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BITCOIN: RINGING THE BELL FOR A NEW ASSET CLASS

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RESEARCH WHITE PAPER BY


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ARK Invest and Coinbase explore the merit of bitcoin as the first of its kind in a new asset class—*cryptocurrency*—distinct from all other asset classes. Universally, we think traditional asset classes must meet the requirement of *investability*. However, traditional asset classes then differ in their politico-economic features, correlation of price movements, and risk-reward profiles. In this paper, all four criteria are explored in the context of the major asset classes.

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INTRO

Bitcoin and its underlying blockchain technology have become a force of innovation since being introduced in the midst of the 2007-2008 Financial Crisis.¹ The utility of the technology has driven the value of the currency that rides on top of it—bitcoin with a lower-case “b”—to grow by more than 1,000 fold in the last five years.² This means a person who invested \$1,000 in bitcoin at the start of 2011 would now be a millionaire. We believe that technical jargon, bad actors, price volatility, and sensational media have kept much of the masses away from what could be the biggest technological development since the Internet.

While this paper will not dive into the specifics of the technology,³ ARK Invest and Coinbase encourage readers new to the subject to start with the originating white paper by Satoshi Nakamoto⁴ and follow it with Marc Andreessen’s article in the *New York Times*.⁵

Despite storing over eight billion dollars in value,⁶ bitcoin still generates confusion around its classification as an asset. The Commodity Futures Trading Commission (CFTC) asserts that it’s a commodity,⁷ the Internal Revenue Service (IRS) deems it property,⁸ and the U.S. Securities and Exchange Commission (SEC) has decided to approach it on a case-by-case basis.⁹

The term cryptocurrency further muddles the regulatory situation, as it implies cryptocurrencies are a subset of the currency asset class, which we think is not the case. In our opinion, it may be better to consider other naming conventions, such as cryptomark, cryptobit, cryptostamp, ledgermark, or consensobit.

The definition of an asset class was addressed in Robert Greer’s seminal 1997 paper, “What is an Asset Class, Anyway?”¹⁰ In his paper, Greer lays out three superclasses of assets, which include capital assets, consumable/transformable assets, and store of value assets. He goes on to say “the lines between asset classes can still be fuzzy,” as is the case with gold fulfilling both consumable/transformable and store of value asset profiles, as shown in Table 1.

Greer derives his three asset superclasses from a study of “fundamental economic features” and the correlation of their returns.¹¹ Nested within the superclasses are traditional asset classes—as listed on the left hand side of the table below—which is the layer of classification that this paper will focus on.¹²

1 “History of Bitcoin,” History of Bitcoin, Accessed June 2016, <http://historyofbitcoin.org>

2 ARK Investment Management LLC & Coinbase, data sourced from TradeBlock XBX data.

3 To summarize, Bitcoin is a protocol that facilitates a 100% digital, transparent and immutable ledger, enabling the transfer of value across the Internet without the need for centralized custodians. The Bitcoin protocol is composed of three moving parts: miners, Bitcoin’s blockchain, and bitcoin (the currency). The miners are the machines that mathematically compile transactions—employing a robust consensus mechanism to maintain an ongoing blockchain (i.e., digital ledger)—and bitcoin is the fuel that incentivizes the machines to churn, while also serving as a unit of account within the ledger.

4 “Bitcoin: A Peer-to-Peer Electronic Cash System,” Satoshi Nakamoto, 2008, <https://bitcoin.org/bitcoin.pdf>

5 “Why Bitcoin Matters,” Marc Andreessen, January 2014, <http://dealbook.nytimes.com/2014/01/21/why-bitcoin-matters>

6 Crypto-Currency Market Capitalizations, CoinMarketCap, Accessed June 2016, <http://coinmarketcap.com>

7 “Release: PR7231-15,” CFTC, September 2015, <http://www.cftc.gov/PressRoom/PressReleases/pr7231-15>

8 “IRS Virtual Currency Guidance,” IRS, March 2014, <https://www.irs.gov/uac/Newsroom/IRS-Virtual-Currency-Guidance>

9 “Adapting the Regulatory Framework to Blockchain Technology,” Panel Speakers, April 2015, Coala Blockchain Workshops.

10 “What is an Asset Class, Anyway?” Robert J. Greer, 1997, *The Journal of Portfolio Management*.

11 *Id.*

12 While not the focus of this paper, ARK and Coinbase believe bitcoin, and cryptocurrencies more broadly, would fall primarily under the store of value asset superclass, though with consumable/transformable superclass characteristics as well.



TABLE 1
 Categorization of Traditional Asset Classes by their Superclass

	CAPITAL ASSETS "Ongoing source of something of value...valued on the basis of net present value of its expected returns."	CONSUMABLE/ TRANSFORMABLE ASSETS "You can consume it. You can transform it into another asset. It has economic value. But it does not yield an ongoing stream of value."	STORE OF VALUE ASSETS "Cannot be consumed; nor can it generate income. Nevertheless, it has value; it is a store of value asset."
EQUITIES	X		
BONDS	X		
INCOME-PRODUCING REAL ESTATE	X		
PHYSICAL COMMODITIES (e.g., grains or energy products)		X	
PRECIOUS METALS (e.g., Gold)		X	X
CURRENCY			X
FINE ART			X

Source: "What is an Asset Class, Anyway?" Robert J. Greer, 1997, The Journal of Portfolio Management

Building upon Greer's work, ARK Invest and Coinbase have defined four distinct characteristics that delineate the boundaries among traditional asset classes:

- | Investability
- | Politico-Economic Features
- | Correlation of Returns: Price Independence
- | Risk-Reward Profile

First, we think that an asset class must be sufficiently investable, providing ample liquidity and opportunity to invest. Second, it should have a distinct politico-economic profile that arises from its basis of value, governance, and use cases. Third, an asset's market value should fluctuate independently of other assets in the marketplace, exhibiting low correlation of returns. Lastly, the prior three characteristics should lead to a differentiated risk-reward profile, which can be broken down into absolute returns and volatility. Combined, these four characteristics clarify which assets belong in each class.

For example, equities and bonds are considered different asset classes because after fulfilling the investability requirement, they differ in the latter three characteristics listed above. The politico-economic profiles of the two are different: an equity provides a perpetual claim on a company's future cash flows, while a bond provides fixed periodic payments over a finite period of time secured by a company's underlying assets. They



behave differently in the marketplace, as witnessed in a “risk-off” environment in which equities struggle and bonds rally. Their historic risk-reward profiles are different, as stocks tend to have higher absolute returns with higher price volatility, while bonds have lower absolute returns with lower volatility.

By analyzing bitcoin’s behavior in the context of these four criteria, ARK Invest and Coinbase aim to unearth its merit as a bellwether for the cryptocurrency asset class. That said, cryptocurrency as an asset class cannot be proven as unique without observing its behavior relative to traditional asset classes: equities, bonds, precious metals, real estate, energy products, and fiat currencies.

METHODOLOGY

ARK Invest and Coinbase have selected the following commonly used benchmarks,¹³ respectively, to compare cryptocurrency to other traditional asset classes:

- | The S&P 500 Index (SPX) (“US equities”);
- | The iShares Lehman Government/Credit Bond Fund Index (GBFNV) (“US bonds”);
- | The index underlying the SPDR Gold Shares ETF (GOLDLNPM) (“gold”);
- | The Morgan Stanley Capital International (MSCI) US Real Estate Investment Trust Index (RMZ) (“US real estate”);
- | The Crude Oil Futures (CL1 COMB) (“oil”); and
- | The MSCI Global Currency Index (MXEF0CX0) (“Emerging Market Currencies”).

We chose these benchmarks as standard representatives of many different asset classes since bitcoin is a standard example of the cryptocurrency asset class.

¹³ Index data was sourced from Bloomberg as total return with reinvested dividends where relevant.

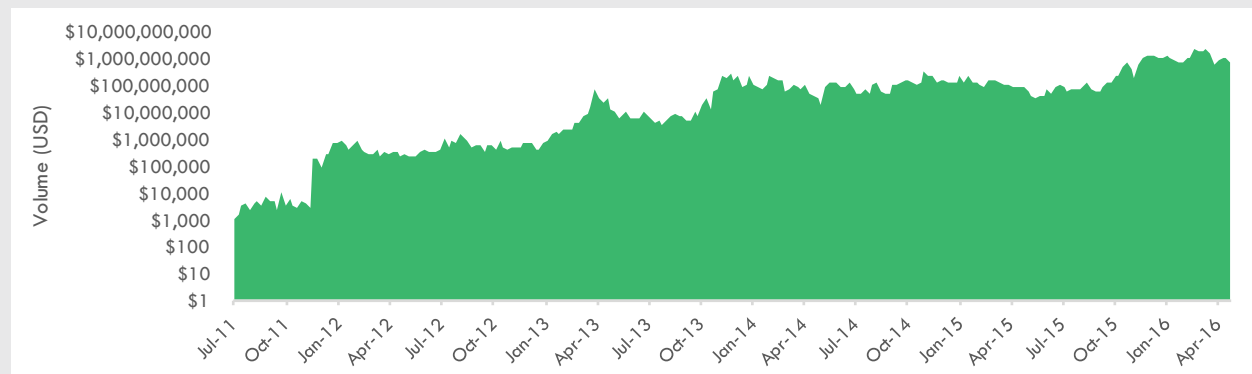


INVESTABILITY

ARK Invest and Coinbase define *investability* as providing ample liquidity and opportunity to invest. Globally, bitcoin exchange trading volumes are a good measure of the liquidity available to investors. As shown in Figure 1, these volumes have been increasing steadily, reaching roughly \$1 billion per day through the first quarter of 2016.

FIGURE 1

Global Daily Bitcoin Exchange Traded Volume

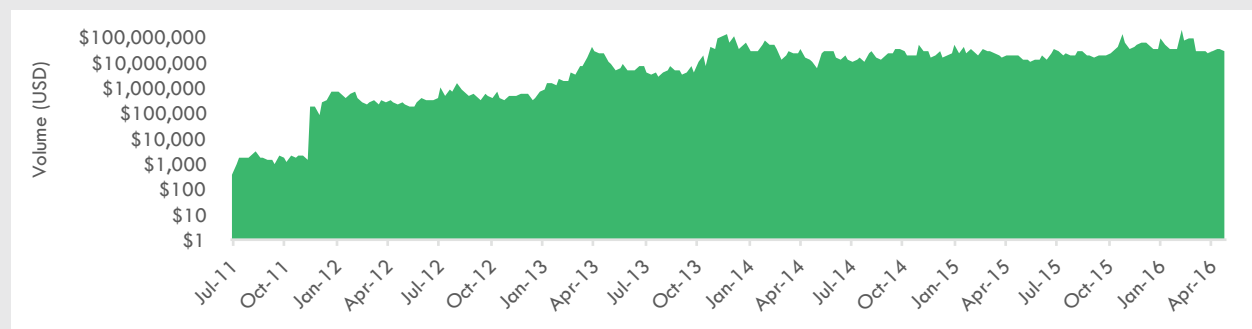


Source: ARK Investment Management LLC & Coinbase, data sourced from Bitcoinity global exchange volume & TradeBlock XBX data
 Note: Log Scale

However, the graph above suffers a shortcoming as trading activity is self-reported by exchanges and not validated by third parties. If we were to look only at bitcoin traded as a cross with the US dollar, euro and British pound—the assumption being that businesses are monitored more closely when handling these currencies—the picture is starkly different.¹⁴ Daily trades made in these three currencies have been ranging between \$10 to \$100 million since early 2014, as shown in Figure 2. For 2016, this comparison puts these three currencies at between 2-10% of global bitcoin trading volume.

FIGURE 2

Daily Bitcoin Exchange Traded Volume: USD, EUR, and GBP Currency Pairs



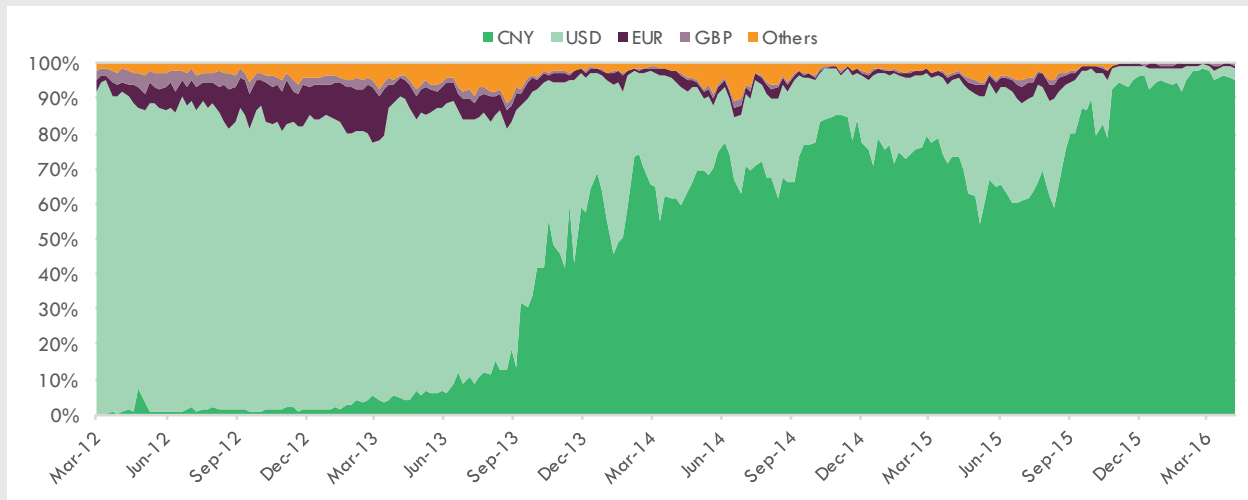
Source: ARK Investment Management LLC & Coinbase, data sourced from Bitcoinity global exchange volume & TradeBlock XBX data
 Note: Log Scale

¹⁴ CoinMarketCap takes a different approach toward discounting trading volume, excluding exchanges that don't charge fees in its calculations: <http://coinmarketcap.com/currencies/bitcoin/#markets>



As a percentage of reported bitcoin volume traded, the Chinese yuan took significant share during the explosive November 2013 price rally, and has continued to dominate (Figure 3). Although over-the-counter (OTC) trading is still a small percentage of total volume generation, and not included in these graphs, itBit's Asian OTC volume soared 300% month-over-month in March 2016.¹⁵

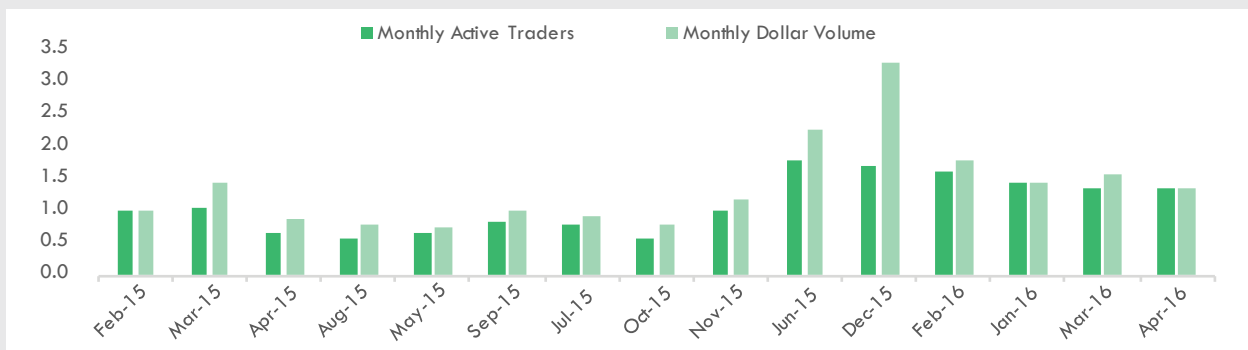
FIGURE 3
 Global Bitcoin Exchange Traded Volume Share by Currency



Source: ARK Investment Management LLC & Coinbase, data sourced from Bitcoinity global exchange volume

In our opinion, traders have more opportunity and desire to interface with bitcoin as currency pairs and order types grow, regulation crystallizes, and macroeconomic uncertainty underscores its value proposition. According to data from Global Digital Asset Exchange (GDAX), the most liquid bitcoin exchange in the US, trading volume is closely connected to the number of active traders for any given month (Figure 4). When there are big price swings like those that occurred in late 2015, a flywheel effect reinforces volume as traders capitalize on the volatility, driving even more volume through GDAX.

FIGURE 4
 Global Digital Asset Exchange (GDAX) Monthly Trader and Dollar Volume Growth



Source: ARK Investment Management LLC & GDAX | Note: February 2015 used as a baseline value of 1

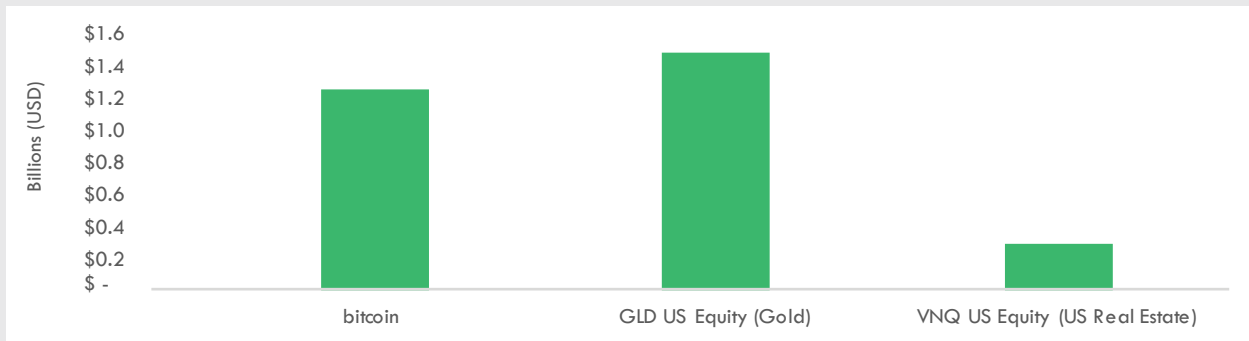
15 "itBit Bitcoin OTC Market Update: March 2016," itBit, <https://www.itbit.com/blog/itbit-bitcoin-otc-market-update-march-2016>



As of May 6, 2016, bitcoin's average daily liquidity for the trailing three months¹⁶ nearly matched the SPDR Gold Shares ETF (GLD) and was three times that of the Vanguard REIT ETF (VNQ), as shown in Figure 5.¹⁷ These numbers are surprising considering bitcoin stored \$7 billion in value at the time, while the GLD stored \$34 billion and the VNQ stored \$56 billion. In our opinion, equal or superior volume with a fraction of the assets under management underscores that bitcoin is punching significantly above its weight.

FIGURE 5

Daily Liquidity (Trailing Three Month Average)

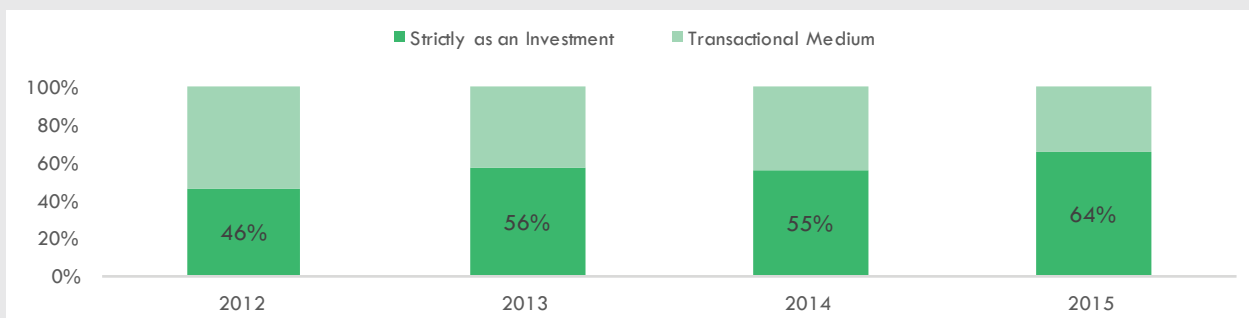


Source: ARK Investment Management LLC & Coinbase, data sourced from Bitcoinity, Bloomberg, & TradeBlock
 Note: Data as of May 6th, 2016

Trading is only half of the investability equation, as traders are short-term “investors,” while many retail holders are long-term oriented. Increasingly, users on Coinbase’s wallet and retail conversion service are using bitcoin strictly as an investment, or long-term store of value, as shown in Figure 6.

FIGURE 6

How Coinbase Users Interact with Bitcoin



Source: ARK Investment Management LLC & Coinbase

Note: This graph includes all Coinbase users with greater than \$1 of bitcoin in their wallets. If a user sends a material amount of bitcoin to another address over the course of the year, they are considered to approach bitcoin as a transactional medium. Users that only purchased or held bitcoin during the year are considered as using bitcoin strictly as an investment. This graph differs from data Coinbase has previously referenced where user behavior is analyzed in dollar terms rather than events.

¹⁶ As addressed earlier in the piece, much of this liquidity goes through the CNY to bitcoin pair.

¹⁷ On a trailing three-month average basis that includes February, March, and April 2016.



Since Coinbase stores nearly half a billion dollars of bitcoin—more than any other provider in the world—arguably it is a representative sample of the ecosystem as a whole. If we assume transactors and investors hold roughly the same amount of bitcoin in their wallets, then 60% of bitcoin worldwide—or north of \$4 billion out of a \$7 billion base—is strictly a store of value. While the value that bitcoin stores is non-trivial, we believe it still has enormous headroom in relation to the \$100 trillion dollars stored in global capital markets.¹⁸

Digging deeper into the numbers, ARK and Coinbase estimate that roughly seven million people around the world hold a material amount of bitcoin. Meanwhile, over 500 million people hold stocks directly or indirectly.¹⁹ Even a modest uptake by those who have shown a propensity to hold higher-risk assets would increase bitcoin liquidity materially. Moreover, while bitcoin is perhaps held by 1% of current equity investors, it has penetrated less than 0.1% of the global population.²⁰ Ultimately, it seems likely that as cryptocurrencies mature, the number of holders will expand meaningfully, providing a positive tailwind for investability within the asset class.

The question of who and how many people hold bitcoin highlights a key characteristic of bitcoin's investability: the censorship-resistant nature of its distributed and permissionless blockchain. While exchanges need a banking relationship to convert local fiat currency into bitcoin, "mining"²¹ is a mechanism by which citizens can acquire bitcoin independent of regulation or capital controls. Local currency buys the mining equipment that then generates bitcoin, which can be traded for a number of fiat currencies. As more support infrastructure is built around the network, bitcoin may become the most secure and accessible asset available to the public.

In summation, while bitcoin is not yet the most liquid or widely held asset on the worldwide market, we believe its thin market and fringe status is overstated. A surprisingly robust ecosystem has grown in the seven years since its inception, giving retail investors the tools and opportunity to drive over one billion dollars in daily liquidity. There are many companies that aim to broaden retail exposure to bitcoin, such as Lawnmower's "Bitcoin investing, simplified" mobile app.²² Meanwhile, an institutional infrastructure is building with products like Grayscale's Bitcoin Investment Trust,²³ TeraExchange's Bitcoin forwards,²⁴ XBT Provider's exchange-traded notes (ETN) on Nasdaq Nordic in Stockholm,²⁵ and potentially exchange-traded funds (ETFs). With each month, bitcoin cements its role as a tradeable and investable asset, drawing second looks from many investors who wrote it off as fraud or fad.

18 "Global Invested Capital Market," Hewitt EnnisKnupp, an Aon Company, June 2014, http://www.aon.com/attachments/human-capital-consulting/2014_HEK_whitepaper_Global_Invested_Capital_Market.pdf

19 "One Half-Billion Shareholders and Counting," Grout, P.A., W.L. Megginson and A. Zalewska, 22nd Australasian Finance and Banking Conference 2009, August 2009, http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1457482

20 Based on a world population of 7.4 billion people, per "Current World Population," Worldometers, Accessed June 2016, <http://www.worldometers.info/world-population>

21 "Mining" refers to the computers that secure and record transactions submitted to Bitcoin's network. In exchange for this service miners receive newly minted bitcoin.

22 "Bitcoin investing, simplified," Lawnmower, Accessed June 2016, <https://lawnmower.io>

23 "The Bitcoin Investment Trust," Grayscale, Accessed June 2016, <http://grayscale.co>

24 "Bitcoin Forwards," TeraExchange, Accessed June 2016, <http://www.teraexchange.com/bitcoin.html>

25 "XBT Provider," XBT Provider, Accessed June 2016, http://www.xbtprovider.com/lang_en



POLITICO-ECONOMIC PROFILE

The politico-economic profile of an asset class is driven primarily by its basis of value, governance, and use cases. In each, bitcoin is distinct from the other major asset classes with gold providing a useful backdrop for comparison (Table 2).

| BASIS OF VALUE

Critics of bitcoin often point out that if it unravels, the platform offers no recourse to tangible goods, nor is any single legal entity accountable for its functioning. Instead, holding bitcoin represents a publicly verified claim on an open but limited resource that can facilitate transactions of all kinds. Bitcoin's vast potential is what sustains its value currently. As more infrastructure is built around it, we think that demand will rise relative to its mathematically metered supply, increasing its price support. A purely digital and consensus-based asset may seem foreign, but it's no surprise that such an asset was born in an increasingly digital and socially networked world.

| GOVERNANCE

While bitcoin's basis of value is unique, its governance is arguably more of an anomaly. Bitcoin transactions are verified through a decentralized and open network of computers called "miners." Furthermore, the code that miners run is open-source and subject to change by the community. Bitcoin supply is mathematically metered by this software and will converge to a fixed 21 million units by 2140 (Figure 7, 8).²⁶ Its supply characteristics are in contrast to fiat currencies, which are governed by monetary policies that can lead to frequent supply shocks (Figure 9, 10). Meanwhile, the global gold supply has inflated steadily over the last hundred years (Figure 11, 12).

Compared to bitcoin, no asset has evolved from concept to billions of dollars in stored value so quickly. Moreover, no asset in history has followed such a predictable supply trajectory.

TABLE 2

GOLD: POLITICO-ECONOMIC PROFILE

BASIS OF VALUE

- | In contrast to other asset classes, gold has unique physical properties—malleability, density, divisibility—that have made it suitable as a unit of account throughout history.
- | Gold is scarce, unlike equities, bonds, real estate, currencies, and to some degree, oil.
- | Gold retains value even in the absence of an underlying legal structure, in contrast to equities, bonds, and real estate.

GOVERNANCE

- | Gold's supply is governed by economic factors affecting the mining community.
- | In contrast to other asset classes, little regulatory governance affects the provisioning of gold. At times, however, nation-states have played a heavy-handed role, even outlawing private ownership.

USE CASES

- | Gold's use cases are diverse, which is highlighted in the context of Greer's three asset superclasses: capital assets, consumable/transformable assets, and store of value assets. Most traditional asset classes are nested under only one of Greer's superclasses. Gold, on the other hand, falls under both the store of value superclass (e.g., gold bars), and consumable/transformable asset class (e.g., gold circuitry in electronics).

²⁶ "Controlled Supply," Bitcoin Wiki, Accessed June 2016, https://en.bitcoin.it/wiki/Controlled_supply



FIGURE 7
 Bitcoin Average Annual Rate of Supply Increase

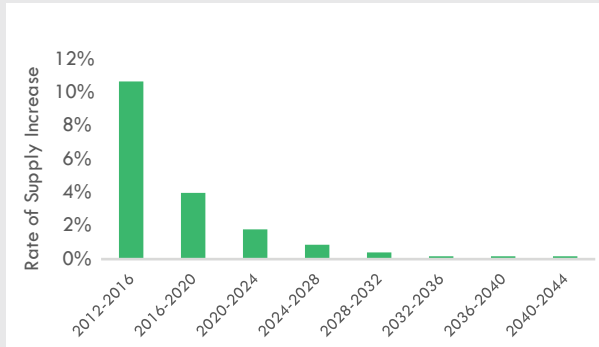
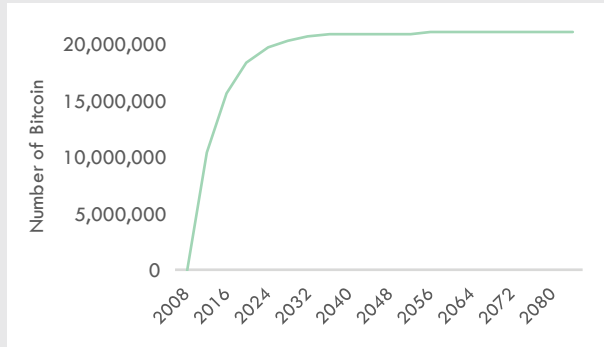


FIGURE 8
 Bitcoin Outstanding



Source: ARK Investment Management LLC & Coinbase, data sourced from Bitcoin Wiki

FIGURE 9
 US Monetary Base Annual Rate of Supply Increase

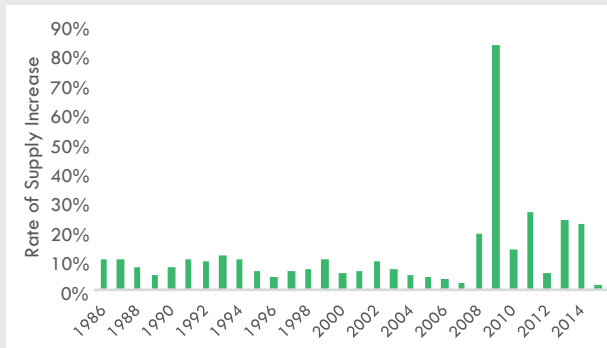
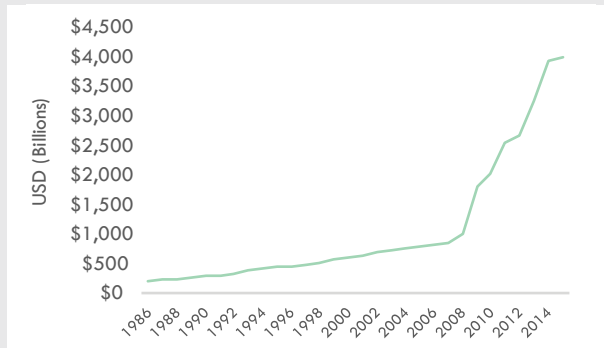


FIGURE 10
 US Monetary Base



Source: ARK Investment Management LLC & Coinbase, data sourced from Federal Reserve Bank of St. Louis

FIGURE 11
 Gold Supply Annual Rate of Supply Increase

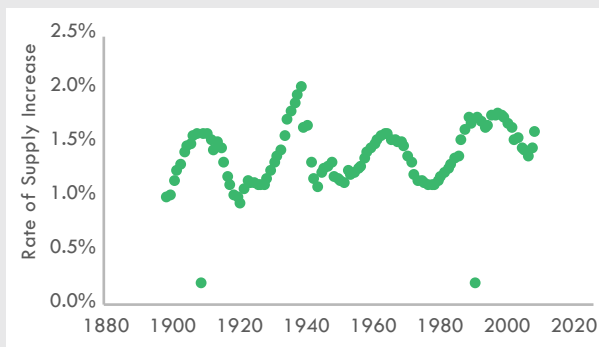
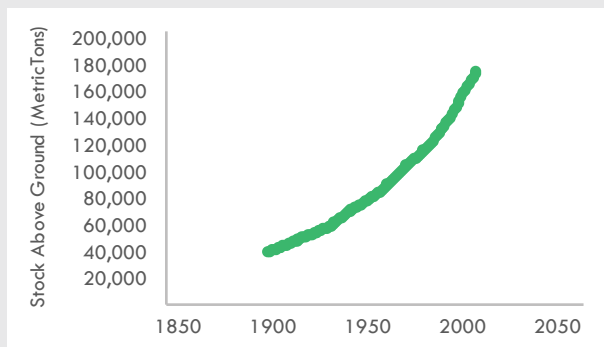


FIGURE 12
 Gold Outstanding



Source: ARK Investment Management LLC, Number Sleuth ("All The World's Gold Facts")

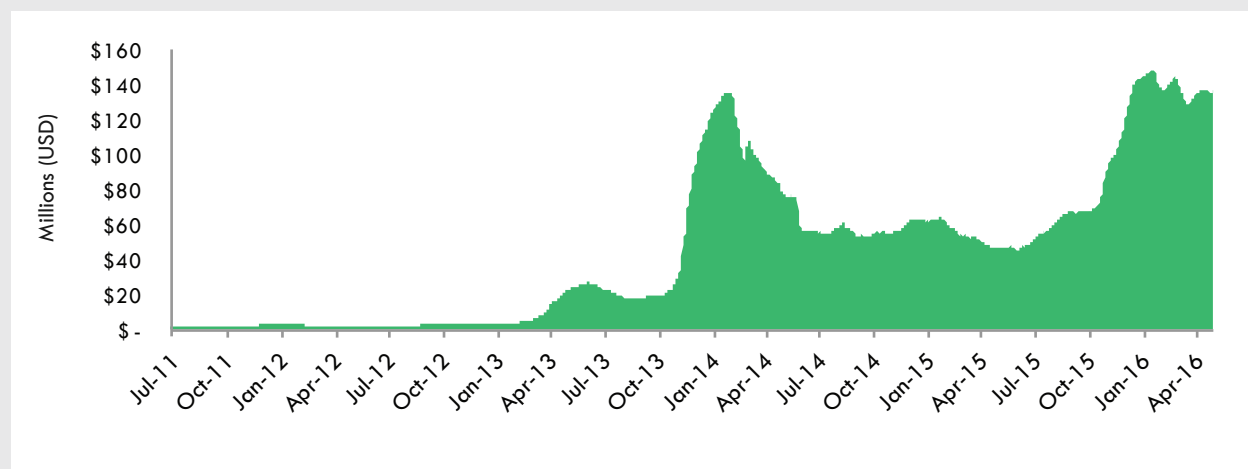


| USE CASES

Bitcoin’s obvious applications resemble those of fiat currencies and gold, while its potential lies outside the realm of any other asset class. Its innovative uses could include serving as a platform for auto-executing a myriad of contracts, enabling Bitcoin to act as a digital ledger for a host of assets from houses to loans to Internet-connected-devices.²⁷

To illustrate bitcoin’s common use cases today, the ratio of its trading volume to transactional volume can be compared to that of fiat currencies. As discussed in the “Investability” section, in 2016 trading volume has averaged more than \$1 billion a day as of May. Transactional volume also is growing rapidly—having topped as much as \$0.5 billion in one day—²⁸and is now in the \$100 to \$150 million range, as shown in Figure 13.²⁹

FIGURE 13
 Daily Bitcoin Transactional Volume (Trailing Quarter Average)



Source: ARK Investment Management LLC & Coinbase, data sourced from Blockchain.info, Coinbase & TradeBlock
 Note: Daily average, based on a trailing quarter

²⁷ “Smart Contracts on Bitcoin Blockchain,” BitFury, April 2015, <http://bitfury.com/white-papers-research/page:2>

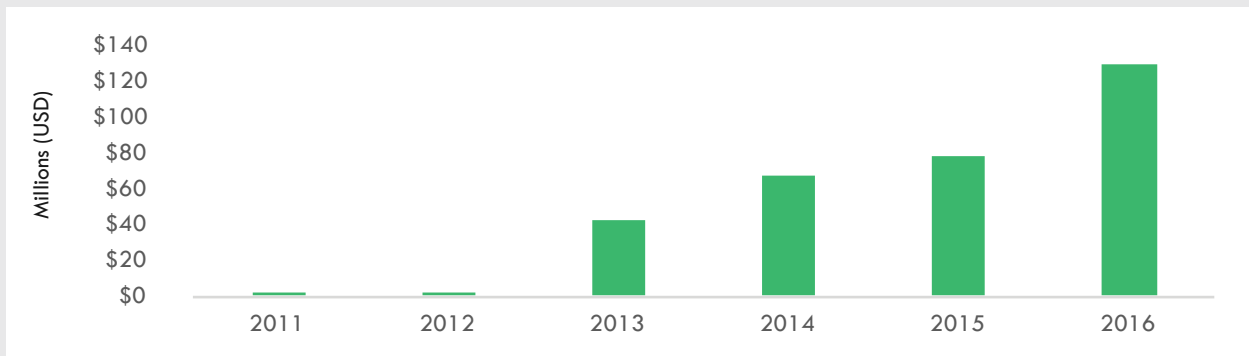
²⁸ On March 7th, 2014 it reached as high as \$578M, per Blockchain.info

²⁹ A point of confusion for many is that there are on-blockchain (on-chain) transactions verified directly by the mining network, and off-blockchain (off-chain) transactions that occur within hosted bitcoin wallet services like Coinbase. An off-chain transaction can be thought of as an “intra-net” transaction, that in this case Coinbase facilitates within its platform, as opposed to the on-blockchain “inter-net” of Bitcoin’s network. Over the last year Coinbase’s off-chain transaction volume has averaged 5% that of Bitcoin’s on-chain volume, implying at a minimum that daily blockchain transaction volume should be multiplied by 1.05. A multiplier of 1.05 was incorporated in Figure 13 beginning in November 2013, as that was when Coinbase reached significant enough scale to warrant the adjustment. ARK and Coinbase believe it produces a better combined picture of worldwide on-chain and off-chain volume, which henceforth will be referred to simply as transactional volume.



The bitcoin price rallies of late 2013 and 2015 obfuscate the longer term trend in Figure 13. When averaged over a year, the daily volume illustrates the traction bitcoin is gathering. For instance, it grew 62%, 16%, and 67% year-over-year in 2014, 2015, and as of May 2016, respectively, demonstrating real underlying demand for bitcoin as a means of exchange (Figure 14).

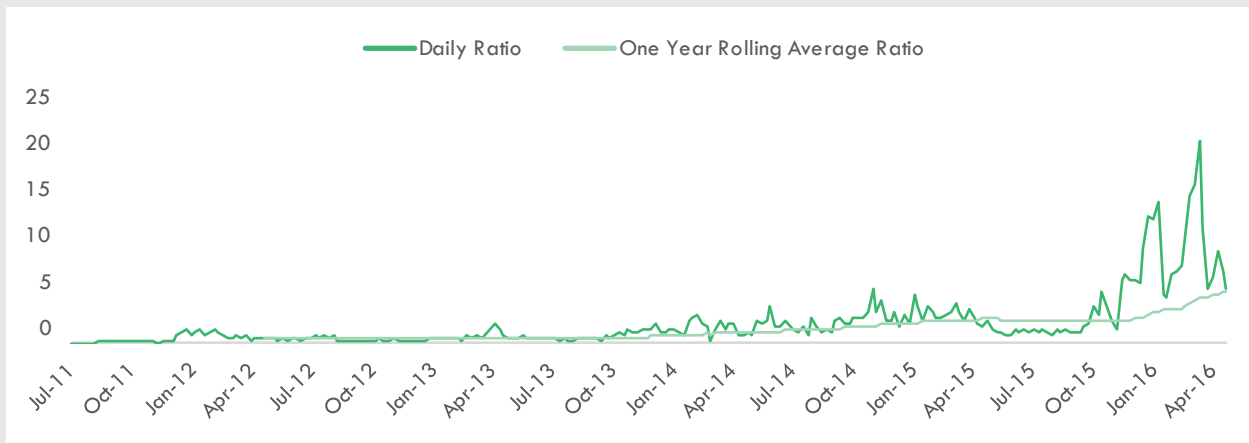
FIGURE 14
 Daily Bitcoin Transactional Volume (Annual Average)



Source: ARK Investment Management LLC & Coinbase, data sourced from Blockchain.info, Coinbase & TradeBlock
 Note: Average daily transactional volume calculated for each year

A comparison of bitcoin’s global trading volume to its transactional volume highlights that the use of bitcoin as an investment medium is increasing faster than its transactional applications. Despite day-to-day fluctuations, the significant shift towards trading volume became clear in late 2015, as shown in Figure 15.

FIGURE 15
 Global Daily Bitcoin Volumes: Trading Relative to Transacting

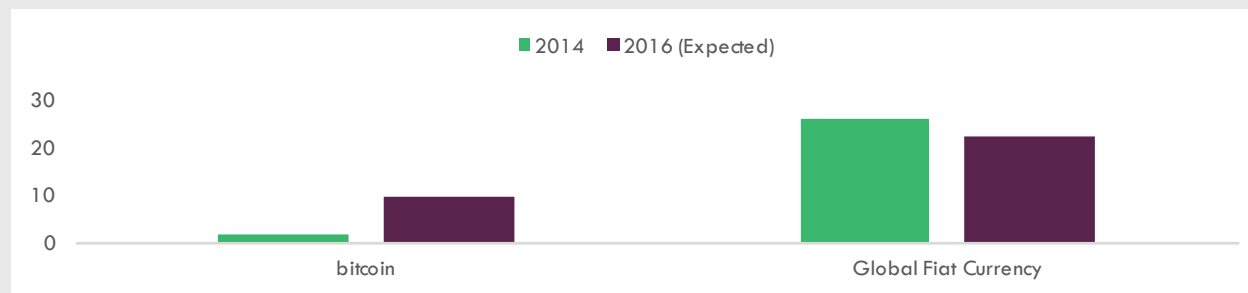


Source: ARK Investment Management LLC & Coinbase, data sourced from Bitcoinity, Blockchain.info, Coinbase & TradeBlock



Although many find bitcoin’s use as a speculative instrument alarming, when compared to fiat currencies,³⁰ bitcoin strikes a closer balance between trading and transacting, as shown below. This means that when people use bitcoin—as opposed to fiat currency—they are more likely to use it to transmit value for goods and services than as a speculative instrument. As previously mentioned, bitcoin’s trading volume is increasing at a faster rate than its transactional volume, as can be seen in the jump of the ratio from 2014 to 2016 (Figure 16).³¹ While concerning to some, ARK and Coinbase see bitcoin’s increased trading volume as a healthy step towards decreasing volatility, further catalyzing transactional volume.

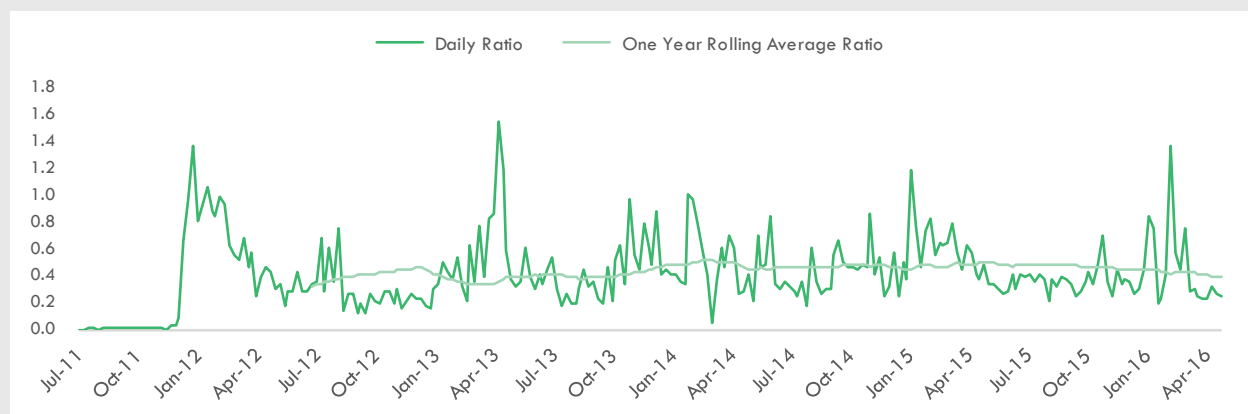
FIGURE 16
 Trading Relative to Transacting



Source: ARK Investment Management LLC & Coinbase, data sourced from Bitcoinity, Blockchain.info, Coinbase, Finance Magnates, IMF, Reuters, TradeBlock & World Bank | Note: Global Fiat Currency ratios derived by dividing Global FX Volumes by Global GDP

While the prior two graphs provide perspective, this data does suffer from the self-reporting shortcoming referenced in the “Investability” section. Limiting the analysis to trading in the more regulated US dollar, euro, and British pound, the ratio looks quite different, as shown in Figure 17. Although trading relative to transacting varies day-to-day, the trend has been stable over time. Roughly half as much trading volume,

FIGURE 17
 Global Daily Bitcoin Volumes: Trading (USD, EUR, GBP) Relative to Transacting



Source: ARK Investment Management LLC & Coinbase, data sourced from Bitcoinity, Blockchain.info, Coinbase & TradeBlock

³⁰ Fiat currency refers to a currency that has been backed by a nation-state as legal tender, but has no underlying anchor of value.

³¹ Additionally, the ramifications of stringent regulations can be seen in the drop of FX trading volumes for fiat currencies thus far in 2016.



relative to global transactional volume, goes through these three currency pairs. The stable ratio implies that bitcoin trading in the more regulated currencies has been growing at roughly the same rate as worldwide bitcoin transactional volumes.

The number of people using bitcoin to transact likely will grow as its more innovative use cases evolve. These use cases harness the power of Bitcoin's blockchain more abstractly, facilitating the transfer of real estate, bonds, and autos, decentralized venture funding, or votes in an election via smart contracts. These applications clearly separate bitcoin from all other asset classes.

CORRELATION OF RETURNS: PRICE INDEPENDENCE

Given its unique politico-economic characteristics, bitcoin's price should behave differently relative to other assets as it is pushed and pulled by distinct market forces. Market behavior can be quantified by correlation, a standardized measure of how assets move together, ranging from +1 to -1.³² If two assets are correlated perfectly at "+1," then when one is up 5%, the other is up 5% as well. If they are negatively correlated at "-1," then when one is up 5%, the other will be down 5%. In "A Random Walk Down Wall Street," Burton Malkiel, a Professor of Economics at Princeton University, offers a simple illustration of correlation coefficients (Table 3).

As shown in Table 3, the more negatively correlated assets are, the more diversification they will provide in an overall portfolio—lowering overall risk—which ARK and Coinbase will address in a future white paper. A strong negative correlation still implies a tight relationship, albeit inverse. For example, going long and short on the same equity should have a correlation of -1, suggesting gains will be offset by losses of equivalent magnitude. Consequently, assets that are close to zero in their correlation are not tethered in their market behavior, which we think is key to the definition of distinct asset classes.

TABLE 3

The Correlation Coefficient and the Ability of Diversification to Reduce Risk

CORRELATION COEFFICIENT	EFFECTS OF DIVERSIFICATION ON RISK
+1.0	NO RISK REDUCTION IS POSSIBLE
+0.5	MODERATE RISK REDUCTION IS POSSIBLE
0	CONSIDERABLE RISK REDUCTION IS POSSIBLE
-0.5	MOST RISK CAN BE ELIMINATED
-1.0	ALL RISK CAN BE ELIMINATED

Source: A Random Walk Down Wall Street, Burton G. Malkiel, 2015

ARK and Coinbase calculated the one year rolling correlations among the various standard assets over the last five years, yielding 21 combinations (Table 4). While assets may be uncorrelated when "times are good," when "times are bad" they often move in tandem, converging on correlations of +1 or -1. To create the table below, we extracted the maximum "absolute value" correlation associated with each asset pair. After identifying the number, we included the correct sign.

³² "Correlation," Investopedia, Accessed June 2016, <http://www.investopedia.com/terms/c/correlation.asp>



Strikingly, bitcoin’s price movements have been separate and distinct from those of other asset classes during the last five years. Bitcoin is the only asset that maintains consistently low correlations with every other asset. Remarkably, the maximum correlation, positive or negative, that bitcoin exhibited with each of the other assets is the minimum correlation that any of the other paired assets displayed with each other (Table 4).

TABLE 4
 Correlation Table

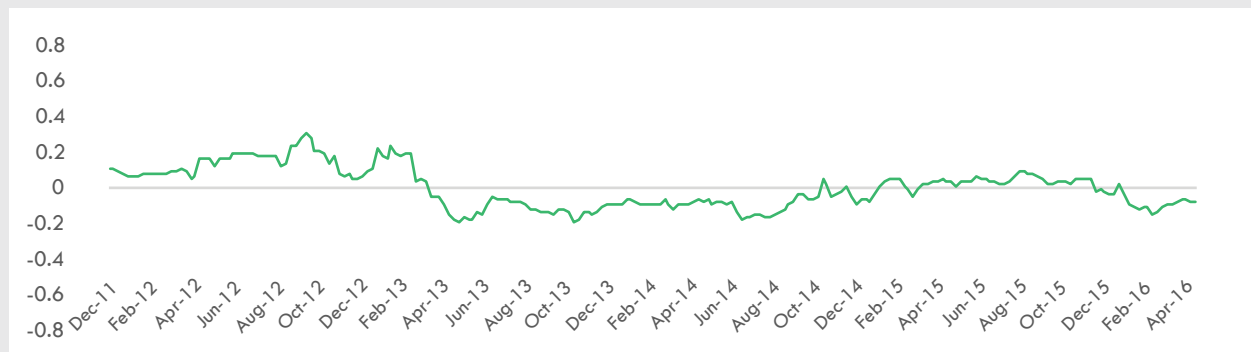
	S&P 500	US Bonds	Bitcoin	Gold	US Real Estate	Oil	Emerging Market Currencies
S&P 500		-0.69	0.36	0.48	0.87	0.73	0.83
US Bonds	-0.69		-0.37	0.47	0.57	-0.53	0.52
Bitcoin	0.36	-0.37		-0.33	-0.36	-0.36	0.29
Gold	0.48	0.47	-0.33		0.45	0.52	0.62
US Real Estate	0.87	0.57	-0.36	0.45		0.63	0.74
Oil	0.73	-0.53	-0.36	0.52	0.63		0.63
Emerging Market Currencies	0.83	0.52	0.29	0.62	0.74	0.63	

Low correlation (-0.4 to 0.4) in green, Mid correlation (absolute value 0.4 to 0.666) in white, High correlation (absolute value > 0.666) in red
 Numbers in the table were chosen based on the maximum "absolute value" one-year rolling correlation that paired assets displayed since 2011

Source: ARK Investment Management LLC & Coinbase, data sourced from Bloomberg & TradeBlock

As shown in the following four figures, rolling one year correlations further demonstrate bitcoin’s independent behavior within the capital markets. We start this comparison with fiat currencies because bitcoin’s primary use cases have been a means of exchange and store of value. In an investing context, however, for bitcoin to fall into the fiat currency asset class, it should behave similarly to other fiat currencies in the marketplace. Given bitcoin’s nascent nature, one would expect it to behave most similarly to the emerging market currencies. To explore this possibility, we compared bitcoin’s returns with the MSCI Global Currency Index, a broad representation of emerging market currencies (Figure 18).

FIGURE 18
 One Year Rolling Correlation: Bitcoin and Emerging Market Currencies



Source: ARK Investment Management LLC & Coinbase, data sourced from Bloomberg & TradeBlock
 Note: The correlation between the two assets over the previous year was calculated on each day represented. When strung together these correlations create a graph showing the one year rolling correlation.

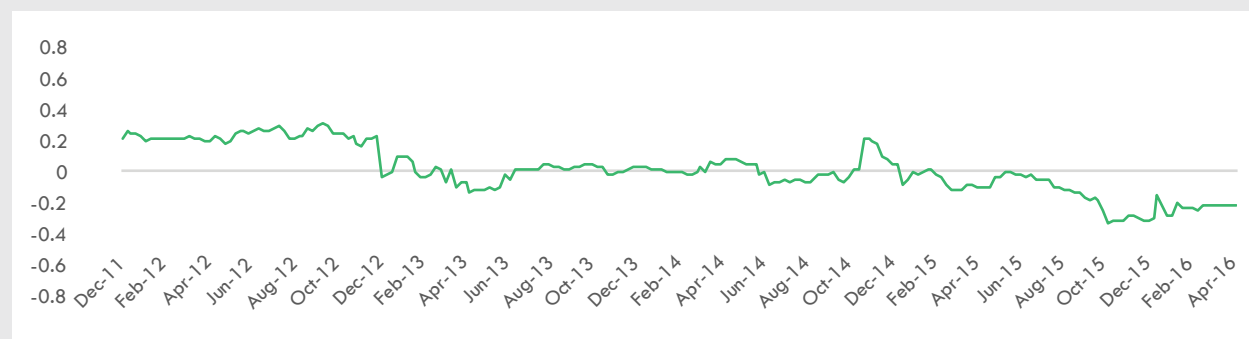


Over the last five years, on average bitcoin has experienced a one year rolling correlation of 0.0002 with emerging market currencies, never reaching higher than 0.3 (Figure 18). When compared to the 0.7 average correlation that US Stocks have maintained with both international stocks and emerging market stocks from 1988 to 2011³³—a good indicator of how assets in the same class should behave—clearly bitcoin and fiat currencies do not belong in the same bucket. As David Yermack from the National Bureau of Economic Research asserted in 2013, “Bitcoin’s value is almost completely untethered to that of other currencies... Macroeconomic events that cause similar impacts on the value of various currencies do not seem to affect [bitcoin] either positively or negatively.”³⁴

Next, we will investigate bitcoin’s performance relative to gold. People typically hold gold as a “safe” investment because its underlying value is not necessarily tied to economic conditions. In this vein, bitcoin has often been compared to digital gold.³⁵ If bitcoin were highly correlated with gold, it might indicate that both assets were being used as similar “risk-off” investments, suggesting that bitcoin could be included in the precious metals asset class.

Surprisingly, bitcoin’s correlation with gold has slipped into negative territory during the past five years (Figure 19). Where once bitcoin and gold had a low positive correlation, they now display moderate negative correlation. Investors may have learned that gold is not the safe investment once believed, as vehicles like the SPDR Gold Shares ETF lost more than 40% of their value from 2011 peaks to 2015 troughs.

FIGURE 19
 One Year Rolling Correlation: Bitcoin and Gold



Source: ARK Investment Management LLC & Coinbase, data sourced from Bloomberg & TradeBlock

Note: The correlation between the two assets over the previous year was calculated on each day represented. When strung together these correlations create a graph showing the one year rolling correlation.

The increasingly negative correlation shown in Figure 19 could suggest that some financial markets participants are exchanging gold for bitcoin at the margin. Indeed, in 2013 when bitcoin made its historic run into the \$1000’s, there were net outflows from gold ETFs and similar investment products.³⁶ Assets under management (AUM) for the two largest gold ETF’s, the SPDR Gold Shares ETF (GLD) and iShares Gold Trust (IAU), dropped from \$73.5 billion and \$11.9 billion at the start of 2013, to \$30 billion and \$6.2 billion by the end of 2013, respectively. The price of gold only fell 25% in that year, so it’s safe to assume

³³ “Dynamic Correlations: The implications for portfolio construction,” Vanguard, April 2012, <http://www.vanguard.com/pdf/s130.pdf>

³⁴ “Is Bitcoin a Real Currency?” David Yermack, December 2013, National Bureau of Economic Research.

³⁵ “Digital Gold,” Nathaniel Popper, May 2015, HarperCollins.

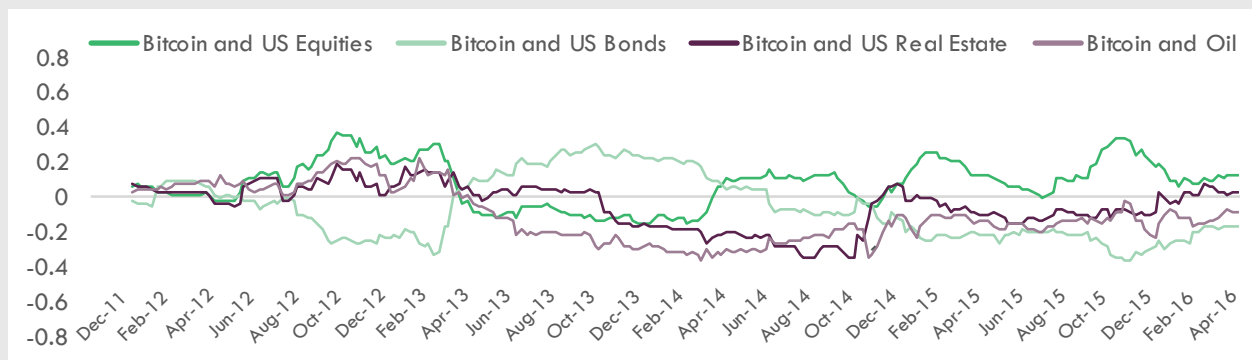
³⁶ “Interactive Gold Market Charting,” World Gold Council, Accessed June 2016, <http://www.gold.org/supply-and-demand/interactive-gold-market-charting>



that a large chunk of this AUM drop can be attributed to outflows. Meanwhile, in 2013, bitcoin started at a market capitalization of \$143 million and ended at \$8.9 billion. In other words, while GLD and IAU’s AUM were halved in 2013, bitcoin’s AUM grew sixty fold.³⁷

Relative to the other major asset classes—equities, bonds, real estate and oil—bitcoin consistently has stayed within boundaries qualifying it as a differentiated risk reducer (Figure 20). It certainly has not been correlated enough to be considered for inclusion as a similar asset. When compared with US real estate, a cornerstone of the average American’s asset holdings, bitcoin has experienced low to negative correlation which is somewhat ironic given the IRS has deemed bitcoin as property. Turning to oil, which the CFTC classifies as bitcoin’s commodity brethren,³⁸ we see a similarly low correlation.

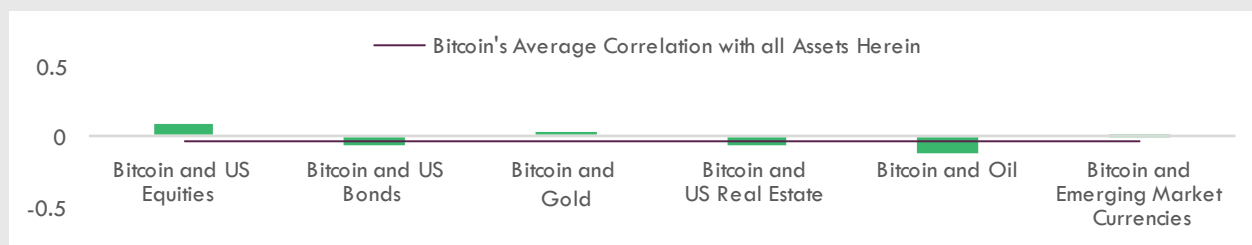
FIGURE 20
 One Year Rolling Correlation: Bitcoin and US Equities, US Bonds, US Real Estate & Oil



Source: ARK Investment Management LLC & Coinbase, data sourced from Bloomberg & TradeBlock
 Note: The correlation between the two assets over the previous year was calculated on each day represented. When strung together these correlations create a graph showing the one year rolling correlation.

As mentioned at the beginning of this section, assets with near zero correlation are the most untethered in their behavior to other assets. Based on the last five years of data, bitcoin’s average one year correlations with other asset classes are centered around zero (Figure 21). As shown by the purple line in Figure 21, the average correlation of bitcoin to all the other asset classes is -0.02. Bitcoin’s price independence—at least in the limited trading history of the asset—is stark.

FIGURE 21
 Average One Year Rolling Correlation Since the Start of 2011



Source: ARK Investment Management LLC & Coinbase, data sourced from Bloomberg & TradeBlock

³⁷ ARK Investment Management LLC & Coinbase, data sourced from Blockchain.info and Bloomberg.

³⁸ “Release: PR7231-15,” CFTC, September 2015, <http://www.cftc.gov/PressRoom/PressReleases/pr7231-15>



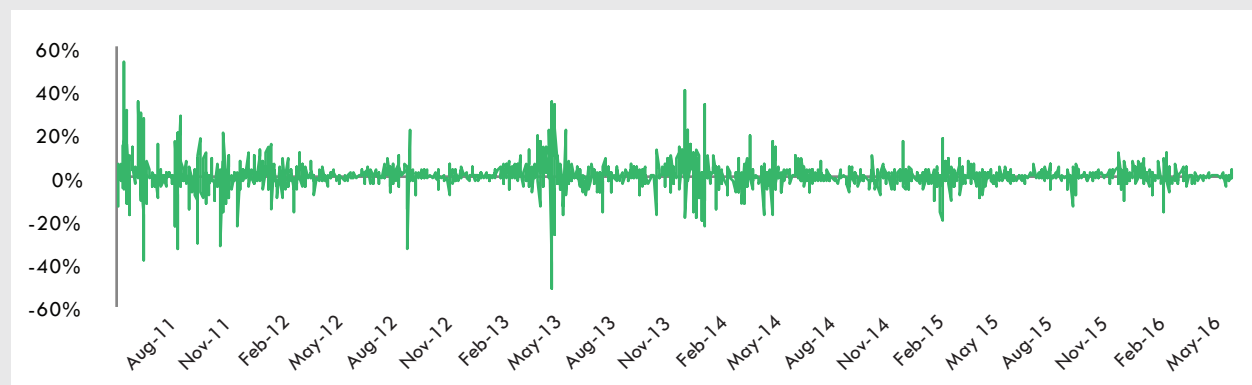
RISK-REWARD PROFILES

Risk-reward profiles are exactly as they sound: a comparison of risk in the form of volatility, and reward in the form of absolute returns. When compared, these values produce the Sharpe Ratio, a measure of returns per unit of risk taken. Our analysis of volatility, absolute returns, and the Sharpe Ratio³⁹ span five years.

VOLATILITY

Bitcoin's volatility is clear in its daily percent price changes. For example, if bitcoin ended Monday at \$100, and ended Tuesday at \$140, then its daily percent change was 40%. With daily price changes as high as 50%, bitcoin has been volatile for much of the last five years, as shown in Figure 22. In contrast, on any given day, stocks and bonds rarely fluctuate by 50% in the absence of a severe financial crisis.

FIGURE 22
 Bitcoin Daily Price Change



Source: ARK Investment Management LLC & Coinbase, data sourced from TradeBlock XBX data

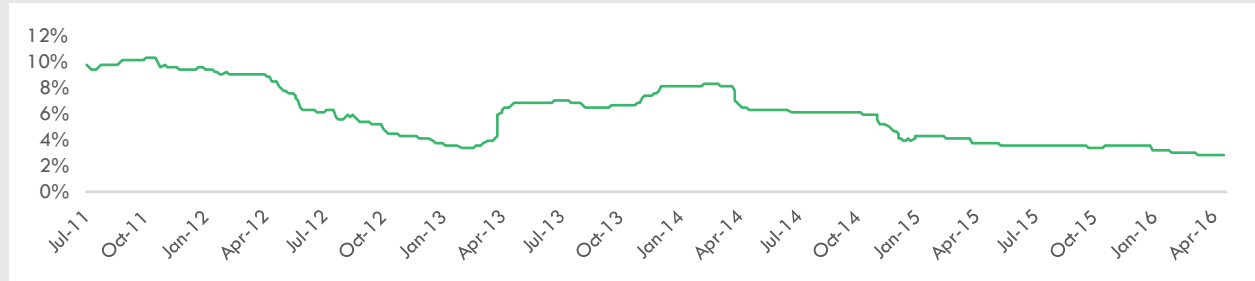
While daily percent change is a useful metric, investors most often measure volatility via the standard deviation of those changes. While bitcoin still experiences large price swings, the magnitude of those swings has diminished resulting in decreased volatility. At the start of May 2016, bitcoin's daily volatility was about a third that of five years ago, and 24% less than at the start of May 2015 (Figure 23). In April 2016, lower volatility triggered headlines as investors began to realize bitcoin had been more stable than gold over the short period of one month.⁴⁰ The decline in bitcoin's volatility has been caused by a number of factors: more stable and liquid spot exchanges, greater regulatory approval, broader ownership, and increasingly reliable price discovery data.

³⁹ Using methods outlined here, "Standard Deviation and Sharpe Ratio," Morningstar, January 2005, http://corporate.morningstar.com/US/documents/MethodologyDocuments/MethodologyPapers/StandardDeviationSharpeRatio_Definition.pdf

⁴⁰ "Is Bitcoin Becoming More Stable Than Gold?" Stephanie Yang, April 2016, <http://blogs.wsj.com/moneybeat/2016/04/19/is-bitcoin-becoming-more-stable-than-gold>



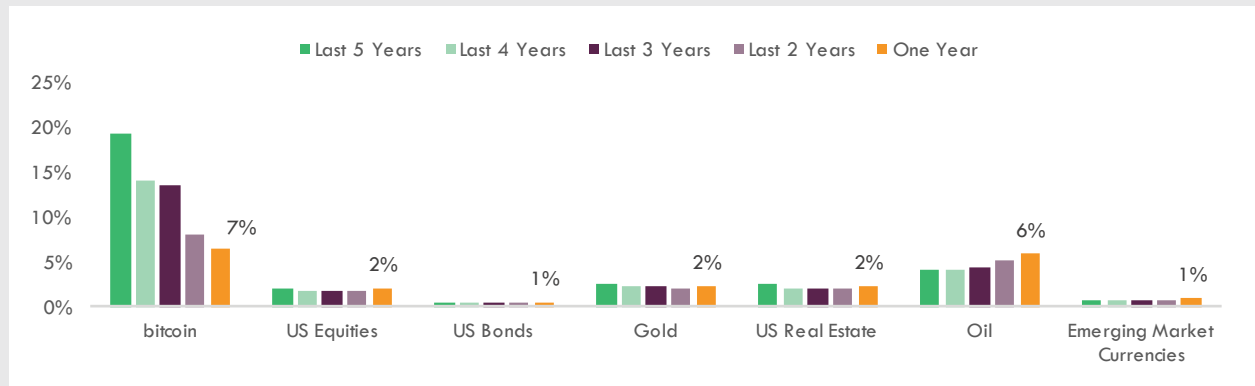
FIGURE 23
 Bitcoin Daily Volatility Over the Trailing Year



Source: ARK Investment Management LLC & Coinbase, data sourced from TradeBlock XBX data
 Note: Measured by the trailing year standard deviation of bitcoin’s daily price changes

While bitcoin’s volatility has dropped considerably, it is still the most volatile of the broad asset classes over all the periods of this analysis, as shown in Figure 24. However, that may not remain the case for long since over the last year bitcoin was slightly more volatile than oil.

FIGURE 24
 Weekly Volatility



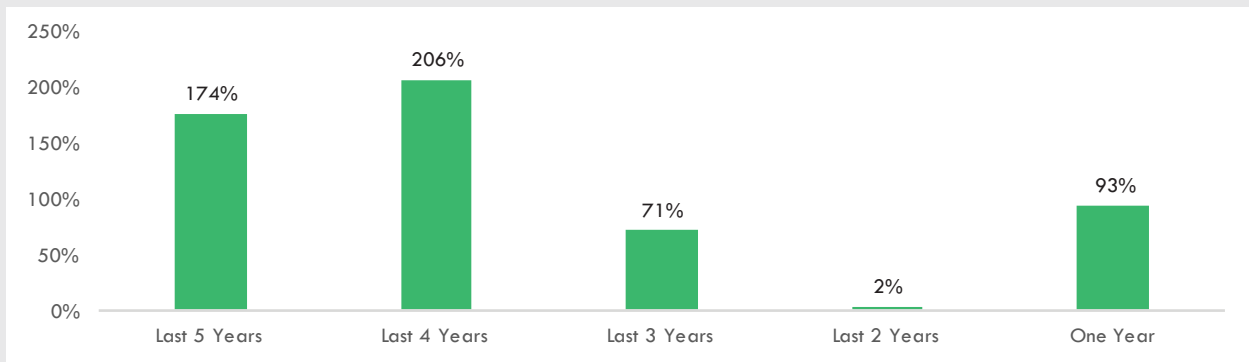
Source: ARK Investment Management LLC & Coinbase, data sourced from Bloomberg & TradeBlock
 Note: Measured by the standard deviation of weekly price changes. Data as of May 6, 2016



ABSOLUTE RETURNS

For the balance of its short life, bitcoin has provided investors with stellar absolute returns, above and beyond that of any other asset class. As shown in Figure 25, only over the “Last 2 Years” have the returns been lackluster.

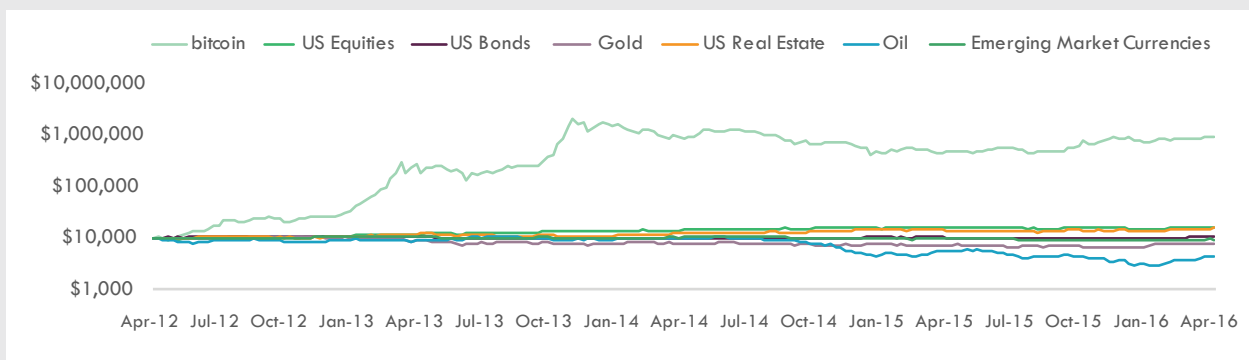
FIGURE 25
 Bitcoin: Compound Annual Returns



Source: ARK Investment Management LLC & Coinbase, data sourced from TradeBlock XBX data
 Note: Data as of May 6, 2016

Turning now to comparisons with the other major asset classes, if one had invested \$10,000 in bitcoin four years ago, it would now be worth nearly \$1 million and have outperformed the other broad asset classes by 56 to 212 fold, as shown in Figure 26.

FIGURE 26
 Hypothetical \$10,000 Investment Over the Last Four Years

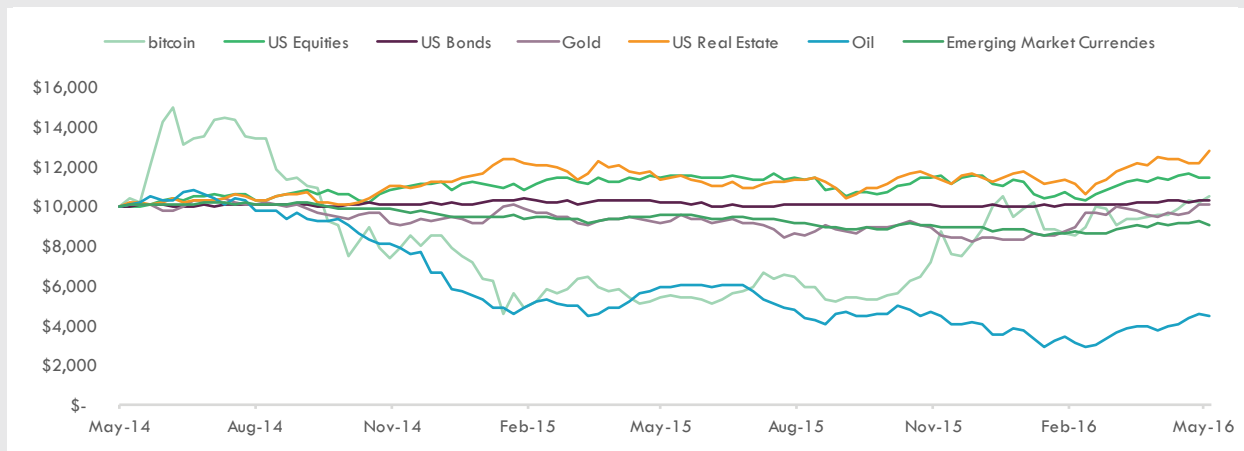


Source: ARK Investment Management LLC & Coinbase, data sourced from Bloomberg & TradeBlock
 Note: Log-scale



However, if one had made a \$10,000 investment two years ago—in the midst of bitcoin’s decline from its November 2013 price spike—it would barely be at breakeven after recovering from a 50% loss in value. Assets around the world, however, have not fared much better than bitcoin. As shown in Figure 27, while bitcoin was once the worst-performing asset during this period, it has since recovered to third best.

FIGURE 27
 Hypothetical \$10,000 Investment Over the Last Two Years



Source: ARK Investment Management LLC & Coinbase, data sourced from Bloomberg & TradeBlock

Bitcoin’s fall from its peak in November 2013 was prolonged and painful, finally hitting a bottom on January 14, 2015 at \$177. During that time, some in the media pronounced bitcoin dead—a claim now made over 100 times.⁴¹ From its bottom, bitcoin entered a relatively stable trading range between \$200 and \$300 for the first three quarters of 2015.⁴²

Then, in late October and early November 2015, bitcoin’s price spiked 55% in 84 hours.⁴³ While it’s possible to identify the broad cause—an increase in demand—isolating a singular reason for the increased demand is not possible. We do know that China experienced high trading volumes, causing a 5-10% premium in bitcoin prices on Chinese exchanges compared to US exchanges. GDAX observed that global algorithmic traders then boosted their trading volumes to exploit the arbitrage opportunity. The spike also likely had roots in Europe’s VAT tax ruling, which put bitcoin on par with traditional currencies for tax purposes. As a result of this significant regulatory ruling, and increasing interest among financial institutions, in late 2015 Coinbase’s daily new user sign-ups were 70% higher than average in many geographies.⁴⁴

Unlike bitcoin’s price surge in November 2013, its ascent and descent in late 2015 proved to be more moderate, settling into a \$350 to \$450 trading range for the first four months of 2016. As a result, if one were to have put \$10,000 dollars into bitcoin one year ago, it would have been the best performing of the broad asset classes (Figure 28).

41 “Bitcoin Obituaries,” 99 Bitcoins, Accessed June 2016, <https://99bitcoins.com/obituary-stats>

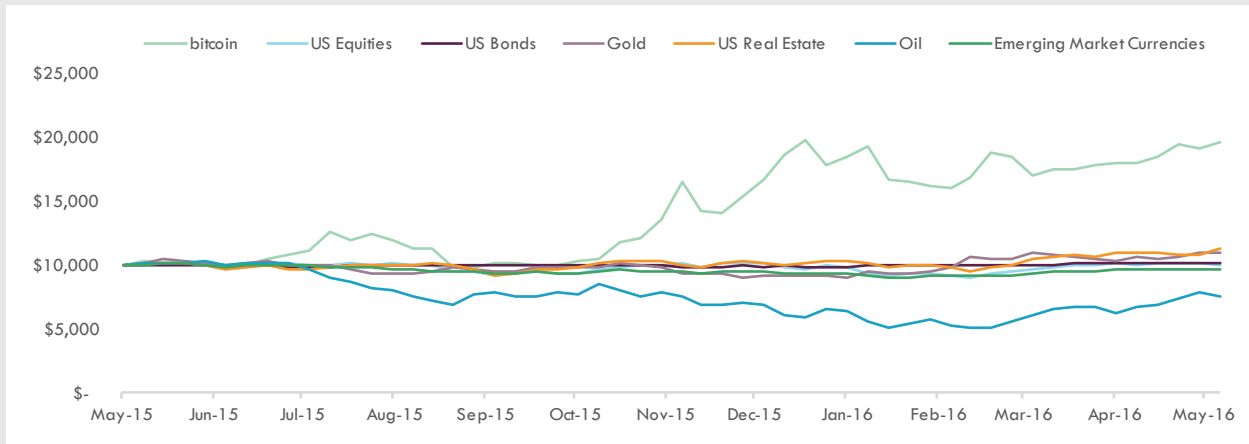
42 TradeBlock XBX data.

43 “Bitcoin’s Big Week In The Rearview Mirror,” Samantha Sharf, November 2015, <http://www.forbes.com/sites/samantha-sharf/2015/11/13/bitcoins-big-week-in-the-rearview-mirror/#7a85e0053599>

44 Coinbase data.



FIGURE 28
 Hypothetical \$10,000 Investment Over the Last Year

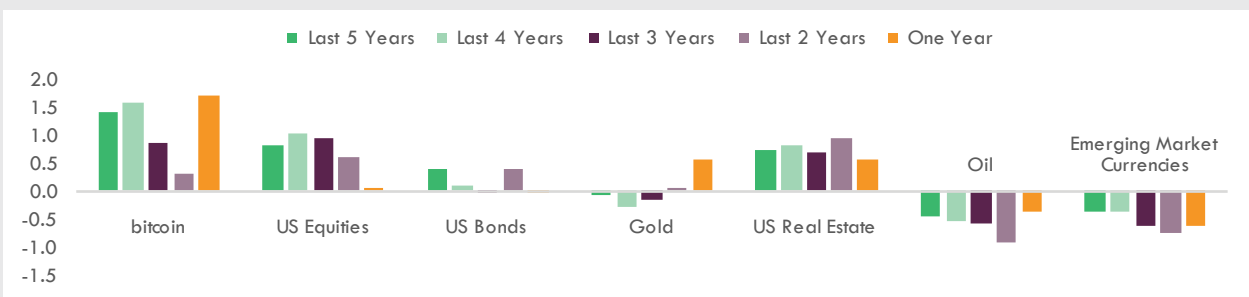


Source: ARK Investment Management LLC & Coinbase, data sourced from Bloomberg & TradeBlock

As modern portfolio theory suggests, neither absolute return nor volatility is a sufficient indicators of a good investment. Instead, one must adjust absolute returns for the amount of volatility, or risk, to calculate risk adjusted returns. The most common measure of risk adjusted returns is the Sharpe Ratio, which measures returns above the risk free rate divided by the volatility of the asset.⁴⁵ Assets can be compared to one another because each unit of return is standardized per unit of risk. Assets with the highest Sharpe Ratio best compensate investors for the risk they are taking.

Although bitcoin has been extremely volatile historically, when its returns are adjusted to account for volatility, its Sharpe Ratios have been superior (Figure 29). While US equities, US bonds and US real estate have delivered isolated instances of better Sharpe Ratios, over the last year bitcoin has been the clear standout. US equities and US real estate are the only two traditional asset classes that also have delivered positive returns relative to risk for all five periods. When compared to what the CFTC would call its commodity counterparts, bitcoin has outperformed gold and oil on a risk adjusted basis in the five periods of our analysis.

FIGURE 29
 Sharpe Ratio



Source: ARK Investment Management LLC & Coinbase, data sourced from Bloomberg & TradeBlock
 Note: Data as of May 6, 2016

⁴⁵ In other words, excess returns divided by total risk. The risk free rate used to derive excess returns is the three month USTreasury Bill.



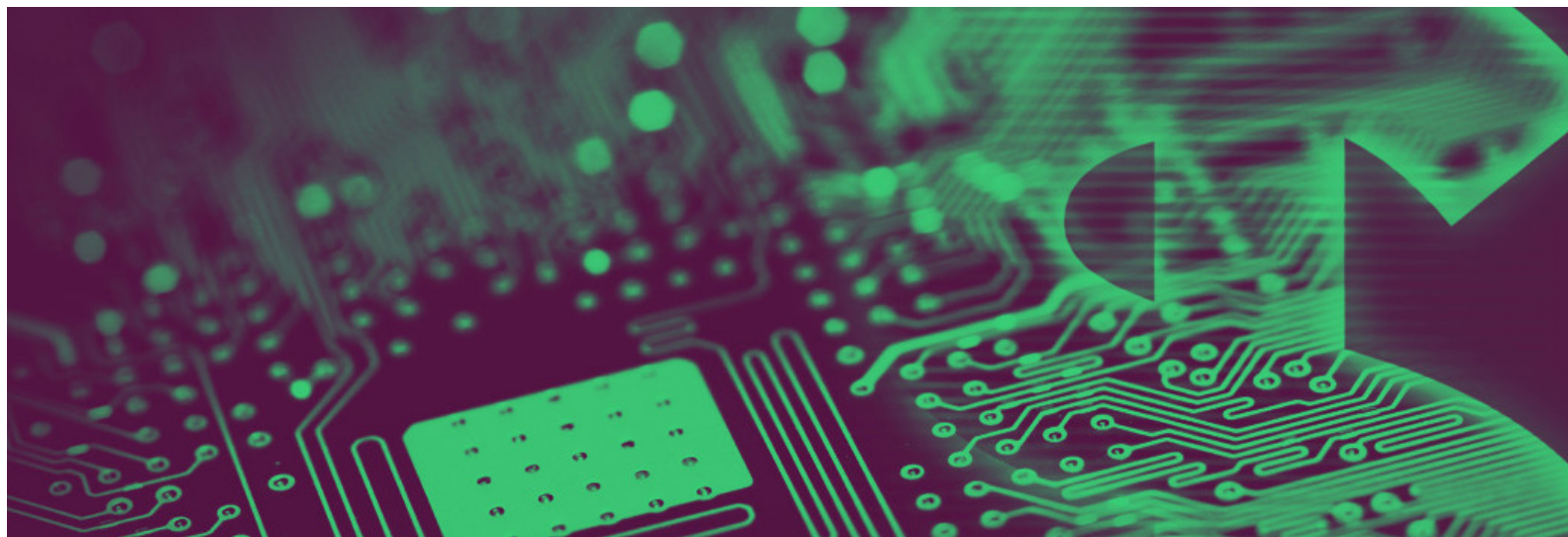
CONCLUSION

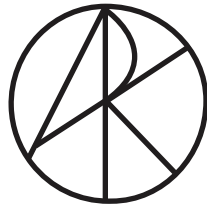
Bitcoin exhibits characteristics of a unique asset class—meeting the bar of investability, and differing substantially from other assets in terms of its politico-economic profile, price independence, and risk-reward characteristics. Because our analysis encompasses only five years, it will be important for the community to continue to monitor its behavior in the context of the broader markets.

As Bitcoin's open-source software evolves, bitcoin will differentiate itself further from other asset classes. Recent innovations like segregated witness⁴⁶ promise to catalyze bitcoin's more innovative use cases. Smart contracts and sidechains, for example, could enable entirely new financial services like liquid private markets and truly peer-to-peer loan issuance.

ARK and Coinbase believe bitcoin is the first of its kind in what is rapidly becoming a distinct asset class. Since cryptocurrencies are subject to the strong network effects of users and developers, they may submit to a "winner takes most" model unlike bonds and equities. The cryptocurrencies that successfully foster the flywheel of user and developer engagement could grow to formidable market capitalizations. In a world where the trend is clearly offline to online, why should financial assets be excused from the transformation?

46 "Segregated Witness Benefits," Bitcoin Core, Accessed June 2016, <https://bitcoincore.org/en/2016/01/26/segwit-benefits>





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