Banking on the Blockchain

Reengineering the Financial Architecture

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INSTITUTE OF INTERNATIONAL FINANCE

HIGHLIGHTS

- The blockchain—the distributed public ledger behind Bitcoin—is widely recognized as an innovation with substantial potential to disrupt financial services.
- Because virtually any type of information can be digitized, codified and placed onto the blockchain, a database that is tamper-proof, permanent, and whose validity is confirmed by the consensus of a community of computer users—rather than by a central authority—the technology's potential to impact the finance industry is significant.
- Traditional financial services firms are becoming increasingly active in the space and investing significant resources in an attempt to find possible ways to transform several of the sector's most inefficient procedures and in the process cut billions of dollars in costs.
- While no clear blockchain model has been adopted by the banking industry and most executives remain open to all promising options, a large number of them remain wary of Bitcoin's open, fully decentralized model due to myriad of reasons, including anonymous transaction validators and Bitcoin's association with volatility, instability and illicit activity.
- Critics maintain that there are numerous obstacles preventing a blockchain-driven financial ecosystem from emerging, including governance and incentive systems, regulatory and legal challenges, interoperability issues, and the cost of overhauling legacy infrastructure.

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Blockchain technology, once viewed as a profound threat to financial intermediaries, is now being embraced by traditional financial services firms as a way to reengineer financial industry infrastructure to their advantage. The industry, working both independently and in partnership with newer players, envisions the technology as a mechanism for lowering costs, reducing risk, introducing new products and freeing up capital. This paper will explore the immense potential of blockchain technology, as well as some of the challenges it poses to the industry and regulators.

WHAT IS BLOCKCHAIN?

The blockchain—the underlying technology on which Bitcoin operates—is a new type of distributed consensus system that enables transactions to be quickly validated and securely maintained through cryptography, computational power, and network users, removing the need for a trusted centralized authority. While bitcoin the currency has received a lot of criticism due to its volatility, lack of liquidity and regulatory concerns, the blockchain—the distributed public ledger behind Bitcoin—is widely recognized as an innovation with substantial potential to disrupt financial services. The digital public ledger, or database, contains time-stamped and irreversible information of all

transactions that is replicated on computers around the world, thereby eliminating a single point of failure.[1]

While the blockchain is most often referred to in the context of the Bitcoin platform, it is not technically dependent upon it. Other applications can, and have, incorporated the technology. Moreover, innovation is ongoing and a wide range of alternative models are being developed. This paper will use the term "blockchain" to refer to both the Bitcoin blockchain as well as to distributed ledger systems in general, though there are some nuanced differences.[2]

The blockchain can be grouped into three broad categories: public, private, and consortium (or hybrid). An example of a public (or permissionless) blockchain would be Bitcoin, a fully decentralized "trustless" system open to everyone and where the ledger is updated by anonymous users. A private (or permissioned) blockchain is where a centralized organization controls the entire system. Possible functions of a private blockchain include a company performing internal auditing or database management, or government maintaining records for a national land registry. Finally, a consortium blockchain is a system that is open to a controlled group of trusted and vetted users that update, preserve, and maintain the network collectively. This particular form of blockchain—a hybrid between the two aforementioned categories—could be considered "partially decentralized" and may prove beneficial to an association of banks, for example.[3]

THE BLOCKCHAIN ADVANTAGE

Thanks to a combination of factors, including increased regulatory compliance in the aftermath of the great financial crisis and rising competition from technology firms, the financial services industry is searching for ways to innovate, introduce new products, reduce expenses, and promote growth. The blockchain, proponents argue, can deliver in these areas.

Because virtually any type of information can be digitized, codified and placed onto the blockchain, a database that is tamper-proof, permanent, and whose validity is confirmed by the consensus of a community of computer users—rather than by a central authority—the technology's potential to impact the industry is significant. Removing the need for a clearing house or financial establishment to act as intermediary during a transaction transfers control and power from a central authority to the many, facilitating quick, secure, and inexpensive value exchanges. The innovation is likely to have important ramifications on companies in the payments space, including those involved in money transfer and credit card transactions, as well as for trade, commerce, and the financial system as a whole. Cryptocurrencies utilizing blockchain technology have shown that digital transaction records can be managed securely without a central authority. Because most of today's financial instruments exist electronically and because the current financial system is comprised of a set of digital records, many observers reason that blockchain technology could eventually supplant the current market infrastructure, where centralized ledgers are held and controlled by large institutions.

Many financial incumbents are beginning to see the technology as a way to transform several of the sector's most inefficient procedures and in the process cut billions of dollars in costs. At a recent conference in London, Alex Batlin, chief technology officer for innovation at UBS, said, "Blockchain technologies can make banks more efficient—for example through instan-

1 Please see our last blockchain report for a more detailed explanation.

2 While terminology is still evolving and strict definitions have not yet been fully established, the term "blockchain" can be thought of as the distributed ledger on the fully decentralized Bitcoin system where anonymous transaction validators use proof of work and mining to reach consensus and maintain the ledger. The term "distributed ledger" is more general and in addition to the Bitcoin blockchain also refers to models that reach consensus through alternative mechanisms.

3 For more information on the blockchain spectrum, please consult "On Public and Private Blockchains."

taneous settlement rather than the days it takes at present, lower costs and lower operational risk…The key attraction is that there is no middle or back office, and no registry, so clearly a major impact on costs." This view is supported by a recent report by Santander InnoVentures, Oliver Wyman and Anthemis Group, which forecasts that the technology could lower banks' infrastructure expenses related to securities trading, regulatory compliance, and international payments by between $15-20 billion annually within seven years.

The aforementioned potential advantages of the innovation have led to an explosion of activity in the space by technology companies, traditional financial services firms, and governments. The following sections will examine this growing activity and specific use cases of distributed ledger technology (DLT).

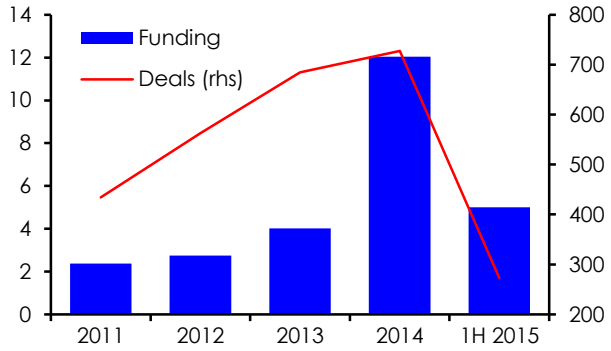
BLOCKCHAIN ACTIVITY AND APPLICATIONS

Technology Companies

According to Accenture, global investment in financial technology ventures continues to surge, tripling from $4 billion in 2013 to over $12 billion in 2014, demonstrating that the digital revolution is well underway in the financial sector (Chart 1). More specifically, the Bitcoin and digital ledger technology universe has seen nearly $400 million in venture capital enter the space during the first half of 2015, more than quadruple the amount from all of 2013 (Chart 2) and (Chart 3). This influx of capital and interest in the space is attributable to the growing list of potential applications of the technology across the finance industry and beyond. Much of the research exploring the potential uses of the blockchain is being conducted by recently established technology firms. While smaller in size and possessing fewer resources, they hold key advantages vis-à-vis traditional financial services companies active in the space—including greater organizational flexibility, specialization, and risk tolerance, as well as fewer regulatory constraints and legacy costs. Many of these firms have built, or are currently designing, various distributed ledger systems with specific use cases for the finance industry in mind, including improving cross border payments, currency exchange, settlement times, collateral management, transparency, regulatory compliance, auditability, and business contracts and agreements.

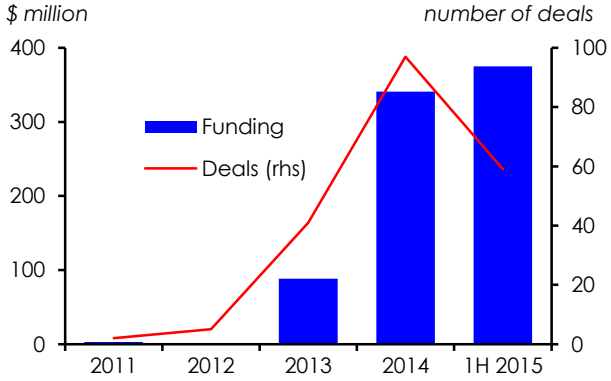
Improving the efficiency of cross border payments and the currency exchange market are some of the most obvious applications of the technology. For example, it could facilitate international payments between banks

Chart 1
Global FinTech Financing Activity



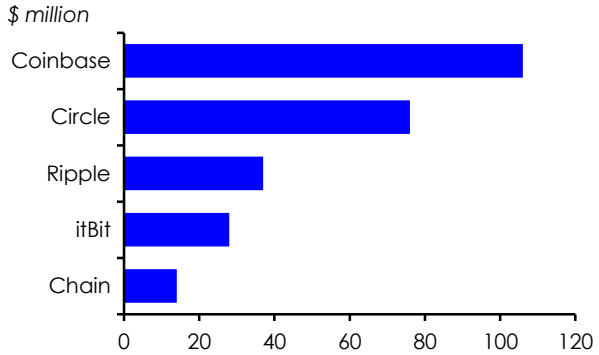
Source: Silicon Valley Bank, CB Insights, KPMG, IIF.

Chart 2
Bitcoin / Distributed Ledger Industry Financing Activity



Source: CB Insights.

Chart 3
Total Venture Funds Raised by Select Technology Firms*

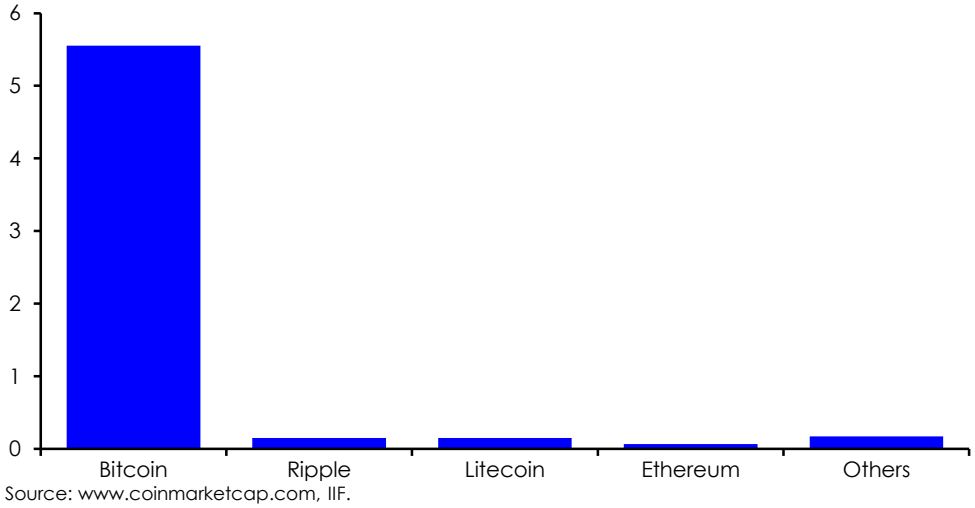


* Data cutoff date: end of 1H 2015.
Source: Wedbush Securities, Inc., CoinDesk.

without costly intermediaries and also improve transparency and oversight in the FX market—the world's largest, with average daily trading volumes reaching more than $5 trillion in April 2013 according to a triennial Bank for International Settlements survey. One of the most active technology firms involved in developing a platform for these use cases is Ripple (the company dropped "Labs" from its name last month). The firm's platform is a distributed open-source protocol that facilitates the secure transfer of any form of value in real time and at nearly no cost. The system—whose native digital currency, XRP, or ripples, is the second largest Internet-based currency in terms of market capitalization (Chart 4)—relies on a consensus process involving voting to update the network's distributed ledger, thus eliminating the need for mining and proof of work as in the Bitcoin system. Users move their funds into the Ripple network through "gateways," a bridge between the system and the external world. Gateways include businesses such as banks and virtual currency exchanges. In addition to allowing people to trade in and out of Ripple, gateways are the regulatory point of the system—regulators can enforce various supervisory measures such as know-your-client (KYC) and anti-money laundering (AML) procedures. The Ripple network is highlighted as an alternative to the Bitcoin distributed ledger model that could gain increasing acceptance going forward. Several banks, including Germany's Fidor and U.S.-based CBW and Cross River Bank, have already embraced the Ripple platform and in doing so are able to execute global money transfers independent of large banking partners. Furthermore, Westpac and Commonwealth Bank of Australia have been trialing the protocol and Santander InnoVentures recently invested in the company.

Other use cases for the technology include minimizing settlement times and the collateral required to back business transactions. Due to legacy infrastructure, the transfer of various financial assets can take a very long time to complete. For example, in the U.S., exchanges involving securities regularly take up to half a week while loan settlements can extend to 20 days or more. This considerable time lag invites financial risks because the longer a trade is outstanding, the possibility that it will not be fulfilled rises. Moreover, since the 2008 financial

Chart 4
Market Capitalization of Internet-based Currencies
$ billion



Source: www.coinmarketcap.com, IIF.

crisis, American and EU regulators have instructed banks within their jurisdictions to earmark ever-larger amounts of capital to protect themselves from such risks. Blockchain advocates such as Blythe Masters, chief executive officer of technology startup Digital Asset Holdings (DAH) and former JPMorgan executive, and Oliver Bussmann, group chief information officer of UBS, highlight that the technology could shorten settlement times from days, or even weeks, to minutes for many financial products, minimizing risk and freeing up capital in the process. Ms. Masters' New York-based company—which recently acquired technology firms, Hyperledger and Blockstack—is one of the most talked about companies exploring these use cases. Another technology firm examining these applications is itBit. The Bitcoin exchange based in New York City recently revealed new details of its Bankchain project, which the company's website describes as "a new clearing and settlement network that leverages blockchain technology" and "the first consensus-based ledger system exclusively for financial institutions." The platform, which does not use bitcoin but rather its own proprietary token, is permissioned. According to Steve Wager, the company's executive vice president of operations and development, itBit has been in discussions with major custodian banks worldwide and has received a "soft commitment" to join the platform from around 15 institutions.

In addition, the technology could be used to enhance transparency, regulatory compliance, and auditability. Since all transactions are documented on the distributed ledger, a comprehensive, secure, precise, irreversible, and permanent financial audit trail would exist for all interested parties. This is significant as regulators are imposing more data transparency and dissemination requirements on financial institutions in the aftermath of the 2008 financial crisis. Countless technology firms are exploring these applications, including those firms mentioned above, and many are looking to implement them through permissioned ledgers. For example, DAH is creating a permissioned blockchain product with identity and regulatory compliance in mind as its leadership team believes that a fully decentralized and trustless design such as the Bitcoin model would likely face enormous obstacles from a heavily-regulated industry like finance where client confidentiality is considered sacred. Therefore, the company is working on a semi-decentralized trust-based blockchain that would be collectively maintained by permissioned users. According to the company's website, permissioned chains with vetted and recognized users would allow financial institutions to "keep balances and transfers private, control who can open accounts on a ledger, and know who is participating in the network and which jurisdiction they are in."

Finally, applications of blockchain technology could extend beyond just the world of finance and into many industries that require a trusted intermediary for verification. Areas such as patents, property titles, legal contracts and licenses could all be affected. Indeed, advocates claim that the blockchain concept and the wave of innovation it has unleashed—commonly referred to as "next-generation platforms"—have nearly endless functions. Colored Coins, for instance, enables the storage and transaction of "smart property" on top of the blockchain. Smart property is property whose ownership is controlled via the blockchain using "smart contracts," which are contracts enforced by computer algorithms that can automatically execute the stipulations of an agreement once predetermined conditions are activated. Examples of smart property could include stocks, bonds, houses, cars, boats, and commodities. By harnessing blockchain technology as both a ledger and trading instrument, the Colored Coins protocol functions as a distributed asset management platform, facilitating issuance across different asset categories by individuals as well as businesses. This could have a significant impact on the global economy as the technology permits property ownership to be transferred in a safe, quick, and transparent manner without an intermediary. Visionaries see many other exciting opportunities too, including linking telecommunications with blockchain

technology. This could, for example, provide car-leasing companies the ability to automatically deactivate the digital keys needed to operate a leased vehicle if a loan payment is missed. Two of the most ambitious and well-known platforms exploring advanced applications of the blockchain and its derivative technologies are Ethereum and Eris. Ethereum—an open-source development project that provides a platform for developers and entrepreneurs to create and publish next-generation distributed applications—uses blockchain technology to facilitate the trading of binding smart contracts that can act as a substitute to conventional business documents. The technology allows the contracts to be traced and used to confirm business deals without the need to turn to the legal system. In addition to a variety of contracts and agreements, the project's website emphasizes that the platform can be used to "codify, decentralize, secure and trade just about anything: voting, domain names, financial exchanges, crowdfunding, company governance, intellectual property, and smart property." According to the International Business Times, Barclays and UBS have begun experimenting with Ethereum though neither bank has revealed exactly how it plans to utilize the decentralized application platform. Nevertheless, Alex Batlin of UBS has stated that, "We do see a lot of value in multi-asset, smart contract-enabled platforms like Ethereum." Eris Industries' platform, Eris, which has been forked from Ethereum, is a "software that allows anyone to build their own secure, low-cost, run-anywhere data infrastructure using blockchain and smart contract technology" according to the company's website. It has been reported that Eris Industries is also currently working with several global banks interested in its platform.

Blockchain technology could lower banks' infrastructure expenses related to securities trading, regulatory compliance, and international payments by between $15-20 billion annually within seven years.

— Santander InnoVentures, Oliver Wyman, Anthemis Group

Banks

"What is our blockchain strategy?" That is the question many bankers have been discussing in boardrooms around the world over the past year. Big banks are becoming increasingly active in the space and investing significant resources exploring DLT in an attempt to find possible ways to improve their current banking infrastructure. In fact, in a twist of irony, no other industry is dedicating as much money researching blockchain as the one that Bitcoin was created to circumvent—the finance industry. The blockchain has attracted the attention of the banks because of its potential to streamline the industry's complex and extensive payment and settlement networks, and in doing so, simultaneously minimize risks and expenditures. Proponents argue that since it removes intermediaries and is faster and more secure and reliable than today's legacy systems it could save banks billions of dollars in expenses.

According to a recent global study by Greenwich Associates, an international market intelligence and advisory services company, 94% of the financial professionals surveyed believe that the blockchain could be used in mainstream finance. Respondents listed OTC derivatives, private stock, repurchase agreements, and syndicated loans as the asset categories that are likely to benefit the most from the technology. The survey also revealed that while only 17% of respondents indicated their institutions were testing some form of the blockchain, 47% said that their institution was evaluating the option. Moreover, in a separate 2015 study by the World Economic Forum, 58% of the more than 800

surveyed executives and experts from the information and communication technology sector believe 10% of global GDP will be stored on blockchain technology by the mid-2020s.

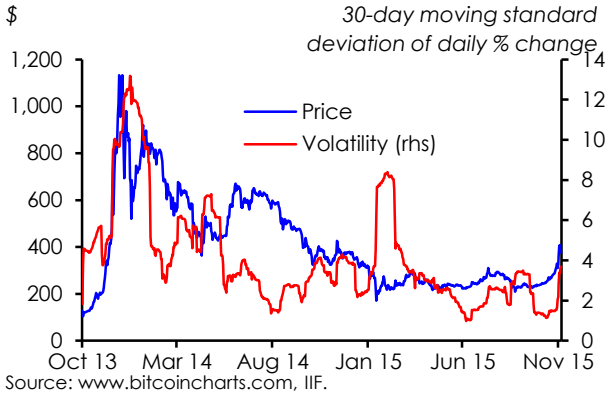
While blockchain technology has a growing number of advocates, its strong association with bitcoin—which has experienced reputational setbacks, including the collapse of a dedicated exchange, lack of liquidity, concerns over its use in illicit online activity, and high price volatility over the years (Chart 5)—has generated apprehension among many regulators and banks over the adoption of the system in the mainstream economy. Consequently, a considerable amount of the research currently being conducted by banks is examining how the blockchain concept can be implemented without bitcoin or other cryptocurrencies.

Blockchain exploration has propelled banks in multiple directions, from examining fully decentralized systems that embed bitcoin or other virtual tokens to function, to ones where only authorized and vetted users are granted access to a network. While it is unknown which exact model is likely to be adopted by the industry, it is evident that several of the largest global banks are working towards harnessing the technology.

One approach undertaken by many large global banks has been the establishment of innovation labs where startup fintech firms, the investor community, and banks work collaboratively in an attempt to accelerate innovation opportunities, including the development of a blockchain solution that is efficient, scalable, secure, and dependable. For example, Citi has launched a global network of innovation labs, including in Dublin, Singapore, and Tel Aviv; UBS has opened labs in London, Singapore and Zurich; Deutsche Bank in Berlin, London, and Silicon Valley; and Barclays in London and New York.

Citi is developing distributed ledger software and is conducting half a dozen different internal experiments, including "Citicoin," its own digital token which employees are currently trialing. In a recent interview, Ken Moore, head of Citi Innovation Lab, Dublin, revealed that he views Citicoin as a means to transfer money internationally and expects an internal "mining" system to perform the work required to maintain the ledger. Mr. Moore has also indicated that Citi has been in exploratory discussions with various governments and regulators around the world to examine the possibility of a global blockchain ledger network being embraced across international jurisdictions and even "the opportunity to create a state-backed digital currency in a number of different countries."

Chart 5
Bitcoin Price and Volatility



Source: www.bitcoincharts.com, IIF.

58% of surveyed executives and experts from the information and communication technology sector believe 10% of global GDP will be stored on blockchain technology by the mid-2020s.

— World Economic Forum

UBS, one of the most active banks in the space, is exploring various use cases for blockchain technology, including issuing bonds and settling trades. At our IIF Annual Meetings in Lima last month, Dr. Axel Weber, chairman of UBS, explained during a global CEO panel discussion the opportunities blockchain technology provides for trade settlement. He said, "With these blockchain technologies, if you can settle in two hours instead of two days, you can turn over your balance sheet in the same activity 24 times. Just imagine the profitability that this will bring to financial institutions that are payment focused and transaction focused…I see this as a huge opportunity for the banking industry." The Swiss company is experimenting across a multitude of distributed ledger systems so that in the future it will be well prepared to quickly adopt the one it sees as the most optimal for its business model and the industry. UBS' Oliver Bussmann, believes that the technology's disruption in various areas of finance will truly begin to be felt by the end of the decade.

Deutsche Bank has also invested a considerable amount of resources investigating the potential commercial uses of the blockchain. According to the bank's response to a call for evidence on virtual currencies and distributed ledger technology by the European Securities and Markets Authority, Deutsche Bank has found several possible uses for the technology in finance, including "fiat currency payment and settlement, securities issuance, transfer, clearing and settlement, enforcing derivative contracts, asset registries without the need for a central administrative authority, know your customer and anti-money laundering surveillance, and creating transparency and facilitating differentiated customer and regulatory reporting."

Barclays, for its part, has been conducting experiments that investigate the technology's ability to upgrade the current financial architecture, including how to accelerate and reduce the costs of consumer payments in order to challenge companies offering credit card and money transfer services.

Other examples of banks exploring the space include Santander, which has identified over 25 possible applications of distributed ledger technology in the finance industry, and DBS Bank, which organized a blockchain hackathon sponsored by IBM in May, the objective of which was to discover use cases of the technology that could benefit the unbanked and improve the current banking infrastructure. The event offered participants $33,000 in cash rewards. In addition, banks like BBVA and Goldman Sachs have invested in startups focusing on the blockchain. BBVA invested in Coinbase, a leading bitcoin wallet and exchange company founded in 2012 and headquartered in San Francisco. One of the main motives behind the investment in the company—which has 4.1 million consumer wallets, 41,000 merchants and 7,000 developer apps—was for BBVA to familiarize itself with the technology. Goldman Sachs invested in Circle Internet Financial, a Boston-based software startup seeking to ameliorate consumer payments by utilizing the Bitcoin payment network to transfer fiat currency inexpensively and rapidly both domestically and across borders. For those customers who do not want to possess bitcoin, Circle allows the option of holding balances in dollars at an insured bank. Moreover, customers can program the Circle app to instantly and automatically convert in and out of bitcoin. Thus, customers would not have to exchange or hold bitcoin; the sole purpose for utilizing the digital token

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— Axel Weber, Chairman, UBS

would be to transfer money over the Bitcoin infrastructure and in the process bypass the charges imposed by money transmitters and payment processors.

Furthermore, USAA—a diversified financial services group of companies that provide insurance, investing and banking services and products to current and former members of the United States military and their families—is exploring applications on various blockchains, including Bitcoin and permissioned models, in an effort to find an optimal way for the company to perform instant and secure record keeping and manage assets and claims. USAA's managing director of corporate development, Alex Marquez, has indicated that the company, which owns and manages approximately $200 billion in assets, is particularly attracted to the auditability of distributed ledger technology and how it could supplant paper trails and time-consuming traditional audits. Furthermore, USAA announced at the beginning of November that it was partnering with Coinbase, a company the bank invested in earlier this year. The partnership will allow USAA customers to view their Coinbase wallet balances when they sign into their bank account. There is speculation that depending on the results of the three month pilot partnership, the bank may introduce added features for their customers such as exchanging the cryptocurrency or transacting in bitcoin directly on USAA channels.

BNY Mellon is also exploring the possibilities of blockchain. The bank has modified open-source Bitcoin code to make it compatible with its internal network and has produced "BK" ditigal tokens, which its employees are trialing. BNY Mellon's chief information officer, Suresh Kumar, is interested in using distributed ledger technology to track securities as well as corporate actions—events that affect a company's equity or debt. The bank envisions the technology to act as a vehicle to distribute key information to all users of a particular blockchain so everyone has access to identical facts.

Finally, in Estonia, LHV Bank—the country's largest independent bank and asset management company—concluded after studying different distributed ledger models that, "The Bitcoin blockchain is the oldest, most tested and secure, and hence suitable for our current applications." The bank is currently "utilizing reliable components" of the Bitcoin blockchain.

Importance of Collaboration

The value of a banking blockchain will depend on banks' openness to work together on a common protocol. While an independent blockchain for each financial institution could prove useful for firms and their customers internally, the true value would entail interoperability between institutions. Many in the industry argue that with a common standard, similar in concept to the protocol behind today's Internet, a blockchain that enables the trading of multiple assets such as currencies, derivatives and securities on one platform could be developed. While partnerships between banks are typically uncommon, the space is beginning to see some banking collaboration—a development many advocates believe is essential for the blockchain to thrive and for the global economy to reap the biggest rewards from the innovation. For example, R3CEV, a consortium of banks interested in blockchain, has recognized the importance of creating uniform protocols and standards. In September the company, along with nine member banks, publicly announced an initia-

"Blockchain technology holds great promise in allowing capital markets to operate more efficiently while simultaneously providing greater transparency and security, all of which are fundamental to the public interest."

— Robert Greifeld, CEO, Nasdaq

tive to develop and apply distributed ledger technology to international financial markets. The company hopes to accomplish this by fostering bank cooperation across areas such as research, development and testing of blockchain models in an effort to establish a "network effect." R3's partnership with leading global institutions is one of the first commitments by banks to work collectively in the space. As of the end of October, 25 global banks, including Barclays, BBVA, Commonwealth Bank of Australia, Credit Suisse, Goldman Sachs, JPMorgan, Royal Bank of Scotland, State Street, and UBS[4] have joined the initiative to funnel concepts, funding and information to R3 in an attempt to promote shared standards and best practices for DLT and accelerate its adoption across the finance industry. R3 has already begun building prototypes for trading international currencies on a communally maintained ledger for banks and is also exploring ways to accelerate and improve the whole transaction process in various markets, including repurchase agreements and syndicated loans.

More and more banks are beginning to recognize the value of collaborating in the new and rapidly changing space. Consequently, many are monitoring distributed ledger startups that are bringing in a broad number of participants to use a common model and that are able to address bank-specific regulatory compliance and security requirements including KYC and AML procedures.

A Continuum of Blockchains

While no clear blockchain model has been adopted by the banking industry and most executives remain open to all promising options, a large number of them remain wary of Bitcoin's open, fully decentralized model due to myriad of reasons, including anonymous transaction validators and bitcoin's association with volatility, instability and illicit activity. Instead, they envision an alternative where the technology operates on their own private network or a joint system with trusted and pre-selected industry partners, or with a central authority—concepts that clearly conflict with the fully decentralized design of Bitcoin and many other cryptocurrency models. The idea of permissioned blockchains has been gaining traction recently thanks in part to the deepening discussions and research on how to integrate blockchain technology into the mainstream economy. Indeed, many banks are drawn to the notion of a network that, unlike Bitcoin, controls access permissions. As explained by UBS' Alex Batlin, with permissioned blockchains "you don't need to do proof of work, so all of a sudden you can have a business model with much higher transaction throughput…The other issue is that given the current regulatory and legal view, you need to know who your payment processors are. So having a permission chain gives you easier integration into the legal and regulatory framework." Moreover, many observers consider it unrealistic, inefficient and unnecessary to maintain all data on one permissionless ledger. They argue that certain information is best suited for public chains while more private data should be stored on permissioned distributed ledgers where network access is restricted to trusted parties.

Going forward, it is entirely conceivable that banks could create one giant digital permissioned bank ledger that would be jointly maintained and secured by the banks within the ledger system rather than anonymous users as in the Bitcoin network. Such a permissioned bank consortium ledger could provide banks with an effective method to deal with one another without intermediaries, facilitate easy auditing, and help mitigate potential regulatory concerns several banks have with bitcoin, while also alleviating many of the expensive redundancies of the current banking financial architecture, including the significant amount of resources spent to develop and maintain individual systems that all perform essentially the same function and to en-

4 Full list: Bank of America, Bank of New York Mellon, Barclays, BBVA, Citi, Commerzbank, Commonwealth Bank of Australia, Credit Suisse, Deutsche Bank, Goldman Sachs, HSBC, JPMorgan, Mitsubishi UFJ Financial Group, Mizuho Bank, Morgan Stanley, National Australia Bank, Nordea, Royal Bank of Canada, Royal Bank of Scotland, SEB, Société Générale, State Street, Toronto-Dominion Bank, UBS, and UniCredit.

sure that all the individual systems are synchronized and reconciled with each other. Furthermore, such a network could potentially provide advantages—such as faster, more efficient, and cheaper transactions—over the traditional Bitcoin model as distributed consensus can be reached between recognized, vetted and trusted actors, rather than through anonymous, relatively expensive and energy-intensive bitcoin mining. This type of model—decentralized but permissioned—could provide the foundation for a modern financial system without a single point of failure.

In the future, it is also quite possible that a continuum of blockchains—public, private, and hybrid versions—coexist and that they will seamlessly interoperate with one another. Examples of hybrid blockchain combinations could include pegged sidechains between permissioned and permissionless distributed ledgers, and privately administered smart contracts on permissionless digital ledgers. The optimal blockchain solution could be based upon a company, sector, or industry's particular needs and desires.

Non-Bank Financial Services Firms

In addition to the explosion of bank activity in the space, other traditional financial services firms, including Nasdaq, the New York Stock Exchange, and Visa are also exploring ways to leverage the technology. For example, in October, Nasdaq, the world's second largest exchange in terms of market capitalization, launched "Linq," a blockchain-enabled platform. According to the company's press release, the platform—the first of its kind—enables the "issuance, cataloguing, and recording of transfers of shares of privately-held companies on The NASDAQ Private Market." Linq clients—which currently include Chain, ChangeTip, PeerNova, Synack, Tango and Vera—will have access to a "comprehensive, historical record of issuance and transfer of their securities, offering increased auditability, issuance governance and transfer of ownership capabilities" according to the company's website. This will improve the present-day labor-intensive process where even the most straightforward trades may require weeks to finalize thanks in part to the fact that paper certificates are still being used. As part of its wider blockchain technology initiative, the exchange is also examining the possibility of employing "blockchain-like ledgers" to speed up and lower the cost of trading in several other markets. This could help reduce the counterparty risk of a trade not being fulfilled by minimizing the time lag between the execution and settlement of a trade, and also freeing up the insurance or collateral capital used to back business transactions. In a July call with investors, the company's CEO, Robert Greifeld, stated, "Blockchain technology holds great promise in allowing capital markets to operate more efficiently while simultaneously providing greater transparency and security, all of which are fundamental to the public interest."

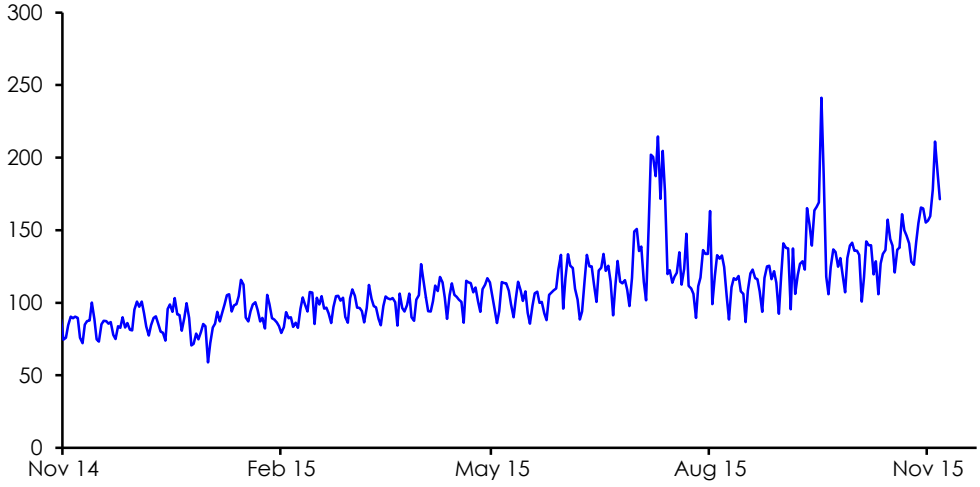
Nasdaq's larger rival, the New York Stock Exchange, has also been active in the space; in January it became a minority stakeholder in Coinbase and later in the year introduced the NYSE Bitcoin Index (NYXBT), the first exchange-calculated and disseminated bitcoin index.

Another example of non-bank traditional financial services firms' activity in the space includes Visa and Nasdaq's investment in Chain earlier this year. According to the San Francisco-based startup's website, its platform "enables institutions to design, deploy, and operate blockchain networks that can power any type of asset in any market" and is "based on open-source protocols to ensure interoperability across systems and networks." In an effort to accelerate the adoption of blockchain technology in the mainstream economy, Visa and Nasdaq, along with other major investors, are establishing a working group at Chain that is dedicated to researching and testing the technology in different markets. The startup helped build the Linq platform.

Official Sector

The official sector is also beginning to take greater notice of the technology and is committing more resources to exploring its capabilities. For instance, in the UK, the Bank of England released in September 2014, the "Innovations in payment technologies and the emergence of digital currencies" report wherein the central bank recognized the blockchain's potential, stating that the technology could have "far-reaching implications" and that because its function could extend beyond just payments, it may be described as a "first attempt at an 'Internet of Finance.'" Moreover, the UK government announced earlier this year that it intends to apply additional regulation in the digital currency technology space, work with the digital currency industry and the British Standards Institution to establish voluntary standards

Chart 6
Number of Bitcoin Transactions per Day
thousand



Source: blockchain.info.

for consumer protection, better equip law enforcement organizations to detect and prosecute illegal activity in the space, and provide an additional £10 million in funding to support research in digital currencies technology. It is also examining possible ways it could harness blockchain technology to enhance its own record keeping.

In Singapore, the city-state's central bank, the Monetary Authority of Singapore (MAS), is also becoming more and more intrigued by DLT. MAS managing director, Ravi Menon, stated at a conference in June that, "The potential benefits of a distributed ledger system include: faster and more efficient processing; lower cost of operation; and greater resilience against system failure." Furthermore, the central bank announced earlier this year that it will allocate a portion of funds from a five-year $225 million financial technology investment program to finance a blockchain-like record-keeping database.

In the United States, David Andolfatto, vice president of the Federal Reserve Bank of St. Louis, has referred to the blockchain as a "stroke of genius" and in June, Vermont's state government authorized a study to examine how a blockchain could be utilized as a legal system of record keeping under state law.

Lastly, in countries such as Honduras and Greece, officials are interested in building inexpensive, transparent, immutable and secure land registries using blockchain technology. Factom, a Texas-based blockchain startup, and Epigraph, a Texas-based title software firm, are working together to build such a database for the Honduran government. The aim of the project, whose first phase is scheduled to be completed by the end of the year, is to remove fraud and corruption and help facilitate "more secure mortgages, contracts, and mineral rights" according to Factom president, Peter Kirby.

BARRIERS TO WIDESPREAD ADOPTION

While there is growing activity in the space by prominent players, many remain skeptical. Critics maintain that there are numerous obstacles preventing a blockchain-driven financial ecosystem from emerging. For example, an often-cited major concern for the traditional decentralized public ledger model is the enormous computational power and the associated high costs required to maintain the system. According to a BBVA report, a decentralized network would need to offer an equal or greater degree of security and trust than the existing centralized financial architecture. For this to occur, the decentralized system would require a "massive amount" of computer power. Detractors argue that this would be unsustainable in the long run as the system expanded. In the Bitcoin ecosystem alone, there are already hundreds of thousands of high-powered computers that have been specifically developed to validate transactions and maintain the system through mining activities. Bitcoin miners now have 13,000 times more combined calculating capacity than the world's 500 most powerful supercomputers and it is estimated that the combined electrical consumption of these computers is enough to power the entire country of Ireland. More striking still is that the Bitcoin system processes only about 150,000 transactions per day (Chart 6, previous page)—a small fraction of Visa's 150 million. The computing power, energy, and carbon footprint required to process all the transactions of the global financial network using the traditional blockchain model would be colossal. It is unclear whether today's technology would be able to process even a fraction of that amount. The BBVA report also highlights the fact that while extremely difficult, sabotaging the traditional blockchain system may prove achievable depending on "computing power, position of the attacker and the timing of the attack."

According to various observers, there are several other potential obstacles to widespread adoption of blockchain technology in general, including governance and incentive systems, regulatory and legal challenges, interoperability issues, and the cost of overhauling legacy infrastructure.

Two of these potential obstacles include central components to the blockchain's functionality—an incentive system that motivates a dispersed workforce to validate and record transactions on the digital ledger and a governance system that provides rules and structures for the platform. It remains unclear exactly how these two systems would develop and function as blockchain technology and models evolve, and what would be the ramifications for the economic and operational efficiency of these models in the conventional economy.

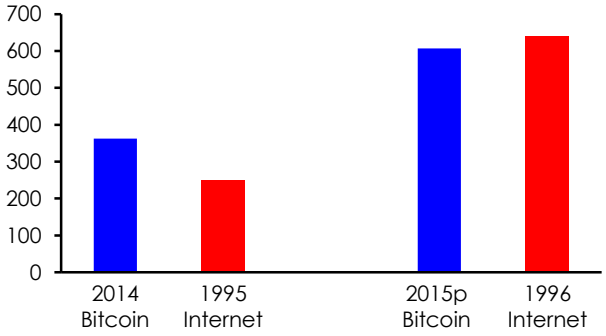
Furthermore, legal, regulatory, and security hurdles will no doubt pose challenges too; legislative bodies, regulators, and law enforcement agencies around the world cite tax evasion, money laundering, and financing of illicit activities such as terrorism and the proliferation of weapons of mass destruction as concerns associated with the novel technology. Blockchain systems will have to be systematically and meticulously developed, tested and evaluated to guarantee that regulatory, legal, and security concerns are tackled to the satisfaction of all

relevant stakeholders. Moreover, important questions related to smart property and smart contracts would also need to be addressed. For instance, would they be accepted by the courts, and if so, how would they operate within the traditional legal system?

Another potential hurdle going forward could be reduced interoperability. With numerous blockchain models competing for market share, companies developing tailored distributed ledger networks for banks and other financial services firms could be creating new problems related to interoperability in their attempt to improve today's highly intermediated global financial industry. Without considerable collaboration and standardized protocols, various blockchain models could emerge that are incompatible with one another, therefore limiting the technology's mass market scalability and its true potential.

Lastly, even if the blockchain evolves and proves to offer significant benefits, many industry observers ask whether it would still be worth the cost of implementing. Reconstructing the architecture of the financial industry is an enormous undertaking that requires cooperation and coordination between many different actors—both in the official and private sector. Companies, regulators, and other key stakeholders would have to be persuaded convincingly that the benefits significantly outweigh the costs and potential risks before a major overhaul of legacy infrastructure systems and practices took place.[5]

Chart 7
Venture Capital Investment in Early Stage Development of Bitcoin and the Internet*
$ million



*Figures are approximate and are unadjusted for inflation. For more information, please click here. p = projected.
Source: CoinDesk, PricewaterhouseCoopers.

BETTER REGULATION, INDUSTRY COLLABORATION, AND ADVANCES IN TECHNOLOGY COULD HELP

While the aforementioned hurdles are valid concerns, advocates point out that technological advances, enhanced regulatory measures, and industry collaboration should not only be able to solve them but also ensure that the benefits of a blockchain system far outweigh the costs of reengineering the legacy infrastructure. On the regulatory front, the case is often made that since the new technology provides digitally replicated records of every transaction that takes place on the system, the movement of funds and assets could be easily traced by law enforcement bureaus and regulators with a couple clicks of the mouse. With appropriate monitoring, it should ultimately prove difficult to conceal criminal activity, as each asset on the system would be identifiable by its unique transac-

The technology could be described as a "first attempt at an 'Internet of Finance.'"

— Bank of England

5 Please consult the University of Chicago Law School's paper, "Economic Aspects of Bitcoin and Other Decentralized Public-Ledger Currency Platforms" for more information on the barriers facing the expansion of the technology from a small niche area to the mainstream economy.

tion history. With regard to technological challenges, proponents argue that with the foundation established and continued advances in technology, it is only a matter of time before a viable, cost-effective, and efficient blockchain model is in place, given the significant expected benefits of widespread adoption.

Proponents are also quick to rule out concerns over governance and incentive systems. As per a report by the Bank of England, "There is more than one way in which a distributed ledger system can work…remuneration would have to be designed in such a way as to incentivize honest participation in the system without leading to socially inefficient over-investment in transaction verification." Advocates highlight the fact that innovation is ongoing and a wide range of models with various sets of rules and operational structures are being developed. For instance, permissioned models such as Coinprism's recently released Openchain—an open-source distributed ledger technology that uses partitioned consensus—avoids the energy-intensive mining associated with Bitcoin's anonymous consensus mechanism. Likewise, the consensus process on the Ripple protocol does not require miners or proof of work, and can validate ledgers within seconds.

Lastly, in regard to the potential issue of reduced interoperability, proponents counter the argument put forth by critics that the industry will not be able to overcome mutual suspicion and share ideas and knowledge with each other—an important condition to developing standardized protocols that help enhance the value of the technology—by highlighting examples of important and widespread industry cooperation, including through the Depository Trust & Clearing Corporation (DTCC), the Society for Worldwide Interbank Financial Telecommunication (SWIFT), and Continuous Linked Settlement (CLS) Bank. Furthermore, proponents cite the promising partnerships emerging in the space thanks to startups such as R3CEV.

"You should be taking this technology as seriously as you should have been taking the development of the Internet in the early 1990s. It's analogous to email for money."

— Blythe Masters, CEO, Digital Asset Holdings

STILL EARLY DAYS

The Bitcoin protocol and its underlying blockchain technology are currently in an evolutionary phase, comparable to when Internet protocols were still nascent. Like the PC and Internet in their early days, the cryptoprotocol ecosystem today should be viewed as a work in progress with immense potential. As Blythe Masters explained during a presentation in June, "You should be taking this technology as seriously as you should have been taking the development of the Internet in the early 1990s. It's analogous to email for money." Many do agree with Ms. Masters' opinion as is evidenced by the relatively similar venture capital investment figures for the two technologies in their early stages of development (Chart 7, previous page) and the growing number of blockchain working groups. Like in the mid-1990s when many companies had an Internet working group, today many major entities, including banks, consulting companies, insurance firms, and governments, have blockchain working groups exploring the technology. This similarity, according to Factom's Peter Kirby, illustrates the enormous potential value of the innovation.

A broad range of developers have also recognized the promise of DLT and have started developing applications that move away from a cryptocurrency-only network to ventures that have added functionality. Some developers are building directly on the Bitcoin blockchain, while others question whether it provides the most optimal platform for continued experimentation in the complex digital universe—and have created new protocols based upon its underlying principles. While no one is certain how or in which direction blockchain technology will evolve, it is clear that the Bitcoin protocol has unleashed a wave of financial innovation. Some of these new platforms may flourish, others may collapse. In fact, it is possible that the platform that can spearhead this technology into the mainstream economy has not yet been designed.

Lastly, blockchain proponents argue that like the Internet in its beginning, the technology should not be over-regulated, as that would impede its advancement. Had the Internet been over-regulated during its early development, many of today's useful and far-reaching innovations would be non-existent. The same concept, advocates argue, is applicable to the blockchain. As both international and national regulators consider the potential implications of the blockchain for financial stability, supporters continue to urge recognition of the important distinction between the technology itself and the applications that operate on it.

CONCLUSION

It remains to be seen whether blockchain technology will be adopted widely enough to become a disruptive force in the global economy, however, a growing number of people and institutions are of the view that it will. A number of traditional financial services firms have now initiated strategic partnerships and investments in the space. The involvement of several key companies has resulted in an acceleration of activity; startups, banks, and financial services firms are dedicating ever-more resources to exploring ways to harness the technology. A variety of blockchain systems have emerged, though it is still too early in the innovation and development cycle to determine which of these systems, if any, will become sustainable, scalable and successful in the future. In all probability, an enormous amount of cooperation between key players, including banks, technology firms, stock exchanges, regulators, developers, programmers, and entrepreneurs, will be required for a blockchain-driven financial ecosystem to emerge. We can, however, assume continued experimentation by technology companies, financial services firms, and other key players in the space going forward as they work to make an effective, secure, and viable real-world blockchain ecosystem a reality.