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Bitcoin, Gold and the Dollar – a GARCH Volatility Analysis

Anne Haubo Dyhrberg, University College Dublin

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Anne Haubo Dyhrberg

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Abstract

This paper explores the financial asset capabilities of bitcoin using GARCH models. The initial model showed several similarities to gold and the dollar indicating hedging capabilities and advantages as a medium of exchange. The asymmetric GARCH showed that bitcoin may be useful in risk management and ideal for risk averse investors in anticipation of negative shocks to the market. Overall bitcoin has a place on the financial markets and in portfolio management as it can be classified as something in between gold and the American dollar on a scale from pure medium of exchange advantages to pure store of value advantages.

Keywords: Bitcoin; GARCH; Volatility

1. Introduction

The market for virtual currencies has grown immensely since 2008 in terms of the number of new currencies as well as the consumer base and transaction frequency. Taking into account that no virtual currency existed outside of online gaming communities, this development is extraordinary. However the disruption caused in the monetary market poses great challenges and opportunities to policy makers, economists and entrepreneurs. The development also forces stakeholders to challenge the fundamental idea of what abilities money should have. Analysis has to originate with classifying what kind of financial asset bitcoin is, as it will indicate what role it has on the market. This paper focusses on this core question. By classifying bitcoin, one will get a sense of what capabilities it might have in the market for risk management and portfolio analysis. Additionally it will remove some of the widespread mystery surrounding the cryptocurrency.

Due to the advantages of bitcoin, legislators and economists have been eager to define what bitcoin is in an economic context. Is it a currency or a commodity? How is it different from cryptographic cash (Chaum, 1983) and other virtual currencies (European Central Bank, 2015)? Glaser et al. (2014) asked this question where they focused on the ability of bitcoin as a medium of exchange. Bitcoin is fairly liquid as one can exchange any currency for bitcoin at any time, but due to its scarcity it has liquidity limitations like other commodities. Furthermore Bohme et al. (2015) found that transactions could be delayed for up to an hour which greatly diminishes the liquidity possibilities. However, the bitcoin protocol does not restrict transfers due to watch-lists or embargoed countries as the identities of its users are not known. This gives bitcoin an immense flexibility and speed of international transfer compared to other currencies managed by banks. Glaser et al. (2014) found that the majority of users treat their bitcoin investments as speculative assets rather than as a means of payment. Therefore bitcoin may be mostly useful as an asset rather than a currency

Generally economists have compared bitcoin to gold as they have many similarities. Gold has some intrinsic value but it most likely does not justify its current market value of approximately 1,200 USD per troy ounce (Datastream). Bitcoin must have some intrinsic value if its users are rational. Though it unlikely justify its current price of 240.5 USD per bitcoin as of June 2015

(Coindesk, 2015). Both bitcoin and gold derive most of their value from the fact that they are scarce and costly to extract. Neither of them has a nationality or is controlled by a government. Both assets are 'mined' by several independent operators and companies. Gold was used as a medium of exchange during the gold standard but was abandoned due to liquidity problems. Similar problems might occur for bitcoin if the user base expands further. However on certain points gold and bitcoin are different. Gold is primarily used for its store of value abilities and for its negative correlation with the American dollar which makes it useful for hedging. Such abilities are not certain for bitcoin, but will be investigated.

Karl Whelan has also argued that bitcoin is similar to the dollar (Whelan, 2013). They both have no or limited intrinsic value and are used primarily as a medium of exchange. The main difference is that the dollar is backed by a government in which people trust, while bitcoin is a "private money" introduced by the private sector. Therefore the supply, governance and control of the two assets are different but the comparison is interesting as it shows which monetary abilities are observable.

As bitcoin is difficult to define, analysing if it reacts to the same variables as the dollar and the gold price is informative. The GARCH framework can give an indication of what elements of the world economy bitcoin is sensitive to. This analysis will therefore suggest the economic abilities of bitcoin in risk management, portfolio analysis and currency capabilities. Consequently the main focus of this paper is to apply the GARCH framework popular amongst finance and asset research to answer the question:

1. *How does the return on bitcoin behave compared to the gold price and the dollar-euro exchange rate when analysing the variance of the assets?*

Essentially this research will explore if bitcoin behaves like a well-known financial asset or as something in between a commodity and a currency by analyzing several aspects of its price volatility. The results will also suggest if any hedging capabilities are observable.

The structure of this paper is as follows. Section 2 presents the data. The methodology is described in Section 3. Section 4 contains the results and Section 5 concludes.

2. A First Look at the Data

Bitcoin price data is sourced from Coindesk Price Index from the 19th of July 2010 to 22nd of May 2015. The explanatory variable selection is based on the research done by Tully and Lucey (2007) who investigated the sensitivities of macroeconomic variables on the price of gold, and will include the gold bullion USD/troy ounce rate (Gold Cash), the CMX gold futures 100 ounce rate in USD (Gold Future), the dollar-euro and dollar-pound exchange rates and the Financial Times Stock Exchange Index (FTSE Index). All variables have daily observations sourced from Datastream. Additionally the federal funds rate is included and sourced from the Federal Reserve Bank of New York with daily observations. Summery statistics can be observed in table 1.

Table 1 Summary statistics

VARIABLES	N	mean	sd	min	max
Time	1,769	885	510.8	1	1,769
Price	1,769	170.3	240.1	0.0505	1,147
Ln(price)	1,769	3.145	2.687	-2.986	7.045
Federal Funds Rate	1,769	0.118	0.0388	0.0400	0.210
USD-EUR Exchange rate	1,769	1.316	0.0796	1.052	1.489
USD-GBP Exchange rate	1,769	1.591	0.0506	1.464	1.717
FTSE Index	1,769	6,150	523.4	4,944	7,104
Gold Futures	1,769	1,444	195.4	1,144	1,892
Gold Cash	1,769	1,442	194.0	1,146	1,898

2.1 Stylised facts and time series properties

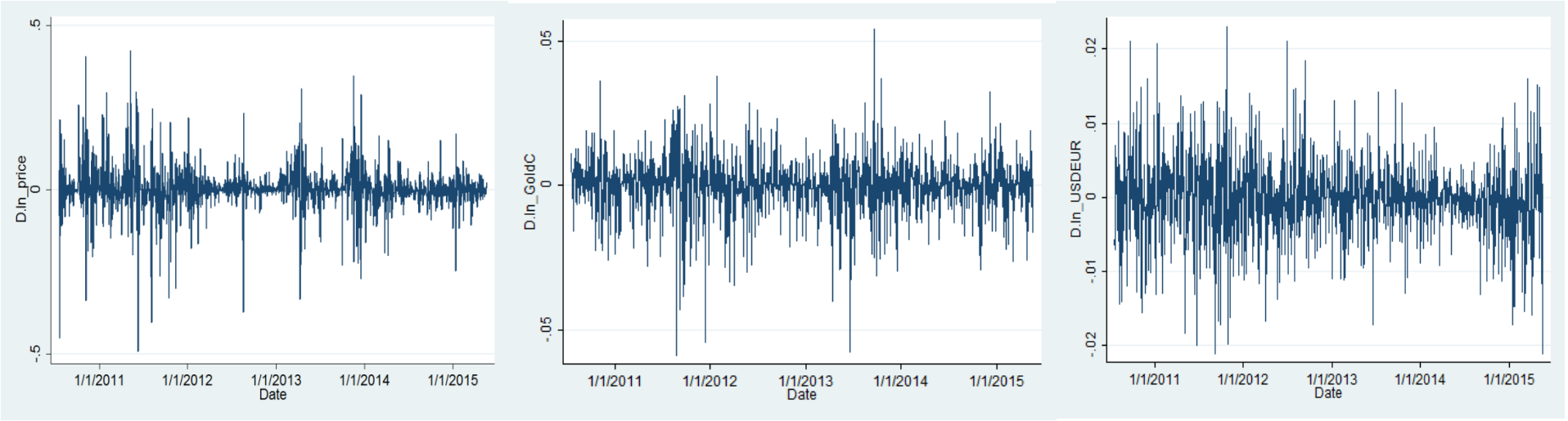
Figure 1 indicates that bitcoin, like other financial assets, is sensitive to certain shocks, may have a positive time trend and shows a clear non-stationarity. The graphs therefore suggest a random walk behaviour. The most noticeable stylised fact (Enders, 2010) is volatility variability. Every graph in figure 2 shows periods of very high volatility and periods of relative tranquillity which is a common feature among financial assets. This indicates that the bitcoin price is suitable for GARCH modelling, and was thus confirmed by Engle's Lagrange multiplier test which indicated

a strong ARCH effect in the residuals of the first differenced logged bitcoin price. DF-GLS and KPSS tests showed a unit root and initial tests identified an AR(1) process which points to a random walk process with no drift. The specification will thereby be the logged first differences of the bitcoin price. Estimation is therefore done by a GARCH(1,1) with an AR(1,2) process.[1]

[1] Details are available upon request.

Figure 1 The levels of the bitcoin price, the gold bullion rate and the dollar-euro exchange rate from July 19th 2010 to May 22nd 2015

Figure 2 The first differences of the logged bitcoin price, gold bullion rate and dollar-euro exchange rate from July 19th 2010 to May 22nd 2015



3. Methodology

Two models are introduced to investigate the similarities between bitcoin, gold and the dollar. First a GARCH model with explanatory variables and mean equation (1) and variance equation (2) is estimated, as presented below.

$$\Delta lnprice_t = \beta_0 + \beta_1 lnprice_{t-1} + \beta_2 lnprice_{t-2} + \beta_3 Fed_{t-1} + \beta_4 USDEUR_{t-1} + \beta_5 USDGBP_{t-1} + \beta_6 FTSE_{t-1} + \beta_7 Gold\ Future_{t-1} + \beta_8 GoldCash_{t-1} + \varepsilon_t \quad (1)$$

$$\sigma_t^2 = \exp(\lambda_0 + \lambda_1 Fed_{t-1} + \lambda_2 USDEUR_{t-1} + \lambda_3 USDGBP_{t-1} + \lambda_4 FTSE_{t-1} + \lambda_5 GoldFuture_{t-1} + \lambda_6 GoldCash_{t-1}) + \alpha\varepsilon_{t-1}^2 + \beta_{\sigma_{t-1}^2} \quad (2)$$

The second model is the exponential GARCH model which investigates if the return on bitcoin is asymmetrically affected by good and bad news (known as the leverage effect) with mean equation (3) and variance equation (4), as presented below.

$$\Delta lnprice_t = \beta_0 + \beta_1 lnprice_{t-1} + \beta_2 Fed_{t-1} + \beta_3 USDEUR_{t-1} + \beta_4 USDGBP_{t-1} + \beta_5 FTSE_{t-1} + \beta_6 Gold\ Future_{t-1} + \beta_7 GoldCash_{t-1} + \varepsilon_t \quad (3)$$

$$\ln(\sigma_t^2) = \lambda_0 + \lambda_1 Fed_{t-1} + \lambda_2 USDEUR_{t-1} + \lambda_3 USDGBP_{t-1} + \lambda_4 FTSE_{t-1} + \lambda_5 GoldFuture_{t-1} + \lambda_6 GoldCash_{t-1} + \alpha(\varepsilon_{t-1}/\sigma_{t-1}) + \gamma\left(|\varepsilon_{t-1}/\sigma_{t-1}| - \sqrt{2/\pi}\right) + \delta ln(\sigma_{t-1}^2) \quad (4)$$

4. Results

The results in table 2 show no signs of a drift. This was expected given the evolution seen in figure 1 and is similar to the findings by Capie et al. (2005) in their investigation of gold. The variance equation indicates low convergence to the long-run equilibrium, volatility clustering and high volatility persistence similar to gold. Past volatility effects clearly dominate past shock effects and should be used in forecasting. The results suggest that the return on bitcoin is more affected by the demand for bitcoin as a medium of exchange and less by temporary shocks to the price which indicate similarities to a currency. Hammoudeh and Yuan (2008) have similar results for gold and identified that gold was much more affected by the demand for jewellery and recycling as it is a precious metal and not an industrial metal, and is less

influenced by short term shocks. Therefore, it seems that bitcoin and gold have similarities when it comes to the volatility of the return and what type of shocks are most influential, though currency similarities were also identified.

Table 2 GARCH(1,1) Volatility persistence of the return on bitcoin with explanatory variables with dependent variable return on bitcoin

VARIABLES	Mean Equation	Variance Equation
Federal funds rate$_{t-1}$	0.0982***	-6.801***
	(0.0359)	(1.127)
USD-EUR Exchange rate$_{t-1}$	0.0502***	9.828***
	(0.0190)	(0.954)
USD-GBP Exchange rate$_{t-1}$	-0.0790***	-10.04***
	(0.0307)	(1.584)
FTSE Index$_{t-1}$	9.25e-06**	-0.000832***
	(3.74e-06)	(0.000158)
Gold Futures rate$_{t-1}$	0.000176	-0.0191*
	(0.000177)	(0.0106)
Gold Cash rate$_{t-1}$	-0.000161	0.0163
	(0.000178)	(0.0107)
L.ar	0.0827***	
	(0.0307)	
L2.ar	-0.0222	
	(0.0269)	
L.arch α		0.327***
		(0.0214)
L.garch β		0.636***
		(0.0159)
Constant	-0.0291	4.930***
	(0.0488)	(1.620)
Observations	1,768	1,768

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Looking at the explanatory variables a number of points are of interest. In the mean equation the coefficient on the federal funds rate suggest that when the federal funds rate increase and the American dollar appreciates, imports will increase and it is therefore likely that online purchases will increase. As bitcoin is particularly useful for international online trade, demand

for bitcoin will increase which will in turn increase returns on bitcoin investments. This result highlights the advantages of bitcoin as a medium of exchange, and its currency similarity.

The coefficients on the exchange rates suggest that bitcoin returns are more sensitive to the value of the dollar relative to the pound, than to value of the dollar relative to the euro. Therefore regional or country specific effects are present. The results are quite similar to previous gold research (Tully and Lucey, 2007), and show that Bitcoin may also be useful in hedging against the dollar. The coefficient on the Financial Times Stock Exchange Index suggests that a positive shock to the stock market may make investors more risk seeking and invest in alternative assets like bitcoin.

The variance equation shows that a positive volatility shock to the dollar-sterling exchange rate decreases the variance of the bitcoin returns which may indicate that bitcoin is a relatively safe asset in such a situation. This result points to additional risk management capabilities of the bitcoin. Based on the coefficient on the federal funds rate one can argue that the bitcoin return will have a lower volatility than the dollar when there is a positive volatility shock to the federal funds rate. Therefore bitcoin may have some risk management capabilities against the dollar similar to what researchers found for gold (Capie et al. 2005). However the extent of these capabilities depends on the previous volatility levels of bitcoin and the dollar. The FTSE Index coefficient points to hedging capabilities of bitcoin against stocks on the London Stock Exchange.

Generally it seems that when there are positive volatility shocks to the variables, with the exception of the dollar-euro exchange rate, the volatility of the returns on bitcoin decrease. This indicates that bitcoin might be preferable for risk averse investors in such instances. Similar results were not however found by Tully and Lucey (2007) as the variance of bitcoin is determined by external factors, and not by endogenous factors like gold, because its value is purely driven by market forces and it lacks a high intrinsic value.

Overall these results indicate that the returns to bitcoin act similarly to an exchange rate due to its sensitivity to the federal funds rate and medium of exchange characteristics. However as discussed, the return on bitcoin has several similarities to gold as seen in its response to

exchange rates and its large volatility persistence. Therefore bitcoin may be somewhere in between a currency and a commodity.

4.1 The exponential GARCH model

How bitcoin reacts to good and bad news will suggest its level of sensitivity and indicate how investors react to events. The exponential GARCH model shown in Table 3 explores these effects.

Table 3 Exponential GARCH(1, 1) dependent variable return on bitcoin

VARIABLES	Mean Equation	Variance Equation
Federal funds rate$_{t-1}$	0.0988***	-0.978***
	(0.0338)	(0.230)
USD-EUR Exchange rate$_{t-1}$	0.0505***	1.813***
	(0.0181)	(0.191)
USD-GBP Exchange rate$_{t-1}$	-0.0844***	-1.914***
	(0.0300)	(0.287)
FTSE Index$_{t-1}$	9.21e-06**	-0.000120***
	(3.66e-06)	(2.88e-05)
Gold Futures rate$_{t-1}$	0.000160	-0.00727***
	(0.000162)	(0.00209)
Gold Cash rate$_{t-1}$	-0.000143	0.00685***
	(0.000163)	(0.00211)
L.ar	0.100***	
	(0.0297)	
L.earch α		0.00776
		(0.0154)
L.earch_a γ		0.545***
		(0.0252)
L.egarch		0.834***
		(0.00982)
Constant	-0.0233	1.203***
	(0.0442)	(0.310)
Observations	1,768	1,768

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

The dominance of the gamma coefficient shows that good and bad news does not have an asymmetric impact on the volatility of the bitcoin returns, similar to gold (Hammoudeh and

Yuan, 2008). The explanatory variables have similar values as in the previous GARCH model, and thus support the initial analysis. As positive and negative shocks do not affect the bitcoin returns and gold asymmetrically, one would be able to use bitcoin or gold to hedge market risks, which affect other assets asymmetrically. Additionally as there is no significant leverage effect bitcoin is a good investment in anticipation of bad news for risk averse investors.

5. Conclusion

The analysis shows that bitcoin has many similarities to both gold and the dollar. Medium of exchange characteristics are clear and bitcoin reacts significantly to the federal funds rate which points to bitcoin acting like a currency. However as bitcoin is both decentralized and largely unregulated it will never behave exactly like the currencies on the market today. Most aspects of bitcoin are similar to gold as they react to similar variables in the GARCH model, possess similar hedging capabilities and react symmetrically to good and bad news. However the frequency may be higher for bitcoin as trading is faster and reactions to market sentiment are quick. The overall result suggests that bitcoin is somewhere in between a currency and a commodity due to its decentralized nature and limited market size. However this does not mean that bitcoin is less useful than current assets on the market. On the contrary, this classification suggests that individuals in portfolio management and market analysis can get a more detailed view of the market by including bitcoin which enables them to make more informed decisions and gain another instrument in hedging. Additionally bitcoin can be used as a tool for risk averse investors in anticipation of bad news. Therefore bitcoin's position on the market would be between gold and the dollar on a scale with one extreme being pure store of value benefits and the other extreme being pure medium of exchange advantages. This result suggests that bitcoin can combine some of the advantages of both commodities and currencies in the financial markets and therefore be a useful tool for portfolio management, risk analysis and market sentiment analysis.

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