Bitcoin: a first assessment

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Tamper-proof, limited supply and divisibility

We believe Bitcoin can become a major means of payment for e-commerce and may emerge as a serious competitor to traditional money transfer providers. As a medium of exchange, Bitcoin has clear potential for growth, in our view.

Store of wealth for the underground economy?

It has been reported that Bitcoin may help users avoid high taxes, capital controls, and confiscation. The correlation between CNY's share of volume of all Bitcoin exchanges and price of Bitcoin is high and rising (Chart 1). That said, the fact that all Bitcoin transactions are publically available and that every Bitcoin has a unique transaction history that cannot be altered may ultimately limit its use in the black market/underworld.

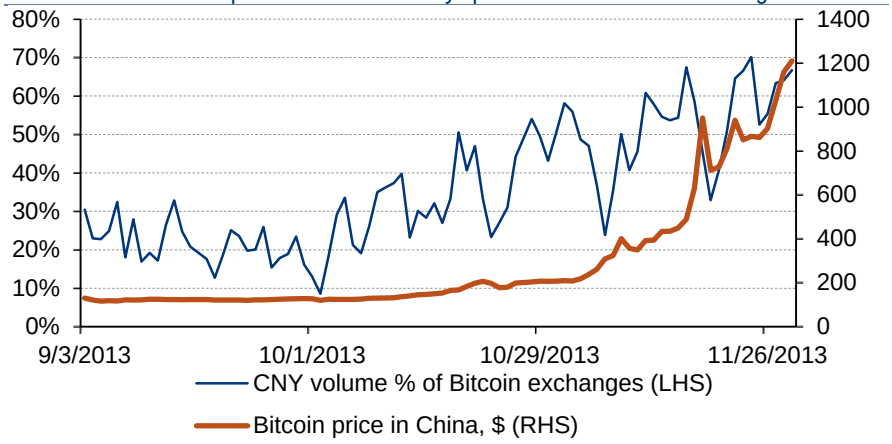
Volatility

Bitcoin's role as a store of value can compromise its viability as a medium of exchange. Its high volatility, a result of speculative activities, is hindering its general acceptance as a means of payments for on-line commerce.

Fair value?

Is Bitcoin a bubble? Assuming Bitcoin becomes (1) a major player in both e-commerce and money transfer and (2) a significant store of value with a reputation close to silver, our fair value analysis implies a ***maximum market capitalization of Bitcoin of $15bn (1BTC = 1300 USD)***. This suggests that the 100 fold increase in Bitcoin prices this year is at risk of running ahead of its fundamentals.

Chart 1: Recent Bitcoin price action is driven by speculation on Chinese exchanges



Source: BofA Merrill Lynch Global Research

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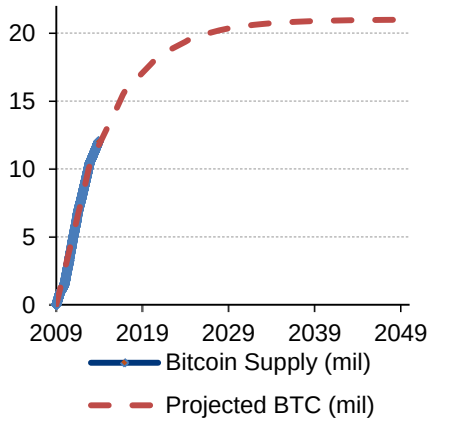
What is Bitcoin?

Bitcoin is a digital currency designed by Satoshi Nakamoto, a pseudonym, in January 2009. Bitcoin allows users to send payments within a decentralized, peer-to-peer network, and is unique in that it does not require a central clearing house or financial institution clearing transactions. Users must have an internet connection and Bitcoin software to make payments to another public account/address.

Chart 2: Bitcoin supply to taper to 21m by 2140



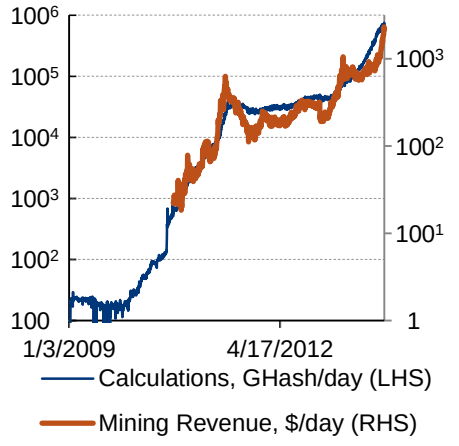
Source: BofA Merrill Lynch Global Research

Satoshi is the smallest unit of Bitcoin; 1 Bitcoin contains 100 million Satoshi. By design, the supply of Bitcoins cannot exceed 21 million Bitcoins (2,100 trillion Satoshi). The total amount of Bitcoin in circulation will increase predictably, based on its underlying code, until reaching the cap in 2140. The current supply is 12 million Bitcoins or 57% of the eventual total (Chart 2).

A **public history of all transactions** is continuously updated and verified by "miners" who gather batches of new transactions into blocks and attach these blocks to the end of the "Blockchain." This public history forms a ledger of transactions where every single Satoshi is tracked from its first owner to the present owner. Having the full history publicly available guarantees that a buyer actually owns the number of Bitcoins he or she wants to spend, preventing fraud.

Bitcoin supply is increased with every new block of transactions added to the public history (i.e. Blockchain). The verification of new transactions by miners is relatively easy and many transactions can be easily compressed in a single block. However, there is a computational task for each block of a high degree of difficulty designed to constrain the increase in the money supply, no matter how slow or fast the overall mining network is. If no external transactions are outstanding, a block with a single transaction to pay the miner would be produced. Indeed, the first several thousand blocks simply paid the miner and contained no other transactions (presently blocks contain a record of hundreds of transactions). This way the initial seed currency was distributed to miners who bore the speculative risk in the Bitcoin's success.

Chart 3: Mining industry has grown exponentially



Source: BofA Merrill Lynch Global Research

As a rough analogy, suppose competing journalists (**miners**) are asked to document the national news on each given day for the National Archives[1]. The journalist is asked to write down the events (**transactions**) in a book (**block**) and the Archive will eventually buy one such book for a fixed fee. To determine which of the books the Archive will buy the archive has an additional requirement for journalists that the book contains the fingerprints of 10 people whose birthday was on that particular day. Note that the list of people isn't related to the national news (**transactions**) but is simply meant to control the supply of books coming out per day. As more journalists collaborate to find people, the Archive increases the number of fingerprints required.

Exchanges allow the conversion between real-world fiat currencies and Bitcoin (Chart 1). The participation in exchanges requires consumers to take on credit risk by transferring Bitcoins from a personal account to a third-party's account, which is similar to entrusting real-life cash to depository institutions. However, unlike banks, Bitcoin third-party accounts are not regulated nor do they provide FDIC protection. While personal accounts are easy to secure, start-up exchanges in overseas jurisdictions with online digital wallets are often targeted by hackers. Exchanges also have some risk of the operator absconding with the money

[1] Mathematics plays the role of the Archive as there is no central authority.

before the currency conversion is completed. Major exchanges ordered by volume are BTC China (CNY), OkCoin (CNY), Mt.Gox (USD, EUR, GBP, JPY, AUD), FXBTC (CNY), Bitstamp (USD), Bter (CNY), BTC-E (USD), BTCTrade (CNY), VirtEx (CAD).

Chart 4: Tech advances favor computational prowess

Source: BofA Merrill Lynch Global Research

Bitcoin as a medium of exchange, distinct from speculative transactions on exchanges, initially gained popularity with companies involved within the Bitcoin ecosystem. For example, miners can purchase specialized chips with Bitcoins. To facilitate transactions, payment processors such as Bitpay provide software to merchants, and absorb FX volatility risk by guaranteeing exchange rates and sending daily bank payments. Since April 2013 significant investment was made into start-ups that develop and promote Bitcoin as a means of exchange for merchants (as opposed to speculation investment on the exchange). For example, CoinLab has received seed money to incubate other Bitcoin start-ups like mining companies and exchanges. The most notable company to accept Bitcoins may be Baidu, a major Chinese portal, which began accepting Bitcoin for its online security services in October 2013.

The rapid rise in BTC prices (292% a year) has generated a comparable exponential growth in **mining revenue**, which in turn has attracted **large capital investment**. Indeed, the number of computations has grown 521% a year (Chart 3), requiring expensive, heavy-duty Bitcoin-mining chips. The competition for revenues has taken away the low-hanging fruit and each dollar mined is now hundred times “deeper” (Chart 4). Electricity costs are also going up as miners use more computers. We describe the miner’s challenge and the mining industry in the Appendix.

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A cost-benefit analysis

Money/currencies are generally thought to have three distinct roles: as a unit of account, medium of exchange, and store of value. To the extent that Bitcoin offers users many benefits and efficiencies as a medium of exchange, this means it possesses some fundamental value that may increase over time as it gains wider use. However, as a unit of account and store of a value, it has considerable shortcomings which we believe will ultimately hinder it from ascending to international currency status. In this section we will review Bitcoin’s advantages and disadvantages in more detail.

Advantages

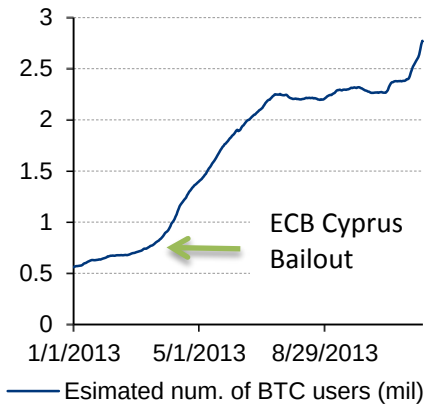
As a medium of exchange, Bitcoin is attractive as it offers low transaction costs. It does so by eliminating the need for a central clearing house or financial institution to act as a third party to financial transactions. Using a decentralized, peer-to-peer network, transactions are verified independently by network users (i.e., miners) who are rewarded for their work with newly minted Bitcoins. In addition, it provides an alternative payment method to users who may not have access to credit or debit cards, or, other forms of electronic payments.

Bitcoin offers an attractive alternative to cash in terms of security, transparency of transactions, and counterfeiting. Bitcoins reside in an encrypted format on their owner’s computer, making it difficult, though not impossible, for hackers to access and steal electronically. Physical Bitcoin theft is also possible, but it seems no easier to carry out on a large scale than for cash.

In addition, given their digital format, Bitcoins are much easier to carry than cash, which could be a particular benefit in economies where large scale transactions are conducted in cash. Bitcoin also offers the benefit of being easier to track than cash given that each coin contains an electronic record of each transaction that coin has gone through since it was created. Not only is each transaction recorded on each Bitcoin, but all transactions are recorded in an online public ledger, offering a level of transparency that is not available with cash. Such transparency offers regulators means to track potentially illicit activity. Lastly, the digital format with automatic verification also makes it impossible to counterfeit[2].

There is a finite supply of Bitcoins. The design of Bitcoin seeks to mimic the supply of gold in that the system will create a finite supply of the currency, which its proponents see as a way to protect its value from profligate governments or central banks. The system is designed such that the supply of Bitcoins will increase over time until it reaches a total supply of 21 million. In order to achieve this target, the incremental supply of new Bitcoins will decrease geometrically by 50% every four years.

Chart 5: BTC user base has grown 5- fold YTD



Source: BofA Merrill Lynch Global Research

Bitcoin's relative anonymity is advantageous to citizens of crisis countries. It has been reported that some believe Bitcoin can be used by those seeking to avoid evade high taxes, capital controls, and confiscation. For example, there was a sharp increase in Bitcoin interest on March 16 when Cypriot authorities, as part of their European assistance package, were prepared to implement a private sector haircut of deposits (Chart 5). Additionally, China has also seen a sharp increase in Bitcoin activity and now accounts for a majority of transactions when broken down by currency, likely reflecting the currency's value as an outlet for those wanting to avoid capital controls or potential confiscation (Chart 1).

"Winner Takes All" market ensures that increasing acceptance and popularity of Bitcoin increases likelihood of success. As Bitcoin becomes more popular, competitors will face higher barriers to entry, making it less likely they will be successful in supplanting Bitcoin's market share. Several other digital currencies with similar features to Bitcoin have been introduced with limited success. However, we believe the structure of the digital currency market is one of "winner takes all" whereby as Bitcoin becomes more popular and is easy to use, consumers will have much less incentive to experiment with an alternative currency with similar features.

Bitcoin offers large benefits (from an asset allocation perspective) given its negative correlation with risk sensitive assets, much like gold. For example, following the October FOMC meeting in which the market interpreted the statement as suggesting a less accommodative stance of policy than was anticipated, gold fell as much as 1% in the aftermath while Bitcoin fell 3%.

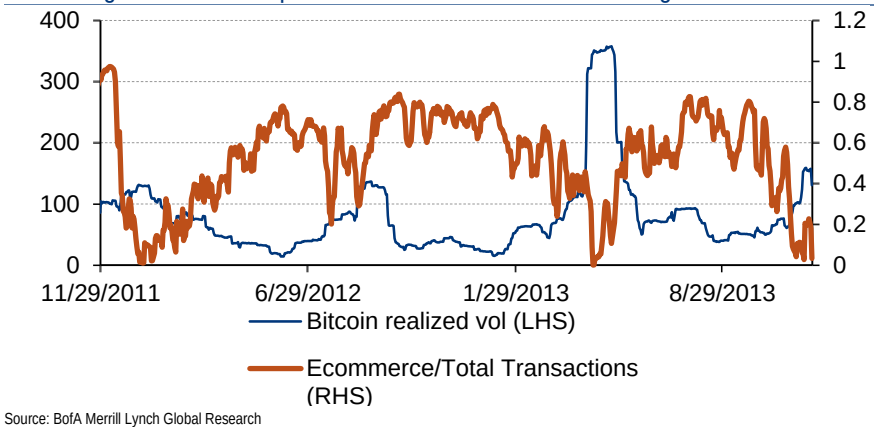
Disadvantages

Bitcoin's role as a store of value is seriously compromised by its elevated price volatility. The dollar price of Bitcoin has moved 10% on a daily basis since its inception including days when the price moved 190% from that day's highs to lows. It can be argued that these swings reflect shifts in estimates about the fundamental value of Bitcoin as more people become aware of it, or, use it. For example, the Bitcoin's dollar price increased 50% to $785 following a Senate

[2] An attacker with 51% of the network may attempt double-spending, similar to passing a bounced check but cannot inflate fake supply as the initial recipient won't be able to tender it. The vast size of the mining industry's computing power makes 51%-attack unprofitable relative to receiving revenue from honest mining.

Hearing on November 18th after which a couple regulators took a more positive stance towards the use of Bitcoin as another form of payment.[3] This is consistent with indications from European officials on Bitcoin. However, it is more likely a function of the highly speculative nature of the market which produces such unstable returns amidst very low circulation and poor liquidity as investors are enticed by the extreme return opportunities. High volatility also undermines Bitcoin's role as a medium of exchange as large retailers are much less likely to accept it as a form of payment with prices so volatile (Chart 6). Stores accepting it now are effectively internalizing the costs of this volatility and not passing it onto consumers, but we would not expect such likely unprofitable practices to last.

Chart 6: High Bitcoin vol compromises its role as a medium of exchange



Source: BofA Merrill Lynch Global Research

Regulators could try to impose controls that would increase the transaction costs for using Bitcoin despite its efficiency and the transparency relative to cash. Firstly, the government is unlikely to want to promote a new currency that could be viewed as one that could help facilitate "black market" activities, or, tax evasion. As a result, regulators are currently thinking about how Bitcoin will fit into the broader payment and tax system, and what makes sense in terms of regulation. The bottom line is any new regulation will raise Bitcoin's transaction costs, offsetting and/or eliminating one its main benefits. In addition, the ease with which Bitcoin can be used internationally increases the need for international regulatory coordination. While coordination raises the risk of an uneven regulatory landscape for Bitcoin, stringent regulation by a few large countries/regions would significantly increase the costs of using Bitcoin, thus limiting its usefulness as a medium of exchange.

The quality of Bitcoin exchange security, where consumers exchange dollars for Bitcoins (and vice versa) is suspect. For Bitcoin users not able to mine their own Bitcoins, their only alternative is to exchange their local currency for Bitcoins at an exchange. Aside from the FX risks these customers take, a large number of Bitcoin exchanges have been hacked with large amounts of customer Bitcoins stolen. In one reported case Bitcoinica, an exchange, lost 18,547 Bitcoins from its deposits after its systems were hacked. More recently, a European exchange called BIPS lost 1,295 Bitcoins (or $990,000) following a security breach.[4] As the vast majority of potential Bitcoin users cannot mine their own Bitcoins, exchanges will be critical for linking local currencies with Bitcoin. Without deposit (FDIC) or investment (SIPC) protection, Bitcoin users/investors have little recourse to retrieve stolen funds so in addition to investment risk they are also carrying credit risk.

[3] Regulators See Value in Bitcoin, and Investors Hasten to Agree (http://dealbook.nytimes.com/2013/11/18/regulators-see-value-in-bitcoin-and-investors-hasten-to-agree/?_r=0)
[4] http://siliconangle.com/blog/2013/11/26/bips-bitcoin-exchange-cleaned-out-in-990k-virtual-heist/

Seigniorage[5] is currently accruing to the "miners" of Bitcoins who have the fastest CPUs. Over time this will undercut seigniorage as a source of revenue for the government as they do not control the creation of Bitcoins. This means the government will have an incentive to crack down on Bitcoin if it becomes too big.

A 50 minute wait before payment receipt confirmation is received will prohibit wider use. Fifty minutes is the time needed for enough additional blocks to be added to the chain to protect against double spending. This is less of an issue for two parties that know each other because they trust the other will not double spend, but when dealing with an anonymous counterparty this creates a high level of unhedgeable risk. As a result, in the absence of a central counterparty verifying transaction/clearing Bitcoin is likely to remain illiquid, and will prevent it from becoming a significant international currency.

Bitcoin's use as an international currency will likely be hindered by the fact that it is not a legal tender. Unlike fiat money, nobody is under any obligation to accept Bitcoins as a mean of payment. Therefore, its value is only as good as the perception of its worth by its users. Without a backstop buyer, Bitcoin could disappear very quickly should perceptions of its usefulness decline. Repeated bouts of volatility and further cyber-attacks which put consumer and investor money in jeopardy will certainly inform this perception even as Bitcoin does offer many benefits. Some aspects of the characteristics of Bitcoins (e.g., it is not centrally cleared and there is a confirmation delay) makes us doubtful about its potential in the OTC market (where most FX trading turnover is executed), even though we cannot rule out that a non-deliverable forward market could emerge.

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How to assess Bitcoin's fair value?

The value of Bitcoin has risen 100 times over the past year, raising the question of whether it is a bubble. To answer this question, we need to be able to assess its intrinsic value. We don't offer a forecast for Bitcoin, but below are our preliminary thoughts on how to approach the fair value question. Bitcoin's is both a medium of exchange as well as a store of value. In our view, it is easier to think about fair value by treating these two purposes separately.

Value as a medium of exchange

As we have argued already, Bitcoin has some attractive attributes as a medium of exchange, especially for e-commerce. What could be the fair value of Bitcoin if it were to become a dominant medium of exchange for e-commerce that accounts for, let's say, 10% of all the payments for B2C transactions? Let's do the following exercise:

- US personal consumption expenditures totaled $11trn in 2012
- Household checking deposits and cash totaled $0.7trn in 2012
- Dividing the former by the latter, we get 0.07 (which we will refer to as velocity from now on)
- Velocity has been rising since 2008, likely reflecting cash hoarding behavior that is likely temporary. To smooth it, we take an average of the velocity of the past ten years to arrive at 0.04 -- we assume US households are holding 4 cents in their cash/near cash balances for every $1 spent over the course of the year

[5] Seigniorage is the revenue earned by the government from issuing money. http://www.bankofcanada.ca/wp-content/uploads/2010/11/seigniorage.pdf

- In 2012, total B2C e-commerce sales in the US totaled $224bn
- If we were to assume that the velocity for on-line sales is the same as the velocity for all US household spending, then households would want to set aside $10bn for their on-line shopping
- Given the assumption that Bitcoin will grow to account for the payment of 10% of all on-line shopping, this would suggest that US households would want to have a balance of $1bn worth of Bitcoins
- What about for the whole world? US GDP is about 20% of World GDP. If we were to assume the same degrees of penetration of e-commerce for the rest of the world and that spending by households outside the US has the same velocity, we get to **$5bn worth of Bitcoins** for the total desired cash/non-cash balance of global on-line shopping.

The above is a very rough calculation and we have made a lot of big assumptions. Moreover, B2C is only one dimension of total e-commerce and we cannot rule out that Bitcoin can become a dominant medium of exchange for B2B transactions. Nevertheless, the exercise shows that if Bitcoins remains only as a medium of exchange, there appears to be a clear upside limit for its value.

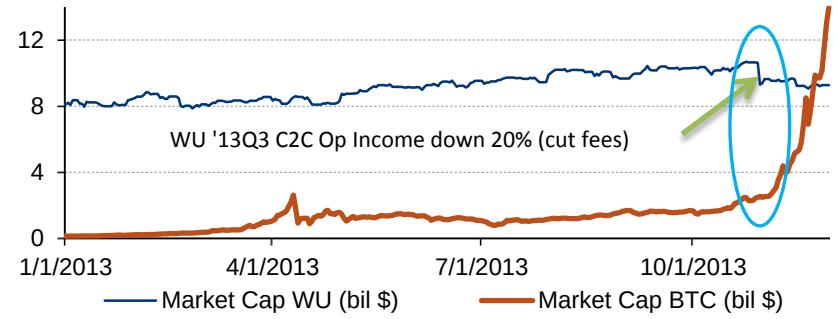
It has been argued that Bitcoin may become a popular means of payment for illicit trade. We don't have an informed view on this subject but the fact that all Bitcoin transactions are publicly available (and therefore can be tracked in theory by law enforcement agencies) and that every Bitcoin is defined by its unique transaction history (making it difficult for criminals to cover their tracks[6]) may limit the growth of its use in the black market/underworld.

In addition to its role as a mean for payment for on-line commerce, Bitcoin can be used for transfer of money (e.g. immigrant worker in the US sending remittances back home). This can be done very cheaply and fast (online settlement in under 10min if the sender is trustworthy like family member or 50min settlement for strangers). How do we assign a maximum fair value to this role of Bitcoin?

Western Union, MoneyGram, and Euronet are the three top players in the money transfer industry (with about 20% of the total market share). Let's assume that Bitcoin becomes one of the top three players in this industry. What does that mean for Bitcoin valuation? Given Bitcoin's supply is fixed, when one buys a Bitcoin, one is acquiring not only a medium of exchange but also an investment in the enterprise value of Bitcoin. From this point of view, Bitcoin's market capitalization could be viewed, with a little leap of faith, as its enterprise value. With the average market capitalization of Western Union, MoneyGram and Euronet at about **$4.5bn**, we will add this number to the maximum market capitalization of Bitcoin's role as a medium of exchange.

[6] Reid and Harrigan (2011) used passive analysis of the public history to identify 60% of the users related to the WikiLeaks donations address. They also validated and traced an alleged theft of 25,000 Bitcoins from a shared mining account despite attempts to launder and reshuffle the money. Law enforcement could do better with subpoenaed IP logs from signups at the exchanges as well as planting and following "marked coins."

Chart 7: BTC surpasses Western Union in market capitalization



Source: BofA Merrill Lynch Global Research, Bloomberg

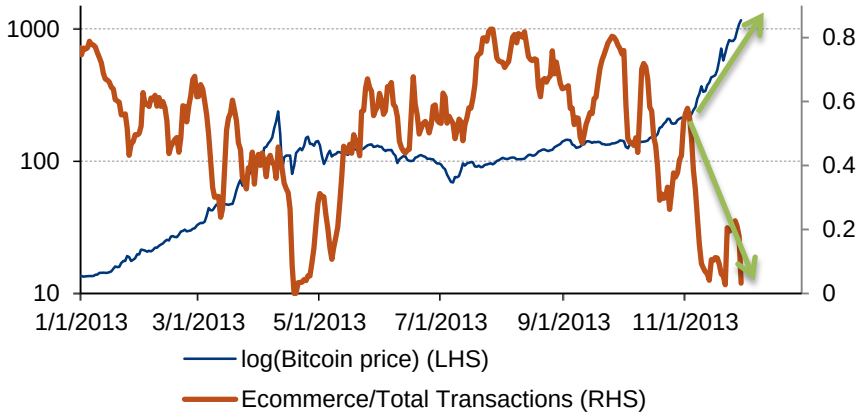
Bottom-line: maximum market capitalization for Bitcoin's as a medium of exchange = $5bn (for B2C e-commerce) + 4.5bn (means for payments) = $9.5bn

Interestingly, our $9.5bn estimate is below the current actual market capitalization of Bitcoin at $13bn. This suggests that the current market value of Bitcoin assumes either that Bitcoin will account more than 10% of market share for e-commerce, will have more than 10% market share of the money transfer industry (Chart 7)., or will have significant value as a store of value.

Value as a store of value

The value of Bitcoin has been recently outstripping the growth of the non-speculative transactions using it (Chart 8). This fact alone would suggest that the price appreciation has been more about Bitcoin as a store of value or investment than as a medium of exchange.

Chart 8: Fewer transactions outside exchanges as prices rose



Source: BofA Merrill Lynch Global Research

How can we assign a value to Bitcoin's role as a store of value? This is a very difficult question. Given Bitcoin does not pay any interest and that there are no investment instruments (equities or bonds) that are denominated in Bitcoin, the value of its store of value role appears limited. From this point of view, as a store value, its closest cousins are probably precious metals or cash (Table 1), in our view.

Table 1: Value of Bitcoin substitutes

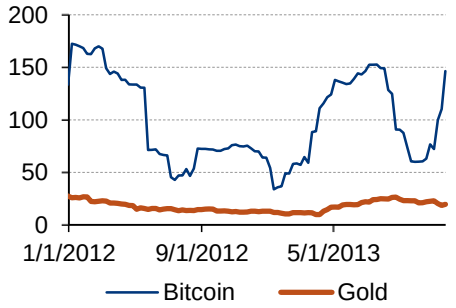
Value of large denomination $+€ bills	Value of gold bar/coins/ETFs in private hands	Deposits of foreigners with Swiss banks
$1.5trn	$1.3trn	$50bn

Source: BofA Merrill Lynch Global Research

Bitcoins and gold have three important common attributes: neither pays any interest, the supply of both is limited, and both are more difficult to trace than most financial assets (except cash). The current outstanding value of gold bar/coins/ETFs is about $1.3trn. Can Bitcoin reach the same market capitalization as gold? We are doubtful.

First of all, Bitcoins are much more volatile than gold, which makes Bitcoins a riskier asset to own. Over the past two years, the volatility of Bitcoin has been on average five times higher than that of gold (Chart 9). All else being equal, this means Bitcoins are five times riskier than gold. Unless Bitcoin volatility declines sharply or gold prices increases sharply, it is reasonable to think that it will be difficult for the market capitalization of Bitcoins to go above $300bn.

Chart 9: Realized vol of Bitcoin versus gold (52w rolling window)



Source: BofA Merrill Lynch Global Research

Furthermore, the reputation of gold as a unique and safe store of value has been growing for the past ten thousand years. It will take some time for Bitcoins to acquire that reputation. We don't know how to quantify the value of gold's reputation, but this reputation is probably the main reason that its value is 60 times that of silver. If we were to assume that Bitcoin were to eventually acquire the reputation of silver (which is an extremely ambitious assumption), this suggests that Bitcoin market capitalization for its role as a store of value could reach $5bn.

By the way, $5bn is not too far from the current value of total US silver eagles minted (since 1986), in our view probably the most relevant comparison to Bitcoin, that is around $8bn (12k tons).

Bottom-line: maximum market capitalization for Bitcoin's as a store of value = $5bn

Bitcoin's has one advantage over gold in that it is easier to transfer. That said, we don't think this is a big advantage given the advent of gold ETFs and the ability to move such ETFs in-between accounts. We would not assign any additional value for Bitcoin in this respect.

Clearly, market perception of the Bitcoin's fair value also depends importantly on the outlook for unconventional monetary policy. If Federal Reserve's quantitative easing does not end over the next year, as is generally expected, the demand for safe haven assets (like gold and Bitcoins) would increase supporting their value. We expect Fed tapering to begin in Q1 next year and the USD to slowly regain its credibility as the world's reserve currency, especially as the US continues to reduce its fiscal deficit that will likely fall below 4% of GDP next year. Bitcoin as a store of value likely will struggle to gain traction if our bullish USD view for 2014 turns out to be correct.

Final tally:

When we add our estimated maximum market capitalization for Bitcoins for its role as a medium exchange with that for its role as a store of value, we get a number that is somewhere around $15bn. Although this does not mean that Bitcoin price cannot rise further (as an object of speculation), we think the recent rise of Bitcoin price could soon run ahead of its fundamentals. Our current view implies a:

Maximum market capitalization for Bitcoin = $15bn

Maximum fair value of Bitcoin = 1300 USD

Conclusions

We believe Bitcoin could become a major means of payment for e-commerce and may emerge as a serious competitor to traditional money-transfer providers. As a medium of exchange, Bitcoin has clear potential for growth, in our view.

There is much speculation that Bitcoin may help avoid high taxes, capital controls, and confiscation. The correlation between CNY's share of volume of all Bitcoin exchanges and price of Bitcoin is rising. That said, the fact that all Bitcoin transactions are publically available and that every Bitcoin has a unique transaction history that cannot be altered may ultimately limit its use in the black market/underworld.

Bitcoin's role as a store of value can compromise its viability as a medium of exchange. Its high volatility, a result of speculative activities, is hindering its general acceptance as a means of payments for on-line commerce.

Is Bitcoin a bubble? Assuming Bitcoin becomes (1) a major player in both e-commerce and money transfer and (2) a significant store of value with a reputation close to silver, our fair value analysis implies a maximum market capitalization of Bitcoin of $15bn (1BTC = 1300 USD). This suggests that the 100 fold increase in Bitcoin prices this year is at risk of running ahead of its fundamentals.

Appendix

Bitcoin is based on **public-key cryptography** where each transaction is referenced by two keys: the public key that encrypts incoming payments and the private key that decrypts them. These keys are represented by long numbers to make encryption secure against brute-force guessing. Although it is possible to use the same account (public key) for all incoming and outgoing transactions, people who desire anonymity would generate unique public keys for each transaction. They would give out a unique address to receive and store one-time payments from other senders, rather than using a static single address as we do with bank accounts. Otherwise, the public can deduce how much money there is in each address and how the owners spend it by looking at the public history. To make large payments, the user may combine several sources of funds e.g. 10 public keys with 0.7 Bitcoins each to make a payment of 5 Bitcoins and simultaneously return 2 Bitcoins as change to a newly created address.

A **miner** acts like a historian logging and verifying new transactions in the public ledger. As an incentive to update the ledger, the miner receives a predetermined amount of Bitcoin when his block is linked to the Blockchain. Each block is an independent challenge: the first miner to compute the proof gets paid while the rest get nothing and have to start over on a new block. Each miner's problem is distinct because it depends on the previous block, outstanding transactions and the unique payment to themselves. Thus, a faster computer does not guarantee victory, but does increase the probability of winning. In practice, miners join guilds to spread profits based on individual contributions to reduce the volatility of large and significant payoffs from acting alone.

The main **block chain** contains the longest series of connected and verified blocks and establishes the definitive consensus on the public history of transactions. A block is considered verified when it contains a "proof of work," which is special piece of code the "miner" has calculated. A miner summarizes

the new transactions using what is known as a cryptographic hash function[7], which gives a compact description of new transaction entries that form the new block. Miners keep calculating new hashes until they're lucky and “hit bull’s eye” when they find a small hash that summarizes the new block and the transactions it contains. The blocks are connected because each new block references the previous block in the longest chain. The purpose of finding this small hash is to prove the miner did billions of calculations[8] and deserves the block. The computational requirement to verify each block makes it impractical to rewrite history by an attacker.

An **arms race** results from competition for easy mining profit where miners compete to outspend each other on the ever-improving mining equipment. Unlike real-life mining, the resource output does not increase with network size because of the difficulty adjustment applied to the verification of each block. The difficulty measures how small the target hash has to be and changes every 2016 blocks (every 2 weeks). As computing power goes up, thus the difficulty increases exponentially and ensures a new block is added every 10 minutes on average. In practice, occasional individual blocks can be 5 or 15 minutes apart. Every 210,000 blocks (4 years) the payments halve so that blocks in 2139 will only earn 1 Satoshi/each and none after 2140. Instead, the system allows for senders of transactions to propose a small transaction fee to go to the winning miner as a form of compensation. The miners then prioritize transactions with larger payments to get included into blocks faster.

Hobby miners have been recently displaced by capitalized industrial miners using specialized mining computer chips as the number of computations to yield $1 has been growing at 157%/year (Chart 4).

[7] A hash function is a one-way encryption that garbles input of any length into output of a fixed length, such as "The quick brown fox jumps over the lazy dog" hashes to 37f332f68db77bd9d7edd4969571ad671cf9dd3b. While “The quick brown fox jumps over the lazy cog" gives 132072df690933835eb8b6ad0b77e7b6f14acad7.

[8] A billion hashes is denoted as a Giga Hash and is used as a standard measurement of network speed.

Link to Definitions

Macro

Click here for definitions of commonly used terms.

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