflationary spiral; even if BTC gains only a marginal acceptance as a currency, each BTC would have to appreciate tremendously. In line with Hanley, Barber et al. conclude that this potential for appreciation means that BTC will tend to be saved (or hoarded) rather than spent.

2.2 Literature review on investor sentiment and sentiment analysis

Sentiment analysis seeks to identify the underlying viewpoints of a certain text, and has long gained interest among the research community (Carbonell, 1982; Wilks & Bien, 1983). Following the popularity of social media, the availability of opinion-rich resources has

increased and thus the opportunity to analyse and benefits from the information holds great potential (Pang & Lee, 2008).

Within behavioural finance, research on how sentiment affects investors' trading decisions has become increasingly studied. These theories contradict the traditional finance models where rational investors force asset prices to equal the present value of expected future cash flows. DeLong (1989), along with the majority of behavioural pricing models, assumes two types of investors including rational arbitrageurs holding Bayesian beliefs and irrational noise traders. Both traders are assumed to have downward sloping demand due to risk aversion and capital constraints and consequently these assumptions imply an equilibrium in which noise traders' random beliefs about future cash flows influence prices. This thus suggests that low sentiment exhibits a downward price pressure and that abnormal sentiment levels will generate high volume.

Antweiler and Frank (2004) extract sentiment from posts on the online forums Yahoo! Finance and Raging Bull and characterize the content as buy, sell, or hold recommendations. Comparing these to the Dow Jones Industrial Average and Dow Jones Internet Index they find that stock messages can predict market volatility. They further find that the volume of posts and the disagreement between posts predict trading volume.

Brown and Cliff (2005) measure investor sentiment by categorizing market newsletters as bullish, bearish or neutral. They subsequently test the hypothesis that excessive optimism leads to periods of market overvaluation, and if so, that high current sentiment is followed by low cumulative long-run returns as the market price reverts to its intrinsic value. By relating sentiment levels directly to stock price deviations from fundamental value they find significant support for asset values being affected by investor sentiment. Namely, overly optimistic (pessimistic) investors drive prices above (below) fundamental values, however reverting over a multi-year horizon.

Tetlock (2007) further investigates the role of media in asset pricing by measuring the interaction between media, the Wall Street Journal column "Abreast of the Market", and the stock market, Dow Jones. In line with previous researchers he finds results showing that high pessimism predicts downward pressure on prices and abnormal sentiment levels predicts high trading volumes.

Baker and Wurgler (2007) suggest that stocks which are difficult to value, such as those of companies that are young, more volatile, with extreme growth potential or analogous characteristics, are most affected by sentiment. The lack of historical performance and the high uncertainty about the future allows for sentiment-based valuations. They also suggest that young, inexperienced investors as opposed to older, experienced investors are more likely to be subject to sentiment.

3 Data & methodology

Our study is based on a combination and extension of Yermack (2013) and Kristoufek (2013). Previous research is based on the relatively stable BTC price development until November 2013, as compared to recent developments where trading activity and volatility has increased significantly. Including this period enables a further analysis and deeper understanding of the underlying dynamics of BTC. Although BTC was first traded in the market on April 25, 2010, the daily trading volume was initially very low, and exceeded USD1,000 on a regular basis only towards the beginning of 2011. Hence, we have chosen to carry out the analysis for a selected period from January 1, 2011 until February 28, 2014 (time period 1). This gives a total of 1,155 observations of daily returns.

Since the trading volume increased significantly in 2013, and especially towards the end of 2013, we have chosen to carry out the analysis for two additional time periods: firstly, from January 1, 2013 to February 28, 2014 (time period 2) and, secondly, from October 1, 2013 to February 28, 2014 (time period 3), which consist of 424 and 151 daily observations respectively.

Our study is carried out in three inter-related parts in order to assure a clear structure so that the reader can easily follow the analysis. First, we perform a statistical analysis on financial data which is extended with a sentiment analysis and followed by a qualitative analysis.

3.1 Statistical analysis

The statistical analysis comprises a comparison between the historical daily returns of BTC to the historical daily returns of traditional currencies, stocks, bonds and commodities to assess whether BTC exhibits similar characteristics.

We have collected historical BTC/USD prices and trading volumes from www.bitcoincharts.com, a webpage which provides financial and technical data related to BTC.

Based on this we have constructed a volume-weighted price index of all the BTC exchanges which have been active in BTC/USD trading during the selected time period. BTC exchanges operate 24/7, but all price quotes are as per midnight UTC. For the variables which are only traded on weekdays, we have interpolated values for the weekends and holidays, with the function *ipolate* in Stata. In total, the index includes 39 exchanges. The three largest exchanges, based on trading volume, are Mt. Gox, Bitstamp and BTC-e which account for 35.9%, 25.5% and 21.9% of the total trading volume respectively.

The analysis comprises five benchmark currencies including the Chinese Yuan (CNY), the Euro (EUR), the British Pound (GBP), the Japanese Yen (JPY), and the Swiss Franc (CHF) with historical daily exchange rates against the USD, collected from www.oanda.com. After the USD, EUR, GBP and JPY are the most traded currencies in the world. CHF has historically been considered as a safe haven currency for several reasons, including the fact that Switzerland was one of the last countries to decouple from gold, and the fact that it is a neutral country with a central bank which maintains a strict policy of price stability. We have also chosen to include CNY in our comparison, since China is a prominent Bitcoin country and since CNY is one of the most traded currencies in the world. Since CNY is partly pegged to a basket of currencies, it might differ in behaviour from the other currencies.

We have collected the daily London gold price as measured in USD per troy ounce at 10.30 a.m., and the daily crude oil Brent price as measured in USD per barrel, from the Federal Reserve Economic Data (FRED). As proxies for the stock and bond markets we use S&P 500 and BofA Merrill Lynch US High Yield Master II Total Return Index, which have also been collected from FRED. These indices are commonly used as benchmarks for the stock and bond markets respectively.

As a proxy for the risk-free rate, we have used the 3-year Treasury Constant Maturity Rate with daily frequency, to match the time horizon of our longest time period (time period 1). The risk-free rate has also been downloaded from FRED.

In line with Yermack (2012) our analysis comprises a variety of statistical measures including risk, return and correlation. However, to obtain more support for assessing the viability of BTC as a currency and an alternative investment, we extend the analysis to also include Sharpe ratio, test for normality and Value-at-Risk (VaR). First, we compare standard risk and return measures of all variables to assess whether they exhibit similar characteristics. Then, we look

at correlation to examine if BTC moves in tandem with any of our other variables, and whether there are any potential possibilities to hedge BTC, or use it to diversify an investment portfolio.

We then calculate 6-month rolling annualized Sharpe ratios to illustrate the risk-return trade-off. The rolling returns and standard deviations have been calculated with January 1, 2011 as start date. The Sharpe ratio is a commonly cited statistic in financial analysis and evaluates the risk-adjusted performance of an investment. Based on this, we can assess the attractiveness of BTC as compared to the other variables. Due to the high volatility of the BTC/USD exchange rate, we have calculated 6-month rolling Sharpe ratios to better capture the trend over the different time periods. For each variable, the Sharpe ratios have been calculated as follows:

$$\text{Annualized Sharpe ratio} = \left(\frac{E(r - r_f)}{\sqrt{\text{Var}(r - r_f)}} \right) \times \sqrt{365}$$

However, the Sharpe ratio is limited in the assumption of normal distribution. Deviations from normality in terms of kurtosis and skewness can distort the ratio. Hence, we test the normality of the return distributions of each variable with the function *sktest* (SK-test) in Stata. SK-test combines a skewness and a kurtosis test into an overall test statistic based on which normality can be confirmed or rejected. The function is based on a test developed by D'Agostino et al. (1990), with the empirical correction developed by Royston (1991). However, both D'Agostino et al. and Royston stress the fact that researchers should not blindly rely on few test statistics alone when determining normality, but also examine the plot of the distribution. For this reason, we also examine histograms of the return distributions.

We then progress to employ some more sophisticated measures of risk, namely fat tails and historical VaR. This allows us to examine the likelihood of extreme events and its subsequent implications on investment evaluation. Tail risk gained attention in 2007 after the publication of *The Black Swan* by Nassim Taleb, who argued that investors often underestimate the likelihood as well as the impact of extreme events. VaR is today a widely used measure for the risk of loss in a certain portfolio, and as opposed to volatility, it measures only downside risk. Specifically, VaR measures the potential loss in value of a risky asset or portfolio over a defined period of time for a given confidence interval.

There are three basic approaches to calculate VaR: the historical method, which we have used, the variance-covariance method and the Monte Carlo simulation. As opposed to the other

methods, the historical method requires no assumption about the nature of return distributions, which is the main reason for our choice of method. However, for the VaR measure to be relevant, the historical method implicitly assumes that the historical data is a representative sample of the risks looking forward (Damodaran, 2007). We use histograms to illustrate the historical VaR at a 95% confidence level.

3.2 Sentiment analysis

The value development of BTC and its exposure to extreme events indicate that it is a highly speculative asset in which noise traders are attracted to invest. This implies that pricing is influenced by noise rather than equalling the present value of future cash flows, as suggested by traditional finance models with rational investors (DeLong, 1989). Baker and Wurgler (2007) strengthen our hypothesis that BTC is affected by sentiment since it exhibits similar features to young, volatile growth companies. Further, Kristoufek (2013) has found support for strong correlation between the BTC price and investor interest and attention.

To investigate this possibility, we first perform an analysis on search queries for “bitcoin” on Google. This method is in line with Kristoufek’s analysis, but we extend the time period and compare weekly changes in searches with weekly changes in the BTC/USD price, as opposed to absolute numbers. We collected data by downloading weekly searches for “bitcoin” from Google Trends, a public web facility provided by Google, which shows search frequencies relative to the total search volume and over time. The highest frequency available is searches per week. Over our longest time period, this gives a total of 169 observations.

However, Kristoufek (2013) recognizes a limitation in not distinguishing between positive and negative sentiment. Subsequently, we move on to perform a more thorough sentiment analysis that distinguishes between sentiment types.

As a proxy for investor sentiment, we have collected forum data from bitcointalk.org, the largest online bitcoin forum, through running a script written by Kairo’s Future, an international research and consulting firm specializing in foresight, market research and scenario-based strategy and innovation. The online forum, started by Satoshi Nakamoto in 2009, hosts free discussions of Bitcoin and related topics and is operated as a service to the Bitcoin community. We have limited the data to include only the forum discussion topics directly linked to Bitcoin, namely the categories “Bitcoin” and “Economy”. As of February 28, 2014 the forum had 259,430 members. During the selected period the average daily page views amounted to

687,920, pending from zero to 8,103,452, with a steady upward trend. The average amount of new posts per day amounted to 4,665.

Sentiment analysis is commonly performed by counting the frequency of words, which have been categorised into sentiment categories by a specified lexicon. Since there is currently no consensus on lexicon performance (Gonçalves et al., 2013) we have chosen to employ a finance adapted lexicon to better fit the finance-related data. It was designed by Loughran and McDonald (2011) and has been established upon previous research (Solomon, 2012; Da et al., 2011). It consists of 2,329 negative, 297 uncertain and 354 positive words. Based on this, Kairo's Future have processed the distracted data and generated a frequency list of positive, negative, uncertain and total number of words per day. The data set includes 1,136 observations between January 1, 2013 and February 13, 2013.

To validate the ability of the word list to capture sentiment we randomly select forum posts included in the data set and identify lexicon words. Table 1 provides an example of contexts from which the words were extracted.

TABLE 1

Example of sentiments in the bitcointalk.org forum

This table shows selected forum posts from bitcointalk.org, and three different types of sentiment as captured by our word lists. The words in bold font have been counted, and the third column shows the total frequency of these words in the forum.

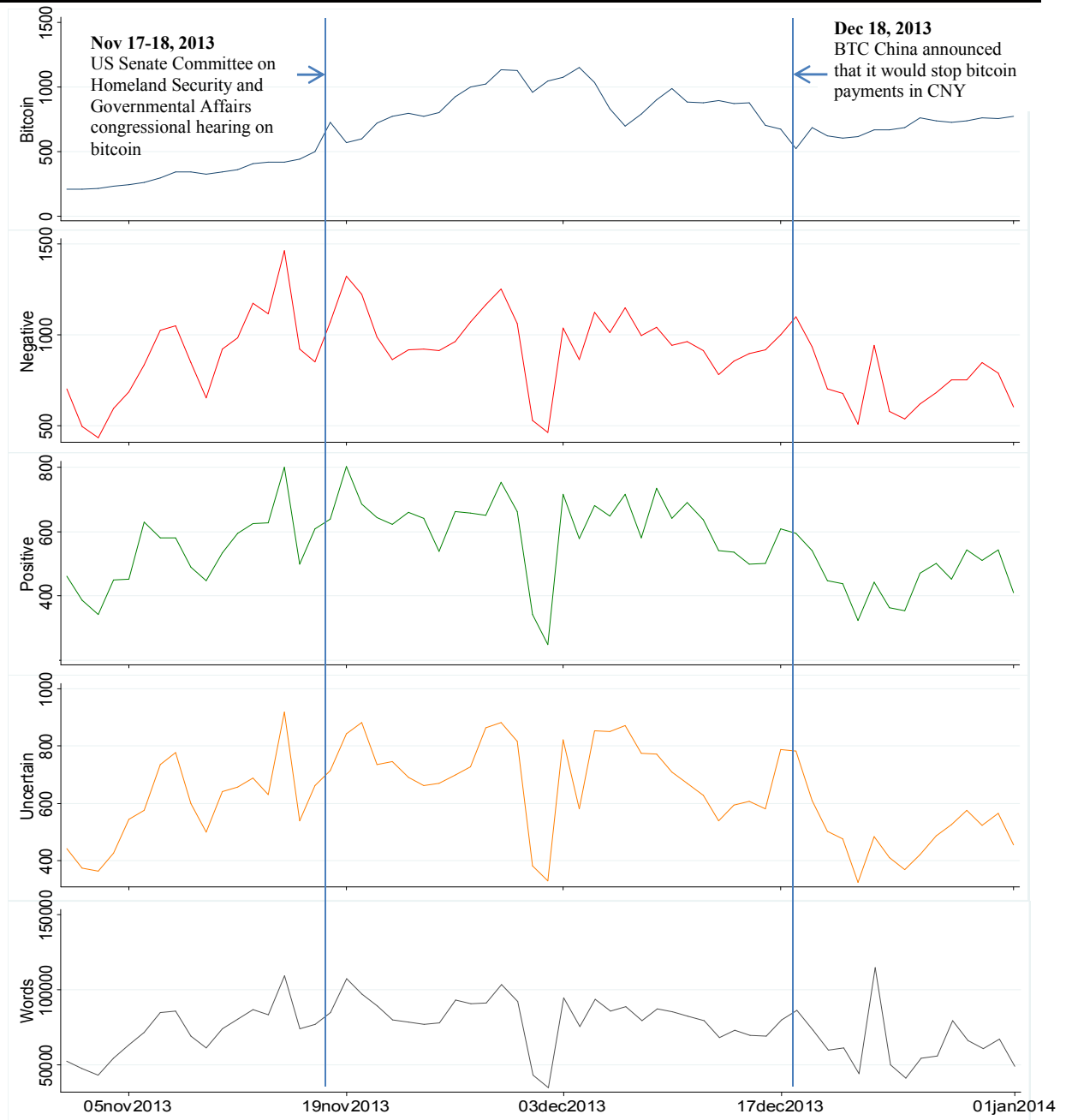
Sentiment	Forum post	Frequency of selected words	
Negative	"Re: BTC gone / Transaction History gone at MtGox" I saw someone else with this issue post a few days ago, so this must be an actual bug. That's pretty bad . It's gotta be worse for MagicalTux, though, since he'll have to pour through a lot of logs to resolve this.	#bad:	14,283
		#worse:	2,759
Uncertain	"Doubt Bitcoin?" I can understand the doubt , actually. It is a volatile time for Bitcoin and it's premise is not 100% fool-proof - at least not yet or determined to be.	#doubt:	4,719
		#volatile:	919
Positive	"Huge arbitrage opportunity at Tradehill" Why isn't anyone taking advantage of the tradehill arbitrage opportunity ? Right now someone is bidding 16.0 on Tradehill. Sell there, buy back on Mt. Gox for less than 15 and boom, you're in quick and easy money.	#advantage:	2,994
		#opportunity:	2,911
		#easy:	10,706

In addition, we validate the frequency lists of words by selecting two extraordinary events which should be reflected in forum activity. Figure 2 provides an example of these events and the related forum activity.

FIGURE 2

Example of activity in the bitcointalk.org forum

This figure shows the forum activity and the BTC price between November 1, 2013 and January 1, 2014, and two randomly selected events.



After validating the data, we compare the frequency lists to the BTC price. First, we examine the correlation between BTC price and sentiment in levels. However, this could be affected by the strong general upward trend in both BTC price and increased activity in the forum. Thus, we also compare changes in words to changes in BTC price to avoid the effect from the upward trend.

By analysing daily changes in frequency of words to the daily BTC returns we examine if they exhibit any correlation. We also compare changes in BTC to changes in the fractions of negative, positive and uncertain words, as a share of the total number of words.

3.3 Qualitative analysis

We have collected qualitative data from meetings with selected industry experts from different backgrounds to obtain comprehensive data for the analysis. Since Bitcoin is a new and complex phenomenon we believe that this will enhance our assessment of BTC as a currency and an alternative investment. We have conducted interviews with; (i) Ludvig Öberg, Bitcoin enthusiast and VP of business development at Safello; (ii) Jon Matonis, Executive Director for the Bitcoin Foundation; (iii) Robin Teigland, Associate Professor at the Center for Strategy and Competitiveness at the Stockholm School of Economics; (iv) Lars Ljungqvist, Professor in Macroeconomics at the Department of Economics at the Stockholm School of Economics; (v) Maria Freme and Thomas Larsson, Skatteverket, and; (vi) Frank Schuil, CEO and co-founder of Safello. All interviews lasted for about 30 to 45 minutes, were recorded and transcribed within 12 hours to preserve the impressions from the interactions.

Data was also obtained from live attendance at the Swedish Bitcoin Conference 2014, a Bitcoin fair held in Stockholm on April 3, 2014, organized by Kurt Andersen, Managing Director at CAC card academy. These data were handled according to the same procedure as for the interviews.

4 Results

4.1 Statistical results

Initially, we examine the risk and return of BTC compared to the other variables, both in terms of average daily returns and standard deviation, as well as in terms of absolute return and annualised standard deviation.

Table 2 shows that BTC has historically exhibited remarkably high return and volatility. Even though it has outperformed all other variables in all three time periods in terms of return, it has also been much more volatile. In terms of the benchmark variables, the traditional currencies have exhibited similar characteristics with low return and low volatility. However, CNY has showed distinctly lower volatility which is expected since it is partly pegged.

Gold has shown an annualized volatility of between 14-17% during the three time periods which is surprisingly high since gold, like traditional currencies, is commonly used as a store of value. The volatility of gold is higher than the volatility of both S&P 500 and for bonds.

TABLE 2

Summary statistics of daily returns, time periods 1, 2 and 3

These three tables show average daily return (Mean), standard deviation (SD), absolute return over the whole time period and annualized standard deviation (Ann SD) for the daily changes of all our variables for the three time periods respectively. The variables include BTC, CNY, EUR, GBP, JPY and CHF, with all exchange rates measured against the dollar, the daily crude oil Brent price as measured in USD per barrel, the daily London gold price as measured in USD per troy ounce at 10.30 a.m., S&P 500 and BofA Merrill Lynch US High Yield Master II Total Return Index (Bonds).

Stats	BTC	CNY	EUR	GBP	JPY	CHF	Oil	Gold	S&P 500	Bonds
Mean	0.93%	0.01%	0.00%	0.01%	-0.02%	0.01%	0.02%	0.00%	0.04%	0.02%
SD	7.44%	0.15%	0.39%	0.31%	0.41%	0.47%	1.11%	0.90%	0.79%	0.17%
Abs Ret	182,905%	8%	3%	7%	-20%	5%	16%	-6%	47%	33%
Ann SD	142%	3%	7%	6%	8%	9%	21%	17%	15%	3%

Stats	BTC	CNY	EUR	GBP	JPY	CHF	Oil	Gold	S&P 500	Bonds
Mean	1.18%	0.01%	0.01%	0.01%	-0.04%	0.01%	0.00%	-0.05%	0.06%	0.02%
SD	7.73%	0.10%	0.31%	0.30%	0.49%	0.36%	0.84%	0.89%	0.54%	0.14%
Abs Ret	4,028%	3%	4%	3%	-16%	3%	-3%	-21%	29%	10%
Ann SD	148%	2%	6%	6%	9%	7%	16%	17%	10%	3%

Stats	BTC	CNY	EUR	GBP	JPY	CHF	Oil	Gold	S&P 500	Bonds
Mean	1.41%	0.00%	0.01%	0.02%	-0.03%	0.01%	0.01%	0.00%	0.07%	0.04%
SD	9.75%	0.04%	0.25%	0.25%	0.31%	0.29%	0.70%	0.72%	0.56%	0.08%
Abs Ret	318%	0%	1%	3%	-4%	2%	2%	0%	10%	6%
Ann SD	186%	1%	5%	5%	6%	6%	13%	14%	11%	1%

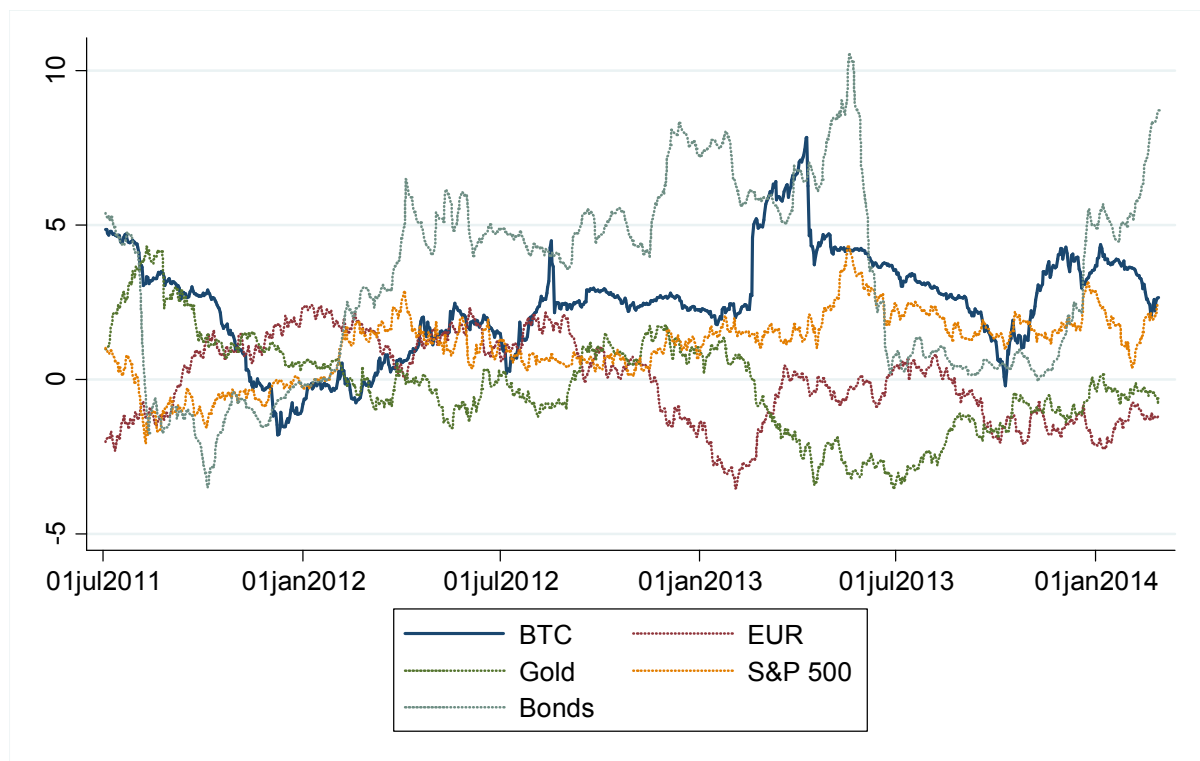
We move on to examine the risk-adjusted return to assess the attractiveness of the variables as investments. Figure 3 shows a comparison of rolling Sharpe ratios for selected variables over the full time period. For all variables, see appendix.

BTC has outperformed all other variables during 27% of the time period and all traditional currencies during 69% of the time (Figure 7). However, the Sharpe ratio of BTC has varied widely during this period. Given the high variation, it is difficult to assess the general trend; the Sharpe ratio of BTC has been higher as well as lower than the other variables at different times.

FIGURE 3

6-month rolling Sharpe ratios, selected variables

This figure shows 6-month rolling, annualized Sharpe ratios for a selection of our variables between July 2, 2011 and February 28, 2014. The rolling returns and standard deviations have been calculated with January 1, 2011 as start date.



Next, we perform a test for normality to assess the return distribution and its implications on performance measures. From Table 3, we can conclude that the SK-test suggests a rejection of the hypothesis that the daily returns of BTC are normally distributed in all three time periods.

In period 1 and 2, the joint test suggests that the daily returns of the other variables, are not normally distributed either. However, on the basis of skewness alone, we cannot reject the hypothesis that several of the variables are normally distributed.

In period 3 however, we cannot reject the hypothesis that CNY, GBP and oil are normally distributed, at least at the 7%, 21% and 8% levels respectively.

TABLE 3

SK-test for normality, time periods 1, 2 and 3

These tables show tests for normality for all our variables for the three time periods respectively. The variables include BTC, CNY, EUR, GBP, JPY and CHF, with all exchange rates measured against the dollar, the daily crude oil Brent price as measured in USDs per barrel, the daily London gold price as measured in USDs per troy ounce at 10.30 a.m., S&P 500 and BofA Merrill Lynch US High Yield Master II Total Return Index (Bonds).

Variable	Obs	Pr(Skewness)	Pr(Kurtosis)	-----Joint Test-----	
				adj chi2(2)	Prob>chi2
BTC	1,200	0.0000	0.0000		0.0000
CNY	1,200	0.0441	0.0000		0.0000
EUR	1,200	0.0021	0.0000	61.24	0.0000
GBP	1,200	0.3360	0.0000	43.85	0.0000
JPY	1,200	0.0000	0.0000		0.0000
CHF	1,200	0.0000	0.0000		0.0000
Oil	1,200	0.0000	0.0000		0.0000
Gold	1,200	0.0000	0.0000		0.0000
S&P 500	1,200	0.0008	0.0000		0.0000
Bonds	1,200	0.0000	0.0000		0.0000

Variable	Obs	Pr(Skewness)	Pr(Kurtosis)	-----Joint Test-----	
				adj chi2(2)	Prob>chi2
BTC	424	0.0100	0.0000	57.150	0.0000
CNY	424	0.0000	0.0000		0.0000
EUR	424	0.0782	0.0000	52.300	0.0000
GBP	424	0.8054	0.0000	26.240	0.0000
JPY	424	0.1239	0.0000	30.940	0.0000
CHF	424	0.0015	0.0000	50.200	0.0000
Oil	424	0.7164	0.0000	29.110	0.0000
Gold	424	0.0000	0.0000	72.090	0.0000
S&P 500	424	0.1029	0.0000	26.620	0.0000
Bonds	424	0.0000	0.0000		0.0000

Variable	Obs	Pr(Skewness)	Pr(Kurtosis)	-----Joint Test-----	
				adj chi2(2)	Prob>chi2
BTC	151	0.0037	0.0000	21.890	0.0000
CNY	151	0.2370	0.0475	5.270	0.0716
EUR	151	0.0013	0.0007	17.600	0.0002
GBP	151	0.4253	0.1167	3.150	0.2073
JPY	151	0.4976	0.0029	8.390	0.0151
CHF	151	0.5052	0.0021	8.820	0.0122
Oil	151	0.5422	0.0331	4.940	0.0846
Gold	151	0.0406	0.0002	15.020	0.0005
S&P 500	151	0.2740	0.0002	12.790	0.0017
Bonds	151	0.0000	0.0000	41.150	0.0000

In addition to the SK-test we also graphically examine the return distributions of all variables to confirm the absence of normality.

Figure 4 clearly shows that the daily BTC returns are not bell shaped, i.e. clustered around the mean, as illustrated by the superimposed normal density function. Thus, in line with the SK-test, the histogram confirms the deviation from normality for BTC.

For the other variables, see Figure 9. The scales differ for the histograms and we note that the tails are much longer for BTC as compared to the other variables, suggesting that BTC is more exposed to extreme events. For BTC, the scale ranges from -0.4 to +0.6 whereas for the most volatile currency, JPY, it ranges from -0.03 to +0.02. Again, CNY stands out as the most stable currency, likely due to the fact that it is pegged.

As shown in the bottom left figure (Figure 4), the distribution of the worst 5% daily returns lies in a range between c.2 to c.5 standard deviations which, given the high standard deviation of BTC at 7.44%, corresponds to a negative daily return of c.-10% to c.-40%. The two worst returns occurred on June 11, 2011 and April 11, 2013, with returns of -38.8% and -36.7% respectively. The major losses were triggered by a successful attack on Mt. Gox and a trading halt on Mt. Gox respectively.

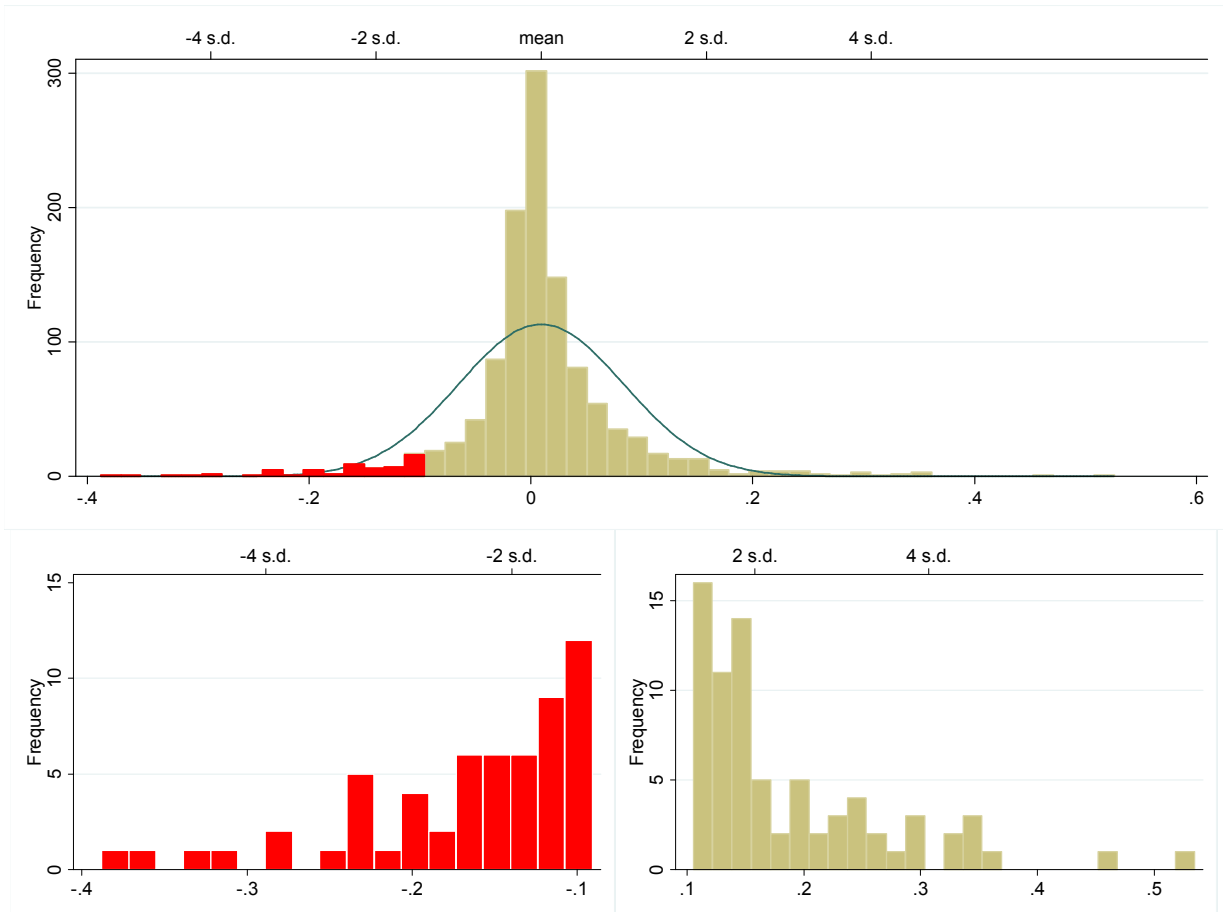
However, the bottom right figure indicates that investors have been compensated for the extreme negative events. The two best returns occurred on May 10, 2011 and 18 November, 2013, with returns of 52.6% and 45.9% respectively. No particular event seems to explain the abnormal return on May 10, 2011 but November 18, 2013 was the day of the US congressional hearing on Bitcoin when policymakers showed support for BTC.

The deviations from normality weaken the implications of the Sharpe ratio. Subsequently, VaR provides a more sophisticated measure of risk, as it is independent of the distribution of returns. In the histograms, the red bars illustrate the VaR at a 95% confidence level. The corresponding numbers are shown in Table 4.

FIGURE 4

Distribution of daily BTC returns, time period 1

The top figure shows the distribution of daily BTC returns for January 1, 2011 to February 28, 2014. The red columns illustrate the downside risk at 5% level. The bottom two figures show the 5% tails of daily BTC returns for time period 1; the left figure illustrates the lowest 5% of daily returns, and the right figure illustrates the highest 5% of daily returns. For the other two time periods, and all other variables in period 1, see appendix.



As compared to the other variables, the historical VaR for BTC is significantly larger in all three time periods. The VaR for BTC implies that, historically, 95% of daily losses have not exceeded 9.7% in time period 1 as compared to 16% in time period 3. The corresponding losses for the most risky traditional currencies, EUR, JPY, and CHF are 0.7% and 0.5% respectively.

TABLE 4**VaR at a 95% level of confidence, time periods 1, 2 and 3**

This table shows VaR at a 95% level of confidence for all our variables for the three time periods respectively. The variables include BTC, CNY, EUR, GBP, JPY and CHF, with all exchange rates measured against the dollar, the daily crude oil Brent price as measured in USD per barrel, the daily London gold price as measured in USD per troy ounce at 10.30 a.m., S&P 500 and BofA Merrill Lynch US High Yield Master II Total Return Index (Bonds).

Variable	Period 1	Period 2	Period 3
BTC	-9.7%	-10.3%	-16.0%
CNY	-0.2%	-0.1%	-0.1%
EUR	-0.7%	-0.5%	-0.5%
GBP	-0.5%	-0.5%	-0.4%
JPY	-0.7%	-0.9%	-0.5%
CHF	-0.7%	-0.6%	-0.5%
Oil	-1.8%	-1.4%	-1.1%
Gold	-1.5%	-1.6%	-1.3%
S&P 500	-1.2%	-0.8%	-0.8%
Bonds	-0.2%	-0.1%	-0.1%

Even though BTC has exhibited unparalleled return and extreme volatility, it is possible that it moves in tandem with any other variable, but with amplified swings. Thus, we move on to investigate correlation.

It is evident from Table 5 that BTC shows virtually no correlation with other variables in either period (for the other two periods, see appendix). The only significant correlations are between BTC and oil in period 1, and BTC and S&P 500 in period 2. However, the correlation of BTC to both variables is too low for this to have significant implications. All other variables exhibit different levels of significant correlation with each other. Especially, the three European currencies exhibit strong and statistically significant correlation with each other. JPY and CNY also show positive correlation to the other currencies, but on lower levels. Further, whereas bonds and S&P 500 also exhibit positive correlation to each other, commodities only seem vaguely correlated both to each other and the other variables.

TABLE 5

Correlation of daily returns, time period 1

This table shows correlations for the daily changes of all our variables between January 1, 2011 and February 28, 2014. The variables include exchange rates for pairs of currencies, with all exchange rates measured against the dollar, the daily crude oil Brent price as measured in USD per barrel, the daily London gold price as measured in USD per troy ounce at 10.30 a.m., S&P 500 and BofA Merrill Lynch US High Yield Master II Total Return Index (Bonds).

Variables	BTC	CNY	EUR	GBP	JPY	CHF	Oil	Gold	S&P 500	Bonds
BTC	1.00									
CNY	0.01 (0.81)	1.00								
EUR	0.03 (0.37)	0.24*** (0.00)	1.00							
GBP	0.04 (0.13)	0.25*** (0.00)	0.65*** (0.00)	1.00						
JPY	0.02 (0.50)	0.11*** (0.00)	0.13*** (0.00)	0.19*** (0.00)	1.00					
CHF	0.00 (0.87)	0.18*** (0.00)	0.65*** (0.00)	0.47*** (0.00)	0.31*** (0.00)	1.00				
Oil	0.07** (0.02)	-0.04 (0.19)	-0.01 (0.68)	0.01 (0.64)	0.04 (0.18)	-0.05* (0.10)	1.00			
Gold	0.03 (0.26)	0.01 (0.72)	0.03 (0.27)	0.09*** (0.00)	0.08*** (0.01)	0.12*** (0.00)	0.16*** (0.00)	1.00		
S&P 500	0.02 (0.60)	-0.02 (0.56)	0.00 (0.87)	0.00 (0.87)	0.01 (0.70)	-0.03 (0.29)	0.35*** (0.00)	0.07** (0.02)	1.00	
Bonds	0.00 (0.92)	0.08*** (0.01)	0.13*** (0.00)	0.15*** (0.00)	0.07** (0.01)	0.01 (0.79)	0.25*** (0.00)	0.12*** (0.00)	0.32*** (0.00)	1.00

* p < 0.10, ** p < 0.05, *** p < 0.01

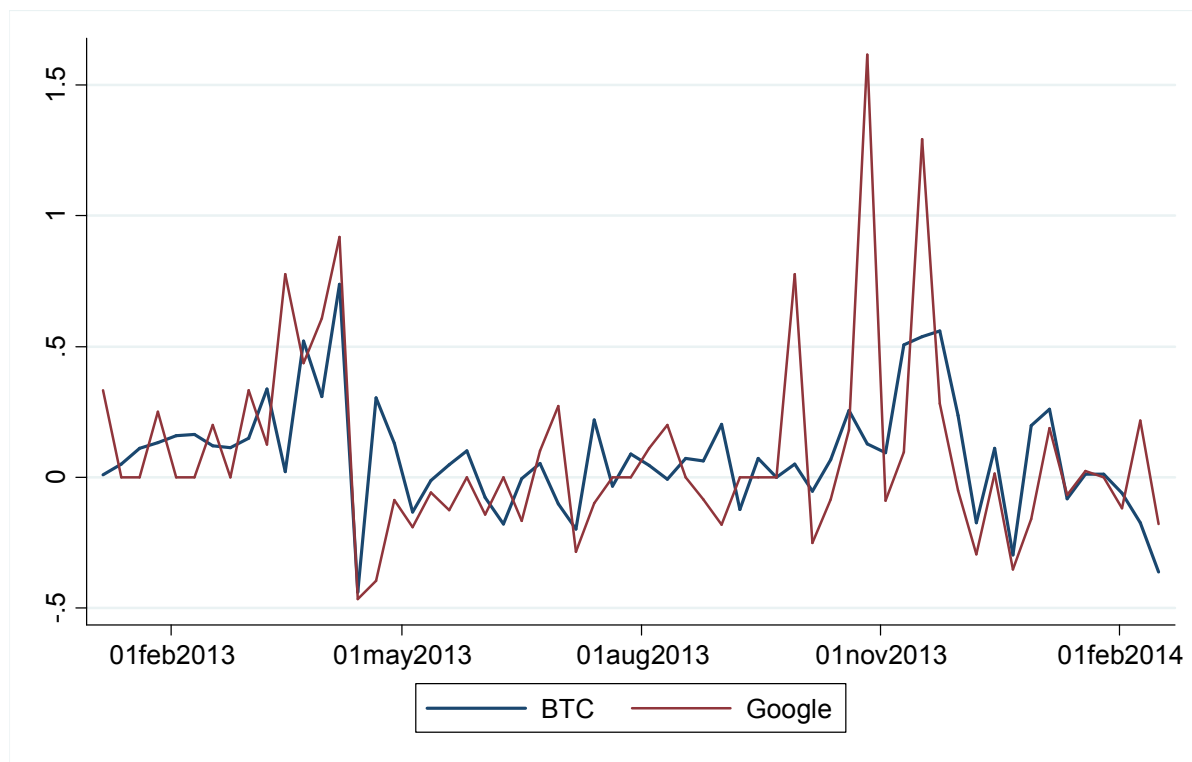
The above statistics show that BTC lacks similarity to traditional currencies, commodities or securities. During its short history, BTC has shown extreme return and volatility. Hence, the question of what has driven the extreme value development remains. We thus proceed to perform the sentiment analysis by first assessing general investor attention and interest by comparing search queries for “bitcoin” on Google with the BTC/USD price development, and then assessing investor sentiment from bitcointalks.org.

Figure 5 evidently shows the strong relationship between weekly changes in the BTC price and weekly changes in search queries for “bitcoin” on Google. Specifically, we find a correlation coefficient of 0.49, with a p-value of less than 1%.

FIGURE 5

BTC and Google Trends, Weekly changes, January 1, 2013 – February 16, 2014

This figure shows weekly changes in search queries for “bitcoin” on Google and weekly changes in the BTC/USD price.



According to Figure 6, there seems to be surprisingly little difference between the three sentiments, i.e. negative words seem to correlate relatively closely with positive and uncertain words, as well as with the total amount of words written in the forum. Note that Figure 6 shows absolute numbers; changes with a daily frequency are not meaningful to show in graphs.

FIGURE 6

Counted words and the BTC/USD price, January 1, 2013 – February 13, 2014

These figures show the (i) daily BTC/USD price development; (ii) number of negative words; (iii) number of positive words; (iv) number of uncertain words and (v) total number of words. The words have been distracted from bitcointalks.org, and counted according to a lexicon by Loughran and McDonald (2011).

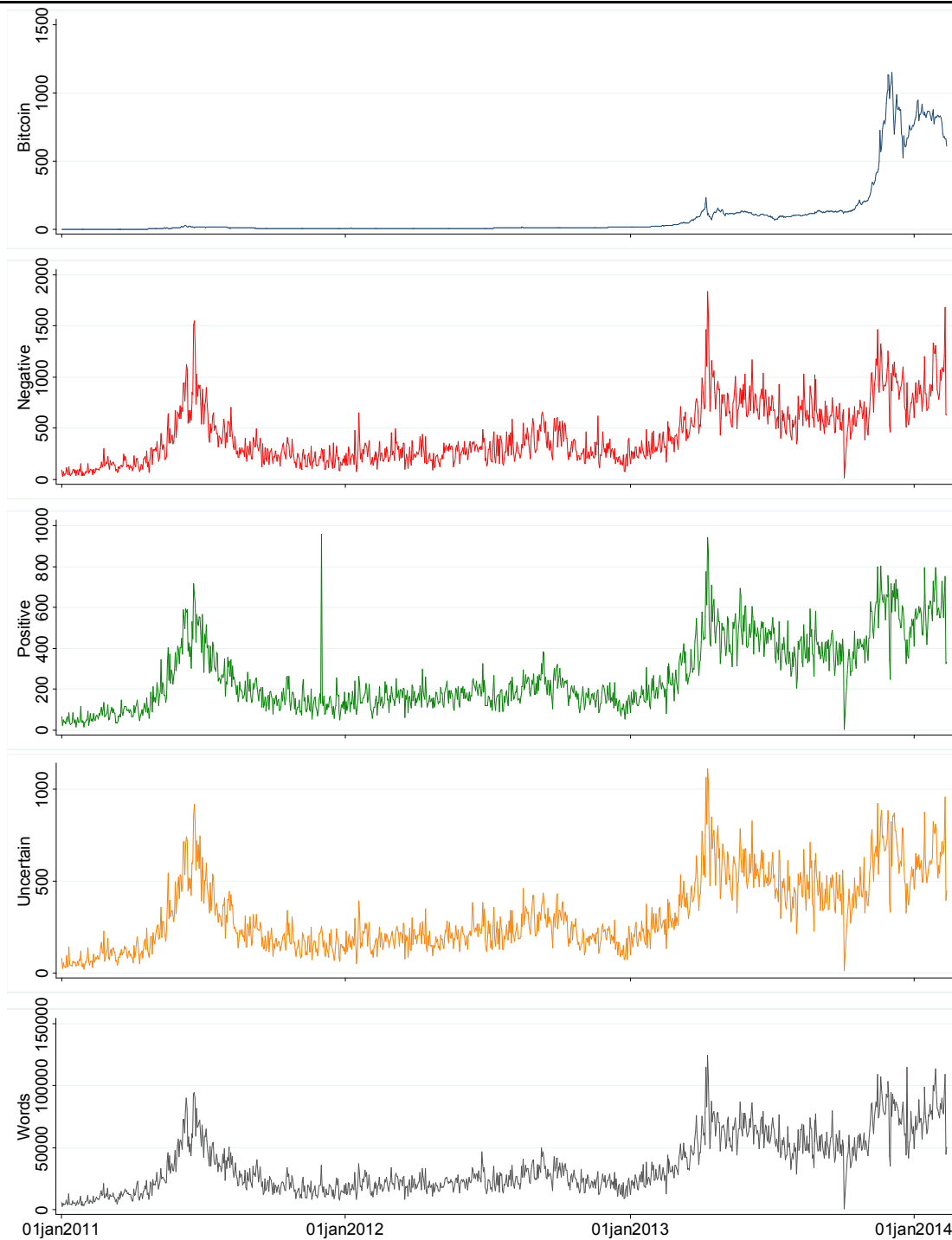


Table 6 confirms that there is little difference between the sentiments since they correlate closely with each other. We also find a relatively strong correlation between the BTC price and negative, positive, uncertain and total number of words. However, the sign is positive for all word lists, which is contrary to our expectations. When comparing the different word lists as fractions of the total number of words, we find a negative and statistically significant correlation between the BTC price and the fraction of negative words. However, the correlation coefficient is very low. The coefficient is higher, and statistically significant for the fraction of uncertain words.

Table 7 instead compares daily changes in BTC price to daily changes in the three different sentiments. This table clearly shows that there is no significant correlation between changes BTC price and changes in sentiment, but again, that there is a strong and statistically significant correlation between the different sentiments.

The fact that the different sentiments exhibit almost perfect positive correlation weakens the implications of the correlations between BTC price and sentiment. Instead, this suggests that, in line with the comparison between BTC and Google Trends, there is a strong relationship between BTC and general investor attention and interest.

TABLE 6**Correlation of BTC price to #words, time period 1**

This table shows the correlations of the BTC price (in levels) to #words (in levels) between January 1, 2011 and February 13, 2014. The words have been distracted from bitcointalks.org, and counted according to a lexicon by Loughran and McDonald (2011). These figures show the (i) daily BTC/USD price development; (ii) number of negative words; (iii) number of positive words; (iv) number of uncertain words (v) total number of words; (vi) fraction of negative words to total number of words; (vii) fraction of positive words to total number of words, and; (viii) fraction of uncertain words to total number of words.

Variables	BTC	Negative	Positive	Uncertain	Words	Neg./Words	Pos./Words	Unc./Words
BTC	1.00							
Negative	0.61*** (0.00)	1.00						
Positive	0.65*** (0.00)	0.96*** (0.00)	1.00					
Uncertain	0.59*** (0.00)	0.98*** (0.00)	0.97*** (0.00)	1.00				
Words	0.65*** (0.00)	0.98*** (0.00)	0.98*** (0.00)	0.98*** (0.00)	1.00			
Neg./Words	-0.07** (0.03)	0.15*** (0.00)	-0.01 (0.75)	0.03 (0.28)	-0.02 (0.40)	1.00		
Pos./Words	-0.03 (0.38)	-0.10*** (0.00)	0.07** (0.03)	-0.08*** (0.01)	-0.11*** (0.00)	0.07** (0.02)	1.00	
Unc./Words	-0.24*** (0.00)	-0.18*** (0.00)	-0.21*** (0.00)	-0.09*** (0.00)	-0.25*** (0.00)	0.27*** (0.00)	0.15*** (0.00)	1.00

* p < 0.10, ** p < 0.05, *** p < 0.01

TABLE 7

Correlation of daily returns of BTC to changes in #words, time period 1

This table shows the correlations between daily returns of BTC to changes in #words between January 1, 2011 and February 13, 2014. The words have been distracted from bitcointalks.org, and counted according to a lexicon by Loughran and McDonald (2011). These figures show the changes in (i) daily BTC/USD price development; (ii) number of negative words; (iii) number of positive words; (iv) number of uncertain words; (v) total number of words; (vi) fraction of negative words to total number of words; (vii) fraction of positive words to total number of words, and; (viii) fraction of uncertain words to total number of words.

Variables	BTC	Δ Negative	Δ Positive	Δ Uncertain	Δ Words	Δ Neg./Words	Δ Pos./Words	Δ Unc./Words
BTC	1.00							
Δ Negative	-0.02 (0.58)	1.00						
Δ Positive	-0.01 (0.80)	0.68*** (0.00)	1.00					
Δ Uncertain	-0.03 (0.28)	0.79*** (0.00)	0.70*** (0.00)	1.00				
Δ Words	-0.02 (0.56)	0.83*** (0.00)	0.76*** (0.00)	0.86*** (0.00)	1.00			
Δ Neg./Words	-0.01 (0.81)	0.59*** (0.00)	0.14*** (0.00)	0.19*** (0.00)	0.08*** (0.01)	1.00		
Δ Pos./Words	-0.02 (0.57)	0.01 (0.83)	0.53*** (0.00)	0.01 (0.84)	-0.08*** (0.01)	0.15*** (0.00)	1.00	
Δ Unc./Words	-0.02 (0.42)	0.09*** (0.00)	0.04 (0.15)	0.42*** (0.00)	-0.05* (0.08)	0.26*** (0.00)	0.17*** (0.00)	1.00

* p < 0.10, ** p < 0.05, *** p < 0.01

4.2 Qualitative aspects of bitcoin

Since Bitcoin is a new phenomenon that has only been observed since 2009, it is especially important to include qualitative data to gain understanding and accuracy in the assessment of BTC. Professors, experts and entrepreneurs contribute with valuable insights which increase the validity of the study.

4.2.1 What need does bitcoin satisfy?

The need for BTC can initially be derived from the need for money. According to Robin Teigland money can be viewed as an inter-temporal promise that links the past, the present and the future. Lars Ljungqvist further describes that while fiat currencies are issued and controlled by governments, they make no explicit promise to guarantee their underlying value. The value of money is instead derived from a network effect, which is based on people's expectations that others will use and ascribe value to it. Jon Matonis and Robin Teigland agree, and they say that scepticism towards the government is prevalent, especially among developing nations, and in hindsight of the financial crisis. This may translate into increased confidence in alternative currencies such as BTC. Trusting BTC should not be a problem according to Jon Matonis, who believes that the Bitcoin protocol is robust, since it is based on math: "an objectively quantifiable thing that cannot be disputed". Frank Schuil adds that the protocol has been tested since 2009 by a global community of people trying to improve it. Although there is a multibillion dollar incentive to hack it no one has been successful so far, and there is no reason to believe anyone will.

Except from fiat currencies, there are about 6,000 complementary currencies globally. According to Robin Teigland, complementary currencies are contra-cyclical and have a counterbalancing power to governments and banks. They can also promote resilience in local communities. Lars Ljungqvist explains that complementary currencies often have limited geographical reach as opposed to BTC, which introduces a global legal tender. However, this implies that national borders are erased, which presents a classic trade-off in economics. Namely, theory advocates both mobility of goods and services, and exchange rate policy to enable adjustments in relative price levels between countries.

Robin Teigland further explains that, in addition to fiat currencies and complementary currencies, there are several real cash economies in virtual worlds, based on virtual currencies such as PED (Project Entropia Dollars) in the virtual universe called Entropia. She argues that people are largely stuck in old mindsets: that currencies have to be backed and controlled by

governments. Hans Henrik H Hemming questions if a trusted third party is needed and suggests that we can decide ourselves as a community what we think that money is.

Further, even though BTC was not necessarily meant to be a full replacement for fiat currencies, Jon Matonis believes that it could gain enough confidence to become a good substitute. On back of its similarities to gold he believes it could even serve as a part of smaller countries' foreign reserve. Robin Teigland is more conservative suggesting that BTC could potentially become a threat to fiat currencies in countries with dysfunctional financial systems, while serving more as a complementary currency in developed nations. Lars Ljungqvist suggests that the importance of value stability undermines BTC's potential to become widespread and compete with fiat currencies. Instead of replacing fiat currency, Ludvig Öberg argues it can fill an important function within certain areas, such as internet payments and international transactions.

BTC's success is partially dependent on the competition imposed by other cryptocurrencies. According to Robin Teigland new industries attract numerous start-ups which subsequently, as the industry matures, are acquired or competed out of business. In addition, Lars Ljungqvist suggests that entry barriers are low because of the ease of copying the Bitcoin protocol or writing similar codes. Consequently, it becomes crucial to identify BTC's competitive edge for assessing its sustainability.

Bitcoin is the first mover and Robin Teigland finds it difficult to assess whether it will translate into an advantage or disadvantage. While Bitcoin faces challenges like changing peoples' mind-sets and getting bugs out of the system, it is also the most well-known and widespread cryptocurrency. Ludvig Öberg believes the large head-start in building a community is enough for BTC to defend its position. People will not switch to a new network before something much better is invented, and so far no cryptocurrency has accomplished this. Frank Schuil further clarifies that since the protocol is open source, continuous improvements can be made. Subsequently, any new innovation by competitors can be added to the protocol to keep the competitive edge.

Jon Matonis employs a more technical perspective and explains that the cryptocurrency industry is a zero-sum game and thus that capacity allocation limits competition. In relative terms this implies that one cryptocurrency will be stronger than the other since mining for one cryptocurrency reduces mining security and strength of another. Frank Schuil adds that Bitcoin

by far has the biggest support today, based on the network effect, adoption by people and merchants as well as investments in currency platforms and infrastructure.

Further, Robin Teigland recognises the need for more efficient financial systems. Bitcoin especially seems to hold promise for safer and more efficient internet payments according to Ludvig Öberg. The increased security is derived from digital scarcity which enables transactions of wealth without the risk of double spending. Bitcoin further fulfils the need of a decentralized financial system says Frank Schuil who believes these two features are the main problems solved by Bitcoin. Lars Ljungqvist, on the other hand, mainly recognizes the need to exert competitive pressure on established payment channels and current financial systems. Bitcoin could potentially force change in terms of lower fees and increased efficiency.

In regards to efficiency, low transaction fees are often mentioned as a main attraction of BTC. Josh Zerlan explains that transaction fees are voluntary today but could be required at some point in the future due to transaction volume. As transaction volumes increase, “space” in blocks becomes more valuable. As block rewards dwindle, the incentive to mine is created through transaction fees. Currently, there is enough “space” in blocks to process all transactions, but in the future, there won't be enough “space” to process all transactions in the next block. Miners will favour transactions with higher fees over ones with lower fees. This implies that lower fee transactions could potentially take hours, days or weeks to get processed if many high fee transactions are prioritized. As transaction volume increases, this issue will become more prevalent, and this development has already started.

4.2.2 What is required for bitcoin to be widely adopted?

The adoption of BTC is dominated by the network effect, according to Frank Schuil, who sees no stopping in sight for the adoption of BTC. The adoption also depends on parameters like switching costs says Robin Teigland, who also believes that adoption is driven by the group of people who wants to take control over their money. These people could be spread across the world; however poorer internet access and applications might have an adverse effect on the adoption in developing countries. From a financial perspective Lars Ljungqvist adds the importance of price stability, and also explains that general adoption requires a substantial deflation due to the limited volume of BTC.

In terms of timing, Frank Schuil says that miners are already professionalized, the protocol has been tested for five years, the infrastructure is currently shaky but under construction, and

subsequently user-friendly applications will be created to increase usability and thus the adoption of BTC. Large amounts have already been invested in the development according to Jon Matonis who thinks the coming three years will contribute to large progress for BTC on back of the quick technological development.

Robin Teigland fears that speculation in BTC may have an adverse impact on adoption. She would rather prefer slow and stable growth and argues that speculators fail to account for the true value of the technology and increase negative media attention. Jon Matonis on the other hand, says speculators perform a necessary function in providing liquidity and keeping spreads low. If the activity ultimately leads to adoption Frank Schuil interprets no downside.

Ludvig Öberg also emphasizes the importance of regulating BTC so that unreliable or fraudulent players are driven out of the market. Jan Tibbling believes that until the inevitable question of regulation is settled, one way or another, digital currencies will be unable to reach their true potential. Despite consensus to regulate BTC, the interviewees recognise risks with too stringent frameworks. Frank Schuil and Ludvig Öberg both believe that innovation could be adversely affected, but at most in terms of delays. Robin Teigland and Jon Matonis add that stringent regulation could be self-defeating since it will push BTC activity to friendlier jurisdictions.

4.2.3 What is bitcoin?

Frank Schuil says BTC is “the reinvention of money” and while it fundamentally is a protocol for money on the internet, he says it is also a commodity, a currency and a medium of exchange.

Skatteverket explains that the assessment of BTC is a legislative matter and that according to the existing Tax Act, BTC is classified as “other currency” as opposed to “official currency” since it is not issued by a central bank or government.

Lars Ljungqvist argues that BTC is a security with no intrinsic value, except the expectation of people using it in the future. He further reasons that it is a speculative asset based on recent price movements that clearly differ from those of a currency. Frank Schuil agrees that, for the moment, BTC might be a speculative asset but he argues that BTC has already gone through several bubbles which are part of the growth cycle.

Robin Teigland argues that Bitcoin has “let the genie out of the bottle”, and should rather be described as a financial instrument than a currency. She derives the value of Bitcoin from the

power of the community, plus the open source and the internet. Jon Matonis, on the other hand, classifies BTC as a new asset class, a digital commodity, since it is not similar to any existing asset. Josh Zerlan takes it one step further, suggesting that Bitcoin is the ultimate expression of a democratic financial system.

5 Discussion

Despite the fact that BTC was originally introduced as a pure peer-to-peer version of electronic cash for online payments, there is no consensus on what it actually is. In order to clarify the confusion and to assess whether BTC is feasible as an asset class for investment we structure a discussion of the results by first assessing the functionality of BTC as a currency and an alternative investment. Fiat currencies typically fulfil criteria including; (i) social construction; (ii) store of value; (iii) medium of exchange, and; (iv) unit of account (ECB, 2013). Further, there is no clear definition of alternative assets, but is often referred to as all assets except stocks, bonds and cash. Alternative assets are thus a diverse asset group including for example, private equity, real estate, infrastructure, art, rare coins and farmland (Ilmanen, 2011). Second, we derive the underlying value of BTC, and third, we assess the future viability of BTC. Finally, we proceed to make some concluding remarks on BTC's viability as a currency and an alternative investment.

5.1 The functionality of bitcoin as a currency and an alternative investment

First, while the high returns are attractive from an investment perspective they reduce the incentive to spend BTC, which erodes the function of BTC as a medium of exchange. To our knowledge, no other asset has yielded the same level of return. Naturally, all else equal, investors would prefer BTC to other investments. However, they need to take the high volatility into consideration. BTC historically exhibits approximately 22, 7, and 15 times the volatility of the average fiat currency, commodity and security respectively, during the same period. The extreme volatility further impedes BTC from serving as a store of value, medium of exchange and unit of account. A future levelling of volatility is possible but depends on whether it derives from the recent market introduction and sensitivity to a few trades imposed by the limited market capitalization, or from inherent features of BTC as such. If return and volatility decrease, the attractiveness of BTC would reasonably shift towards using it as a medium of exchange rather than investing in it. However, this seems unlikely to happen since volatility should be

expected to continue due to the regulated supply of BTC which is not adjusted for demand. In addition, the deflationary nature of BTC suggests that high returns are expected to continue.

Further, the Sharpe ratio suggests that the various risk premia found in BTC vary strongly over time. It seems, however, that the risk is fairly well compensated for over time. Except for bonds, the risk-adjusted return for BTC outperforms the other variables most of the time. Even though BTC periodically has had a relatively attractive Sharpe ratio, investors need to consider the extensive tail risk. Intuitively, it seems investors would avoid investments exhibiting fat left tails since they risk incurring large losses. But, in the case of BTC our data suggest that right tails are similarly fat and that extreme positive events thus compensate for the tail risk. Subsequently, investors with low risk aversion should be willing to hold BTC, despite the extensive tail risk. Further, the fat tails of BTC evidently differ from those of traditional currencies, which are seldom exposed to extreme events.

Second, the lack of correlation suggest that BTC behaves differently from major currencies, commodities, equities and bonds, and is thus potentially attractive from a diversification point of view. This is a typical feature of alternative assets, but BTC seems unique in this aspect; to our knowledge, there are few other assets which are virtually uncorrelated with all asset classes. However, the lack of correlation limits the ability to hedge BTC against other assets. The volatility further limits the ability to hedge through forward contracts or options. Specifically, the lack of correlation with traditional currencies suggests that BTC does not behave like a currency. It also reduces the likelihood of companies to use BTC due to the lack of foreign exchange hedging possibilities.

5.2 The underlying value of bitcoin

Our analysis suggests that BTC exhibits a deviating behaviour from the benchmark variables. Consequently, it implies that BTC reacts differently to general macro conditions and external shocks. Naturally, this raises the question of what its underlying value derives from and if there is any predictability in its value development.

We argue that it is unlikely that BTC's value development derives from rational investment decisions. As Baker and Wurgler (2007) suggest that valuations of young firms with limited historical data and highly uncertain future prospects are more likely to be influenced by sentiment it appears likely that the same reasoning would apply for BTC.

In line with Kristoufek (2013) we find significant correlation between Google Trends and the BTC value development which supports that BTC trading is not derived from rational investment decisions, since general interest in BTC is such a strong variable. Thus, we are surprised not to find any relationship between investor sentiment and BTC's value development, either for specific sentiment or for total activity.

Critical steps in the performance of the sentiment analysis are the choice of sentiment proxy and wordlist. First, it could be argued that Bitcointalks.org serves as a poor proxy. Forums allow for longer posts with a variety of informative, discussion and personal opinion characteristics. It is also a niched type of social media that presumably consist mostly of Bitcoin enthusiasts. However, several researchers find significant results using similar types of data, including online forums (Antweiler & Frank, 2004), financial newsletters (Brown & Cliff, 2005), newspaper columns (Tetlock, 2007). Second, with the lack of consensus on which method and lexicon are superior our finance adopted lexicon should be appropriate for this analysis (Gonçalves et al., 2013) and has been established in previous research (Solomon, 2012; Da et al., 2011). Potential explanations for the lack of results could be the complexity and ambiguity of BTC suggesting that investors interpret news differently.

5.3 The viability of bitcoin

To assess the future viability of BTC the only available forward looking indicators to rely on seem to be the societal and user value. These are mainly derived from the network size and whether BTC introduces improvements or any unique features over traditional currencies or assets.

Just like any currency, BTC is a social construction. It has not yet reached its full potential in terms of network size but the interviews reveal several indicators that the network will grow. Despite the possibility that BTC emerged as a reaction to poorly performing governments we are reluctant to believe that Bitcoin can incur the same trust and loyalty. Governments have proved their ability for decades or even centuries while the Bitcoin protocol has only been tested since 2009. Further, although the network is expected to grow, we identify a risk of delay in the process of building a trustworthy social construction. While there is no doubt that the Bitcoin community has faith in BTC, it is possible that the value of the social construction is diluted by investors who interpret BTC as an alternative investment rather than a currency. Although a growing network is crucial for the success of BTC, it likely also translates into higher

transaction fees, as explained by Josh Zerlan, which we believe constitutes a threat to BTC's attractiveness as a currency.

In theory, one of the original key features of BTC is decentralization. However, in practice, it seems to us that the Bitcoin economy is currently not decentralized, since the block chain is controlled by a few mining pools. As the network grows and the mining process becomes increasingly complicated, we believe that increasing economies of scale will drive further consolidation of miners.

Further, we argue that the idea of decentralization has several drawbacks. First, increasing decentralization of the Bitcoin mining system would likely lead to inefficiencies. With a larger number of miners, it is likely that the process of solving technical problems with the Bitcoin protocol through majority voting will become less efficient. Second, it seems decentralization would increase transparency, but we argue the power is limited to a certain group of people, i.e. the miners. The user value of the code being open source P2P can be questioned since there are probably few people who understand and can review its functionality. This could thus introduce information asymmetry which has negative impact from an investment perspective, but is a common feature for alternative investments. Third, from a monetary perspective, there is no active third party to compensate for monetary policy, which currently is carried out by central banks.

Another key feature of BTC is the predictable and limited supply which means that, with increasing demand, BTC is deflationary. From an investment perspective this is attractive since it suggests that the value will increase going forward. But, from a monetary perspective it further undermines the function as a medium of exchange. Even if BTC is protected from inflation there is ultimately a risk for a deflationary spiral eroding the BTC economy. Barber et al (2012) also recognize the deflation risk but argue the predictable supply is an attractive feature.

Further, the uncorrelated nature of BTC introduces a unique feature from an investment perspective, since it fills an attractive function from a diversification perspective. From a monetary perspective, BTC and its global tender seem to introduce a strong improvement over other complementary currencies, by combining the ideas of local initiatives with virtual economies. It also introduces unique technological innovation in terms of more efficient payment solutions, both in terms of improved security and speed for internet payments and foreign transactions, and in terms of offering developing nations access to a functional financial

systems and thus improving their access to goods and services on global markets. Although BTC is increasingly accepted as a medium of exchange by merchants, it is to our knowledge never used as a unit of account.

To summarise, the features of BTC only partly seem to translate into improvements and unique features over traditional currencies and assets. While the network seems to be growing, we identify a weaker foundation and thus no improvement over social constructions built around traditional currencies and assets. We argue that BTC is not as decentralized as commonly stated, and that decentralization is not necessarily an improvement. It is ambiguous, however, whether the deflationary nature of BTC, introduces an improvement or not. On the other hand, the lack of correlation, and the technology innovation are clearly unique features through which BTC and Bitcoin introduce societal and user value. Further, the presence of speculators constitutes a double-edged sword. It increases trading volume which is positive for the adoption of BTC but there is a possibility that the speculators undermine BTC's potential to become a stable inter-temporal promise of value.

6 Conclusions and implications

BTC seems to exhibit features more similar to an alternative asset than a traditional currency. It seems that the features that make BTC an attractive investment are also the factors that impede the functionality of BTC as a currency, and vice versa. Thus, there seem to be conflicting forces in whether it will function as a currency or alternative investment going forward. BTC serves as an interesting and potentially attractive investment to investors with little risk aversion. Further, even though BTC struggles to fulfil traditional currency criteria we cannot rule out its functionality as a medium of exchange in the future. It is possible that some emerging market currency behaves similarly to BTC but is considered a fiat currency.

It is difficult to predict the future value development. But, however small, the societal and user value introduced by BTC indicates future viability. Until the BTC economy is stimulated to increase incentives to spend BTC, it will likely function more as an alternative investment and thus not realize its initial purpose.

While our results are mainly in line with those of other researchers, e.g. Yermack (2013), they may have wider implications. In theory, our results, at least partly, contradict the initial purpose of bitcoin as decentralised electronic cash. In practice, this could impose a threat to the BTC economy, suggesting that the community should engage in shifting incentives from investing

in, to spending BTC, for BTC to realise its initial purpose. For policymakers, our results imply an increased uncertainty in the classification of BTC.

Further, we have identified some areas for potential further research. First, with time and as the number of observations increases, more general conclusions on the behaviour of BTC can be drawn. Second, a possible variation of our study could include other benchmark variables. Especially, a comparison with emerging currencies, highly volatile shares, and previous financial bubbles could add new valuable insights. Third, a variation of our sentiment analysis could include other proxies for investor sentiment, such as Tweets, news articles or blogs, and could be performed with alternative lexicons. Finally, while no other cryptocurrency has yet gained comparable attraction, a similar study could be extended to other cryptocurrencies in the future.

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8 Appendix

FIGURE 7

6-month rolling Sharpe ratios, all variables

This figure shows 6-month rolling, annualized Sharpe ratios for all our variables between July 2, 2011 and February 28, 2014. The rolling returns and standard deviations have been calculated with January 1, 2011 as start date.

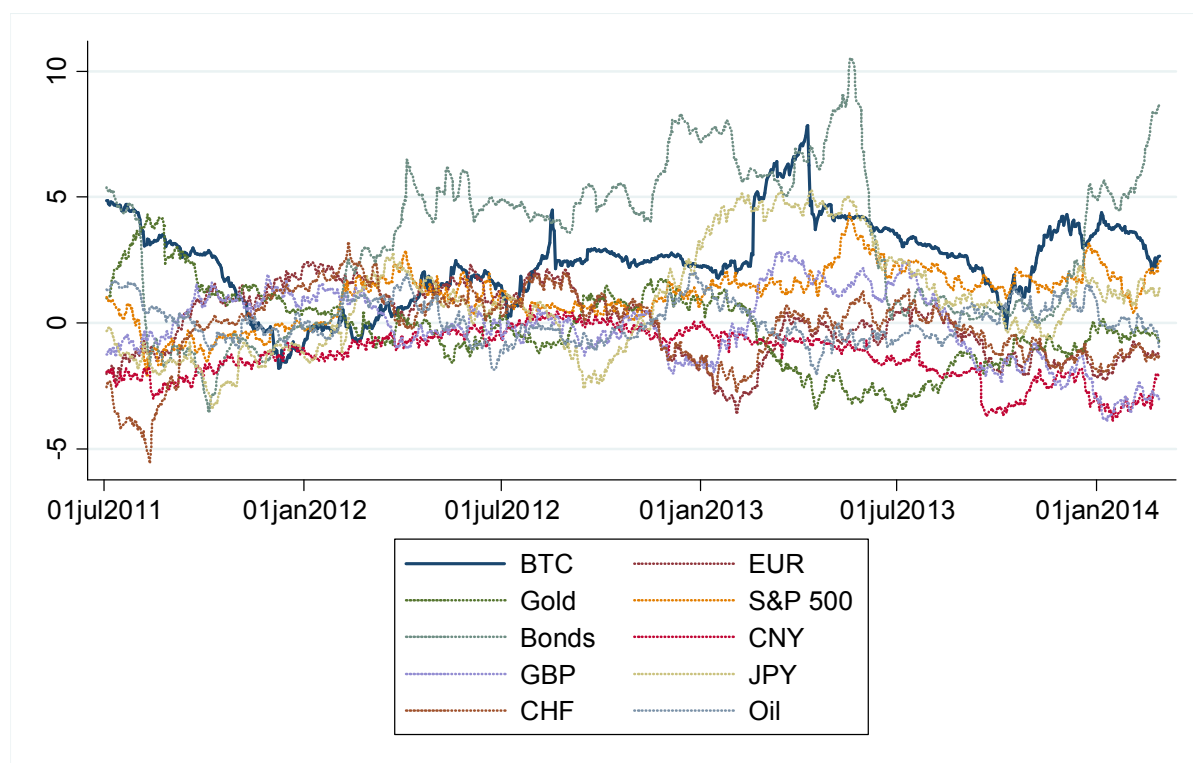


FIGURE 8

Distribution of daily BTC returns, time period 2 and 3

The top figure shows the distribution of daily BTC returns for January 1, 2013 to February 28, 2014 and October 1, 2013 to February 28, 2014. The red columns illustrate the downside risk at 5% level. The bottom two figures show the 5% tails of daily BTC returns for time period 1; the left figure illustrates the lowest 5% of daily returns, and the right figure illustrates the highest 5% of daily returns.

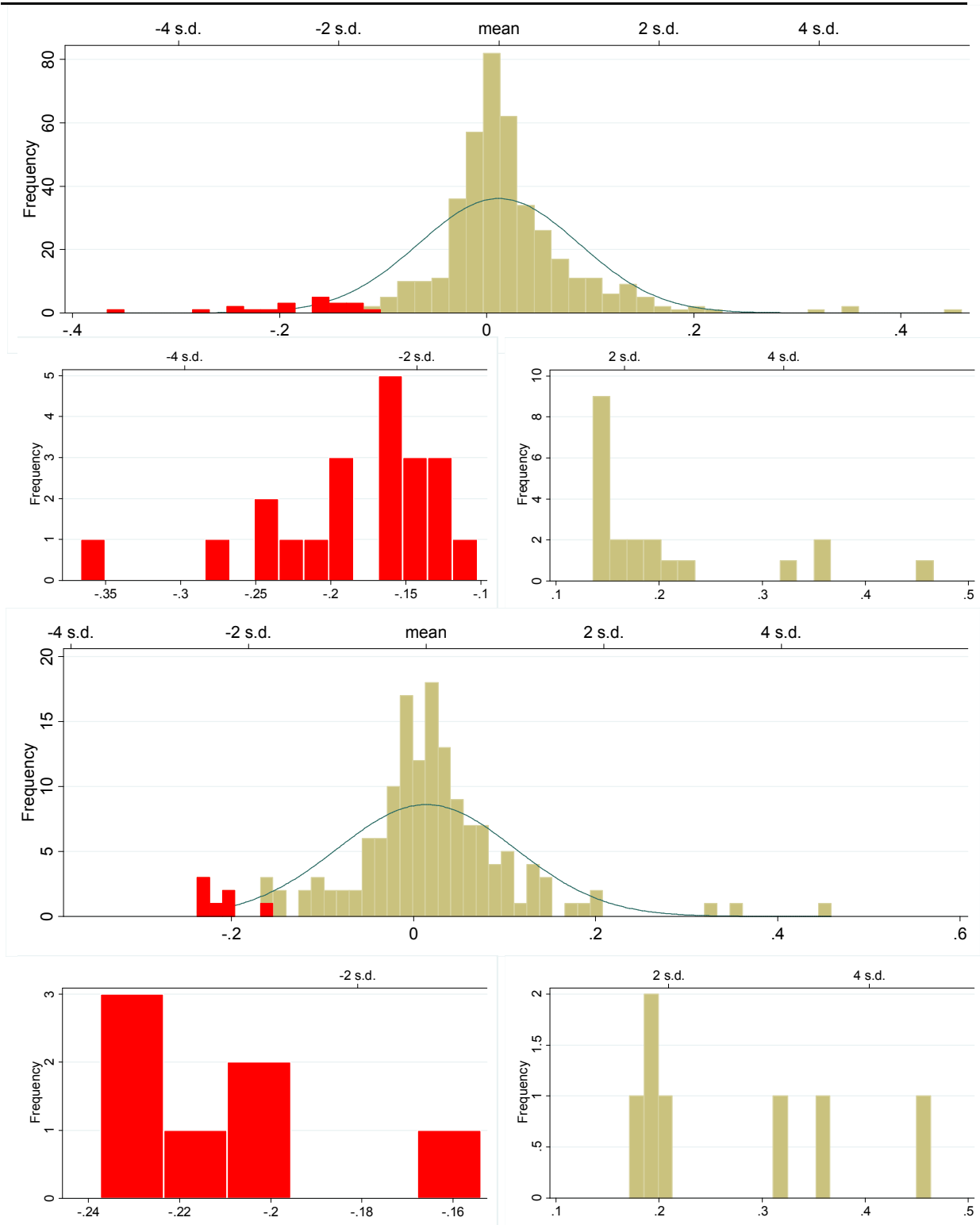


FIGURE 9

Distributions of daily returns, time period 1

The figures below show the distributions of daily returns for all our variables except BTC between January 1, 2011 and February 28, 2014. The variables include CNY, EUR, GBP, JPY and CHF, with all exchange rates measured against the dollar, the daily crude oil Brent price as measured in USD per barrel, the daily London gold price as measured in USD per troy ounce at 10.30 a.m., S&P 500 and BofA Merrill Lynch US High Yield Master II Total Return Index (Bonds). The red columns illustrate the downside risk at 5% level. The bottom two figures show the 5% tails of daily BTC returns for time period 1; the left figure illustrates the lowest 5% of daily returns, and the right figure illustrates the highest 5% of daily returns.

Figure 9.1: Distribution of daily CNY returns

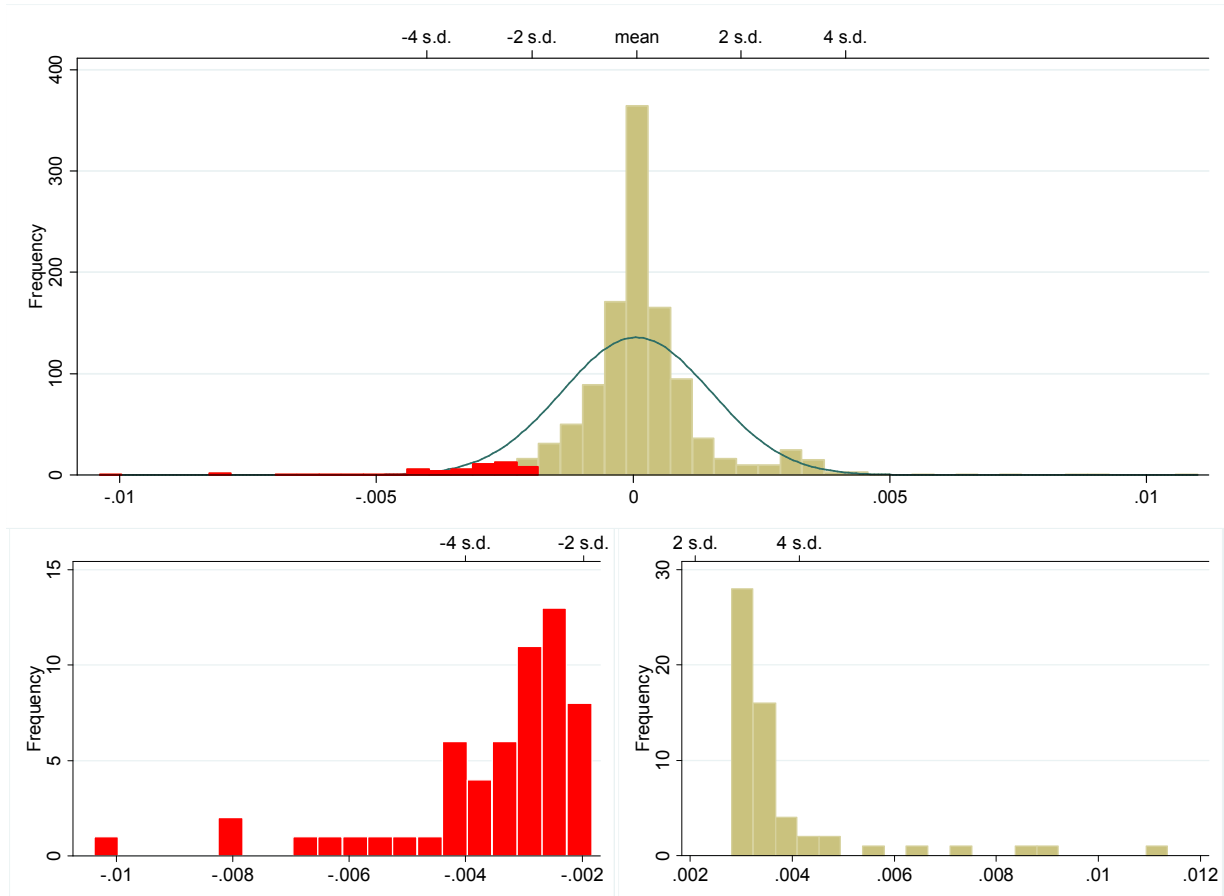


FIGURE 9, cont'd

Figure 9.2: Distribution of daily EUR returns

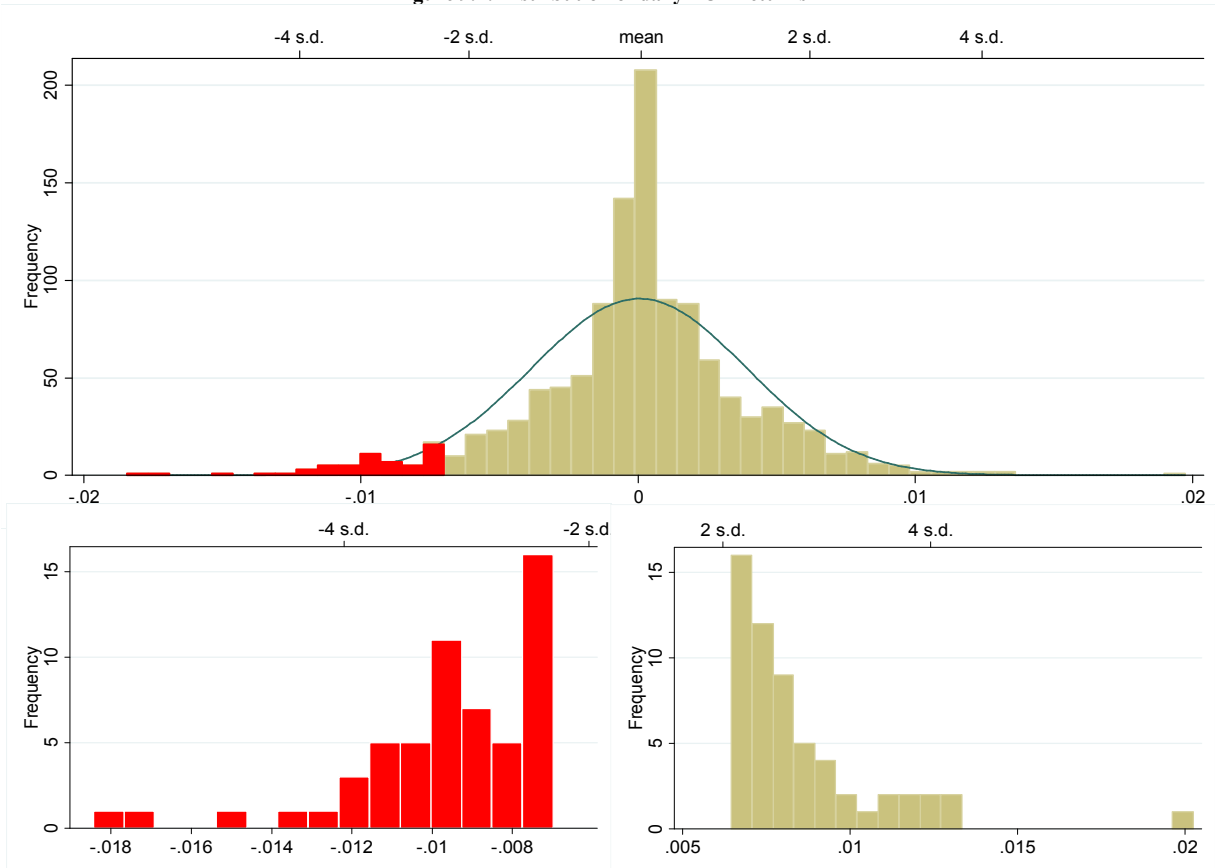


Figure 9.3: Distribution of daily GBP returns

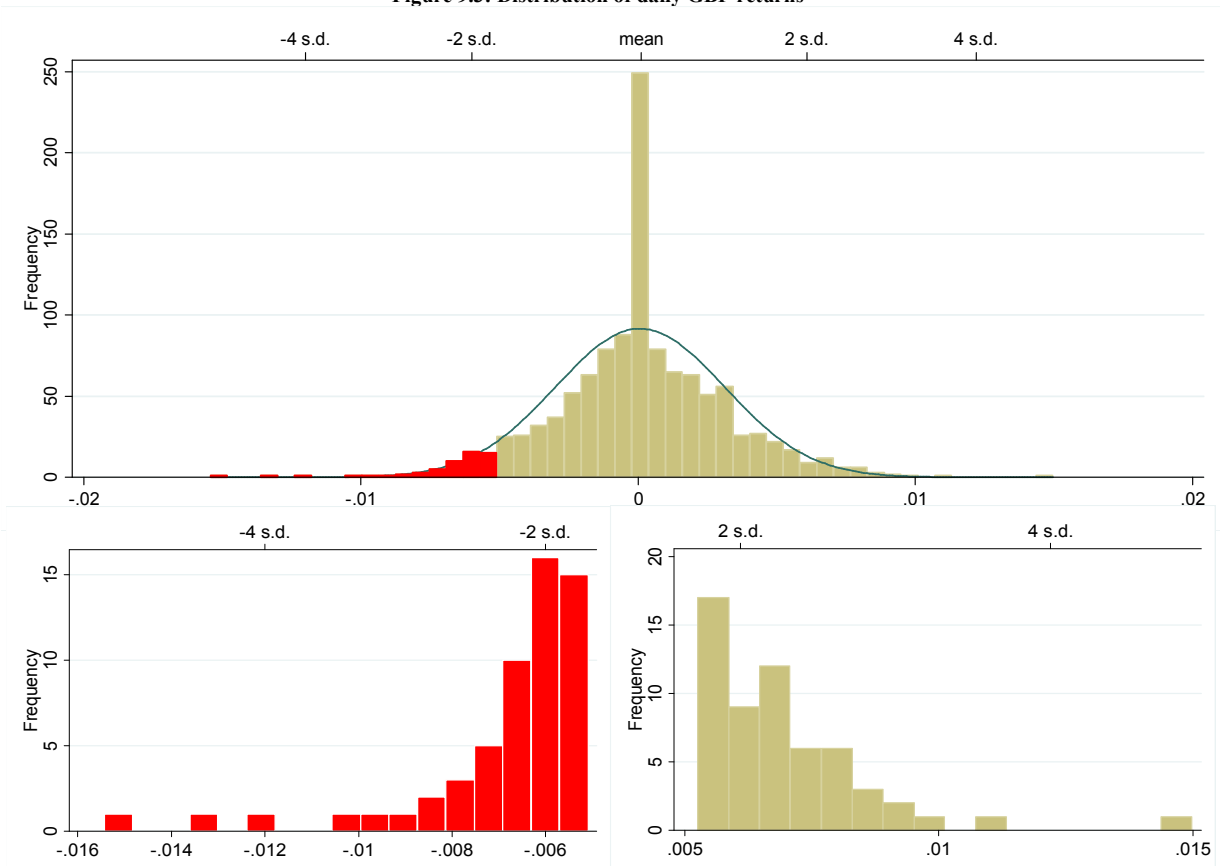


FIGURE 9, cont'd

Figure 9.4: Distribution of daily JPY returns

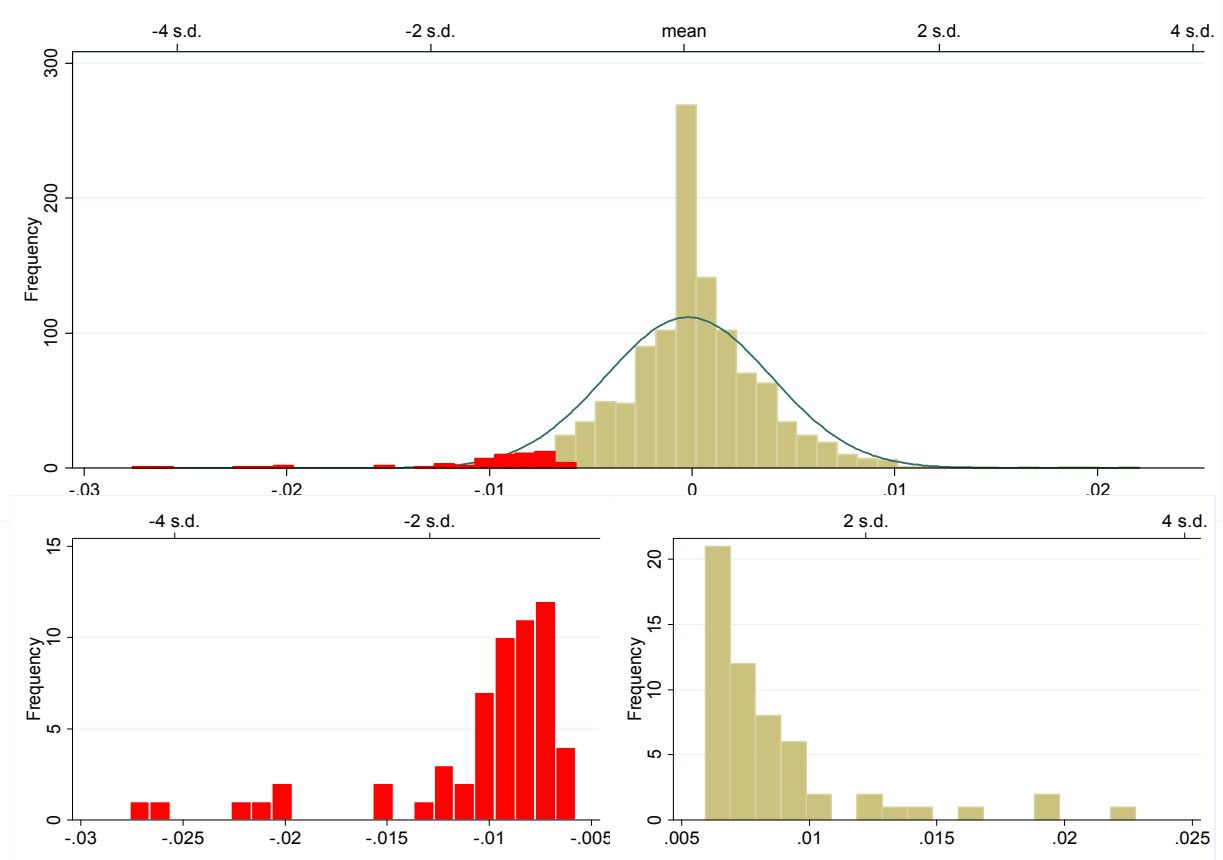


Figure 9.5: Distribution of daily CHF returns

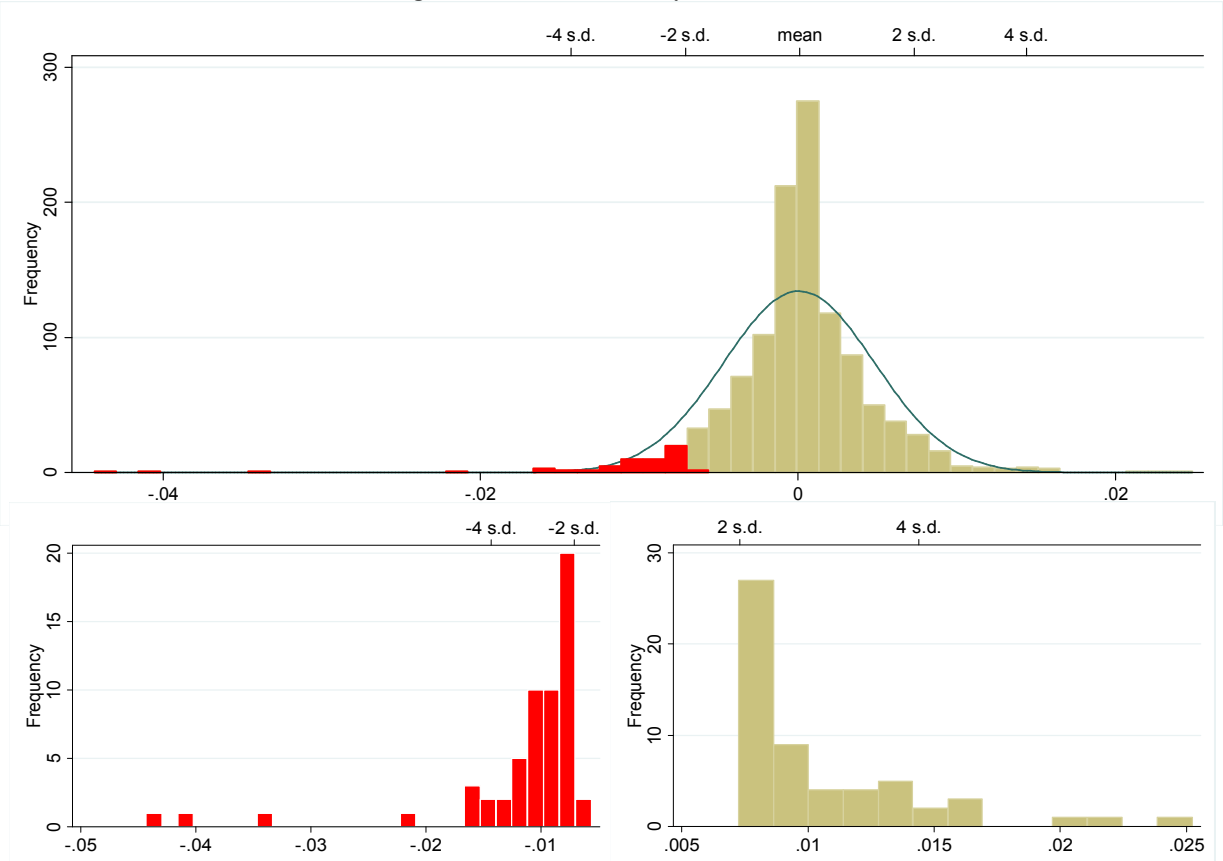


FIGURE 9, cont'd

Figure 9.6: Distribution of daily S&P 500 returns

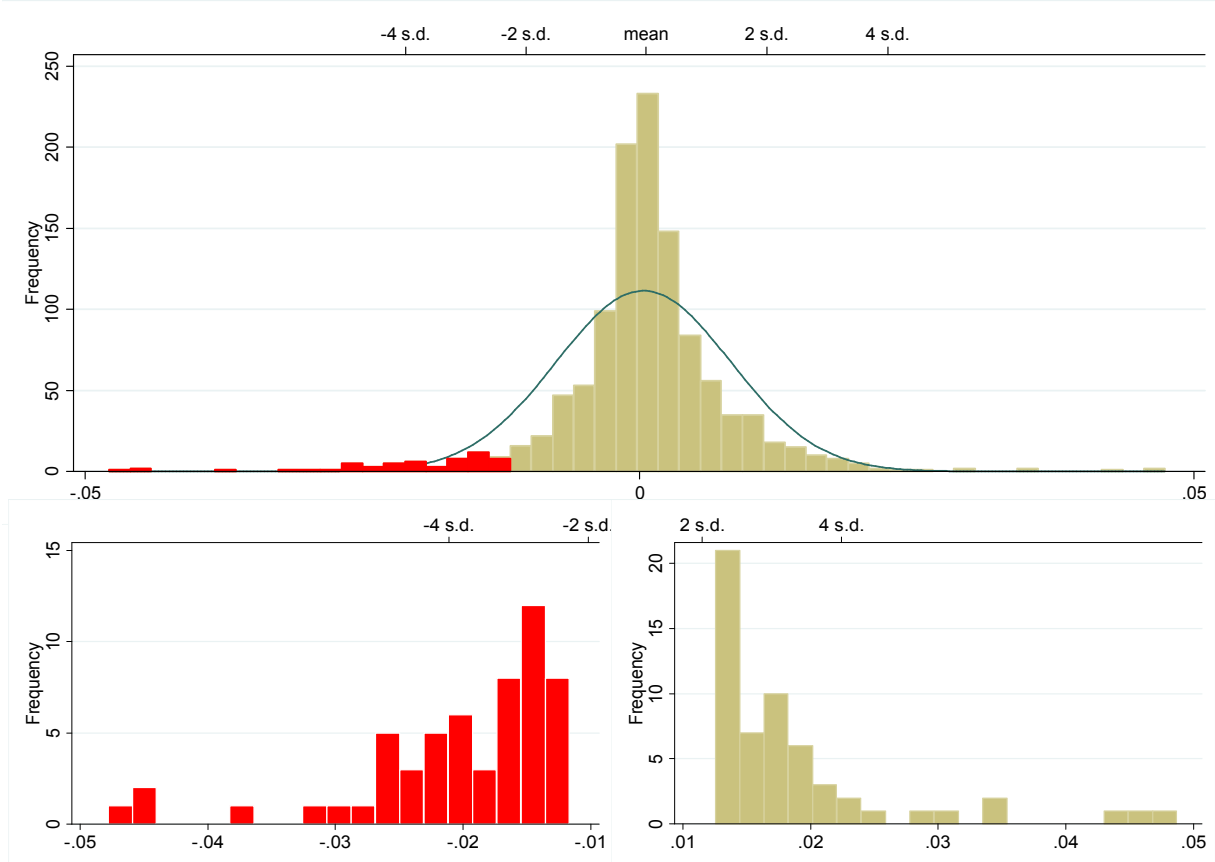


Figure 9.7: Distribution of daily bond returns

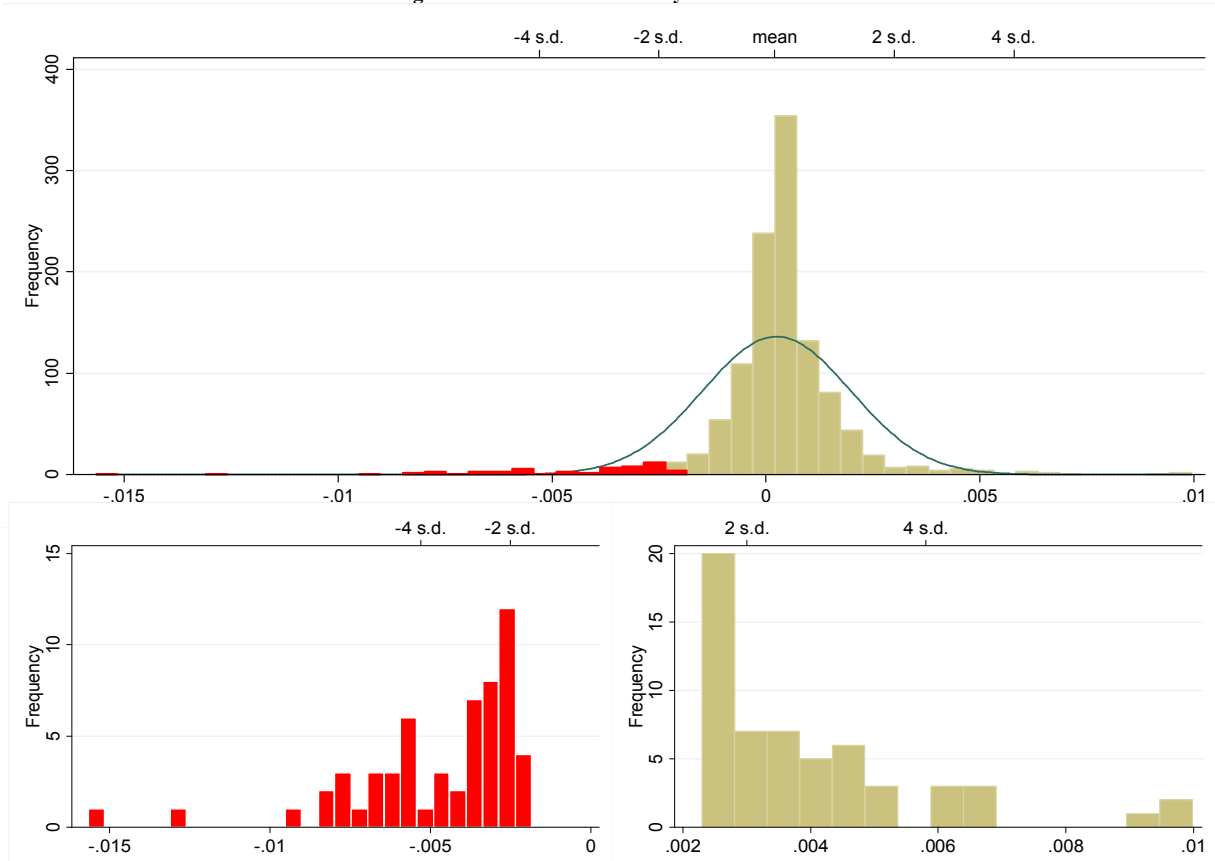


FIGURE 9, cont'd

Figure 9.8: Distribution of daily oil returns

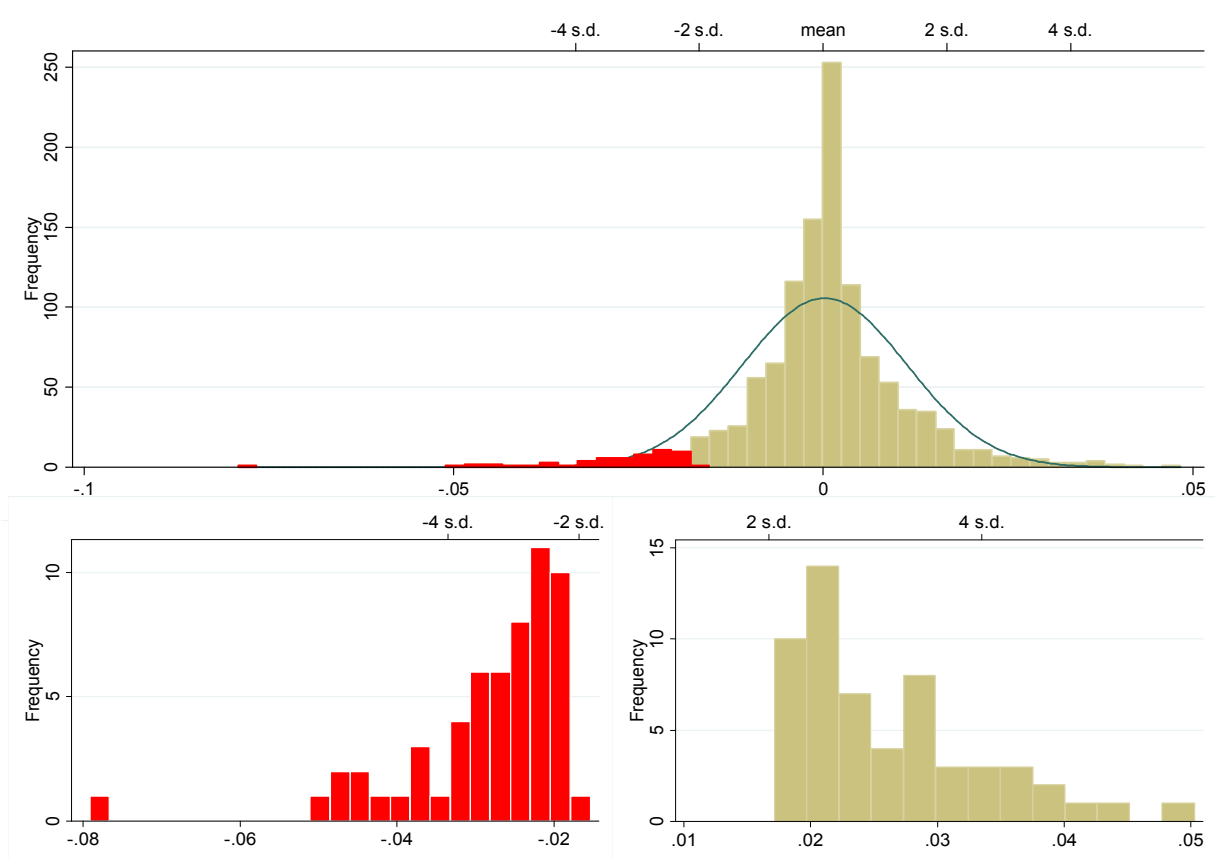


Figure 9.9: Distribution of daily gold returns

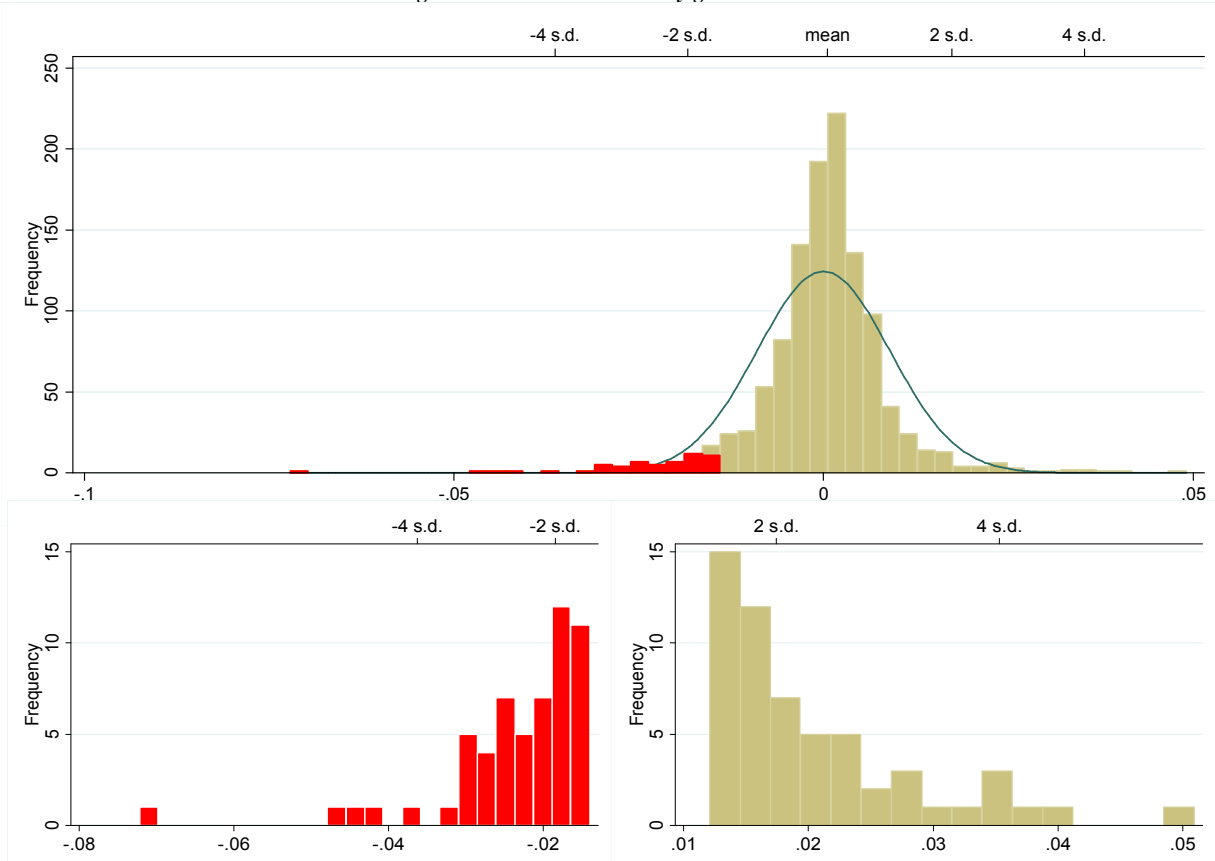


TABLE 8

Correlation of daily returns, time period 2 and 3

This table shows correlations for the daily changes of all our variables between January 1, 2013 and February 28, 2014, and October 1, 2013 and February 28, 2014 respectively. The variables include exchange rates for pairs of currencies, with all exchange rates measured against the dollar, the daily crude oil Brent price as measured in USD per barrel, the daily London gold price as measured in USD per troy ounce at 10.30 a.m., S&P 500 and BofA Merrill Lynch US High Yield Master II Total Return Index (Bonds).

Variables	BTC	CNY	EUR	GBP	JPY	CHF	Oil	Gold	S&P 500	Bonds
BTC	1.00									
CNY	-0.05 (0.28)	1.00								
EUR	-0.06 (0.20)	0.20*** (0.00)	1.00							
GBP	-0.01 (0.76)	0.22*** (0.00)	0.55*** (0.00)	1.00						
JPY	-0.05 (0.28)	0.20*** (0.00)	0.17*** (0.00)	0.32*** (0.00)	1.00					
CHF	-0.06 (0.22)	0.22*** (0.00)	0.86*** (0.00)	0.61*** (0.00)	0.42*** (0.00)	1.00				
Oil	-0.03 (0.60)	-0.05 (0.28)	-0.04 (0.40)	0.02 (0.64)	0.03 (0.49)	-0.06 (0.22)	1.00			
Gold	0.06 (0.24)	0.01 (0.76)	0.05 (0.27)	0.14*** (0.00)	0.06 (0.23)	0.07 (0.14)	0.14*** (0.01)	1.00		
S&P 500	-0.12** (0.01)	-0.03 (0.57)	-0.13*** (0.01)	-0.05 (0.28)	-0.01 (0.82)	-0.11** (0.03)	0.20*** (0.00)	0.07 (0.13)	1.00	
Bonds	-0.04 (0.40)	0.09* (0.06)	0.04 (0.38)	0.12** (0.02)	0.13*** (0.01)	0.03 (0.52)	0.20*** (0.00)	0.24*** (0.00)	0.38*** (0.00)	1.00

* p < 0.10, ** p < 0.05, *** p < 0.01

Variables	BTC	CNY	EUR	GBP	JPY	CHF	Oil	Gold	S&P 500	Bonds
BTC	1.00									
CNY	-0.12 (0.14)	1.00								
EUR	-0.06 (0.49)	0.35*** (0.00)	1.00							
GBP	0.04 (0.64)	0.06 (0.50)	0.44*** (0.00)	1.00						
JPY	-0.07 (0.38)	0.19** (0.02)	0.24*** (0.00)	-0.05 (0.57)	1.00					
CHF	-0.06 (0.49)	0.29*** (0.00)	0.92*** (0.00)	0.39*** (0.00)	0.42*** (0.00)	1.00				
Oil	0.00 (0.95)	-0.07 (0.42)	-0.04 (0.59)	-0.04 (0.61)	-0.17** (0.04)	-0.10 (0.21)	1.00			
Gold	-0.02 (0.84)	0.04 (0.66)	0.12 (0.16)	0.08 (0.35)	0.19** (0.02)	0.14* (0.08)	-0.26*** (0.00)	1.00		
S&P 500	-0.10 (0.23)	0.00 (0.96)	-0.07 (0.37)	-0.16* (0.05)	-0.11 (0.17)	-0.11 (0.20)	0.28*** (0.00)	-0.11 (0.16)	1.00	
Bonds	-0.01 (0.89)	0.01 (0.86)	0.05 (0.58)	0.04 (0.66)	-0.06 (0.47)	-0.02 (0.78)	0.00 (0.96)	0.17** (0.04)	0.27*** (0.00)	1.00

* p < 0.10, ** p < 0.05, *** p < 0.01

TABLE 9

Correlation of BTC price to #words, time period 2

This table shows the correlations of the BTC price (in levels) to #words (in levels) between January 1, 2013 and February 13, 2014. The words have been distracted from bitcointalks.org, and counted according to a lexicon by Loughran and McDonald (2011). These figures show the (i) daily BTC/USD price development; (ii) number of negative words; (iii) number of positive words; (iv) number of uncertain words (v) total number of words; (vi) fraction of negative words to total number of words; (vii) fraction of positive words to total number of words, and; (viii) fraction of uncertain words to total number of words.

Variables	BTC	Negative	Positive	Uncertain	Words	Neg./Words	Pos./Words	Unc./Words
BTC	1.00							
Negative	0.53*** (0.00)	1.00						
Positive	0.59*** (0.00)	0.95*** (0.00)	1.00					
Uncertain	0.49*** (0.00)	0.95*** (0.00)	0.95*** (0.00)	1.00				
Words	0.58*** (0.00)	0.96*** (0.00)	0.96*** (0.00)	0.95*** (0.00)	1.00			
Neg./Words	-0.01 (0.92)	0.30*** (0.00)	0.11** (0.02)	0.17*** (0.00)	0.05 (0.29)	1.00		
Pos./Words	0.13*** (0.01)	0.11** (0.02)	0.28*** (0.00)	0.15*** (0.00)	0.06 (0.21)	0.23*** (0.00)	1.00	
Unc./Words	-0.28*** (0.00)	-0.12** (0.01)	-0.15*** (0.00)	0.03 (0.52)	-0.23*** (0.00)	0.36*** (0.00)	0.10* (0.06)	1.00

* p < 0.10, ** p < 0.05, *** p < 0.01

TABLE 10**Correlation of BTC price to #words, time period 3**

This table shows the correlations of the BTC price (in levels) to #words (in levels) between October 1, 2013 and February 13, 2014. The words have been distracted from bitcointalks.org, and counted according to a lexicon by Loughran and McDonald (2011). These figures show the (i) daily BTC/USD price development; (ii) number of negative words; (iii) number of positive words; (iv) number of uncertain words (v) total number of words; (vi) fraction of negative words to total number of words; (vii) fraction of positive words to total number of words, and; (viii) fraction of uncertain words to total number of words.

Variables	BTC	Negative	Positive	Uncertain	Words	Neg./Words	Pos./Words	Unc./Words
BTC	1.00							
Negative	0.66*** (0.00)	1.00						
Positive	0.69*** (0.00)	0.95*** (0.00)	1.00					
Uncertain	0.64*** (0.00)	0.97*** (0.00)	0.96*** (0.00)	1.00				
Words	0.70*** (0.00)	0.98*** (0.00)	0.97*** (0.00)	0.98*** (0.00)	1.00			
Neg./Words	-0.08** (0.02)	0.13*** (0.00)	-0.04 (0.19)	0.00 (0.91)	-0.06 (0.10)	1.00		
Pos./Words	-0.02 (0.51)	-0.10*** (0.00)	0.09*** (0.01)	-0.08** (0.01)	-0.11*** (0.00)	0.01 (0.86)	1.00	
Unc./Words	-0.27*** (0.00)	-0.21*** (0.00)	-0.23*** (0.00)	-0.10*** (0.00)	-0.27*** (0.00)	0.26*** (0.00)	0.12*** (0.00)	1.00

* p < 0.10, ** p < 0.05, *** p < 0.01

TABLE 11**Correlation of daily returns of BTC to changes in #words, time period 2**

This table shows the correlations between daily returns of BTC to changes in #words between January 1, 2013 and February 13, 2014. The words have been distracted from bitcointalks.org, and counted according to a lexicon by Loughran and McDonald (2011). These figures show the changes in (i) daily BTC/USD price development; (ii) number of negative words; (iii) number of positive words; (iv) number of uncertain words; (v) total number of words; (vi) fraction of negative words to total number of words; (vii) fraction of positive words to total number of words, and; (viii) fraction of uncertain words to total number of words.

Variables	BTC	Δ Negative	Δ Positive	Δ Uncertain	Δ Words	Δ Neg./Words	Δ Pos./Words	Δ Unc./Words
BTC	1.00							
Δ Negative	0.04 (0.41)	1.00						
Δ Positive	0.05 (0.29)	0.85*** (0.00)	1.00					
Δ Uncertain	0.05 (0.30)	0.86*** (0.00)	0.87*** (0.00)	1.00				
Δ Words	0.05 (0.28)	0.87*** (0.00)	0.87*** (0.00)	0.87*** (0.00)	1.00			
Δ Neg./Words	-0.02 (0.76)	0.37*** (0.00)	0.09* (0.09)	0.09* (0.07)	-0.10** (0.04)	1.00		
Δ Pos./Words	-0.02 (0.71)	0.02 (0.67)	0.29*** (0.00)	0.06 (0.25)	-0.15*** (0.00)	0.36*** (0.00)	1.00	
Δ Unc./Words	0.03 (0.55)	0.06 (0.24)	0.09* (0.07)	0.34*** (0.00)	-0.12** (0.02)	0.38*** (0.00)	0.33*** (0.00)	1.00

* p < 0.10, ** p < 0.05, *** p < 0.01

TABLE 12**Correlation of daily returns of BTC to changes in #words, time period 3**

This table shows the correlations between daily returns of BTC to changes in #words between October 1, 2013 and February 13, 2014. The words have been distracted from bitcointalks.org, and counted according to a lexicon by Loughran and McDonald (2011). These figures show the changes in (i) daily BTC/USD price development; (ii) number of negative words; (iii) number of positive words; (iv) number of uncertain words; (v) total number of words; (vi) fraction of negative words to total number of words; (vii) fraction of positive words to total number of words, and; (viii) fraction of uncertain words to total number of words.

Variables	BTC	Δ Negative	Δ Positive	Δ Uncertain	Δ Words	Δ Neg./Words	Δ Pos./Words	Δ Unc./Words
BTC	1.00							
Δ Negative	0.05 (0.57)	1.00						
Δ Positive	0.06 (0.50)	0.86*** (0.00)	1.00					
Δ Uncertain	0.03 (0.74)	0.90*** (0.00)	0.88*** (0.00)	1.00				
Δ Words	0.05 (0.55)	0.90*** (0.00)	0.85*** (0.00)	0.86*** (0.00)	1.00			
Δ Neg./Words	-0.01 (0.89)	0.14 (0.12)	-0.06 (0.48)	-0.02 (0.81)	-0.28*** (0.00)	1.00		
Δ Pos./Words	-0.05 (0.58)	-0.08 (0.35)	0.17* (0.05)	-0.02 (0.85)	-0.23*** (0.01)	0.42*** (0.00)	1.00	
Δ Unc./Words	0.02 (0.80)	-0.16* (0.06)	-0.12 (0.17)	0.07 (0.44)	-0.33*** (0.00)	0.48*** (0.00)	0.24*** (0.01)	1.00

* p < 0.10, ** p < 0.05, *** p < 0.01