Bitcoin Investment Trust (GBTC)

Bitcoin Adoption Growing & Fundamentals Improving; Raising Price Projection

INVESTMENT HIGHLIGHTS: Due to faster-than-expected adoption and improving fundamentals we are raising our Bitcoin price projection (from $655 to $848) but downgrading GBTC (to HOLD from BUY) based on the substantial premium at which shares trade relative to their net asset value. Focusing on Bitcoin, we're encouraged that 1) adoption is trending faster than we forecasted in March, 2) fundamentals are improving, and 3) there are upcoming protocol improvements that we think present attractive optionality for the price of Bitcoin. At the highest level, we continue to see value in Bitcoin as a "digital gold" and as a payment network that is enabling a global, open, permissionless financial system.

- **Faster-than-expected adoption:** Adoption of Bitcoin as both a digital gold and as a payments network has grown faster than we forecasted in March and, as a result, we are raising our price projection and forecasts. At the end of August, transaction volume was roughly 30% higher than we projected, and as a result we are raising our 2020 market share estimates by a more conservative 10%. Adoption of Bitcoin as a digital gold has similarly outpaced our expectations.
- **Attractive & improving fundamentals:** Historically, Bitcoin's volatility, liquidity, and correlation have been primary concerns, but we find that all these factors have trended very favorably.
  - **Volatility:** Bitcoin's price volatility has declined significantly over recent years and now roughly resembles that of the average small-cap security.
  - **Correlation:** Likely among the most appealing aspects of Bitcoin for institutional investors and portfolio managers is the absence of significant correlation to other major assets. We found a lack of significant correlation to every major asset class and sub-group we measured, including commodities, fixed income, and various equity sectors (among others).
  - **Liquidity:** Even our significantly constrained liquidity analysis found that Bitcoin's daily trading volume roughly resembles that of a mid-cap security. However, this liquidity is dispersed across exchanges and more difficult to access.
- **Protocol improvements induce compelling optionality:** Looking ahead, there are several forthcoming improvements to the Bitcoin protocol that we believe could significantly 1) benefit scaling, 2) accelerate the pace of development and innovation, and 3) augment Bitcoin's functionality and use cases. Taken together, we believe these developments could serve to significantly increase the utility of (and demand for) Bitcoin. Therefore, we think the outlook is very bright.
- **Ultimately,** and contrary to popular narrative, we see Bitcoin's fundamentals trending very favorably. We find the outlook very encouraging, and we believe the short- to intermediate-term horizon is among the most exciting Bitcoin has seen.

RATING CHANGE

Stock Rating	**HOLD** From Buy
Price Target	**NA** NA

Internet/Financial Technology

Spencer Bogart, CFA
(415) 262-4877
sbogart@needhamco.com

Stock Price Performance

Bitcoin Investment Trust 09/22/16

Market Data

Price (09/21/2016)	$93.00
52-Week Range	$144.00 - $26.01
Shares Outstanding	1.75
Market Cap (MM)	$162.3
Avg. Daily Volume	8,931.0
Total Debt/Cap.	-

Relevant disclosures begin on page 28 of this report.

Investment Thesis

The Bitcoin Investment Trust is a private open-ended Trust that invests exclusively in Bitcoin, and consequently the value of shares in the Trust is driven primarily by the price of Bitcoin. While investors can buy Bitcoin directly from an exchange, the advantage for accredited and institutional investors of gaining exposure through the Bitcoin Investment Trust is the titled auditable exposure provided and because the Trust addresses the unique challenges of acquiring and securely storing Bitcoin.

Bitcoin is a decentralized, borderless, peer-to-peer, electronic cash system that is disintermediating and removing friction in the exchange of value by enabling fast, low-cost, global, peer-to-peer payments.

Similar to how the internet created a global open network for the exchange of information, so too is Bitcoin and its underlying "blockchain" technology enabling an open and global network for the exchange of value. For reasons addressed in this report, we see Bitcoin and its underlying technology as among the most significant innovations in payments and money in recent history.

Driven by market and secular changes such as the rise of ecommerce, globalization, and the ubiquity of enabling technology such as mobile phones, Bitcoin is beginning to disrupt trillion-dollar markets in payments and value exchange. While other digitally-native payments networks have incrementally improved the experience of digital value exchange, these solutions ultimately rely on the same pre-existing and siloed infrastructure as the legacy financial system. So while these modern networks have made it easier to use that same aged financial infrastructure—particularly in a digital context—they have not created new infrastructure. **Bitcoin, on the other hand, is new infrastructure for digital value exchange.**

We see value in Bitcoin as a "digital gold" and as a payment network that is enabling a global, open, permissionless financial system. Bitcoin has a four-sided network effect that includes developers, transaction processors ("miners" securing the network), merchants, and consumers. All four of these major stakeholder segments are showing impressive growth but, most importantly, the strongest growth is in the stakeholder segments we see as most important to the first of two major growth stages.

While Bitcoin has at times been associated with illicit activities and portrayed as anti-government or anti-establishment, we believe these narratives entirely miss the essential point: Bitcoin is pro-human empowerment—it enables people to be fully in control of their money and transaction activity and is used extensively for legitimate purposes. Far from being static, **Bitcoin is constantly growing and improving** thanks to the vibrant global community of developers that is constantly making improvements and helping to add new features and functionality to money and value exchange.

We deduce that the price of Bitcoin benefits from two main sources of demand: its value as a "digital gold" and its utility as a payments channel. **Based on Bitcoin's extensive network effects, rapid growth, and roadmap for significant enabling network improvements, we estimate that both sources of demand will grow significantly over the next five years and ultimately drive the price of Bitcoin significantly higher.**

We see the fastest adoption rates for Bitcoin as a payments channel in emerging markets with lower financial inclusion, fewer and lower quality payment alternatives, and because emerging market countries tend to have less stable currencies, more onerous capital controls, and more frequent economic, monetary, or financial crises. We also estimate that adoption of Bitcoin as a payment channel will be greater for cross-border transactions (vs. domestic) because relative to alternatives the advantages of leveraging Bitcoin as a low-cost, fast, and borderless payment channel are greater for cross-border transactions than for domestic transactions.

Contents

Investment Thesis 2
Background 4
Bitcoin Metrics & Fundamentals 4
Volatility 4
Correlation 7
Liquidity 9
Supply 10
Transaction Volume 12
Hash rate 13
Price Action 14
Bitcoin Keeps Improving & the Outlook Is Compelling 15
Segregated Witness 15
Lightning Networks 15
Sidechains 16
Privacy 16
Smart Contracts 17
Contextualizing the Bitcoin Opportunity 17
Market Opportunity, Assumptions & Valuation 17
Accelerated Adoption 21
Updating Our Estimates (Raising Bitcoin Price Projection) 22
The Road Ahead 22
Conceptualizing a Path from Niche to Mainstream 22
Hurdles to Adoption 23
Side Notes 24
…on scaling & protocol conservatism 24
…on blockchain without Bitcoin 25
A Note of Caution on GBTC Premium 25
Risks 25

Background

This report largely builds upon our previously published research. Investors that are less familiar with Bitcoin may find our initiation report for the Bitcoin Investment Trust helpful as it answers some basic background questions on Bitcoin and provides more information on the Bitcoin Investment Trust. Among others, some of the topics discussed in that report that are NOT in this report include:

- Bitcoin Background:
    - What is Bitcoin?
    - Why should anyone care about Bitcoin? Why is it significant to payments, money, and finance?
    - What's the difference between Bitcoin the token ("cryptocurrency") and Bitcoin the network?
    - What can one do with Bitcoin?
    - What are the problems with money and value transfer today, and how might Bitcoin be a solution?
    - What are the secular and market trends (changes in demographics, technology trends, laws, regulations) that are driving the need for a new solution?
    - In what ways is Bitcoin potentially inferior to other modern payment networks?
    - How does Bitcoin compare to fiat currencies and gold as a form of money?
    - What are the potential catalysts for the price of Bitcoin?
- Specific to Bitcoin Investment Trust:
    - What is the Bitcoin Investment Trust? Why use the Trust to access Bitcoin?
    - What are the details of the Bitcoin Investment Trust? Who can invest? Is there a minimum investment? What are the associated fees?
    - Why do GBTC shares often trade at a premium or discount to their NAV? What does this mean for investors accessing shares in primary and secondary markets?

Bitcoin Metrics & Fundamentals

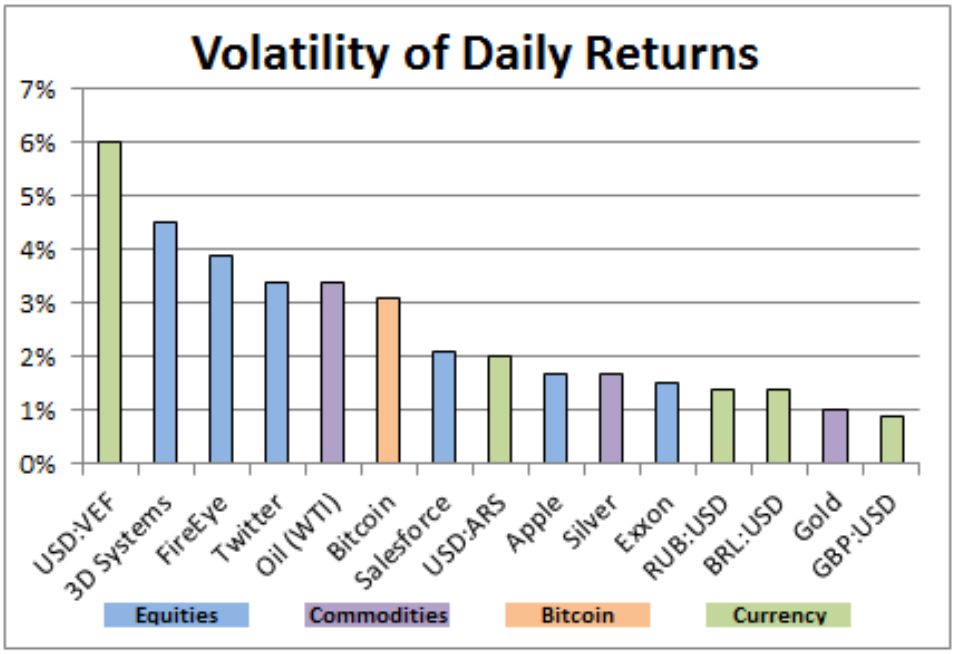
In this section we examine some of the aspects of Bitcoin that are particularly relevant to portfolio managers and how these factors have evolved over time.

Volatility

While Bitcoin is notoriously volatile—especially relative to the world's major currencies—its volatility has declined significantly in recent years and is similar to several more well-known assets.

Specifically, **Bitcoin's daily volatility is now comparable to small cap equities**: For example, the average daily return volatility of stocks in the S&P Small Cap 600 is 2.6% vs. 3.3% for Bitcoin. Given the large opportunity ahead and the overall nascence of Bitcoin itself, the similar levels of volatility between Bitcoin and small-cap stocks are not altogether surprising, in our view.

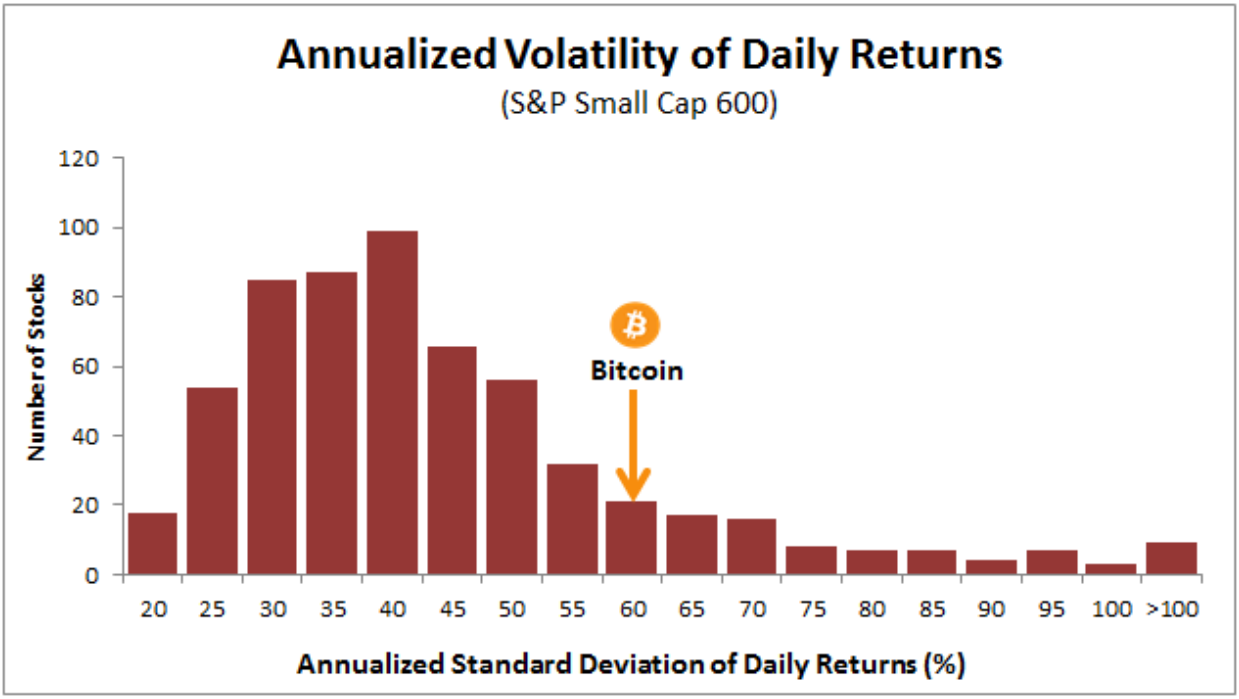
Figure 1 Comparing Bitcoin's Volatility



Source: FactSet, CoinDesk Bitcoin Price Index, Needham & Company, LLC

When all the respective equity securities of the companies in the S&P Small Cap 600 are ranked by volatility, Bitcoin falls in the 85th percentile. In essence, Bitcoin's daily volatility is similar to the high end of small-cap stocks.

***Figure 2* Volatility: Bitcoin vs. S&P Small Cap 600**

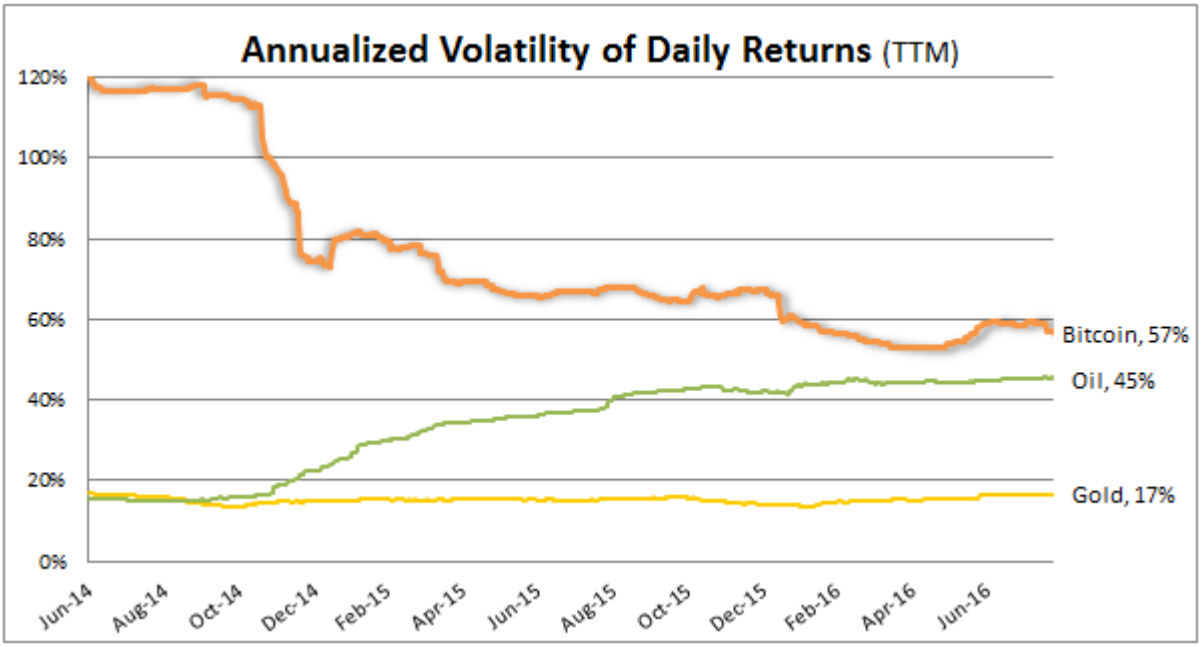


Source: FactSet, CoinDesk Bitcoin Price Index, Needham & Company, LLC

As Bitcoin adoption, trading, and liquidity has grown over time, volatility has steadily declined. In particular, **the annualized volatility of Bitcoin's daily returns has nearly halved from mid-2014 to mid-2016, and daily price volatility is now similar to the volatility of oil. Interestingly, as**

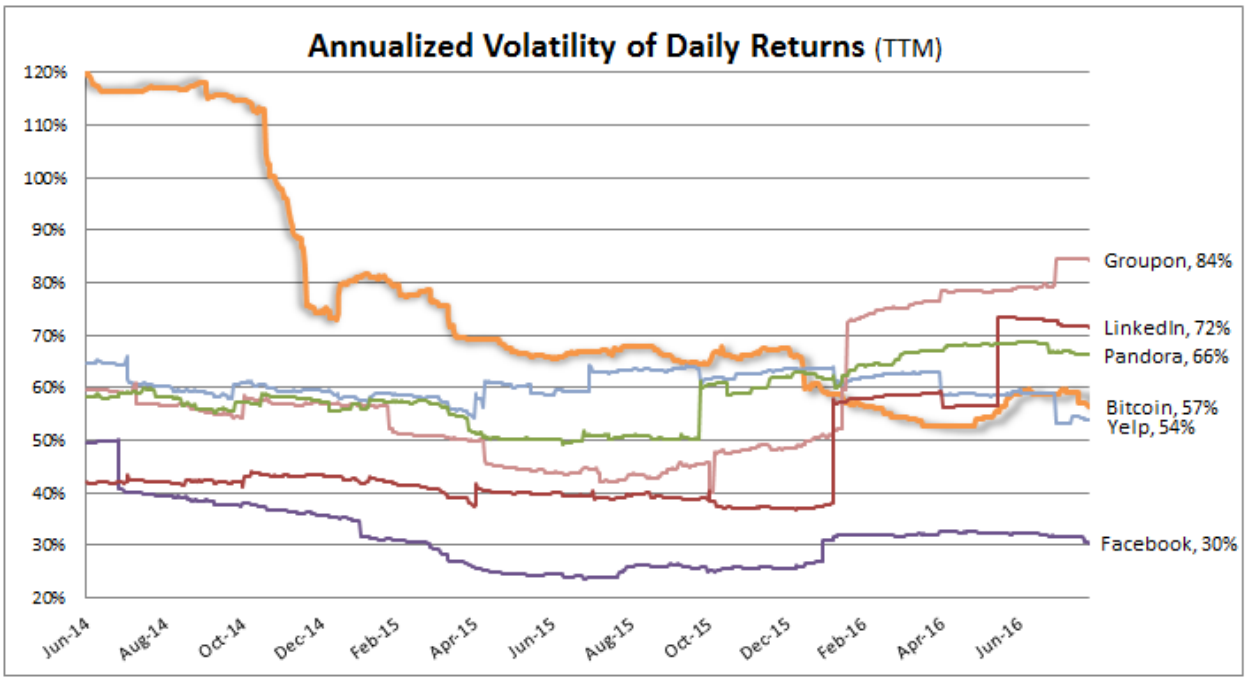
Bitcoin's volatility has declined over the past two years it has fallen below that of some of the most popular internet IPOs in the last few years. As Bitcoin liquidity continues to increase and volatility falls within a range that would be more tolerable for a greater number of investors, we think there will be a corresponding increase in interest among institutional investors.

Figure 3 Volatility Over Time: Bitcoin vs. Oil & Gold



Source: FactSet, CoinDesk Bitcoin Price Index, Needham & Company, LLC

Figure 4 Volatility Over Time: Bitcoin vs. Recent Tech IPOs



Source: FactSet, CoinDesk Bitcoin Price Index, Needham & Company, LLC

Correlation

Aside from its upside potential, one of the most appealing aspects of Bitcoin for institutional investors in our opinion is its low correlation to major asset classes. Earlier this year Ark Investment Management and Coinbase published a whitepaper[1] presenting a compelling argument that digital currency ought to be considered its own asset class based on its investability, unique politico-economic features, lack of correlation to other asset classes, and unique risk-reward profile.

Regardless of whether investors consider Bitcoin the first of a new asset class or not, we certainly find Bitcoin's lack of correlation to major asset classes to be among the most compelling features for portfolio managers. That said, we'll be watching how this correlation profile evolves over the coming years—as Bitcoin's investor base evolves it's possible that its correlation profile will shift as well.

In the tables below we highlight Bitcoin's average 6-month rolling correlation over the past 18 months. In place of a longer period, we use a trailing 18-month window because Bitcoin's price dynamics have changed significantly as its investor base has evolved in recent years—thus negating any benefits of using a longer measurement period. Bitcoin's lack of correlation to any of the major asset classes or subgroups that we measured is readily apparent throughout the tables below.

We use a representative ETF for each major asset class and subgroup to assess correlation to Bitcoin's returns; a list of ETF tickers used as proxies is included in the footnotes.

Figure 5 Correlation: Bitcoin vs. Major Asset Classes[2]

	Average Bitcoin Correlation to Major Assets/Groups						
	Equity: US	Equity: Emerging Mkts	Equity: Dev. Markets (Ex-US)	US Fixed Income	Oil	Gold	Bitcoin
Equity: US		0.69	0.83	-0.01	0.38	-0.04	0.04
Equity: Emerging Mkts	0.69		0.84	0.17	0.69	0.32	-0.13
Equity: Dev. Markets (Ex-US)	0.83	0.84		-0.06	0.60	-0.01	-0.12
US Fixed Income	-0.01	0.17	-0.06		-0.10	0.64	-0.23
Oil	0.38	0.69	0.60	-0.10		0.20	-0.05
Gold	-0.04	0.32	-0.01	0.64	0.20		-0.21
Bitcoin	0.04	-0.13	-0.12	-0.23	-0.05	-0.21	

Source: FactSet, CoinDesk Bitcoin Price Index, Needham & Company, LLC

Figure 6 Correlation: Bitcoin vs. Commodities[3]

	Average Bitcoin Correlation to Commodities						
	Broad Market	Gold	Silver	Platinum	Oil	Agriculture	Bitcoin
Broad Market		0.31	0.44	0.58	0.95	0.77	0.02
Gold	0.31		0.83	0.79	0.20	0.32	-0.21
Silver	0.44	0.83		0.81	0.33	0.40	-0.18
Platinum	0.58	0.79	0.81		0.45	0.58	-0.10
Oil	0.95	0.20	0.33	0.45		0.67	-0.05
Agriculture	0.77	0.32	0.40	0.58	0.67		0.17
Bitcoin	0.02	-0.21	-0.18	-0.10	-0.05	0.17	

Source: FactSet, CoinDesk Bitcoin Price Index, Needham & Company, LLC

[1] The white paper "Bitcoin: Ringing the Bell for a New Asset Class" (2016) can be found at http://research.ark-invest.com/Bitcoin-asset-class

[2] **ETF Proxies:** US Equity Markets: VTI; Emerging Market Equities: VWO; Developed Market Equities (ex-US): EFA; US Fixed Income: AGG; Oil: USO; Gold: GLD; Bitcoin: CoinDesk BPI;

[3] **ETF Proxies:** Silver: SLV; Platinum PPLT; Agriculture DBA;

Figure 7 Correlation: Bitcoin vs. Fixed Income Segments[4]

Average Bitcoin Correlation to Fixed Income Segments

	US Treasurys	IG Corporate	HY Corporate	TIPS	Emerging Mkt Sovereign	Preferreds	Bitcoin
US Treasurys		0.62	-0.09	0.60	0.10	0.09	-0.16
IG Corporate	0.62		0.49	0.67	0.55	0.59	-0.22
HY Corporate	-0.09	0.49		0.45	0.83	0.70	-0.14
TIPS	0.60	0.67	0.45		0.61	0.47	-0.13
Emerging Mkt Sovereign	0.10	0.55	0.83	0.61		0.66	-0.03
Preferreds	0.09	0.59	0.70	0.47	0.66		-0.08
Bitcoin	-0.16	-0.22	-0.14	-0.13	-0.03	-0.08	

Source: FactSet, CoinDesk Bitcoin Price Index, Needham & Company, LLC

Figure 8 Correlation: Bitcoin vs. Equities[5]

Average Bitcoin Correlation to Equities

	US Large Caps	US Small Caps	US Equity (broad market)	Global Equity (Ex-US)	Emerging Market Equity	Developed Markets (Ex-US)	Bitcoin
US Large Caps		0.86	0.99	0.79	0.66	0.80	0.09
US Small Caps	0.86		0.91	0.79	0.67	0.80	-0.08
US Equity (broad market)	0.99	0.91		0.82	0.69	0.83	0.04
Global Equity (Ex-US)	0.79	0.79	0.82		0.92	0.98	-0.11
Emerging Market Equity	0.66	0.67	0.69	0.92		0.84	-0.13
Developed Markets (Ex-	0.80	0.80	0.83	0.98	0.84		-0.12
Bitcoin	0.09	-0.08	0.04	-0.11	-0.13	-0.12	

Average Bitcoin Correlation to Equities (by Sector)

	Tech	Financial	Utilities	Energy	Consumer Non-Cyclicals	Consumer Cyclicals	Bitcoin
Tech		0.84	0.08	0.49	0.61	0.86	0.10
Financial	0.84		0.02	0.46	0.58	0.88	0.13
Utilities	0.08	0.02		0.12	0.52	0.01	0.07
Energy	0.49	0.46	0.12		0.23	0.39	-0.01
Consumer Non-Cyclicals	0.61	0.58	0.52	0.23		0.66	0.23
Consumer Cyclicals	0.86	0.88	0.01	0.39	0.66		0.08
Bitcoin	0.10	0.13	0.07	-0.01	0.23	0.08	

Average Bitcoin Correlation to Equities (by Size & Style)

	Large Cap Growth	Large Cap Value	Mid Cap Growth	Mid Cap Value	Small Cap Growth	Small Cap Value	Bitcoin
Large Cap Growth		0.87	0.93	0.85	0.87	0.81	0.09
Large Cap Value	0.87		0.88	0.93	0.77	0.89	0.04
Mid Cap Growth	0.93	0.88		0.93	0.93	0.91	-0.07
Mid Cap Value	0.85	0.93	0.93		0.81	0.94	-0.11
Small Cap Growth	0.87	0.77	0.93	0.81		0.87	-0.07
Small Cap Value	0.81	0.89	0.91	0.94	0.87		-0.07
Bitcoin	0.09	0.04	-0.07	-0.11	-0.07	-0.07	

Source: FactSet, CoinDesk Bitcoin Price Index, Needham & Company, LLC

[4] **ETF Proxies:** US Treasuries: GOVT; Investment Grade Corporate Bonds: LQD; High-Yield Corporate Bonds: HYG; TIPS: TIP; Emerging Market Sovereign Bonds: EMB; Preferreds: PFF;

[5] **ETF Proxies:** US Large Caps: SPY; US Small Caps: IWM; Global Equity (ex-US) VEU; US Tech Equities: VGT; US Financial Equities: VFH; US Utilities Equities: VPU; US Energy Utilities: VDE; US Consumer Non-Cyclical Equities: VDC; US Consumer Cyclical Equities: VCR; US Large Cap Growth: IWF; US Large Cap Value IWD; Mid Cap Growth: IWP; Mid Cap Value: IWS; Small Cap Growth: IWO; Small Cap Value: IWN

While Bitcoin's apparent lack of correlation to all major asset classes and subgroups is encouraging, we believe there's more to consider in evaluating the potential for Bitcoin in reducing portfolio variance. This is readily observed in the portfolio variance formula which can be summarized as:

Portfolio Variance = (Variance$_a$ x Weight$_a^2$) + (Variance$_b$ x Weight$_b^2$) + Correlation Effect

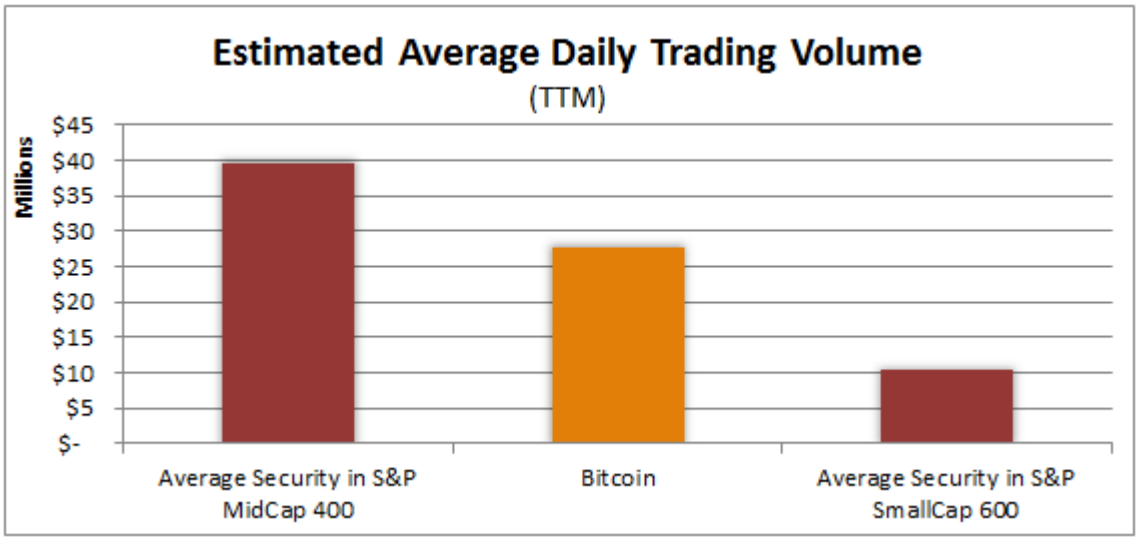
In short, often the biggest factor in reducing portfolio variance is actually the combination of assets with different levels of volatility into the same portfolio (correlation effect taking a secondary role). As such, the impact of correlation in reducing portfolio variance is strongest in portfolios composed of assets exhibiting similar volatility.

In this sense, we can conclude that the potential for Bitcoin's lack of correlation to reduce portfolio variance will be strongest in portfolios that are largely composed of assets exhibiting volatility similar to Bitcoin's. One such group of assets would be a portfolio of small-cap equities—which, as we identified earlier, have a similar volatility profile to Bitcoin. **We think this is particularly interesting considering that portfolio managers dealing mainly in small-cap equities (alongside commodities, currencies, and technology portfolio managers/analysts) are probably among the most predisposed to closely evaluating Bitcoin.**

Liquidity

Bitcoin's daily dollar volume roughly resembles that of a US MidCap security. We restrict our volume analysis to only include the top 5 BTC-USD exchanges because there is a tremendous amount of no-fee BTC-CNY volume on Chinese exchanges that is difficult to access outside of China.

Figure 9 Bitcoin Daily Trading Volume Relative to Mid and Small Cap Equities



Source: FactSet, CoinDesk Bitcoin Price Index, Needham & Company, LLC

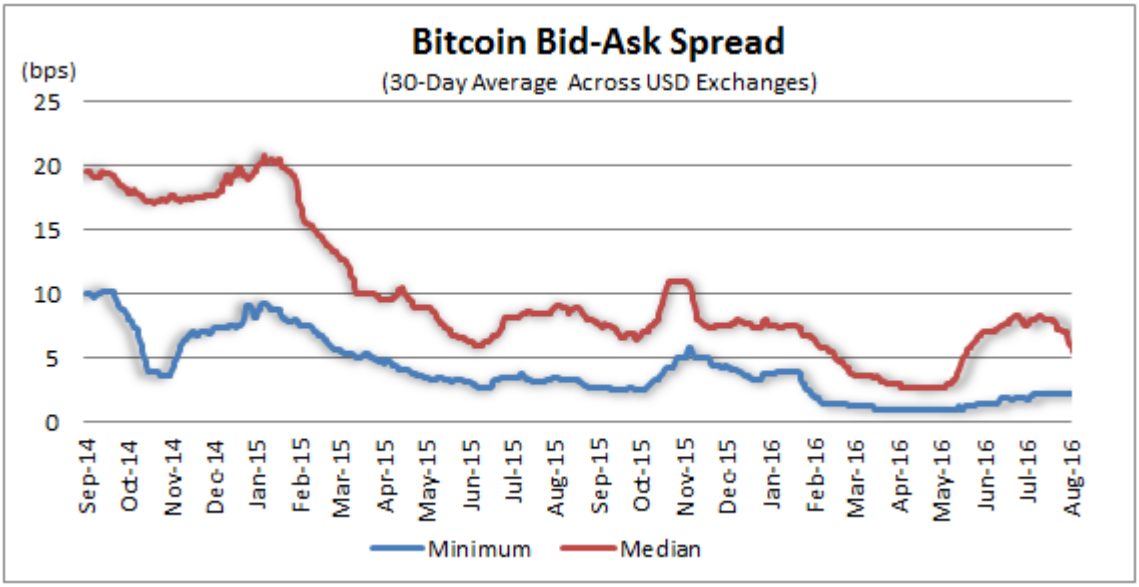
Despite heavily restricting our analysis to the top 5 BTC-USD exchanges, we find that the median daily dollar volume over the past year was $28 million (vs. roughly $39 million for the average security in the S&P MidCap 400 vs. roughly $10 million for the average security in the S&P Small Cap 600). Total daily Bitcoin volume would be drastically higher if we included volume from all exchanges and across all currency pairs, but we think this would not be reflective of a typical investor's experience.

Indeed, the picture presented here of Bitcoin liquidity might already be overstated given that this liquidity is spread across five exchanges and because we use summary statistics (averages) which likely obfuscate the decline in liquidity and corresponding increase in bid/ask spreads during large price moves.

Another factor to consider in regard to investors' ability to enter and exit Bitcoin positions is that Bitcoin markets are open 24/7—which, for example, is particularly appealing should investors want to open a position in response to an unexpected macroeconomic event over the weekend.

As would be expected, as Bitcoin trading volume has increased over the past two years, bid-ask spreads have declined significantly. In the chart and table below we graph summary statistics of Bitcoin's average spread over time and compare that to the securities in the S&P Small Cap 600.

Figure 10 Bitcoin Bid-Ask Spreads



	Bid/Ask Spread (bps)	
	Bitcoin[1]	Equities in S&P Small Cap 600[2]
Median	5.5	5.3
25th Percentile	3.6	2.4
75th Percentile	7.6	10.2

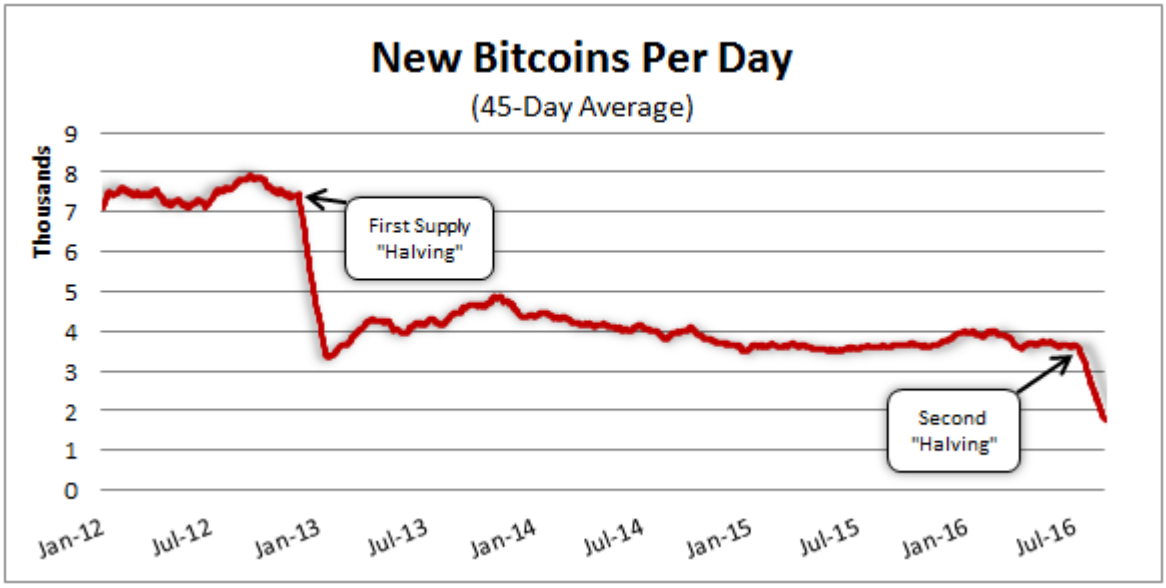
[1]Based on median values across USD exchanges from 1/8-8/28/16
[2]Based on median values of equities in S&P Small Cap 600 from 1/8-8/28/16

Source: FactSet, bitcoinity.org, Needham & Company, LLC

Supply

In July, Bitcoin incurred its second "halving"—where the rate of supply of new Bitcoins falls in half every 210,000 blocks (approximately every 4 years). As a result, the "block reward" (newly created Bitcoin rewarded to miners for processing transactions and adding a block to the blockchain) fell from 25 Bitcoin to 12.5 Bitcoin per block.

Figure 11 Bitcoin Creation Over Time



Source: Blockchain.info, Needham & Company, LLC

This "halving" event is part of Bitcoin's disinflationary process that will eventually cap total Bitcoin supply at 21 million**. The stark contrast of Bitcoin's historical and projected supply relative to the US Dollar and gold is readily observed in the charts below.**

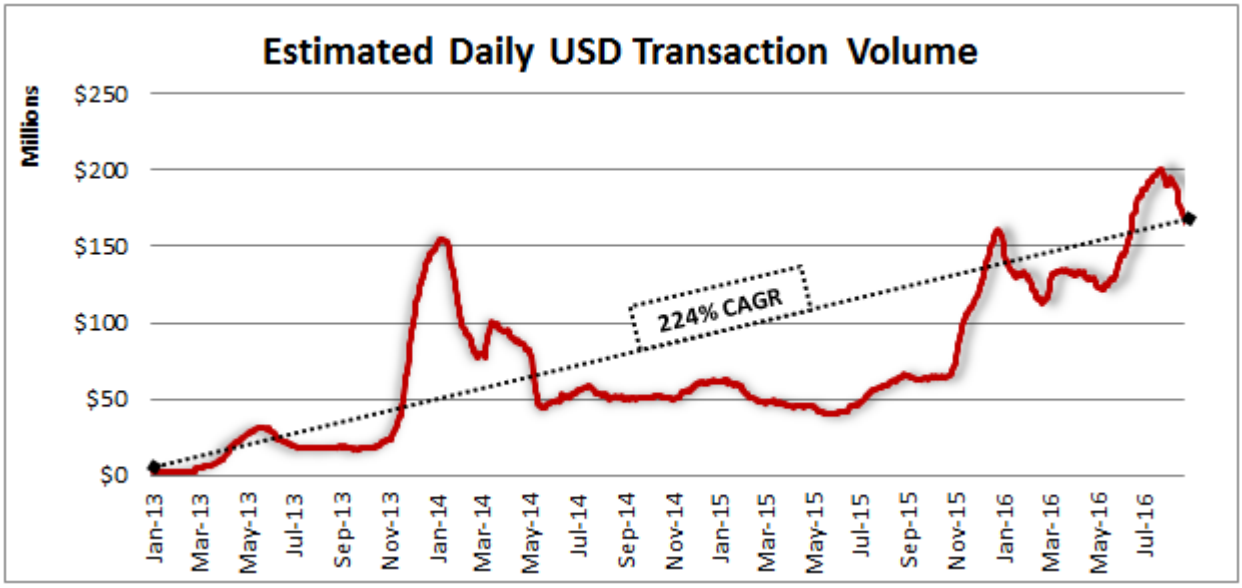
Figure 12

Source: Ark Investment Management and Coinbase, "Bitcoin: Ringing the Bell for a New Asset Class" (June 2016)

Transaction Volume

Daily USD on-chain transaction volume, as estimated by Blockchain.info, has grown at an impressive 224% CAGR since January 2013. Spikes in USD-equivalent transaction volume tend to occur when price rises significantly. In particular, we note that transaction volume in mid-2016 has grown more than threefold over a year ago.

Figure 13 Bitcoin Daily Transaction Volume

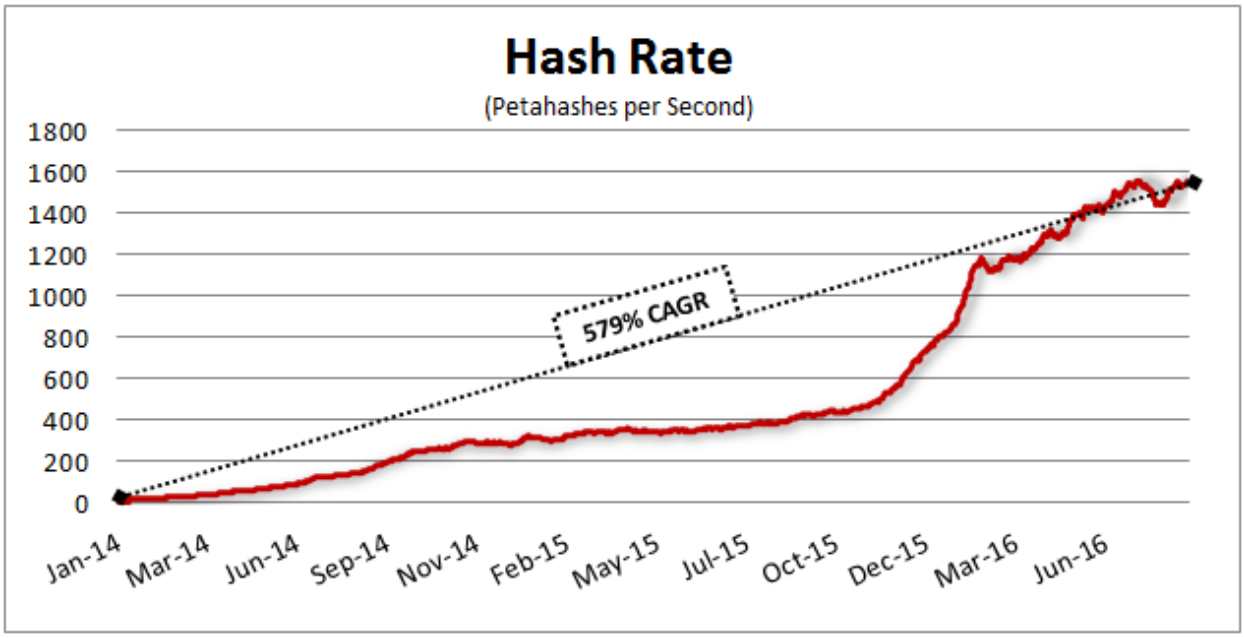


Source: Blockchain.info, Needham & Company, LLC

Hash rate

Hash rate is a measure of the amount of computing power that is securing the Bitcoin blockchain. At current levels, Bitcoin is estimated to have many thousands of times more computing power than the world's top-500 supercomputers combined. All else equal, a higher hash rate implies a higher cost to attempt a "double-spend" (fraud) on the Bitcoin blockchain so we are very encouraged by the strong, persistent growth in hashing power.

Figure 14 Bitcoin Hash Rate



Source: Blockchain.info, Needham & Company, LLC

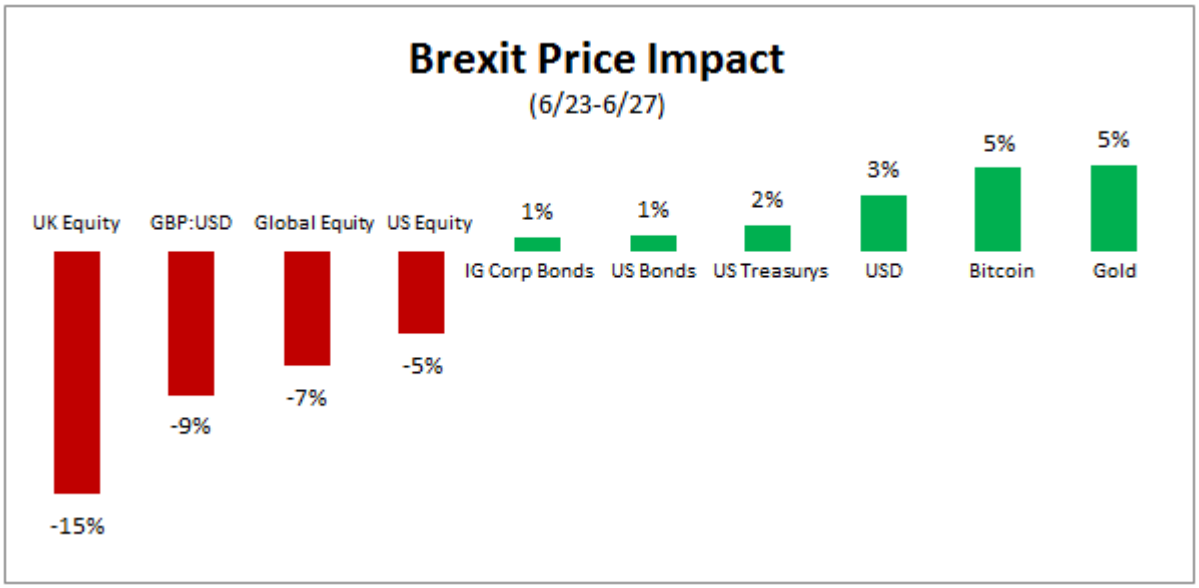
Price Action

The price of Bitcoin, as measured by the CoinDesk Bitcoin Price Index (BPI), is up 46%—from $415 to $608—since we published our initiation report in March, and a couple recent events (Brexit, Bitfinex hack) have highlighted some interesting price action.

Bitcoin Thrives in Macro-Economic Uncertainty?

Of particular note was Bitcoin's interesting (we think appealing) price action during and in the aftermath of the Brexit vote—likely the biggest macro event YTD. In short, most major asset classes declined significantly as Brexit results began to roll in on the evening of June 23 and over the days that followed. Very few assets appreciated during this "risk-off" period except for traditional "safe-haven" assets and Bitcoin.

Figure 15 Bitcoin & Brexit



Source: FactSet, CoinDesk Bitcoin Price Index, Needham & Company, LLC

While it is encouraging to see Bitcoin appreciate even while other assets declined, we note that the relevant data points here are extremely limited and we're hesitant to project similar price action for future macro events. As we commented in a prior note to clients:

> *"While it is true that Bitcoin rallied alongside other traditional safe haven, 'risk-off' assets (Gold, US Treasury Bonds, Yen, USD), we're hesitant to dub it a safe-haven asset for a number of reasons. For one, calling it such obfuscates the fact that Bitcoin is a high-risk and volatile investment and, second, Bitcoin's correlation to other traditional safe-haven assets has fluctuated significantly."* –Needham in June 2016 Note to Clients

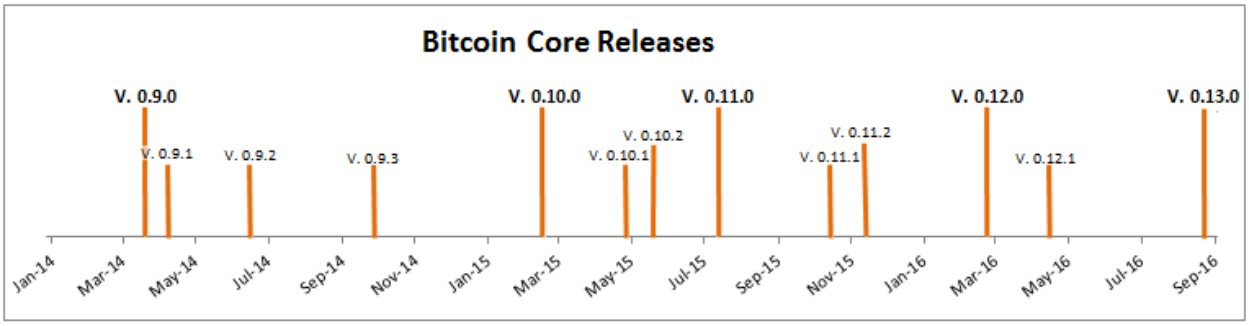
Price Resilience

The other interesting recent price move was following the news of a ~120,000 Bitcoins ($60M+) heist from one of the world's largest Bitcoin exchanges, Bitfinex. The exchange theft was the second largest in Bitcoin's history after the 2014 Mt. Gox incident, but the resulting price move wasn't nearly as severe. Part of the reason is likely that the Bitfinex hack was only a fraction of the value of the Mt. Gox theft ($66 million vs. $350 million at Mt. Gox) but the relative stability is also likely due to greater confidence in Bitcoin's future—For instance, the Mt. Gox implosion appeared to be an existential threat to Bitcoin whereas the Bitfinex hack was largely shrugged off by the market. Regardless, for at least one serious test the invested capital in Bitcoin appeared relatively sticky.

Bitcoin Keeps Improving & the Outlook Is Compelling

Bitcoin has improved significantly since it was initially released nearly 8 years ago, and we think the outlook is bright. The latest major version (released August 23) contains 14 notable changes from 101 contributors around the world (decentralized much?), including a set that benefits scaling at the protocol level and eases the process for further scaling improvements ("segregated witness"). For those interested in the specifics of the latest release, we recommend the **release notes** which summarize the big changes.

Figure 16 Bitcoin Core Releases



Source: GitHub, Needham & Company, LLC

We see a multitude of developments throughout the Bitcoin ecosystem that are poised to move from conceptual to real over the next 3-7 months—each of which could augment Bitcoin's features and functionality and, consequently, increase demand for Bitcoin. While some of these developments might never come to fruition, might be delayed or may prove less valuable than anticipated, each of them individually could prove to be immensely important to Bitcoin's future, and with multiple potentially highly impactful developments ahead we believe it's an opportunity that investors would want to be in front of. We think the outlook is very bright indeed.

In particular, we will be watching for the rollout and impact of segregated witness, lightning networks, sidechains, privacy enhancements, and smart contracts.

Segregated Witness

As the number of transactions on the Bitcoin network has grown over time, the finite space available for transactions in each block on the blockchain is increasingly under pressure to the point where most blocks added to the blockchain are now at capacity. The consequence is upward pressure on transaction fees. Now, after many months of contentious debate, Bitcoin's first real move toward increasing transaction capacity is likely to be deployed over the coming months.

Among other benefits, this particular set of improvements (known as "Segregated Witness") effectively scales Bitcoin by ~1.75x, eases the process for further scaling improvements, and fixes a known "transaction malleability" bug. Segregated witness is part of the improvements included in that latest version release (0.13.0 on August 23rd) and, presuming there is sufficient adoption, will be activated with a later minor release (TBD).

Beyond segregated witness, advances such as lightning networks (discussed below) and other second layer solutions will likely help alleviate pressure from rising adoption and usage of Bitcoin going forward—with minimal negative effect on Bitcoin's decentralization, which is widely perceived to be its most crucial feature.

Lightning Networks

Lightning networks/payment channels show significant promise for enabling high-volume, low-value transactions. A lightning network is a method for decentralized, off-chain transactions between

untrusted parties. Relative to what is currently possible on the Bitcoin network, a lightning network allows for drastically higher throughput (potentially beyond Visa-level capacity) at faster speeds (near instantaneous), with greater privacy, and at significantly lower cost.

The enabling factor that allows for drastically higher throughput on a lightning network relative to the Bitcoin network itself is that it's much easier to scale point-to-point transactions (as on a lightning network or payment channel) than those that need to be broadcast to the entire Bitcoin network. In essence, lightning networks keep transactions "off-chain" in a way where transacting parties can prove that they have funds locked up and can then trade smart contracts (cryptographically signed IOUs) back and forth that are tied to the locked-up collateral. At any point the transacting parties can bring their cryptographically signed IOUs to the final arbiter, the Bitcoin blockchain, to "cash out" with an actual on-chain Bitcoin transaction.

In this way, parties can confidently transact directly amongst each other without (1) constantly using the blockchain, (2) trusting one another, and (3) requiring a trusted intermediary. By not using the blockchain constantly, transacting parties circumvent much of the associated cost and throughput limitations. Although these transactions don't constantly use the blockchain, they do rely on it to secure value and act as a final arbiter and thus the blockchain is absolutely critical to the functionality of lightning networks and other payments channels.

We note that one of the main downsides of lightning networks is that they require users to "lock up" an amount of funds on the Bitcoin blockchain equal to the maximum amount they wish to transact on the lightning network. For example, if a user locks up 2 BTC for a lightning network, that user can't subsequently send a 3 BTC payment or "IOU"—so there is a capital cost associated with the idle funds that are necessary to leverage such networks. Still, considering the substantial benefits of lightning networks, we think this downside is minor (but not negligible).

Sidechains

Sidechains have been a concept for more than two years, but sidechain projects are finally inching their way toward more widespread deployment. The concept and potential value of sidechains is relatively straightforward: With sidechains, developers get the freedom to try new concepts, features and functionality in a production environment while still leveraging Bitcoin's first-in-class network effects (its security in particular). Conceptually, sidechains bear some resemblance to "special economic zones" where a country has established different (relaxed) constraints in order to encourage a particular type of activity or industry while still maintaining a base layer of compatibility with the remainder of the country (the Bitcoin network in this case). The two primary consequences of this "best of both worlds" technology are an accelerated development cycle and new Bitcoin functionality.

In terms of an accelerated development cycle, sidechains would allow for real-world testing of otherwise conceptual ideas in a strictly opt-in environment—that is, every Bitcoin user needn't be exposed to the consequences of an experimental sidechain. Concepts that are proven on a sidechain can either be incorporated into the main Bitcoin blockchain to benefit all users or can remain as opt-in sidechains that users leverage by choice. This is particularly important considering how difficult it is to achieve a high degree of network-wide consensus—for instance, if a feature can only be added with 95%+ of the network in agreement, very few features will ever be added. Sidechains may help alleviate much of this friction to innovation on the Bitcoin blockchain.

In terms of new functionality, sidechains may also enable blockchain applications for which Bitcoin was not originally designed—such as prediction markets—which ultimately increases the utility of (and demand for) Bitcoin.

Privacy

Bitcoin is pseudonymous—so while real identities are not directly available on the Bitcoin blockchain, one can potentially deduce the identities of counterparties and link their pseudonymous address to other transactions to glean competitive information. Naturally, this is a no-go for companies that are

considering using the Bitcoin blockchain within competitive industries. Aside from that, addresses with large amounts of value can be identified and thus potentially become targets for thieves.

The even greater risk associated with a lack of confidentiality/anonymity—and likely one of the biggest risks to Bitcoin in general—is the potential negative impact on fungibility. We believe that fungibility will ultimately be critical to Bitcoin retaining its value. If a particular Bitcoin is worth less because it has been "tainted" due to association with a nefarious address or transaction it could compromise the value of all Bitcoins. Of course, it's only possible for a Bitcoin to be "tainted" if individual Bitcoin can be identified and linked to specific addresses and transactions. At least partially reassuring in this respect is that there are solutions available that help improve privacy (e.g. "tumbling" services like CoinJoin) and that this issue is front and center for many of the developers that contribute to improve Bitcoin and they already have a few techniques available that likely help mitigate risks to fungibility.

Methods to improve privacy, such as by concealing transaction amounts as in Blockstream's "Elements" sidechain, are currently being developed and could potentially be used in a Bitcoin context in the not too distant future. In addition, second layer solutions such as lightning networks, sidechains, and privacy-specific layers (e.g. TumbleBit) also show early promise for improving the privacy of Bitcoin transactions.

The gold standard for privacy is the ability to be able to withhold as much information as possible (transaction amounts, addresses, etc) but to have the ability to selectively reveal transaction activity and information exclusively to intended parties. We're optimistic that this will eventually be possible in Bitcoin.

Smart Contracts

The basic premise of smart contracts is to reduce mutual agreements between businesses, individuals, or machines to transparent software code that self-executes and self-enforces. On the surface, the functionality is relatively straightforward: A software protocol performs an action (releases funds, sends information, makes a purchase, etc) when certain conditions are met (a payment is received, the outcome of an event is determined, etc) all without dependence on any centralized intermediary.

Bitcoin has always had a base level of smart contracting functionality built in, but the lure of a "turing-complete" smart contracts blockchain has accelerated interest in alternative blockchain Ethereum to the tune of $1 billion (the current market capitalization of Ether—the native cryptocurrency of Ethereum). Some of this interest has recently been tempered by security issues with contracts built on Ethereum (as exemplified by the exploitation of the $150M DAO fund which enabled $50M+ to be siphoned from the fund against the intentions of most participants). Still, projects such as Rootstock are seeking to bring the same functionality to the most secure blockchain—the Bitcoin blockchain—via a two-way peg (2WP). This additional functionality could become an additional driver of Bitcoin demand and may see initial deployment before year-end.

Contextualizing the Bitcoin Opportunity

Market Opportunity, Assumptions & Valuation

With an equity security there are ways to calculate the intrinsic current value of the security based on potential future cash flows, but Bitcoin is different: the only future cash flow to consider is its terminal value upon sale. In this sense, we assess the value of Bitcoin by answering a series "what if" questions (e.g., "'what if Bitcoin represented a ___ % of the _____ market?" and then tracking progress toward those milestones and adjusting as necessary).

To contextualize the magnitude of the market opportunity for Bitcoin, we divide the market into two major sources of demand: Bitcoin's value as a "digital gold" and its value as an alternative payment channel.

"Digital Gold"

Based on evaluations of the movement of individual Bitcoin[6,7] we estimate that roughly 75% of all Bitcoin is currently dormant or held as an investment in Bitcoin as a "digital gold". Bitcoin's appeal in this segment is largely attributable to its known finite supply and its value as a liquid speculative investment in a nascent technology. Given a current total Bitcoin market capitalization of $9.6 billion, we estimate that the portion of Bitcoin's total market capitalization associated with its value as a "digital gold" is roughly $7 billion.

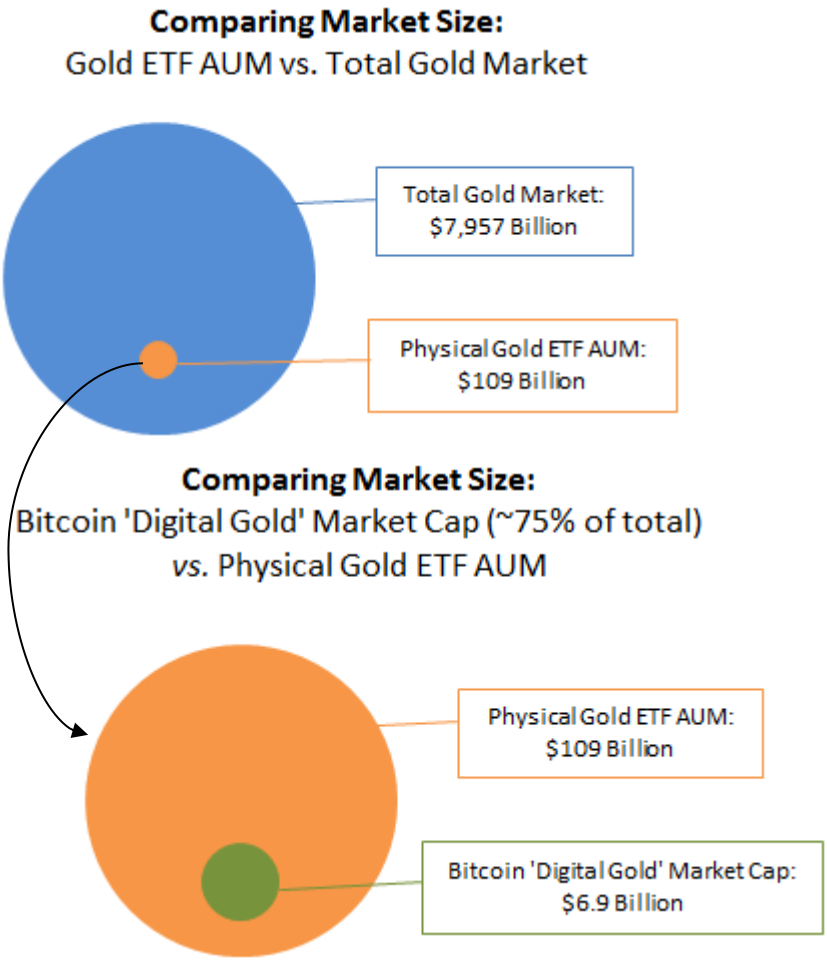
In comparing this market capitalization to the gold market, we differentiate the overall total gold market (which includes those owning and holding physical gold) from the portion of the gold market that is held in exchange-traded funds (ETFs). In actuality, owning and holding Bitcoin is probably closer to owning physical gold in that the owner is (or can be) completely and solely in control of the asset without any potentially competing claims. However, this overall physical gold market includes many segments that may not find appeal in Bitcoin in the short to medium term. For example, we think it is highly unlikely that segments of this market where gold has cultural value (i.e., in India, where gold may be passed down for generations) will adopt Bitcoin as a supplement or alternative.

Instead, we believe that the better comparable is the portion of the gold market held in ETFs—that is, we think that people who gain exposure to gold via ETFs are significantly more likely to add Bitcoin to their investment portfolio than the segment of the gold market that buys physical gold. We estimate there is $84 billion worth of gold held in ETFs around the world. In comparison, the portion of Bitcoin's total market capitalization that we attribute to its value as a "digital gold" is $7 billion—roughly 8% of the size of the gold ETF market. We estimate that demand could push this figure to 27.5% of the gold ETF market by the end of 2020—which would represent $23 billion in market cap for Bitcoin as a "digital gold". While this $27 billion is significant relative to the gold ETF market, it would represent less than 0.5% of the broader $7 trillion gold market.

[6] Nermin Hajdarbegovic, "Analysis: Around 70% of Bitcoins Unspent for Six Months or More" (2014), CoinDesk

[7] Dan Goodin, "78 percent of Bitcoin currency stashed under digital mattress, study finds" (2012), Ars Technica

Figure 17 Visualizing the Size of Bitcoin Relative to Gold Markets



Source: World Gold Council, Needham & Company, LLC

We think that our estimate of 27.5% of the gold ETF market could ultimately prove conservative given that, in at least one respect, Bitcoin has an access advantage (it can be acquired without a bank or brokerage account) and because holding gold ETFs and Bitcoin are not at all mutually exclusive (we think that gold ETF investors would find value in Bitcoin for its diversification and upside potential). Further, we believe the investment appeal in Bitcoin as a "digital gold" extends well beyond its finite supply (analogous to a commodity investment) and also includes a sizable portion of the market that essentially owns Bitcoin as a liquid speculative investment in a nascent technology (analogous to a VC equity investment).

There could also be significant upside to our estimate if mainstream financial institutions were to further integrate Bitcoin into offered services—for example, if a Bitcoin ETF were approved to trade on one of the world's major stock exchanges or if major banks or FX brokers began offering Bitcoin services (purchase, storage, payments, etc.)—but this is not currently priced into our estimates and assumptions.

Payments Value

The global payments market is immense: According to Boston Consulting Group's "Global Payments 2015" report[8] and corresponding interactive edition[9], the total value of global non-cash transactions topped $430 trillion in 2014 and is forecasted to top $619 trillion in 2020.

The total $619 trillion forecast can be divided into retail payments (those initiated by consumers) and wholesale payments (those initiated by businesses and governments). Of the two, the total value of wholesale payments is significantly larger than the total value of retail payments (2020 forecast of $552 trillion vs. $68 trillion). While it's certainly possible that Bitcoin finds traction in the wholesale payments market (for example, Align Commerce targets underserved SMB businesses and uses the Bitcoin payment rail), for conservatism we're currently limiting our adoption projections to the retail market given some reluctance among financial institutions and governments in particular to consider public blockchains like Bitcoin. While recently there have been significant shifts among some financial institutions toward Bitcoin (e.g. Bitcoin integration at USAA via Coinbase), we think it's too early to price this scenario into our assumptions. For these reasons and because the pain point is stronger in the retail market where fees (especially as a percentage of transaction value) are significantly greater, we limit our adoption projections to the retail market for now.

Figure 18 High Cost of Retail Payments

"Although retail payments accounted for a small fraction of transaction values in 2014 (11 percent), they generated 78 percent of total payments revenues"

Source: Boston Consulting Group report "Global Payments 2015"

We further subdivide the retail payments market to arrive at Bitcoin's addressable market opportunity as a payments channel. The first distinction we make within the retail payments market is between emerging markets and developed markets. **We believe that adoption will be significantly greater in emerging markets (albeit still a small portion overall) than in developed markets given that financial inclusion is significantly lower in emerging markets, the viable alternatives are fewer (and of lower quality), and emerging market countries tend to have less stable currencies, more onerous capital controls, and more frequent economic, monetary, or financial crises.**

We also subdivide both the developed retail payments market and the emerging retail payments market into the portion of transactions that are domestic versus cross-border. **We assume greater adoption for cross-border transactions given that, relative to alternatives, the advantages of leveraging Bitcoin as a low-cost, fast, and borderless payment channel are greater for cross-border transactions than for domestic transactions.**

Taken together, we assume the greatest rate of adoption for retail cross-border transactions initiated in emerging markets (2% of $2 trillion market), followed by cross-border transactions initiated in developed markets (1% of $1 trillion market), followed by domestic emerging market transactions (0.4% of $24 trillion market), followed by domestic developed market transactions (0.1% of $40 trillion market).

[8] Stefan Dab, Mohammed Badi, Laurent Desmangles, Gero Freudenstein, Alenka Grealish, Federico Muxi, Pedro Rapallo, Olivier Sampieri, Yann Senant, Kuba Zielinski, "Global Payments 2015: Listening to the Customer's Voice" (2015), Boston Consulting Group and SWIFT

[9] "Global Payments 2015: The Interactive Edition" (2015), Boston Consulting Group

Figure 19 Estimated Bitcoin Retail Payments Market Share

The Market

2020 Estimated Retail Payments Values ($billion)		
	Developed Markets	Emerging Markets
Cross-Border	$813	$2,137
Domestic	$40,224	$24,363

Bitcoin % Share

Estimated 2020 Bitcoin Retail Payments Market Share		
	Developed Markets	Emerging Markets
Cross-Border	1.10%	2.20%
Domestic	0.11%	0.44%

Bitcoin $ Share

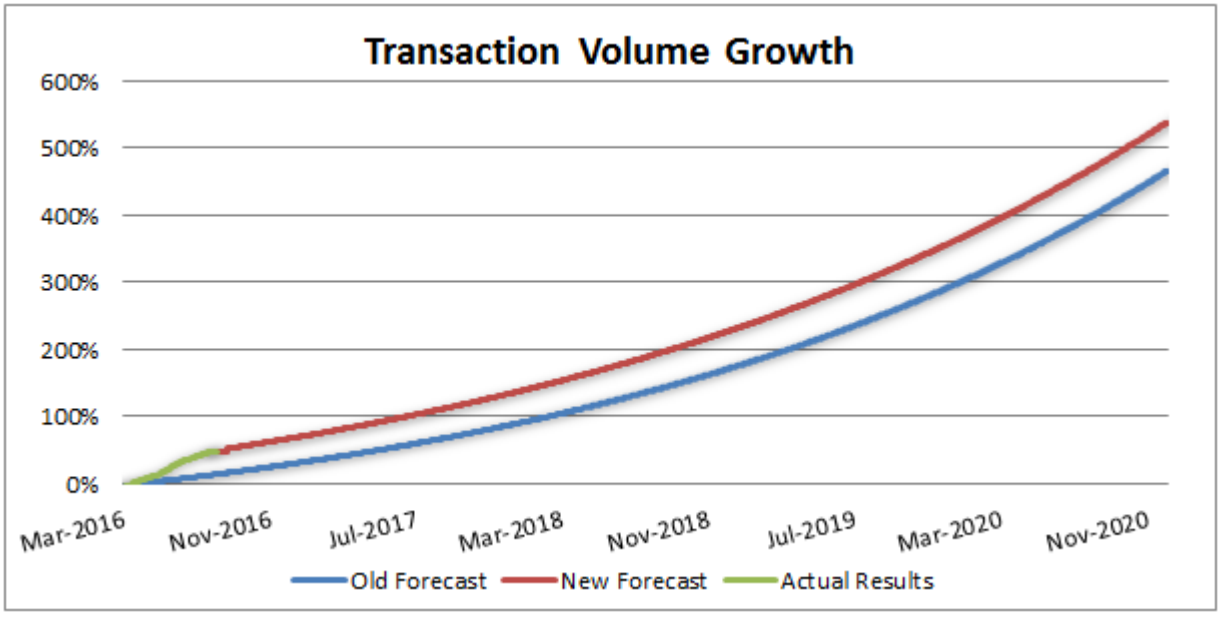
2020 Estimated Retail Payments Values ($billion)		
	Developed Markets	Emerging Markets
Cross-Border	$9	$47
Domestic	$44	$107

Source: Boston Consulting Group, Needham & Company, LLC

Accelerated Adoption

The pace of Bitcoin adoption has exceeded our expectations (as outlined in our estimates published in March) and we are adjusting our forecast accordingly. At the end of August 2016, estimated TTM transaction volume was roughly 30% higher than we projected in March, and as a result of this faster-than-expected growth we are raising our 2020 market share estimates by a more conservative 10%.

Figure 20



Source: Company data, Blockchain.info, Needham & Company, LLC

Updating Our Estimates (Raising Bitcoin Price Projection)

In providing our estimates, our goal is to help put Bitcoin's usage, price, and market capitalization in the context of its respective market segments. Bitcoin only has value to the extent that people use it for payments or hold it as a digital gold, and so we try to provide perspective and context on the room for growth in these markets. While we're encouraged by Bitcoin's rapid progress and the major room that we see for growth, it's important that investors are aware that Bitcoin has limited intrinsic value—especially compared to equity in a dividend-producing company—and price could go to $0.

When we consider Bitcoin's major growth opportunity coupled with its diversification benefits, we find the Bitcoin opportunity to be highly compelling, but we also recognize that it is a highly speculative investment with significant downside opportunity.

Supported by the compelling forward opportunity, we are raising our Bitcoin price projection from $655 to $848 based on faster than expected growth in the adoption of Bitcoin as a digital gold and as an alternative payments channel.

The Road Ahead

Conceptualizing a Path from Niche to Mainstream

In considering the future of Bitcoin we first must understand where Bitcoin thrives today. As a payment network, Bitcoin currently thrives in markets that are poorly served by traditional financial institutions. Most notably, that currently includes those escaping onerous regulation on capital flows, un(der)banked populations, and online "darknet" markets (where, for example, people sell Bibles in North Korea, or cocaine in France).

As a digital gold, Bitcoin currently thrives among 1) early speculative investors and 2) those that want to hold all or a portion of their wealth in a form that is resistant to centralized control from financial institutions or governments (those that wish to "be their own bank").

While these two are often separate groups, they have a symbiotic relationship in that Bitcoin's growth as a payment network tends to drive price higher and attract more people that value Bitcoin as a digital gold. Similarly, adoption of Bitcoin as a digital gold tends to support a higher Bitcoin price which, in turn, supports the security and infrastructure that enables Bitcoin to function reliably as a payment network.

In this sense, Bitcoin's use in underserved markets (such as the darknet) provides the impetus for a critical mass of value that supports improved security and network functionality. In this sense, Bitcoin in its current form is essentially still a minimum viable product: It doesn't have all the same convenience and consumer protection features that the well-banked expect and receive. Instead, Bitcoin has a different feature set and, as such, is currently only appealing in certain markets and situations. Perhaps among the most notable of Bitcoin's advantages today is that the minimum requirement for participation and inclusion in the Bitcoin economy is access to a mobile phone—which is a significantly lower bar for participation than requiring a bank account.

Major financial institutions are understandably *not* concerned about Bitcoin as a competitive threat because the vast majority of their customers aren't looking for and don't particularly need Bitcoin. Instead, Bitcoin is currently thriving in markets that traditional financial institutions are unable or disinterested in serving.

> *"A disruptive innovation…takes root in a tier of the market that is unattractive to the established leaders in an industry." "Disruptive technologies bring to market a very different value proposition than had been available previously. Generally, disruptive technologies underperform established products in mainstream markets. But they have other features that a few fringe (and*

> *generally new) customers value."* –Clayton Christensen, *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail* (1997)

Importantly, while Bitcoin is thriving in these fringe markets it's also getting stronger, its capabilities are advancing and, as this continues, we think Bitcoin will become increasingly attractive within more mainstream markets. The past couple years alone have seen marked improvement: Bitcoin security has grown significantly (both in terms of hashing power securing the network and 'bug' fixes), developers have added compelling new features (e.g. multi-sig, CLTV, etc.), and the outlook for network improvements now appears brighter than ever. As this cycle continues, we think Bitcoin will gain more features and capabilities for value transfer and storage that simply aren't possible with traditional money and investments and, as a result, we think Bitcoin itself will become more attractive to larger and larger segments of users—not because they fundamentally "care" about Bitcoin from any ideological perspective but simply because they can do new things with Bitcoin that aren't otherwise possible.

In a prior report (on page 30) we also outlined a similar but different potential path to mainstream adoption that focuses less on Bitcoin's feature set (or lack thereof) and more on its potential to grow over time as various economies around the world and their respective currencies inevitably falter (e.g., Venezuela, Argentina). We think both of these scenarios are viable, non-mutually-exclusive, paths to greater Bitcoin adoption.

Hurdles to Adoption

Perception: Bitcoin is still often associated with illegal activity, hacking, and bankruptcies, and this perception likely inhibits adoption. Much like how the Internet is an open communications system that can be used by anyone for good or for bad, Bitcoin is an open financial system that can be used by anyone—including both good and bad actors. Open systems such as the Internet and Bitcoin tend to find initial adoption among the most underserved populations—which often includes those engaged in illegal or shunned activities. As with the internet in its early days, the task is to avoid throwing Bitcoin out with the bathwater and to avoid letting bad actors ruin what could ultimately be a boon to millions of people around the world.

Volatility: While the volatility of Bitcoin is part of what makes it attractive as an investment, it also inhibits adoption for its potentially bigger use case: as a payments mechanism and store of value. That said, there are many companies in recent years that have created solutions that make Bitcoin's volatility a non-issue: Merchants that accept Bitcoin via BitPay or Coinbase, for example, needn't incur any currency risk from Bitcoin; instead, these vendors accept Bitcoin on the merchant's behalf, immediately convert it to local currency, and deposit it directly to the merchant's account (at the price they expected to receive for the sale). Furthermore, as Bitcoin adoption increases and its market capitalization grows, fluctuations in demand will be relatively less impactful to price and consequently volatility would diminish over time.

Awareness & know-how: Another barrier to adoption is that much of Bitcoin's potential user base is still relatively unfamiliar with Bitcoin, including where to buy it, how it works, and how to store it. This is common to any new technology but likely remains an adoption hurdle for Bitcoin at least in the short term. This is particularly true for well-banked consumers that have access to high-quality financial services that typically deliver smooth consumer experiences. In comparison, Bitcoin is currently more challenging to use and comes with a greater level of personal responsibility. While the amount of effort required to use Bitcoin might be a hurdle for well-banked consumers, it's much less of a hurdle in underserved markets where the alternatives are fewer and of lower quality. In these markets, even those that may have less formal education and aren't technically inclined have figured out how to use Bitcoin—because it offers something they can't get elsewhere.

User experience & utility: In Bitcoin's earliest days, the only way to acquire Bitcoin was to mine it, and there was very little that a user could do with it. The Bitcoin industry has come a long way since

then in that there are now many places to easily buy Bitcoin (including numerous mobile phone apps) and there are thousands of merchants accepting Bitcoin. However, the user experience can be further improved and Bitcoin could be applied to other use cases—both of which would drastically improve the utility of Bitcoin for users and consequently further Bitcoin adoption. We're encouraged that, after a spate of funding in recent years, there are many competent and well-funded companies working on solving these problems and improving the experience and utility of using Bitcoin.

Regulatory uncertainty: Overall, regulators have shown an interest in letting the nascent Bitcoin industry innovate without strict regulation. However, there is still significant regulatory uncertainty in many jurisdictions, and without explicit endorsement or regulation some businesses and users may be hesitant to adopt Bitcoin. New York was the first U.S. state to create specific licensing requirements unique to Bitcoin companies (termed the "BitLicense") and other states such as California are currently working on Bitcoin-specific regulatory clarity—either or both of which could become a basis for regulation in other jurisdictions around the world. While the regulatory burden could be costly for some Bitcoin companies, there's also an indirect cost to the regulatory *un*certainty that is apparent in the challenge that many Bitcoin companies have in establishing some professional partnerships.

Side Notes

...on scaling & protocol conservatism

As Bitcoin transaction volume has approached its upper limits, there has been much debate within the Bitcoin community as to how best to move forward in terms of scaling Bitcoin. Nearly everyone actually wants to scale bitcoin—the debate is mainly regarding the pace and method for doing so.

At least one subset of users is lobbying to scale bitcoin by conducting a hard-fork in order to raise the 1MB block-size limit, which would allow more transactions per block and thereby increase network throughout.

Another subset of users sees raising the block size limit as problematic because increasing block size risks compromising one of Bitcoin's most critical features—its decentralization—because at some level bigger blocks require more specialized equipment that fewer can afford to support the network. Moreover, were adoption to continue growing after raising the limit, the network would inevitably be faced with the same decision again down the road, and already the precedent would have been set that raising the limit is an acceptable response. This side of the debate sees this "blocksize raising as a scaling solution" path as a slippery slope that risks greatly increasing Bitcoin centralization over time and consequently undermining what might be Bitcoin's most critical feature.

Raising the block size limit would also require a "hard-fork" of Bitcoin. While a hard fork and raising the block size limit may ultimately be inevitable longer term, recent events highlight the risk of such an event: Ethereum (the second most popular blockchain/cryptocurrency by market cap) conducted a hard-fork that was supposedly not contentious yet nonetheless resulted in two chains that are now competing against one another.

Ethereum addresses a different use case but given that Bitcoin is used as both a payment network and as a "digital gold," the negative effects of two competing chains would likely be worse for Bitcoin than the negative effects observed in Ethereum. Ultimately, a similar split of Bitcoin into two competing chains would diminish Bitcoin's network effect—which is critical to Bitcoin's value as a digital gold and as a payment network.

Instead, the loose-knit group of developers ("Core") that contribute code to the main Bitcoin reference client have, in our opinion, been prudently "conservative" with regard to protocol changes. Many updates from Core over the past 18+ months have laid the groundwork for second-layer technologies (such as lightning networks and sidechains) to be built on top of Bitcoin while also helping alleviate some short-term scaling pressure (segregated witness + Schnorr signatures could scale Bitcoin throughput by ~2x+ without introducing a hard fork).

We see this "conservatism" as prudent given the high stakes involved (Bitcoin market cap > $9B) and because for Bitcoin to be used as a digital gold and as a payment network users need to be reasonably confident that there won't be potentially jeopardizing changes at the protocol level. Instead, the focus appears to be on shifting innovating to the future "edges" of the network (i.e., lightning networks, payment channels, sidechains). In this sense, we're supportive and encouraged by these efforts that focus on creating a highly stable base protocol that won't be critically jeopardized even if higher layers fail.

...on blockchain without Bitcoin

A year ago we published an industry report highlighting Bitcoin and potential use cases for its underlying blockchain technology. In that short time the term "blockchain" has gone from relatively obscure to quite well known—especially within technology and finance circles. Following this trend, the majority of the interest and investment that we've seen over the past year has gone to companies doing "blockchain without the Bitcoin".

However, as the purported applications of blockchain technology have grown several-fold, we've become increasingly skeptical of the potential success for blockchain across these applications. It's still relatively early for some of the pilot projects and teams that are building in the space, but we note that we have not seen any astounding successes or rapid growth in traction among the alternative applications of blockchain to date.

Our sense is that there are a few things happening: 1) The ability to switch and substitute the various elements of the Bitcoin blockchain—especially its proof of work consensus mechanism—has been drastically overestimated; 2) Blockchain is being applied to use cases that don't actually need a blockchain or are better served by more mature technologies; 3) The regulatory environment makes it challenging for financial institutions to work with the Bitcoin blockchain (the only proven, well-functioning blockchain so far).

Nonetheless, despite the discouraging lack of traction among non-Bitcoin blockchains, we're very encouraged by the outlook for Bitcoin and its ecosystem.

A Note of Caution on GBTC Premium

GBTC regularly trades at a premium to its Net Asset Value (NAV). For example each share of GBTC currently represents ~0.094 Bitcoin. At a price of $608.41 this equates to a NAV of $57.37. Said differently, with Bitcoin trading around $608, each share of GBTC is equivalent to about $57.37 worth of Bitcoin. However, shares of GBTC might be trading (and do trade) on OTCQX at ~$91/share, or about a 60% premium. This premium is a risk because it means that an investor could correctly speculate on the price of Bitcoin but still realize a loss if the premium on GBTC shares falls more than the price of Bitcoin rises—hardly the outcome an investor might naively expect.

That said, we certainly see value in the titled and auditable investment wrapper that the Bitcoin Investment Trust provides and if an investor values those features plus the fact that they needn't be concerned with the details of how to acquire and store Bitcoin, then buying GBTC on OTCQX might make sense. However, we note that as the premium grows the premium becomes harder to justify. Instead, accredited institutional investors that want/need the titled and auditable investment wrapper might be better off acquiring shares of the Bitcoin Investment Trust via its ongoing private placement.

Risks

Hard fork: If there were a significant number of users and transaction processors ("miners") on the network that elected to choose an alternative version of the Bitcoin software, the Bitcoin network could fork and potentially result in two different blockchains. This *could* have a significant adverse effect on the price, perception, and usage of Bitcoin.

"Cyber" Attacks: There are numerous ways that users or attackers could try to manipulate, diminish or otherwise attack the Bitcoin network, including but not limited to "51% attack", "selfish mining",

Sybil attack, and Denial of Service (DoS) attacks. While the risk of these attacks and others is real, the Bitcoin network has overall been able to sustain and avert substantial attacks over its 7+ year history, and thousands of upgrades have made it better able to withstand potential attacks.

Alternative Blockchains / Alternative Digital Currencies: As Bitcoin has gained popularity over recent years, there have been hundreds of alternative crypto coins ("alt coins") created that have attempted to serve a different use case or to improve upon Bitcoin's real or perceived deficiencies. It is possible that one of these "alt coins" could out-compete Bitcoin. However, blockchains and especially digital currencies tend to exhibit strong network effects and no other blockchain or digital currency has come close to matching Bitcoin in terms of total market capitalization.

Regulation: While regulatory agencies, particularly in the United States, have taken a relatively cautious approach to Bitcoin regulation, governments and regulators certainly have the ability to ban, outlaw or otherwise make it excessively onerous to access Bitcoin.

Bitcoin Investment Trust Liquidity: A decrease in liquidity for shares of the Bitcoin Investment Trust, specifically GBTC shares traded on OTCQX, could adversely affect the premium or discount of shares relative to their Net Asset Value (NAV). Currently GBTC shares on OTCQX trade at a substantial premium to their Net Asset Value and because this premium could rise or fall independent of demand for Bitcoin, it introduces additional risk to owning GBTC shares.

Demand Source 1: Payments Utility

2020 Retail Payments Value (Domestic)			
Region	**Value ($billion)**	**Market share**	**Share Value (billion)**
APAC (EM)	12,502	0.44%	$55.0
LatAm	5,537	0.44%	$24.4
MENA	1,920	0.44%	$8.4
Rest of World	1,683	0.44%	$7.4
Eastern Europe	2,720	0.44%	$12.0
APAC (DM)	4,346	0.11%	$4.8
North America	24,830	0.11%	$27.3
Western Europe	11,048	0.11%	$12.2
Domestic Retail Total	**64,587**	**0.234%**	**$151.4**

2020 Retail Payments Value (X-border)			
Region	**Value ($billion)**	**Market share**	**Share Value ($billion)**
APAC (EM)	1,851	2.20%	$40.7
LatAm	63	2.20%	$1.4
MENA	58	2.20%	$1.3
Rest of World	77	2.20%	$1.7
Eastern Europe	88	2.20%	$1.9
APAC (DM)	266	1.10%	$2.9
North America	196	1.10%	$2.2
Western Europe	350	1.10%	$3.9
X-border Retail Total	**2,950**	**1.897%**	**$56.0**

2020 Retail Payments Value (Domestic & Cross Border)			
Region	**Value ($billion)**	**Market share**	**Share Value (billions)**
APAC (EM)	14,353	0.67%	$95.7
LatAm	5,601	0.46%	$25.8
MENA	1,979	0.49%	$9.7
Rest of World	1,760	0.52%	$9.1
Eastern Europe	2,808	0.49%	$13.9
APAC (DM)	4,612	0.17%	$7.7
North America	25,026	0.12%	$29.5
Western Europe	11,399	0.14%	$16.0
Retail Total	**67,537**	**0.307%**	**$207.4**
Assumed Velocity			12
2020E Bitcoin Payments Monetary Base (billions)			**$17.3**

Demand Source 2: "Digital Gold"

Bitcoin as "Digital Gold"	
Bitcoin Price (1 Month Average)	$591
Bitcoin Supply (millions)	15.88
Bitcoin Market Cap (billions)	$9.38
"Digital Gold" % of Total BTC Cap (Estimate)	75%
BTC Digital Gold Market Cap (billions)	$7.04

Gold ETF Market	
Top 10 Gold ETF AUM (Tonnes of Gold- 1 yr avg)	1,860.3
Estimated Total Gold ETF AUM (Tonnes) (+5%)	1,953.3
Estimated Total Gold ETF AUM (Ounces)	68,901,314
$/Ozgold (2 year Average)	$1,213
Gold ETF Market Cap (billions)	$84

Total Gold Market	
Est. Total Above Ground Gold (Tonnes)	168,300
$/OZgold	$1,213
Total Gold Market Cap (billions)	$7,200

Bitcoin "Digital Gold" vs. Gold ETF Market & Total Gold	
Bitcoin Digital Gold as % of Gold ETF Market	8.4%
Bitcoin Digital Gold as % of Total Gold Market	0.1%
Target % of Gold ETF MC	27.5%
2020E Bitcoin Digital Gold Monetary Base (billions)	**$23.0**

Total

Aggregated Demand	
Total 2020E Bitcoin Monetary Base (billions)	$40.3
Total 2020E Average Bitcoin Supply	18,046,875
2020E Price Based on Supply/Demand	$2,231
Discount Rate	25%
Estimated Bitcoin Present Value	**$848**

Source: Boston Consulting Group for Payments Market Forecasts; World Gold Council for Gold Market Estimates; Needham & Company, LLC Estimates

Valuation (Price Target: NA)

We view shares of the Bitcoin Investment Trust (OTCQX: GBTC) as benefiting from the rise of value in their underlying security, Bitcoin. Based on our projected demand for Bitcoin as a "digital gold" and as a payments channel, we estimate a present value of $848 per Bitcoin. However, given the substantial premium at which GBTC shares trade relative to their net asset value, we are downgrading GBTC shares to HOLD.

Potential Upside Drivers

Mainstream payment adoption: The most obvious longer-term positive catalyst for the price of Bitcoin is greater mainstream payment adoption. As shown in our estimates of potential adoption into major payment markets, even a very small slice of the global retail payments pie moving onto Bitcoin rails would be a significant positive catalyst for demand (and price). While we don't think that consumer adoption is about to turn exponential, we do expect to see rapid acceleration in the use cases and geographies where we believe Bitcoin is most useful, including cross-border payments and in many emerging market countries.

Scaling solution: While we view the current scaling debate as less of a problem and more of a product (and a strength) of an open-source development process for money, we also believe that major payments volumes that could move into Bitcoin are holding back until a solution is implemented and the outlook is clear. If a scaling solution is implemented without major turbulence we think it will be a positive catalyst not just because it would enable greater volumes but also because it would serve as an important historical precedent for Bitcoin's ability to tackle tough scaling challenges while simultaneously addressing leadership concerns.

Technical advancements: We think that technologies such as sidechains and the lightning network that are currently being developed could be positive catalysts for demand and price if they prove successful. Sidechains and the lightning network promise to help alleviate some of the biggest concerns with Bitcoin today, including privacy, speed and throughput. Similarly, these technologies (and others) could bring other use cases and increased demand to the Bitcoin blockchain (such as smart contracts as being developed by Rootstock).

Monetary crises: Throughout history, monetary, financial, and economic crises tend to occur at fairly regular intervals. These crises could be isolated to one country, one region, or even be global but, regardless, when traditional money and finance doesn't work well, people tend to seek alternatives and for many, the next crisis will be the first time that Bitcoin is an available alternative.

Improvements in access: While the on-ramps to Bitcoin have improved significantly over recent years, they still typically require a specialized Bitcoin provider. If Bitcoin and Bitcoin services were available through major financial institutions such as banks and FX brokers, we think this could significantly improve access and ultimately be a positive catalyst for price. Similarly if investors were able to gain exposure to Bitcoin through an exchange-traded fund (ETF) listed on a major stock exchange such as the NYSE or Nasdaq directly through their regular brokerage account, it could have a significant positive impact on price.

Risks to Target

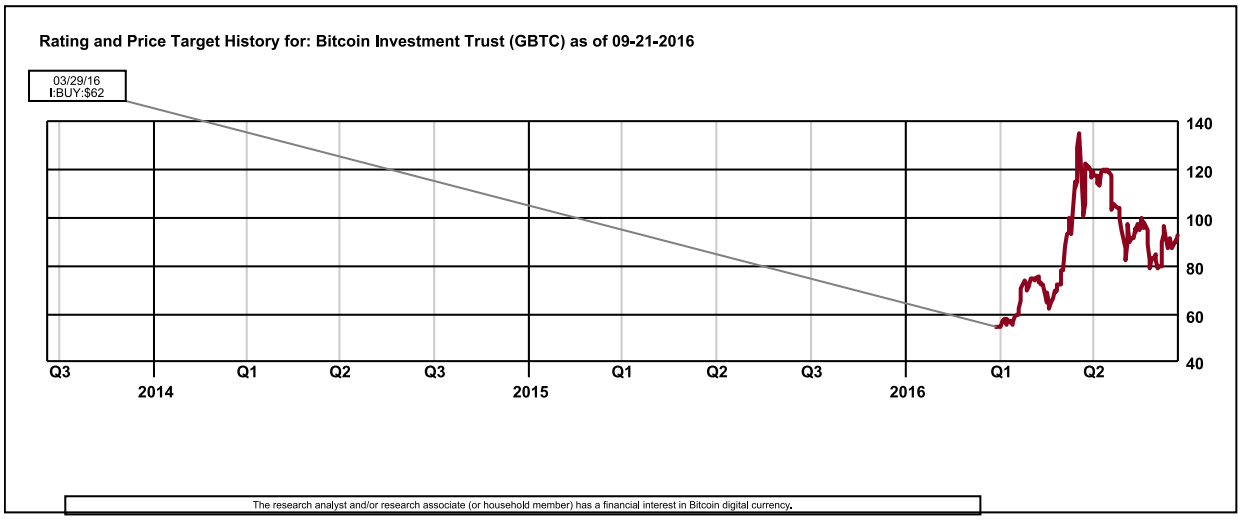
Hard fork: If there were a significant number of users and transaction processors ("miners") on the network that elected to choose an alternative version of the Bitcoin software the Bitcoin network could fork and potentially result in two different blockchains. This could have a significant adverse effect on the price, perception, and usage of Bitcoin.

"Cyber Attacks": There are numerous ways that users or attackers could try to manipulate, diminish or otherwise attack the Bitcoin network including but not limited to "51% attack", "selfish mining", Sybil attack, and Denial of Service (DoS) attacks. While the risk of these attacks and others is real, the Bitcoin network has overall been able to sustain and avert substantial attacks over its 7+ year history, and thousands of upgrades have made it better able to withstand potential attacks.

Alternative Blockchains / Alternative Digital Currencies: As Bitcoin has gained popularity over recent years there have been hundreds of "alt-coins" created that have attempted to serve a different use case or to improve upon Bitcoin's real or perceived deficiencies. However, blockchains and especially digital currencies tend to have a strong network effect and no other blockchain or digital currency has come close to matching Bitcoin in terms of total market capitalization.

Regulation: While regulatory agencies, particularly in the United States, have taken a relatively cautious approach to Bitcoin regulation, governments and regulators certainly have the ability to ban, outlaw or otherwise make it excessively onerous to access Bitcoin.

Bitcoin Investment Trust Liquidity: A decrease in liquidity for shares of the Bitcoin Investment Trust, specifically GBTC shares traded on OTCQX, could adversely affect the premium or discount of shares relative to their Net Asset Value (NAV). Currently GBTC shares on OTCQX trade at a substantial premium to their Net Asset Value and because this premium could rise or fall independent of demand for Bitcoin, it introduces an additional element of risk to owning GBTC shares.


Rating and Price Target History for: Bitcoin Investment Trust (GBTC) as of 09-21-2016
03/29/16
I:BUY:$62
140
120
100
80
60
40
Q3
Q1
Q2
Q3
Q1
Q2
Q3
Q1
Q2
2014
2015
2016
The research analyst and/or research associate (or household member) has a financial interest in Bitcoin digital currency.

ANALYST CERTIFICATION

I, Spencer Bogart hereby certify that the views expressed in this research report accurately reflect my personal views about the subject company (ies) and its (their) securities. I, also certify that I, have not been, and will not be receiving direct or indirect compensation in exchange for expressing the specific recommendation(s) in this report.

RATINGS DISTRIBUTIONS FOR NEEDHAM & COMPANY, LLC

	% of companies under coverage with this rating	% for which investment banking services have been provided for in the past 12 months
Strong Buy	5	12
Buy	62	17
Hold	31	0
Underperform	< 1	0
Rating Suspended	< 1	33
Restricted	< 1	0

Needham & Company, LLC employs a rating system based on the following:

Strong Buy: A security, which at the time the rating is instituted, we expect to outperform the average total return of the broader market as well as the securities in the analyst's coverage universe over the next 12 months.

Buy: A security, which at the time the rating is instituted, we expect to outperform the average total return of the broader market over the next 12 months.

Hold: A security, which at the time the rating is instituted, we expect to perform approximately in line with the average total return of the broader market over the next 12 months.

Underperform: A security, which at the time the rating is instituted, we expect to underperform the average total return of the broader market over the next 12 months.

Rating Suspended: We have suspended the rating and/or price target, if any, for this security, because there is not a sufficient fundamental basis for determining a rating or price target. The previous rating and price target, if any, are no longer in effect and should not be relied upon. This rating also includes the previous designation of "Under Review".

Restricted: Needham & Company, LLC policy and/or applicable law and regulations preclude certain types of communications, including an investment recommendation, during the course of Needham & Company, LLC's engagement in an investment banking transaction and in certain other circumstances.

For disclosure purposes, in accordance with FINRA requirements, please note that our Strong Buy and Buy ratings most closely correspond to a "Buy" recommendation. When combined, 68% of companies under coverage would have a "Buy" rating and 17% have had investment banking services provided within the past 12 months. Hold ratings mostly correspond to a "Hold/Neutral" recommendation; while our Underperform rating closely corresponds to the "Sell" recommendation required by the FINRA.

Our rating system attempts to incorporate industry, company and/or overall market risk and volatility. Consequently, at any given point in time, our investment rating on a security and its implied price appreciation may not correspond to the stated 12-month price target. For valuation methods used to determine our price targets and risks related to our price targets, please contact your Needham & Company, LLC salesperson for a copy of the most recent research report.

Price charts and rating histories for companies under coverage and discussed in this report are available at http://www.needhamco.com/. You may also request this information by writing to: Needham & Company, LLC, Attn: Compliance/Research, 445 Park Ave., 3rd Floor, New York, NY 10022

By issuing this research report, each Needham & Company, LLC analyst and associate whose name appears within this report hereby certifies that (i) the recommendations and opinions expressed in the research report accurately reflect the research analyst's and associate's personal views about any and all of the subject securities or issuers discussed herein and (ii) no part of the research analyst's or associate's compensation was, is or will be directly or indirectly related to the specific recommendations or views expressed by the research analyst or associate in the research report.

Disclosures

The research analyst and/or research associate (or household member) has a financial interest in Bitcoin digital currency.

The research analyst and research associate have received compensation based upon various factors, including quality of research, investor client feedback, and the Firm's overall revenues, which includes investment banking revenues for the following: Bitcoin Investment Trust

Equity Options Disclosure

Any Equity Options or Technical Strategy Opinions ("Opinions") contained within this report was prepared by the Equity Options Sales and Trading Desk of Needham & Company, LLC ("Needham" or the "Firm") for distribution to Needham's clients. This Opinion consists of market information and general market commentary only. It is not intended to be an analysis of any security or to provide any information sufficient upon which to base an investment decision.

THIS EQUITY OPTIONS OR TECHNICAL STRATEGY OPINION IS NOT A PRODUCT OF NEEDHAM'S RESEARCH DEPARTMENT AND IS NOT A RESEARCH REPORT. Unless otherwise specifically stated, the information and commentary expressed herein are solely those of the author and may differ from the information, views and analysis expressed by Needham's Research Department or other departments of the Firm or its affiliates.

Needham and its affiliates may have positions (long or short), effect transactions or make a market in the securities or financial instruments referenced in this Opinion. Needham or its affiliates may engage in securities transactions that are not consistent with the information and commentary expressed in this Opinion. Needham may have provided investment banking or other services to the issuers mentioned herein and may solicit such services in the future.

If this Opinion includes extracts or summary material derived from research reports produced by Needham's Research Department, you are directed to the most recent research report for further details, including analyst certifications and other important disclosures. Copies of such reports may be obtained from your Needham sales representative or at www.needhamco.com

This material is provided for informational purposes only and is not intended as a recommendation or an offer or solicitation for the purchase or sale of any security or financial instrument. Any investment decision by you should be based on your specific investment objectives and financial situation. Please contact your Needham sales representative for specific guidance.

The information contained in this Opinion has been obtained from or is based upon sources believed to be reliable, but neither Needham nor the author makes any representation or warranty as to its accuracy or completeness. The information contained in this Opinion is as of the date specified herein. Needham does not undertake any obligation to monitor or update the information. Past performance is not indicative of future results and no representation or warranty, express or implied, is made with respect to future performance. Needham disclaims all liability for any loss that may arise (whether direct or consequential) from any use of the information contained in this Opinion.

Structured securities, options, futures and other derivatives are complex instruments, may involve a high degree of risk, and may be appropriate investments only for sophisticated investors who are capable of understanding and assuming the risks involved. Because of the importance of tax considerations to many options transactions, any investor considering the purchase or sale of any options contract should consult with his or her tax advisor as to how taxes affect the outcome of contemplated transactions. Needham and its affiliates do not provide tax advice.

OPTIONS ARE NOT SUITABLE FOR ALL INVESTORS. For further information on the risks associated therewith, please consult the Options Clearing Corporation's options risk disclosure document available at the following web address: http://www.optionsclearing.com/about/publications/character-risks.jsp

Clients should call the Equity Options Sales and Trading Desk (212-705-0369) for additional information.

Additional Disclosures for Israeli Clients

All information presented in this document is, unless otherwise specified, under copyright of Needham & Company, LLC ("Needham"). No part of this publication may be copied or redistributed to other persons or companies without the prior written consent of Needham. These reports have been prepared by Needham and distributed by Clal Finance Batucha Brokerage, Ltd. ("Clal"), which accepts sole responsibility for its content subject to the terms set forth below.

Neither Clal or its affiliates (and any director, officer or employee thereof) nor Needham is liable for any incomplete or improper transmission of these reports or for any delay in transmission. Any unauthorized use, disclosure, copying, distribution, or taking of any action in reliance on these reports is strictly prohibited. The views and expressions in the reports are expressions of opinion and are given in good faith, but are subject to change without notice. These reports may not be reproduced in whole or in part or passed to third parties without permission. Clal or its affiliates (and any director, officer or employee thereof) and Needham do not guarantee their accuracy or completeness, and neither Clal or its affiliates (and any director, officer or employee thereof) nor Needham shall be liable in respect of any errors or omissions or for any losses or consequential losses arising from such errors or omissions.

Neither the information contained in these reports nor any opinion expressed constitutes an offer, or an invitation to make an offer, to buy or sell any securities or any options, futures or other derivatives related to such securities ("related investments"). Clal or its affiliates (and any director, officer or employee thereof) and Needham may trade for their own accounts as odd-lot dealer, market maker, block positioner, specialist and/or arbitrageur in any securities of the issuer or in related investments, and may be on the opposite side of public orders. Clal or its affiliates (and any director, officer or employee thereof) and/or Needham may have a long or short position in any securities of the issuer or in related investments. Clal or its affiliates (and any director, officer or employee thereof) and/or Needham may from time to time perform investment banking or other services for, or solicit investment banking or other business from, any entity mentioned in these reports.

These reports are prepared in general for the Israeli clients of Clal who are qualified institutional customers as defined by reference to the First Schedule to the Securities Law, 1968, of the State of Israel. They do not have regard to the specific investment objectives, financial situation and the particular needs of any specific person who may receive any of these reports. Investors should seek financial advice regarding the appropriateness of investing in any securities or investment strategies discussed or recommended in these reports and should understand that statements regarding future prospects may not be realized. Investors should note that income from such securities, if any, may fluctuate and that each security's price or value may rise or fall. Accordingly, investors may receive back less than originally invested. Past performance is not necessarily an indication of future performance.

Foreign currency rates of exchange may adversely affect the value, price or income of any security or related investment mentioned in these reports. In addition, investors in securities such as ADRs, whose value are influenced by the currency of the underlying security, effectively assume currency risk. Unless agreed in writing with Clal, this research is intended solely for use internally by the recipient.

Needham is not an authorized broker, dealer or investment adviser outside the United States. The research does not constitute an offer to provide financial services to anyone outside the United States. Any investor in Israel wishing to buy or sell the securities mentioned in this report should do so through Clal.

Neither Needham, the research analyst nor anyone else acting on behalf of Needham is an Israeli investment advisor, investment marketer or portfolio licensed under the Israeli Regulation of Investment Advice, Investment Marketing and Investment Portfolio Management law, 1995. Accordingly, Needham does not maintain the insurance specifically required of a licensee in accordance with such law.