MORNINGSTAR® | PitchBook®

Blockchain
Observer April 2018

Disruption by Decentralization?

Contents

Important Disclosure

Blockchain is full of promise. Investment in the space totals billions of dollars. Large corporations, venture capital funds, and initial coin offerings are funding projects. The activity is not completely misguided; blockchains have the potential to disrupt economic activities ranging from simple payments to the structure of a corporation as it currently exists. We see three broad categories of applications for the technology: financial transactions, data management, and marketplace activity. Companies that engage in these functions are seemingly at risk, as blockchain technology can potentially lower transaction costs as well as the costs of recordkeeping. However, we've identified some narrow- and wide-moat companies that will be less vulnerable to the blockchain threat. These companies provide value-added services along with simpler transaction processing and recordkeeping functions. Then, we point out that the early-stage technology still suffers from a handful of technical issues, including problems with scalability, privacy, and leadership.

Exhibit 1 Blockchain Could Disrupt Multiple Industries

Industry	Blockchain Threat Synopsis	Intangible assets	Network effects	Switching costs	Cost advantages
				Relevant moat sources	
Custody	An immutable public record on the blockchain could eliminate the need for custody, storage, and record-keeping services.			●	●
Securities exchanges	Blockchain enables direct value transfer and record-keeping, eliminating the need for costly capital markets intermediation.	●	●		
Payments	Blockchain enables direct value transfer without issuers, acquirers, networks, and other intermediaries.	●	●		
Cloud computing	A decentralized network of computers can be used for data processing and storage.	●			●
Transportation brokerage	Third-party intermediaries connect buyers and sellers of transportation services.	●	●		
Marketplaces and distributors	Buyers and suppliers can coordinate activities via blockchain.	●	●		●
Credit reporting	Blockchain enables secure storage and personalized control of private customer data.	●			

Source: Morningstar

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Key Takeaways

▶ Ideally, a blockchain is trustworthy, transparent, and decentralized. These features provide most of the technology's appeal, allowing businesses to solve problems related to trust, recordkeeping, and transaction costs.

▶ Blockchain technology provides a way to decentralize three important economic functions: financial transactions, identity and data management, and marketplaces. Decentralized solutions could disrupt companies that create value by centralizing such activities.

▶ The financial services sector abounds with companies that serve to centralize financial transaction activity. Blockchain technology removes the need for a trusted third party and lowers transaction costs.

▶ Centralized control of data and identity management is increasingly creating security and privacy issues. Blockchains allow individuals to maintain control over their own digital identities.

▶ Marketplaces such as Amazon and Expedia, which serve as intermediaries between buyers and sellers, have arisen in numerous sectors. Marketplace activity can conceivably migrate to a blockchain, removing the need for a corporate intermediary.

▶ Corporations exist to lower transaction costs and solve problems of trust. Blockchain technology therefore can also enable entirely new forms of economic organization.

▶ Moats arising from network effects and cost advantages are, on the surface, most vulnerable to a technology that decentralizes activity and reduces transaction costs. Moats arising from switching costs and intangible assets are less vulnerable.

▶ Blockchain technology removes the need for a trusted third party and potentially lowers transaction costs, but cost advantages are seldom the only variable in play. Many intermediaries provide value-added services in addition to commoditized transaction processing and recordkeeping, and companies often benefit from multiple moat sources. Even in commoditized lines of business, incumbents often benefit from massive economies of scale.

▶ Blockchain technology is in its infancy, with major technical hurdles to overcome before reaching mainstream viability. Scalability and cost are primary concerns, as are privacy issues, despite the security inherent to encrypted, distributed ledgers. Decentralized control can exacerbate differences, slow progress, and lead to balkanization. Ironically, private and permissioned blockchains might better balance the benefits of decentralized ledgers with those of centralized systems. In this case, the benefits of blockchain technology could accrue to incumbents or their customers.

▶ Narrow- and wide-moat companies serving as trusted intermediaries in several industries are trading at significant discounts to fair value. American Express, McKesson, Anixter, TripAdvisor, and Facebook are some of our top current picks among these companies.

▶ Utility token demand rests on 1) the ability of an individual token to add value for users, and 2) the lack of viable alternatives to its use. We believe that value creation in the token world will depend not only on networks of users and developers, but also durable competitive advantages over both decentralized and centralized competitors.

Exhibit 2 Financial Services Companies Affected

Ticker	Stock Name	Morningstar Rating	Price at Close	Fair Value Estimate	Price/Fair Value	Moat Rating	Market Cap (Bil)	Analyst
WU	The Western Union Co	★★★	19.14	23.00	83%	Wide	8.8	Horn, CFA
C	Citigroup Inc	★★★	69.48	78.00	89%	Narrow	177.2	Sinegal
AXP	American Express Co	★★★	100.61	112.00	90%	Wide	86.5	Sinegal
TRI	Thomson Reuters Corp	★★★	39.76	43.50	91%	Narrow	28.2	Plunkett
TRI	Thomson Reuters Corp	★★★	51.02	56.00	91%	Narrow	36.3	Plunkett
LSE	London Stock Exchange Group PLC	★★★	4,215.00	4,550.00	93%	Wide	14.8	Compton
BNP	BNP Paribas	★★★	63.90	67.00	95%	Narrow	79.7	Scholtz
DFS	Discover Financial Services	★★★	73.31	77.00	95%	Narrow	25.9	Sinegal
BK	Bank of New York Mellon Corp	★★★	55.73	58.00	96%	Wide	56.3	Compton
S68	Singapore Exchange Ltd	★★★	7.69	8.00	96%	Narrow	8.2	Wu
STT	State Street Corporation	★★★	102.30	107.00	96%	Wide	37.4	Compton
BNPQY	BNP Paribas	★★★	38.98	40.00	97%	Narrow	96.7	Scholtz
DB1	Deutsche Boerse AG	★★★	111.25	109.00	102%	Narrow	20.1	Compton
V	Visa Inc	★★★	124.46	118.00	105%	Wide	289.4	Sinegal
ICE	Intercontinental Exchange Inc	★★★	73.92	70.00	106%	Wide	43.0	Wong
8697	Japan Exchange Group Inc	★★★	1,997.00	1,870.00	107%	Wide	1045.7	Wu
HSBC	HSBC Holdings PLC	★★★	49.95	46.30	108%	Narrow	197.3	Guzel
JPM	JPMorgan Chase & Co	★★★	110.93	103.00	108%	Narrow	377.7	Sinegal
SPGI	S&P Global Inc	★★	192.05	173.00	111%	Wide	47.9	Plunkett
MA	Mastercard Inc	★★	175.43	156.00	112%	Wide	184.4	Sinegal
NDAQ	Nasdaq Inc	★★★	86.95	76.00	114%	Narrow	14.5	Wong
CSGP	CoStar Group Inc	★★	368.86	316.00	117%	Wide	13.3	Schwer
ASX	ASX Ltd	★★	56.74	47.50	119%	Wide	11.0	James
NTRS	Northern Trust Corp	★★	107.39	88.00	122%	Wide	24.2	Compton
CME	CME Group Inc	★★	164.20	133.00	123%	Wide	55.9	Plunkett
FDS	FactSet Research Systems Inc	★★	191.78	147.00	130%	Wide	7.5	Plunkett
MSCI	MSCI Inc	★★	150.00	113.00	133%	Wide	13.5	Plunkett
PYPL	PayPal Holdings Inc	★★	78.21	59.00	133%	Narrow	92.9	Sinegal
388	Hong Kong Exchanges and Clearing Ltd	★★	258.80	187.00	138%	Wide	320.9	Wu

Source: Morningstar
Price at close as of April 23.

Blockchain Observer | 10 May 2018 | See Important Disclosures at the end of this report.

Exhibit 3 Consumer Companies Affected

Ticker	Stock Name	Morningstar Rating	Price at Close	Fair Value Estimate	Price/Fair Value	Moat Rating	Market Cap (Bil)	Analyst
EXPE	Expedia Group Inc	★★★★	110.39	175.00	63%	Narrow	16.8	Wasiolek
4755	Rakuten Inc	★★★★	767.20	1,200.00	64%	Narrow	1033.2	Ito
CTRP	Ctrip.com International Ltd	★★★★	42.94	57.00	75%	Narrow	22.0	Tam
TRIP	TripAdvisor Inc	★★★★	42.69	55.00	78%	Narrow	5.9	Wasiolek
BABA	Alibaba Group Holding Ltd	★★★★	175.57	210.00	84%	Wide	450.5	Hottovy
BKNG	Booking Holdings Inc	★★★	2,133.69	2,300.00	93%	Narrow	103.0	Wasiolek
AMZN	Amazon.com Inc	★★★	1,517.86	1,600.00	95%	Wide	736.1	Hottovy
EBAY	eBay Inc	★★★	41.60	44.00	95%	Narrow	41.3	Hottovy
MELI	MercadoLibre Inc	★★★	330.46	340.00	97%	Wide	14.6	Hottovy
TVPT	Travelport Worldwide Ltd	★★★	17.31	17.00	102%	Narrow	2.2	Wasiolek

Source: Morningstar
Price at close as of April 23.

Exhibit 4 Technology Companies Affected

Ticker	Stock Name	Morningstar Rating	Price at Close	Fair Value Estimate	Price/Fair Value	Moat Rating	Market Cap (Bil)	Analyst
700	Tencent Holdings Ltd	★★★★	394.00	641.00	61%	Wide	3744.3	Tam
SINA	SINA Corp	★★★★	95.34	136.00	70%	Narrow	6.8	Tam
SABR	Sabre Corp	★★★★	20.21	26.00	78%	Narrow	5.9	Wasiolek
FB	Facebook Inc	★★★★	165.84	198.00	84%	Wide	480.8	Mogharabi
IBM	International Business Machines Corp	★★★	145.86	168.00	87%	Narrow	134.4	Lange
GOOGL	Alphabet Inc	★★★	1,073.81	1,200.00	89%	Wide	744.4	Mogharabi
GOOG	Alphabet Inc	★★★	1,067.45	1,200.00	89%	Wide	744.4	Mogharabi
MSFT	Microsoft Corp	★★★★	95.35	106.00	90%	Wide	734.2	Nelson
CAR	Carsales.com Ltd	★★★	13.92	13.90	100%	Narrow	3.4	James
DHG	Domain Holdings Australia Ltd	★★★	3.05	3.02	101%	Narrow	1.8	James
SEK	Seek Ltd	★★★	19.33	18.30	106%	Narrow	6.8	James
TME	Trade Me Group Ltd	★★★	4.23	3.88	109%	Narrow	1.7	James
WB	Weibo Corp	★★★	117.95	106.00	111%	Narrow	26.1	Tam
MTCH	Match Group Inc	★★	46.41	37.00	125%	Narrow	12.7	Mogharabi
REA	REA Group Ltd	★★	79.43	56.00	142%	Narrow	10.5	James

Source: Morningstar
Price at close as of April 23.

Exhibit 5 Healthcare Companies Affected

Ticker	Stock Name	Morningstar Rating	Price at Close	Fair Value Estimate	Price/Fair Value	Moat Rating	Market Cap (Bil)	Analyst
CVS	CVS Health Corp	★★★★★	65.68	99.00	66%	Wide	66.6	Lekraj
CAH	Cardinal Health Inc	★★★★	62.22	89.00	70%	Wide	19.6	Lekraj
MCK	McKesson Corp	★★★★★	148.33	210.00	71%	Wide	30.6	Lekraj
PDCO	Patterson Companies Inc	★★★★	22.79	31.00	74%	Narrow	2.2	Lekraj
ESRX	Express Scripts Holding Co	★★★★	75.19	92.00	82%	Wide	42.2	Lekraj
ABC	AmerisourceBergen Corp	★★★★	90.74	106.00	86%	Wide	19.9	Lekraj
HSIC	Henry Schein Inc	★★	73.79	65.00	114%	Narrow	11.4	Lekraj
AMN	AMN Healthcare Services Inc	★	67.30	22.00	306%	Narrow	3.2	Lekraj

Source: Morningstar
Price at close as of April 23.

Exhibit 6 Industrials Companies Affected

Ticker	Stock Name	Morningstar Rating	Price at Close	Fair Value Estimate	Price/Fair Value	Moat Rating	Market Cap (Bil)	Analyst
AXE	Anixter International Inc	★★★★	78.15	107.00	73%	Narrow	2.6	Bernard
HDS	HD Supply Holdings Inc	★★★★	39.15	45.00	87%	Narrow	7.3	Bernard
MSM	MSC Industrial Direct Co Inc	★★★	88.40	101.00	88%	Narrow	5.0	Bernard
FAST	Fastenal Co	★★★	50.37	53.00	95%	Wide	14.5	Bernard
RHI	Robert Half International Inc	★★★	58.36	60.00	97%	Narrow	7.2	Silver
EFX	Equifax Inc	★★★	119.62	122.00	98%	Wide	14.5	Horn, CFA
INFO	IHS Markit Ltd	★★★	49.05	46.50	105%	Wide	19.6	Akbari, CFA
EXPGY	Experian PLC	★★★	22.87	21.50	106%	Wide	20.6	Horn, CFA
WP	Worldpay Inc	★★★	80.80	76.00	106%	Narrow	25.3	Sinegal
KNIN	Kuehne + Nagel International AG	★★★	154.70	144.00	107%	Narrow	18.5	Field
GPN	Global Payments Inc	★★	110.25	99.00	111%	Narrow	17.6	Sinegal
GWW	W.W. Grainger Inc	★★★	286.08	258.00	111%	Narrow	16.0	Bernard
HUBG	Hub Group Inc	★★	43.70	39.00	112%	Narrow	1.5	Young, CFA
CHRW	C.H. Robinson Worldwide Inc	★★	93.71	81.00	116%	Wide	13.1	Young, CFA
EXPD	Expeditors International of Washington Inc	★★	64.30	54.00	119%	Wide	11.3	Young, CFA
RBA	Ritchie Bros Auctioneers Inc	★★	42.38	35.00	121%	Narrow	4.6	Mokha
RBA	Ritchie Bros Auctioneers Inc	★★	33.03	27.00	122%	Narrow	3.5	Mokha
DSV	DSV A/S	★★	496.90	403.00	123%	Narrow	91.0	Field
LSTR	Landstar System Inc	★★	108.00	86.00	126%	Wide	4.5	Young, CFA
ECHO	Echo Global Logistics Inc	★★	29.25	23.00	127%	Narrow	0.8	Young, CFA
JBHT	JB Hunt Transport Services Inc	★★	120.32	95.00	127%	Narrow	13.2	Young, CFA
ADP	Automatic Data Processing Inc	★★	117.10	89.00	132%	Wide	51.9	Plunkett

Source: Morningstar
Price at close as of April 23.

Blockchain Basics

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Some of the strongest competitive advantages come from centralization. Network effects, for example, can lead to huge profits for companies that centralize and control transaction activity—for example, payment networks, marketplaces, social networks, and futures exchanges. Similarly, centralization can create competitive advantages via economies of scale, as fixed costs are spread over a large number of transactions.

Less than a decade since the introduction of Bitcoin as a means to solve a problem in the realm of digital payments, the underlying technology it introduced is making it possible to decentralize all types of activities. Cryptocurrencies began as a threat to the payment industry, but it is becoming clear that blockchain technology and cryptoeconomics could someday threaten a wide variety of business models, and conceivably the traditional means of corporate organization itself. The decentralized autonomous organization, or DAO (not to be confused with "The DAO"[1], a specific investor-directed fund organized in this way), allows algorithms or owners to govern an organization, rather than by layers of bureaucracy.

As with any new technology, blockchain has created intense debate among prognosticators. Some[2] believe there will be no valid uses at all over the long run. Others have proposed that blockchain will disrupt nearly every industry[3], and that decentralized networks will eventually surpass the capabilities of most centralized companies[4]. In fact, Ronald Coase's Nobel prize-winning theory of the firm is based on the idea that the high cost of using decentralized markets is the very reason why companies—with centralized management and delegation of activities—exist at all.

We suspect the truth lies somewhere in between. Blockchain technology has plenty of potential, but there are still obstacles to world domination. These include difficulties inherent to the technology itself, as well as the established moats of the incumbents in various industries.

A Brief History of Blockchain

Bitcoin was not the first attempt to create a viable digital currency[5]. Interest in such a system dates back more than 20 years. The "cypherpunk" movement incorporating elements of philosophy, computer science, and mathematics—along with a strong desire for privacy—spawned a number of efforts. In fact, prominent figures within this movement are occasionally rumored to be responsible for the creation

1 https://en.wikipedia.org/wiki/The_DAO_(organization)
2 "Don't Believe the Hype: There Are No Good Uses for Blockchain," Jan. 2, 2018, Kai Stinchcombe, American Banker
3 "What If I Told You … the Blockchain Could Disrupt Everything," The Atlantic, Goldman Sachs, sponsored content.

4 "Why-Decentralization-Matters," Feb. 18, 2018, Chris Dixon, Medium
5 "The Untold Story of Bitcoin: Enter the Cypherpunks," Jan. 26, 2018, PetriB, The Startup

of Satoshi Nakamoto and Bitcoin. False starts in the digital currency field include DigiCash (1989), E-gold (1996), and b-Money (1998). PayPal was initially envisioned[6] as a "new world currency" before finding success in the more mundane world of traditional payment processing.

Introduced in a 2008 whitepaper by the mysterious Mr. Nakamoto, Bitcoin solved the problem of trust in online financial transactions. Previously, transferring digital assets required the involvement of one or more trusted third parties. For example, a customer purchasing a soda via debit card at a convenience store depends on effective coordination among his own bank, the merchant's bank, and a card network such as Visa or Mastercard. These trusted third parties deal with the problems of double-spending and transaction reversal. The customer's bank keeps a record of his spending, the card network assists in communication and funds transfer, and the merchant's bank records and stores funds as they come in. Disputes are handled according to standards set over time by the networks and the participants in them.

Bitcoin, in contrast, utilizes a distributed peer-to-peer network to authenticate and record all transactions in the order they occurred, eliminating the need for intermediaries. In this way, participants can verify a clear chain of ownership for digital funds without relying on a trusted third party. The peer-to-peer network maintaining the digital ledger is known as a blockchain—a decentralized record of transactions.

Others were quickly captivated by the technology's potential, and introduced rivals to Bitcoin and new blockchain-based functionalities. Ethereum may be the most important of these later introductions. While Bitcoin's software performs relatively simple transaction processing, Ethereum's software essentially provides an operating system by which the network can be programmed to perform a variety of computations, making it a "world computer." A variety of applications (decentralized applications, or "dapps") can be built on top of Ethereum. For example, EtherTweet is a decentralized rival to Twitter. While Twitter has a staff of paid programmers and its own data centers and servers, EtherTweet is open-source software running on the Ethereum blockchain. Thus anything that can be programmed can potentially be decentralized. That said, the technology is still in the very early stages. Satoshi Nakamoto's paper was published as the Internet celebrated its 40th anniversary.

6 "Bitcoin is the 'new world currency' Peter Thiel wanted PayPal to be," Jan. 3, 2018, Joon Ian Wong, John Detrixhe

Exhibit 7 Blockchain and the Internet
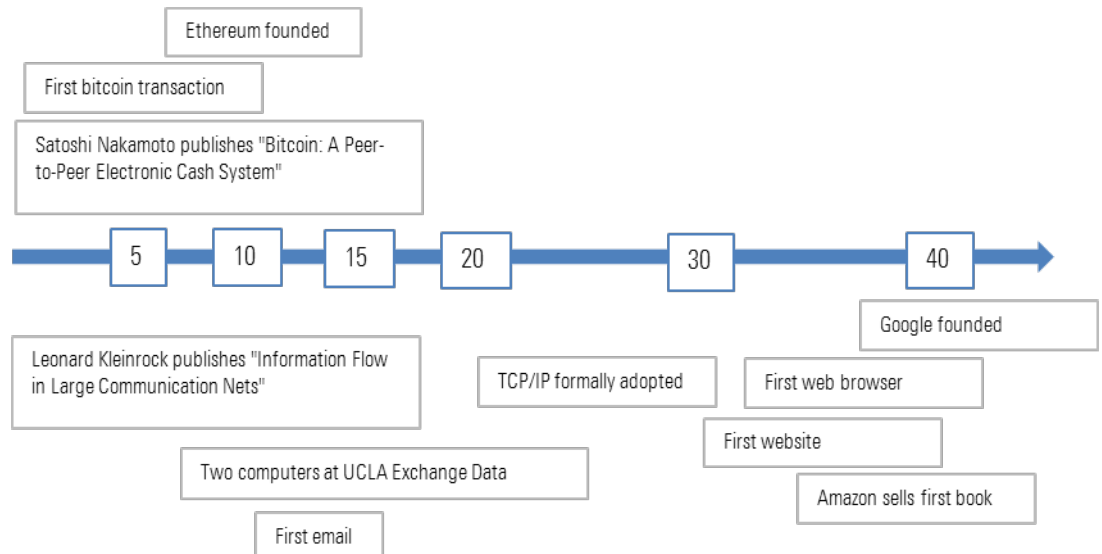
Source: Phys.org, Wikipedia

Technical Summary

The peer-to-peer networks that process instructions and maintain records in a blockchain depend on a few cryptographic principles and the mechanism laid out in Nakamoto's whitepaper. One of these principles is private key cryptography, which allows two-way message transmission[7] using public and private keys. In one example, a sender can encrypt a message with the recipient's public key, ensuring that only the intended recipient (who possesses the associated private key) can decrypt it. Conversely, a user can use his private key to encrypt a message. The recipient can use the sender's public key to decrypt it, proving that the message was legitimately sent. This method can also be used to sign documents. A sender/signer can pair the hash[8] of a digital document or asset with his private key. When the result is decrypted by his public key, a check of the decrypted hash against the accompanying digital document or asset proves the "transaction" is legitimate (any changes would not result in a matching hash).

A blockchain consists of a chain of such signed "transactions." Each new transaction is joined to the existing chain, signed by the sender's private key and the recipient's public key, and can be verified by the sender's public key. In order to ensure the data is accurate, the process is made more difficult with a proof of work. All computers in the network, upon receiving a new transaction, combine it with a "nonce"—a random string of text—looking for a desired output. In the case of Bitcoin, the desired output is a long string of zeros at the beginning of the hash, but it could be any difficult-to-find string. The successful user is awarded new coins for his efforts, and the new block becomes the de facto standard for the network moving forward.

7 https://msdn.microsoft.com/en-us/magazine/mt845650
8 A unique, irreversible string of text generated by algorithm from any input.

Exhibit 8 The Blockchain Process
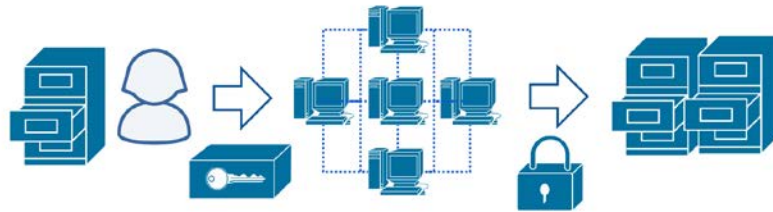
1. USER BROADCASTS A TRANSACTION TO THE NETWORK
2. NETWORK VERIFIES THE TRANSACTION
3. TRANSACTION IS SECURELY COMBINED WITH PREVIOUS RECORDS

Source: Morningstar

Blockchain zealots fiercely debate the technical definition of a blockchain. For our purposes, a blockchain is essentially a distributed database, with data shared across a network of computers, and a consensus mechanism—rather than a central point of control—used to ensure the accuracy and trustworthiness of the shared data. Some insist that a correct definition must include a description of the economic incentives involved, but we assume that both types of distributed databases pose similar competitive threats. We also acknowledge that the degree of centralization varies within the blockchain economy. Bitcoin and its peers are public blockchains—anyone is able to fully participate in the network. On the other end of the spectrum, private blockchains are open only to those with explicit permission to participate. For the purposes of competitive analysis, a variety of applications across the entire spectrum of decentralization are worth examining.

Exhibit 9 Blockchain Applications Vary by Structure and Use Case
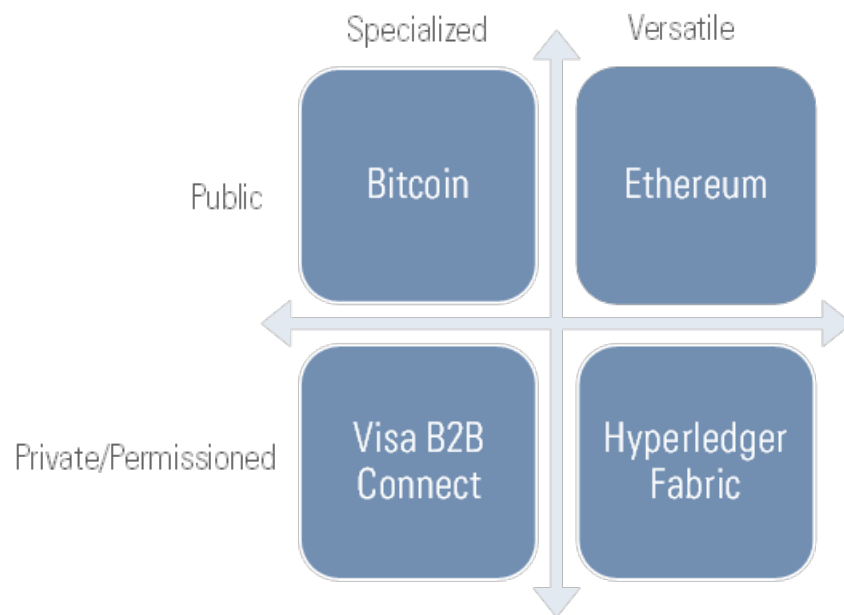
Source: Morningstar

In addition to its distributed nature, an immutable record is another key feature of the technology. A blockchain incorporates a full history of transactions (changes to the database), ensuring that all participants can verify and agree on the state of the database. A block contains a group of transactions, while a blockchain contains multiple blocks. Very simply, when any change occurs (as in the case of a single transaction), the proposed change is broadcast across the network and verified by a chosen consensus mechanism.

Consensus mechanisms are another key feature of blockchains. Initially, Bitcoin and similar applications used a proof-of-work method of reaching consensus. Proof-of-work involves a difficult system of trial-and-error computation. Nodes attempt to cryptographically transform the new data into a desired output, which must be done using a trial-and-error method. Once a solution is found, it is broadcast to the network, which incorporates the transaction into the existing blockchain. More recently, this costly and time-consuming consensus mechanism has been supplemented by other methods. One such method, proof-of-stake, typically combines a node's standing in the network (measured by ownership, age, reputation, or other means) with other methods, including random selections.

Blockchains in all their permutations have several attributes making them potentially useful for a variety of business applications. A blockchain is ideally trustworthy, transparent, and decentralized. These features provide most of the technology's appeal, allowing businesses to solve problems related to trust, recordkeeping, and transaction costs.

Exhibit 10 Glossary of Blockchain Terms

| Term	Definition
Blockchain	A decentralized digital ledger that securely and transparently records transactions using cryptographic techniques
Cryptocurrency	A type of digital asset associated with a blockchain
Cryptography	The field of secret communication
Cryptographic hash function	A mathematical function that produces a unique, repeatable, non-reversible output from a given input
Distributed ledger technology	Technology similar to blockchain, but which involves some degree of centralized control or permission
Hash	The output of a hash function
Mining	Participating in the verification of blockchain transactions in exchange for crytpocurrency
Private key	A key that can encrypt a message sent with its associated public key, or encrypt a message that can be read with an associated private key
Proof-of-stake	A process used to verify changes to a blockchain. Network participants pledge their existing cryptocurrency as collateral in return for the chance to participate in the validation process.
Proof-of-work	A process used to verify changes to a blockchain. Computing power is used to find the solution to a difficult puzzle, ensuring that network participants must expend resources in order to make changes.
Public key	A key that can decrypt a message sent with its associated private key, or encrypt a message that can be read with an associated private key
Security token	A digital asset representing a financial security
Utility token	A digital asset used to access a decentralized application or service

Source: Morningstar/PitchBook

Investment in Blockchain

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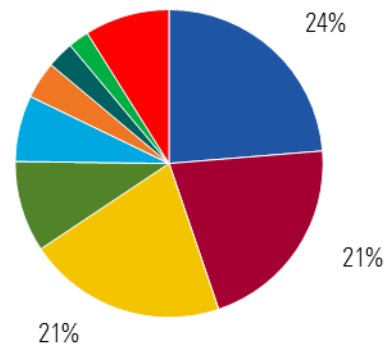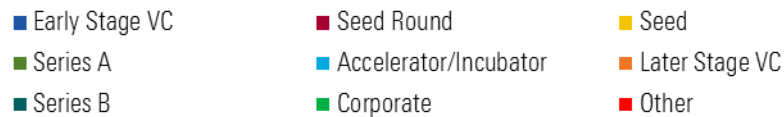+1 312-696-6015
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Among existing firms, several industries are dominating early experimentation with blockchain technology. Blockchain was invented for payments, so it's no surprise that the financial services sector has taken an interest—Bank of America and Mastercard have filed for dozens of patents between them. The technology sector—namely, IBM, Apple, Intel, and Accenture—each have accumulated patent filings in the double digits. Applications are not limited to these two sectors, however. GE, Walmart, and others have joined in the rush to create proprietary blockchain applications.

Exhibit 11 Financial and Technology Firms Lead the Way in Patent Applications
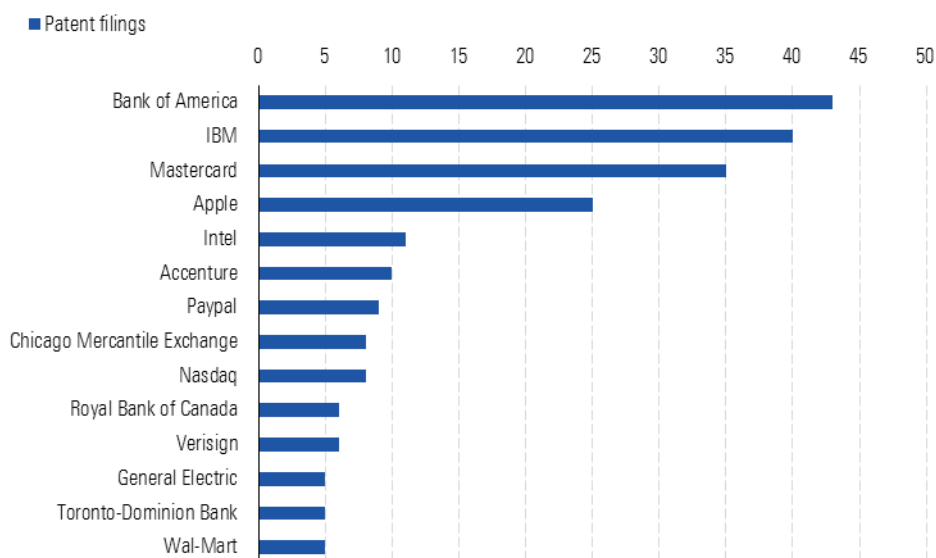
Source: USPTO. Data as of Feb. 6, 2018.

As with any emerging technology, the bulk of investment activity is occurring at early-stage companies.

Exhibit 12 Blockchain Deal Activity Is in the Early Stages

- ■ Early Stage VC
- ■ Seed Round
- ■ Seed
- ■ Series A
- ■ Accelerator/Incubator
- ■ Later Stage VC
- ■ Series B
- ■ Corporate
- ■ Other

Source: PitchBook. Data as of Feb. 27, 2018.

Excluding endeavors that have funded themselves via token offering, companies utilizing blockchain technology have raised billions in venture capital funding, with dozens having raised more than $10 million. Companies such as R3, Ripple, Chain, Ledger, and Digital Asset may not yet be household names, but these well-funded firms are increasingly working with companies that are. The investment activity of the largest public companies and venture capital firms leads is consistent with our view that there are a handful of immediate-use cases for the technology[9].

Most of the activity is happening in the world of financial transactions, though other applications are arising. R3 has produced an open source distributed ledger product that enables a variety of financial applications. Digital Asset's offerings are similar, in that a permissioned blockchain is used to avoid some of the privacy and regulatory issues associated with public blockchains. Ledger provides security solutions for cryptocurrencies. Ripple is focused on cross-border payments, enabled by using its own digital asset, XRP. Blockstream is developing a variety of sidechain applications.

9 "What Are the Applications and Case Uses of Blockchains?" Nolan Bauerle, Coindesk

Exhibit 13 The Financial Services Industry Accounts for Most Blockchain Deal Activity

■ Number of deals
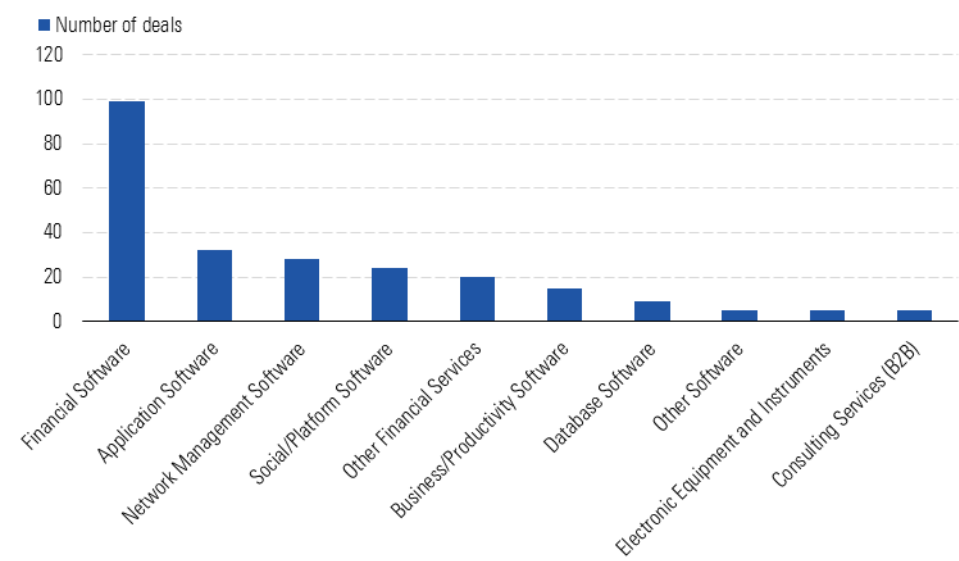
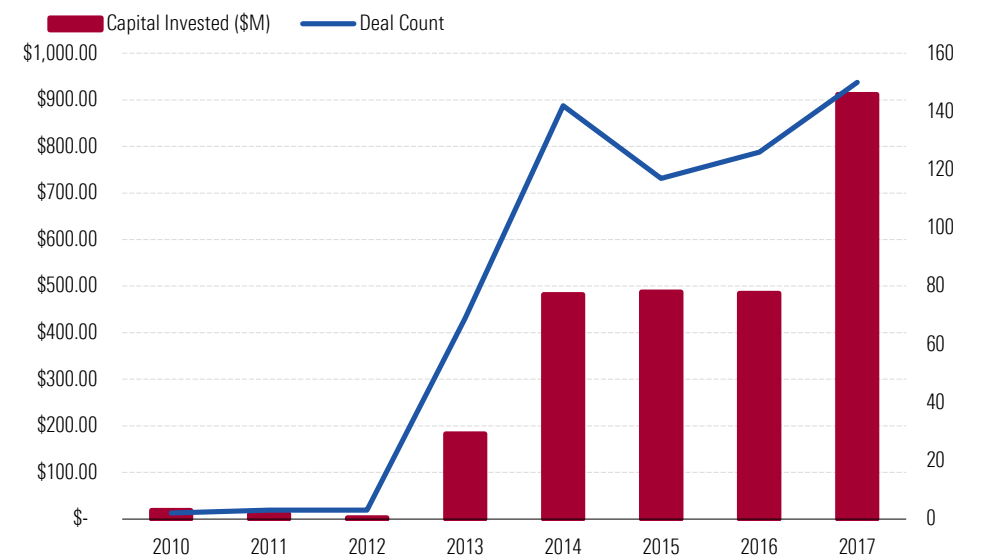

Source: PitchBook. Data as of Feb. 27, 2018.

Steem is an interesting experiment outside of the financial services sector. It produced a crypto-based social publishing platform along the lines of Reddit. Users earn financial rewards in cryptocurrency rather than "upvotes." Canaan Creative produced specialized bitcoin mining hardware. PitchBook's Market Map provides a helpful guide to activity across the space.

Exhibit 14 PitchBook Market Map

Source: PitchBook

Exhibit 15 Venture Capital Deal Activity

Source: PitchBook. Data as of Feb. 27, 2018.

Exhibit 16 Representative Investments in Blockchain Firms

Company	Industry	Amount raised ($ millions)
Canaan Creative	Hardware	471
Steem	Social media	270
R3	Financial infrastructure	107
Ledger	Bitcoin payments	77
Digital Asset	Financial infrastructure	60
Blockstream	Financial infrastructure	55
Ripple	Financial infrastructure	55
Algebraix Data	Advertising	41
PokitDok	Healthcare	38
BitPay	Bitcoin payments	30
BitFury Group	Hardware and software	30
Chain	Financial infrastructure	30
Everipedia	Media	30
I-House	Real estate	30

Source: PitchBook. Data as of Feb. 27, 2018.

Venture capital firms and publicly traded companies are not the only source of funding for blockchain projects, though. The technology has also made possible a completely new asset class, as ventures raise funds by selling digital assets. These initial coin offerings, or ICOs, have resulted in several billion dollars in funding for blockchain projects in the past year alone.

Clearly, ICOs have produced even more speculative activity on average than the venture capital space. Larger amounts of money have been raised by ventures straying even further away from Nakamoto's initial ambitions for payments. As a new, highly speculative asset class, ICOs have generated significant regulatory attention, with some parties engaging in outright fraud as fundraising activity skyrockets.

Exhibit 17 Initial Coin Offerings Have Created a New Avenue for Fundraising

Company Name	ICO Size
Telegram Group Inc	$850 million +
EOS	$700 million +
AriseBank	$600 million
Filecoin	$262 million
Tezos	$232 million
BANCOR	$153 million
The DAO (Decentralized Autonomous Organization)	$100 million
STATUS	$100 million
TENX	$80 million
MOBILEGO	$53 million
SONM	$42 million
BRAVE	$35 million
Ethereum	$18 million
ICONOMI	$10.6 million

Source: Inc.com., Bloomberg, Techworld.com

Exhibit 18 ICO Fundraising Has Grown Exponentially
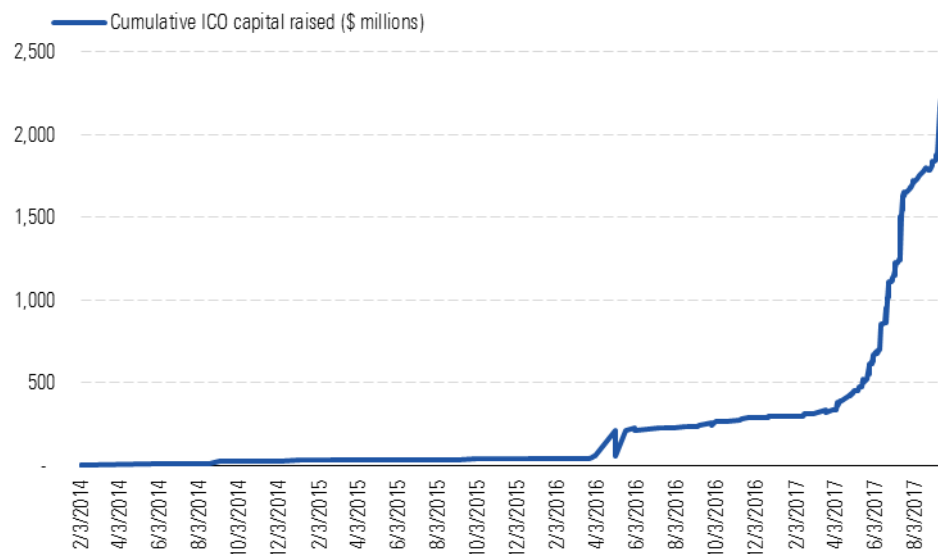
Source: Coindesk

That said, there have been notable ICOs with viable product plans and talented teams, and sophisticated investors have backed some of them. Ethereum and Filecoin, for instance, provide distributed computing. PitchBook has developed a seven-factor framework for qualitatively assessing initial coin

offerings[10]. In addition to factors common to other early-stage ventures (market opportunity, founding team, key milestones, and legal/regulatory considerations), PitchBook suggests analysis of the incentive structure, token classification, distribution, purpose, and the potential network ecosystem.

Exhibit 19 PitchBook Token Analysis Framework

Factor	Key questions
Incentive structure	How are nodes/miners, end-users, and developers incentived to participate?
Token analysis	What is the purpose of the token? Currency, utility, asset-backed, or security?
Market opportunity	What is the total addressable market, and what is the reason for decentralization?
Development team	Who is providing technical and strategic leadership?
Milestones	How much progress has been made?
Legal and regulatory	Do the tokens conform to best practices?
Network ecosystem	Is the network of participants diverse and growing?

Source: PitchBook.

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10 https://files.pitchbook.com/website/files/pdf/PitchBook_1Q_2018_Analyst_Note_Foundational_Framework_for_Analyzing_Crypto_Assets.pdf

Blockchain Applications

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Our analysis, along with the bulk of investment activity in the space, points to three broad primary categories of business applications for blockchain/distributed ledger technology, with significant overlap between them. These categories are: financial transactions, data management, and marketplace activities. Financial transactions involve trust, recordkeeping, and the transfer of information and value. Data management often requires trustworthy, permanent (or at least long-lasting) storage of information. Marketplaces coordinate trust, transactions, and information transfer between unrelated parties.

Financial Transactions

> *Blockchain is another example where, again, this is clearly a threat to our correspondent banking business. —Bank of America*

> *The challenges of speed, of transparency and costs, both in domestic and cross-border payments in B2B, are more interesting —Mastercard*

> *The value that we see in Blockchain really is in settlements. —IBM*

Within the financial services sector, payment transactions were the first application for blockchain technology. We've been bearish on Bitcoin as a method for consumer-to-business payments[11], but other types of payment transactions are proving more amenable to blockchain processing. Cross-border payments, for example, are often accompanied by high fees and long settlement times.

Experiments with trading applications followed initial activity in the payment space. The current financial ecosystem often involves slow transactions, costly and time-consuming recordkeeping activities by multiple parties, and limited transparency[12]. Settlement activities often take days, with information and funds passing through multiple parties as they travel between buyers and sellers.

Blockchain-based clearing and settlement solutions are already being explored by exchanges. These solutions promise to speed up transactions and eliminate the need for costly, duplicative recordkeeping and reconciliation[13]. For example, post-trade processes currently involve payment systems, securities

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11 "Bitcoin: Don't Believe the Hype," Morningstar, April 9, 2014
12 https://www.bis.org/cpmi/publ/d157.pdf

13 https://www.federalreserve.gov/econresdata/feds/2016/files/2016095pap.pdf

settlement systems, central securities depositories, and central counterparties[14], often across multiple jurisdictions.

A simple example of such needless complexity is the practice of balancing a checkbook. There was a time when most bank customers would record all of their transactions, and match that record to the statement sent by the bank at the end of the month. Any differences or disputes could be costly and painful to resolve, as each party has its own version of events. A similar process is undertaken by financial institutions around the world as they reconcile thousands of transactions across a wide variety of markets. Shared, verified ledgers provide an obvious solution, replacing hundreds of hub-and-spoke connections with a means for every node to interact directly with the others.

Companies that engage in similar activities on a large scale are theoretically at risk of being disrupted by decentralization solutions that allow customers to exchange value and share information without the need for a trusted intermediary. Within financial services, these include companies in the payments, custody, and trading industries.

Exhibit 20 Financial Services Intermediaries Are Potentially at Risk

Ticker	Stock Name	Moat	Business	Cost Advantage	Customer Switching Costs	Efficient Scale	Intangible Assets	Network Effect
BK	Bank of New York Mellon Corp	Wide	Custody	●	●			
NTRS	Northern Trust Corp	Wide	Custody	●	●		●	
STT	State Street Corporation	Wide	Custody	●	●			
C	Citigroup Inc	Narrow	Custody	●	●			
HSBC	HSBC Holdings PLC	Narrow	Custody	●	●			
JPM	JPMorgan Chase & Co	Narrow	Custody	●	●			
BNP	BNP Paribas	Narrow	Custody	●	●			
CME	CME Group Inc	Wide	Trading	●			●	●
ICE	Intercontinental Exchange Inc	Wide	Trading	●			●	●
ASX	ASX Ltd	Wide	Trading	●			●	●
LSE	London Stock Exchange Group PLC	Wide	Trading	●	●		●	●
388	Hong Kong Exchanges and Clearing Ltd	Wide	Trading	●			●	●
8697	Japan Exchange Group Inc	Wide	Trading	●			●	●
AXP	American Express Co	Wide	Payments				●	●
MA	Mastercard Inc	Wide	Payments				●	●
WU	The Western Union Co	Wide	Payments	●				●
V	Visa Inc	Wide	Payments				●	●
MKTX	MarketAxess Holdings Inc	Narrow	Trading	●				●
NDAQ	Nasdaq Inc	Narrow	Trading	●				●
DB1	Deutsche Boerse AG	Narrow	Trading	●	●		●	●
S68	Singapore Exchange Ltd	Narrow	Trading	●				●
DFS	Discover Financial Services	Narrow	Payments	●			●	●
PYPL	PayPal Holdings Inc	Narrow	Payments				●	●

Source: Morningstar

14 https://www.federalreserve.gov/econresdata/feds/2016/files/2016095pap.pdf

Identity and Data Management

> *These reflect a wide variety of use cases like … supply chains in retail, valuable goods authentication in industrials and digital identification for governments.* —IBM

> *We must build upon this success to create an open, person-centered health IT infrastructure.*[15] —The Office of the National Coordinator for Health Information Technology

> *(Facebook) is unable to anticipate the ways its platform, and the incredibly powerful trove of sensitive data it produces, can be misused.*[16] —The Wall Street Journal

A blockchain is a distributed database, so it's logical that the technology can be useful in various data management applications. The technology provides a way to secure data, to permit ownership, and to share that data when desired. Companies in a wide variety of industries could move data onto decentralized databases, improving access, security, and transparency in fields from healthcare to transportation. Healthcare records require high levels of security, but this is usually offset by inferior portability as fragments of data are kept at a variety of individual providers over time. As privacy concerns continue to grow and hacking becomes more damaging, consumers may wish to retake control of their own data from the corporations that have been controlling and monetizing it. Decentralized control of identity has the potential to give individuals the rights to share only the aspects of themselves they choose to release.

Supply chain management activities often involve information flow and recordkeeping by hundreds of parties, making a blockchain a seemingly perfect vessel for the maintenance of trade records. Food safety incidents could more quickly be traced back to their origins, for example, and goods and funds could be more easily tracked across international borders.

Companies that gather, manage, and sell data on a large scale could be disintermediated if data collection and management functions move onto a blockchain, with individual citizens or companies controlling the ability to share their data. Financial and consumer data could represent low-hanging fruit for the disruptive technology.

15 https://www.healthit.gov/sites/default/files/hie-interoperability/nationwide-interoperability-roadmap-final-version-1.0.pdf

16 https://www.wsj.com/articles/facebooks-identity-crisis-looms-1521579929

Exhibit 21 Data Aggregators Are Potentially at Risk

Ticker	Stock Name	Moat	Business	Cost Advantage	Customer Switching Costs	Efficient Scale	Intangible Assets	Network Effect
FDS	FactSet Research Systems Inc	Wide	Financial data		●		●	
SPGI	S&P Global Inc	Wide	Financial data		●		●	
EFX	Equifax Inc	Wide	Financial data				●	
INFO	IHS Markit Ltd	Wide	Financial data		●		●	
EXPN	Experian PLC	Wide	Financial data				●	
BIDU	Baidu Inc	Wide	Consumer data				●	●
GOOGL	Alphabet Inc	Wide	Consumer data				●	●
700	Tencent Holdings Ltd	Wide	Consumer data				●	●
TCEHY	Tencent Holdings Ltd	Wide	Consumer data				●	●
FB	Facebook Inc	Wide	Consumer data				●	●
GOOG	Alphabet Inc	Wide	Consumer data				●	●
CSGP	CoStar Group Inc	Wide	Financial data		●		●	●
TRI	Thomson Reuters Corp	Narrow	Financial data		●		●	
SINA	SINA Corp	Narrow	Consumer data					●
WB	Weibo Corp	Narrow	Consumer data					●

Source: Morningstar

Marketplaces

Marketplaces rely on trusted middlemen to broker transactions of all kinds. Blockchains, in contrast, provide the ability to construct decentralized marketplaces. One such example, OpenBazaar, is a decentralized e-commerce market along the lines of an eBay or Amazon. In contrast to its centralized competitors, OpenBazaar charges no platform fees and has few to no restrictions. Most sectors have companies that engage in marketplace activity, matching buyers and sellers and brokering transactions of all kinds, such as C.H. Robinson in industrials and Intercontinental Exchange in financials.

The growth of the "sharing economy" has created new such marketplaces. Firms such as Uber and Airbnb are increasingly serving as markets for unused resources. Over time, more and more economic activity could be organized and consummated using blockchains. Taking this to the extreme, one can easily envision a futuristic scenario in which all capital and labor transactions are decentralized using blockchains. If suppliers, customers, and employees can all arrange transactions via blockchain, the need for profitable intermediation services could decline rapidly.

Exhibit 22 Marketplaces and Distributors Are Potentially at Risk

Ticker	Stock Name	Moat	Business	Cost Advantage	Customer Switching Costs	Efficient Scale	Intangible Assets	Network Effect
SABR	Sabre Corp	Narrow	Application Software		●	●		●
RBA	Ritchie Bros Auctioneers Inc	Narrow	Business marketplace					●
RHI	Robert Half International Inc	Narrow	Employment marketplace				●	●
AMN	AMN Healthcare Services Inc	Narrow	Employment marketplace				●	●
FAST	Fastenal Co	Wide	Industrial distribution	●	●			●
AXE	Anixter International Inc	Narrow	Industrial distribution	●				●
MSM	MSC Industrial Direct Co Inc	Narrow	Industrial distribution	●				●
GWW	W.W. Grainger Inc	Narrow	Industrial distribution	●	●			●
WCC	WESCO International Inc	Narrow	Industrial distribution	●				●
HDS	HD Supply Holdings Inc	Narrow	Industrial distribution	●				●
ABC	AmerisourceBergen Corp	Wide	Medical distribution	●				
CAH	Cardinal Health Inc	Wide	Medical distribution	●				
MCK	McKesson Corp	Wide	Medical distribution	●				
HSIC	Henry Schein Inc	Narrow	Medical distribution		●			
PDCO	Patterson Companies Inc	Narrow	Medical distribution		●			
API	Australian Pharmaceutical Industries Ltd	Narrow	Medical distribution			●		
SIG	Sigma Healthcare Ltd	Narrow	Medical distribution			●		
EBO	Ebos Group Ltd	Narrow	Medical distribution			●		
SEK	Seek Ltd	Narrow	Employment marketplace					●
REA	REA Group Ltd	Narrow	Retail marketplace					●
CAR	Carsales.com Ltd	Narrow	Retail marketplace					●
TME	Trade Me Group Ltd	Narrow	Retail marketplace					●
MTCH	Match Group Inc	Narrow	Retail marketplace					●
DHG	Domain Holdings Australia Ltd	Narrow	Retail marketplace					●
AMZN	Amazon.com Inc	Wide	Retail marketplace	●			●	●
MELI	MercadoLibre Inc	Wide	Retail marketplace					●
BABA	Alibaba Group Holding Ltd	Wide	Retail marketplace	●			●	●
EBAY	eBay Inc	Narrow	Retail marketplace					●
4755	Rakuten Inc	Narrow	Retail marketplace				●	●
CHRW	C.H. Robinson Worldwide Inc	Wide	Logistics					●
EXPD	Expeditors International of Washington Inc	Wide	Logistics					●
LSTR	Landstar System Inc	Wide	Logistics					●
HUBG	Hub Group Inc	Narrow	Logistics	●				●
JBHT	JB Hunt Transport Services Inc	Narrow	Logistics	●				●
KNIN	Kuehne + Nagel International AG	Narrow	Logistics					●
DSV	DSV A/S	Narrow	Logistics					●
ECHO	Echo Global Logistics Inc	Narrow	Logistics					●
CTRP	Ctrip.com International Ltd	Narrow	Retail marketplace					●
EXPE	Expedia Inc	Narrow	Retail marketplace					●
BKNG	Booking Holdings Inc	Narrow	Retail marketplace					●
TRIP	TripAdvisor Inc	Narrow	Retail marketplace					●
TVPT	Travelport Worldwide Ltd	Narrow	Retail marketplace				●	●

Source: Morningstar

Industry-Specific Moat Analysis

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Decentralization via blockchain offers several potential benefits to customers. For example, Bitcoin offers more privacy, greater transparency, more security, and lower costs (at least in theory) than centralized methods of payment processing. These potential advantages provide much of the appeal of blockchain applications.

On the other hand, these benefits are not always the sole factor in a customer's decision process. The source of a company's moat plays a role in its susceptibility to disruption by decentralization. We recognize five distinct moat sources: cost advantages, intangible assets, switching costs, network effects, and efficient scale. All five sources of economic moat can prevent disruption by decentralization. It takes years to build the network effects and intangible assets possessed by some of the companies we cover. Switching costs—especially those related to complex technology—can be quite high. Finally, decentralization does not always lead to lower costs—the redundancy inherent to initial blockchain applications adds time and expense over centralized solutions. Efficient scale moats are created when centralization is needed to attain satisfactory returns on capital, and is often grounded in measures of proximity that blockchain does not address (railroads, airports, and so on).

Cost advantages often stem from production at scale—a clear benefit to centralization in most cases. Retailers such as Amazon, Costco, and Walmart use scale to procure goods at low cost and to distribute them cheaply. Similarly, providers of cloud computing such as Amazon, Microsoft, Alphabet, and Alibaba spread the large costs of hardware, software, power, and staffing across a broad base of customers.

Other moat sources are less dependent on the centralization of activity. Intangible assets confer competitive advantages via pricing power associated with brands, patents, proprietary technology, and/or regulation. The consumer sector abounds with strong brands, while healthcare companies rely on patent protection to sustain excess profits.

We believe companies benefiting from switching costs can also be well-protected from the disruptive threat of decentralization. Switching costs sometimes arise because of accumulated customer expertise. Customers of technology companies such as Adobe Systems, Autodesk, and Microsoft (Office) would incur significant costs to retrain on a new software package. Similarly, doctors sometimes invest years learning the intricacies of a particular medical device. Enterprise software companies often benefit from high switching costs due to long product cycles, high costs of implementation and training, and difficulty of data migration. Interestingly, the mission-critical nature of many enterprise software applications—

including financial, supply chain, and data management—increases switching costs[17], although these functions are some of the most mentioned use cases for blockchain technology.

Interestingly, some of the widest moats are held by companies able to centralize economic activity. Network effects are a strong force driving activities toward centralization. Globally, we cover around 100 companies across various sectors with wide or narrow moats stemming from network effects. Within the consumer space, marketplaces such as Expedia, Priceline, eBay, MercadoLibre, Alibaba, Rakuten, Ctrip, and Amazon create value by coordinating the transactions of buyers and sellers. In financial services, American Express, Visa, Mastercard, PayPal, Western Union, and Discover transfer funds from consumers to merchants. Exchanges such as Deutsche Boerse, the London Stock Exchange, Intercontinental Exchange, ASX, and Singapore Exchange allow customers to trade securities. Industrial firms such as Expeditors International and C.H. Robinson serve as marketplaces for transportation services. Within the technology sector, social networks such as Facebook and Weibo coordinate social interactions, while platforms such as operating systems of Microsoft and Alphabet create networks of developers and customers.

Of course, these are all centralized networks, while blockchain enables decentralized networks. Network moats are powerful because they are often difficult to form and to disrupt, and because they rapidly lead to efficient scale in many cases. Forming a new network business typically requires both large amounts of funding and a brilliant business plan. Blockchain tokens, however, provide a completely new way to incentivize network participation. Network users and developers benefit from their participation as demand for services grows. This is the key mechanism by which current economic paradigms could be disrupted.

In the sections that follow, we explain how blockchain technology could be applied to a variety of economic activities and we identify the moat sources that could allow incumbents to resist the threat of decentralized competition.

Application: Consumer-to-Business Payments
Companies Affected: Visa, Mastercard, American Express, Discover, PayPal, Square, Vantiv
Incumbent C2B payment companies benefit from intangible assets, offer value-added services beyond transaction processing, and have spent decades building network effects.

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17 "Economic Moat Source Series: Switching Costs" Morningstar, Oct. 9, 2017

Exhibit 23 Blockchain Technology Could Replace Payment Middlemen
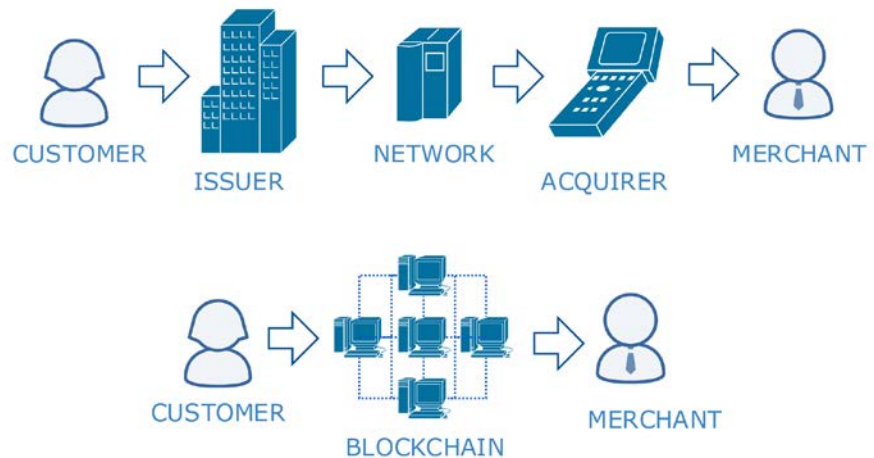
Source: Morningstar

Bitcoin is the first and most obvious example of blockchain technology. The cryptocurrency is now worth tens of billions of dollars, with billions of dollars changing hands in (primarily) peer-to-peer transactions on a daily basis. With merchants clamoring to lower their cost of accepting payments, the consumer-to-business payment market (with its multiple highly profitable intermediaries) provides a straightforward use case for a decentralized ledger.

However, nearly 10 years after it was introduced, the consumer-to-business Bitcoin ecosystem is still in its early stages, with numerous parties still in the process of building a network of consumers, merchants, miners, and bitcoin businesses. Note that unlike the traditional payment paradigm, there is no theoretical need for financial institutions acting as issuers and acquirers. In practice, though, companies like BitPay and Coinbase provide services to merchants, and a variety of firms provide storage in the form of bitcoin wallets and exchange other currencies for bitcoins.

To pose a threat to the current payment paradigm, the bitcoin ecosystem must establish a network effect comparable to those of Visa, MasterCard, PayPal, and other major players. This will require a critical mass of each of the participants. Just as Visa's network's value depends on its enormous base of cardholders, issuers, merchants, and acquirers more so than its technology, the bitcoin ecosystem's value depends on the same.

The primary obstacle is that bitcoins do not have large enough base of users to compete with the network of Visa and MasterCard. The importance of the network effect to payment providers cannot be overestimated. In our view, the decentralized nature of bitcoins is a major disadvantage in building a network of users and merchants. Both credit cards and debit cards rely on banks for distribution to customers. This provides the Visa and MasterCard brands with an enormous base of users. PayPal was

able to build its network by focusing on eBay transactions and providing a valuable service to both users and merchants selling online, and is still attempting to establish a physical presence. Sears — the largest U.S. retailer at the time — originally issued the Discover card, which has only recently expanded acceptance to a level competitive with Visa and MasterCard. At present, bitcoins essentially rely on word of mouth to gain consumer users and only a few small startups are actively attempting to sign up merchants. Merchant acceptance is rumored to be falling, not growing. Thus the new payment paradigm has a steep hill to climb if it is ever to threaten Visa and MasterCard. We note that companies that have already established extensive user bases, such as Google, Apple, and Facebook, have a major distribution advantage over bitcoins but have yet to introduce successful proprietary payment systems.

In addition to their distribution systems, the established payment networks put significant efforts into marketing campaigns. Over the years, these expenditures have contributed to the establishment of valuable brand intangible assets as well as helped the companies build their customer bases. In our view, a decentralized system like Bitcoin cannot hope to match these efforts on its own.

We think the relative lack of protections will be an issue for consumer adoption. Bitcoin transactions are designed to be nonreversible — a benefit for merchants who would no longer need to take responsibility for preventing fraud, but a major impediment to consumer adoption. Finally, the current payment paradigm passed benefits on to consumers in the form of rewards. In theory, the lower cost of bitcoin transactions would eventually be passed on to customers in the form of lower prices, but the initial loss of benefits is also likely to hinder consumer uptake.

On the merchant side of the equation, barriers to adoption also exist. First, it is costly and difficult to roll out new point-of-sale technology to physical locations on a large scale. Square has utilized iPads for small merchants, but PayPal has partnered with Discover in order to achieve acceptance, and the United States is still waiting for the EMV chip-and-pin infrastructure that would significantly reduce fraud.

That said, bitcoin/blockchain technology may be able to provide a cost savings to merchants. Traditional merchant acquirers charge discounts averaging around 2.3% of transaction value, which is split among issuers, networks, acquirers, and cardholders. Bitcoin appears at first glance to be a much cheaper option. Bitcoin's lack of reversibility is an obvious source of cost advantage for merchants. We estimate that fraud costs account for about one fifth of a typical 2.3% merchant discount fee. The bitcoin peer-to-peer network, perhaps surprisingly, is not a major advantage to merchants. We estimate that network operation costs, including marketing functions, account for only a small portion of a typical discount fee, with network operating profits making up a slightly larger portion. Card issuer and acquirer operating costs make up almost half of the discount fee. At first glance, this seems like an obvious advantage for bitcoins. However, we note that most merchants and cardholders will need to employ similar services to access the bitcoin network, keep records, and so on, and these newer companies will not enjoy the scale of large card issuers and acquirers. In our view, a bitcoin cost advantage therefore depends primarily on shifting the burden of security away from banks and merchants to the buyer.

We also think bitcoin's current competitive advantages pale in comparison to the economic moats established by existing payment firms. In order for bitcoins to pose a real threat, the early-stage business models based on the technology must figure out how to increase benefits to consumers while developing powerful distribution models, trusted brands linked to—but separate from—bitcoins themselves, and keep costs of acceptance low. At this point, we believe the probability of a firm succeeding across all these fronts is minimal. While this shouldn't and won't stop venture capitalists from investing in bitcoins' potential, we think the excitement about the cryptocurrency may be overdone.

The final obstacle is that bitcoin processing alone can already be quite expensive. The average transaction fee is currently less than $1.00[18], but fees have spiked well above that over time. In comparison to the average U.S. debit transaction, bitcoins are currently no bargain.

Application: Clearing and Settlement, Custodial Services
Companies Affected: CME Group, Bank of New York Mellon, State Street
The value-added services provided by custody banks create high switching costs, and centralized intermediaries now benefit from tremendous economies of scale.

Exhibit 24 Blockchain Could Reduce the Need for Costly Capital Markets Intermediaries
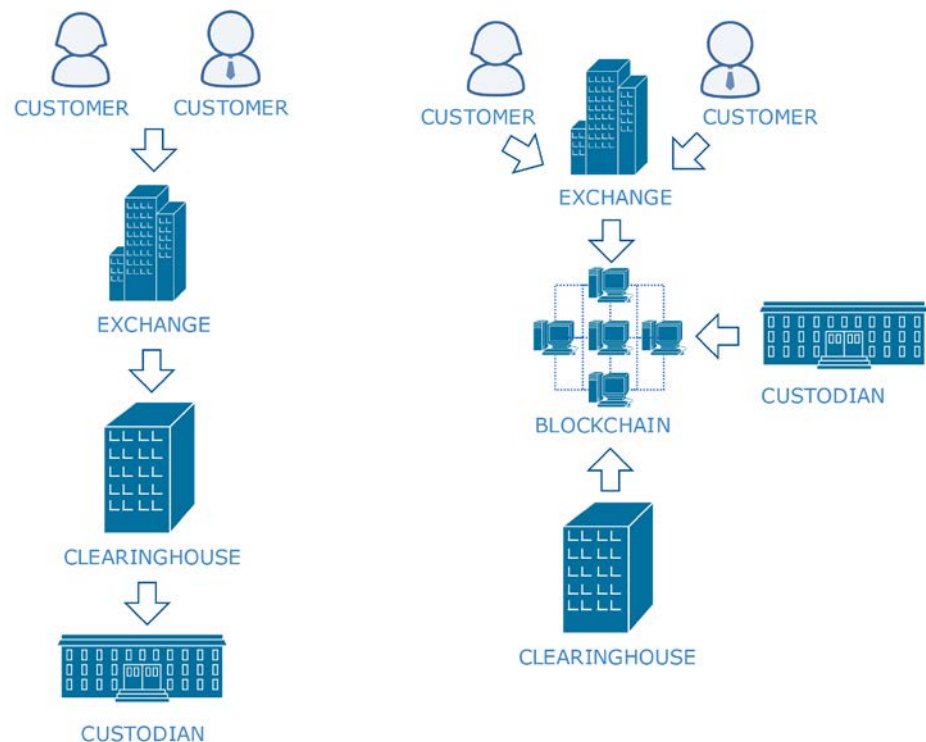
Source: Morningstar

18 https://bitcoinfees.info/

Blockchain promises to eliminate centralized control of transactions, reduce transaction costs, and eliminate redundant records. Financial markets are some of the most complex, costly, and redundant systems in the economy. For example, post-trade processes currently involve payment systems, securities settlement systems, central securities depositories, and central counterparties[19], often across multiple jurisdictions. The Federal Reserve has outlined[20] a few key motivations leading financial firms to explore blockchain solutions, including reduced complexity, improved processing speed, decreased need for reconciliation, increased transparency, improved network resiliency, and reduced operational risk. In general, combining trading and post-trading activities into a single step offers immense increases in speed and decreases in costs. Accenture estimates[21] that investment banks could save 70% on central financial reporting, up to 50% on compliance, and 50% on centralized client management activities and back-office operations (including clearing and settlement).

The Federal Reserve's report on blockchain also highlighted the importance of network effects in payments, clearing, and settlement activities. Both market participants and regulators would likely have to join and participate in a blockchain-based system. It follows that an industry consortium may be the source of new technologies, rather than a disruptive, decentralized force from outside the industry, as it would be difficult for a disrupter to gain enough buy-in from the major financial industry players.

Switching costs are another factor. Banks are still using, in some cases, legacy systems dating back more than 30 years. In addition to the need for a new technology to be interoperable with these systems, the advanced age of some existing financial systems illustrates the slow speed at which the financial industry moves and the high switching costs for participants.

In the world of custody, switching costs are high. Client back-office infrastructures are often tightly connected to the infrastructures of a custodian. The services provided are mission-critical, with extremely high costs of failure. Additionally, large custodians are typically providing multiple value-add services in addition to basic custody and reporting, further increasing switching costs. The complex needs of institutional investor clients extend far beyond basic post-trade processing and recordkeeping.

While blockchain promises to decrease costs, the cost savings in post-trade and custody may not be the best opportunity for blockchain. The largest custody banks, exchanges, and industry utilities (such as the Depository Trust & Clearing Corporation) are already well-scaled: they are custodian of trillions in assets and process tens of millions of trades per day. Additionally, because of the scalable nature of many of these activities and either competitive forces or nature of being an industry utility, cost of services is generally kept low.

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19 https://www.federalreserve.gov/econresdata/feds/2016/files/2016095pap.pdf

20 https://www.federalreserve.gov/econresdata/feds/2016/files/2016095pap.pdf

21 https://www.accenture.com/t20171108T095421Z__w__/us-en/_acnmedia/Accenture/Conversion-Assets/DotCom/Documents/Global/PDF/Consulting/Accenture-Banking-on-Blockchain.pdf#zoom=50

We don't see blockchain technology replacing many of the trading and clearing functions of the wide-moat futures exchanges that are based in intangible assets. While blockchain can be used in some aspects of trade processing, one of the main value-added aspects of trading at the futures exchanges is in their created or licensed intellectual property. While a new blockchain system could enable trading, it may not have the ability to trade products that belong to other entities, such as S&P 500 futures. It would also be difficult for any new entrant using blockchain to duplicate the physical infrastructure, such as warehouses, needed to trade and settle many physical commodities, such as metals and agriculture.

Important functions of clearinghouses may not be immediately replaced by blockchain. For the futures clearinghouses, their main function is the amelioration of counterparty credit risk. A blockchain entrant into futures clearing would have to gain the trust of many of the largest financial institutions and be able to transfer assets from their accounts when their trading positions are in a loss position to ensure that the holder of the other side of the trade that is in a gain position can be paid. For futures clearing, we currently view blockchain as a way to make existing processes more efficient, rather than a completely disruptive force. In fact, the Australian Securities Exchange is already planning to use blockchain technology for clearing and settlement purposes.

Application: Cloud Computing
Companies Affected: Amazon, Microsoft, Dropbox
The largest players in cloud computing have enormous cost advantages due to scale, while blockchain technology's technical and regulatory limitations remain a significant hurdle to overcome.

Exhibit 25 Blockchain Could Offer Low-Cost Distributed Computing

Source: Morningstar

A blockchain is a form of distributed computing power, so it makes sense that technology companies entered the fray in short order, using blockchain to decentralize computing power. Ethereum itself is a distributed computing system. Filecoin, a decentralized storage network competing with Box and

Dropbox, raised more than $250 million in its initial coin offering. At first glance, it seems that decentralized, distributed computing resources could replace large corporate providers in short order.

However, this use case illustrates some of the tensions inherent to the sharing economy. The most successful companies in this business, such as Uber and Airbnb, are essentially a means of monetizing excess or underutilized capacity rather than a means of organizing all such capacity. Indeed, Uber is already embarking on a program to maintain its own fleet of automated vehicles, rather than merely match supply and demand. Similarly, computing power is increasingly being centralized due to the massive cost advantages that accrue with scale. Corporations are increasingly outsourcing the capital intensive, high fixed-cost functions of computing power and data storage supply to a handful of large vendors rather than running these functions in-house and attempting to sell varying amounts of excess capacity on the open market.
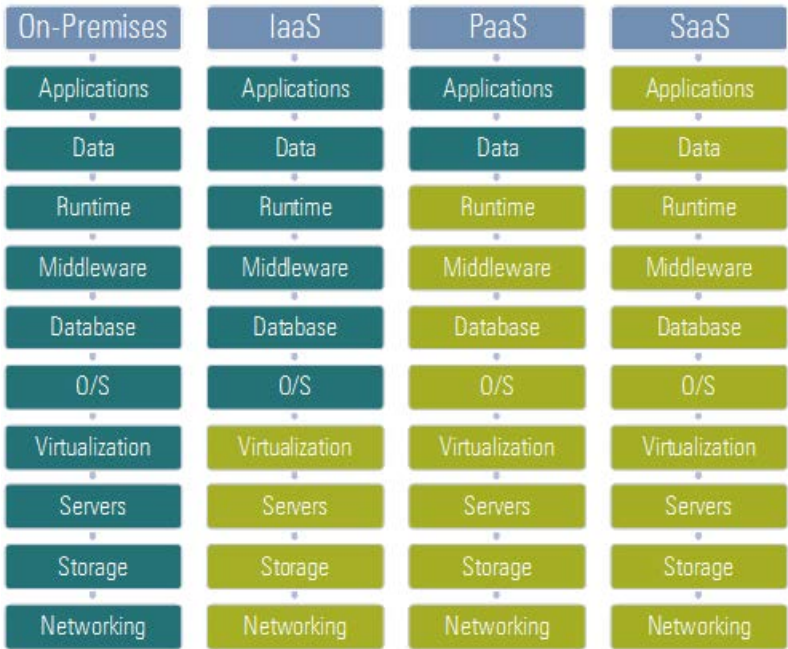
Technical considerations are an obstacle to some blockchain-based solutions. Centralized control is actually necessary for certain types of processing, including serial computations and others that are difficult to run in parallel. Decentralized systems work well for tasks that can easily be broken into smaller pieces, and when a high degree of redundancy/resiliency is required. IBM's Watson, for instance, is made up of a cluster of processors, providing enhanced communication speed and flexibility (ideal for Jeopardy), while the BOINC system running SETI@Home and other similar projects runs on thousands of smaller computers around the world (ideal for searching large amounts of data for alien signals).

Once again, security and data sovereignty issues also favor the incumbents over a distributed solution. Sensitive data is often required to in a specific jurisdiction. This is an issue for all providers of cloud-based solutions—not just blockchain. Furthermore, even Ethereum's Vitalik Buterin admits[22] that, "neither companies or individuals are particularly keen on publishing all of their information onto a public database that can be arbitrarily read without any restrictions by one's own government, foreign governments, family members, coworkers and business competitors."

Cloud computing can be broken down into three segments: infrastructure-as-a-service (outsourced virtualization, servers, storage, and networking), platform-as-a-service (outsourced infrastructure, operating system, database, middleware, and runtime), and software-as-a service (outsourced infrastructure, platforms, plus applications and data). Blockchain-based distributed systems are initially offering primarily infrastructure-as-a service and platform-as-a-service. The chart below summarizes the functions that are outsourced by customers (light green) versus performed in-house (dark green) in each type of cloud application.

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22 "Privacy on the Blockchain," Jan. 15, 2016, Vitalik Buterin, Ethereum Blog

Exhibit 26 Blockchain Offers Decentralized Infrastructure and Platform Capabilities

On-Premises	IaaS	PaaS	SaaS
Applications	Applications	Applications	Applications
Data	Data	Data	Data
Runtime	Runtime	Runtime	Runtime
Middleware	Middleware	Middleware	Middleware
Database	Database	Database	Database
O/S	O/S	O/S	O/S
Virtualization	Virtualization	Virtualization	Virtualization
Servers	Servers	Servers	Servers
Storage	Storage	Storage	Storage
Networking	Networking	Networking	Networking

Source: Morningstar

Cost advantages stemming from scale favor the incumbents in the IaaS market. Vendors must be able to generate scale efficiencies on the input costs that are included with running a data center: technology hardware, infrastructure software, land, power, cooling, networking, and IT staffers to manage the infrastructure. This requires significant initial investment to build out a large enough network of data centers to meet customer service-level agreements, clear governance, data sovereignty, and regulatory hurdles, and provide enough supply in the event of outages or spikes in demand. Again, the services provided—above and beyond commoditized computing power—are the more valuable part of the IaaS business.

We believe competitive advantages in PaaS will primarily come by way of switching costs. Most platform-as-a-service offerings create a natural lock-in for customers, as applications are developed on a fixed software stack that often features proprietary components such as programming languages, data sets, and other software layers. At the same time, large tech firms such as Microsoft, IBM, and Amazon are adding blockchain-as-a-service to their current PaaS offerings[23].

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23 "Blockchain as a Service (BaaS): Plug and Play of Blockchain Services," Durga Prasad and Kuljit Singh, Jan. 10, 2017, Infosys

Application: Credit Reporting
Companies Affected: Equifax, Experian

The enormous databases and established performance records of existing credit bureaus create powerful intangible assets, despite the security advantages of blockchain technology.

Exhibit 27   Credit Data Could be Securely Stored via Blockchain

Source: Morningstar

Credit reporting agencies demonstrate the risks associated with centralized control of ostensibly private data. Major credit bureaus have suffered breaches in recent years, including Equifax's loss of millions of customers' personal information in September 2017. Other private data, such as healthcare records, may be equally vulnerable. A secured, shared distributed ledger offers the promise of greater security and privacy for customers. Ventures intending to produce such a system have already launched. Bloom, for instance, allows users to create an identity, allow others to verify that identity, securely stores debt repayment data, and produces a score without revealing the personal data it uses.

However, disruption of these business lines also seems unlikely. The credit bureaus' moats stem from valuable intangible assets stemming from data collected over years—established credit bureaus have a long head start over newcomers to the space.

Application: Freight Brokerage
Companies Affected: C.H. Robinson, Echo Global Logistics, Landstar

Existing freight brokers provide a variety of value-added services beyond simple matchmaking, and utilize large sales forces to grow and maintain their network effects.

Exhibit 28 Customers and Suppliers Could Arrange Transactions via Blockchain

Source: Morningstar

Logistics functions involve the coordination of information between various parties in the supply chain—the storage and transportation of goods often requires multiple intermediaries. Communication between parties in trucking remains quite manual; sometimes it takes brokers and asset-based truckers hours to complete a transaction, given the need for multiple phone calls and emails including scheduling, rate negotiation, status updates, and so on. Like the financial markets, transportation markets seem like a good fit for simplification via distributed ledgers.

In fact, transportation markets are already beginning to evolve. Digital freight markets such as Uber Freight now match shippers and truckers on demand, using algorithms to replace the intermediaries that have historically brokered such transactions. We think the key differences between DFMs and traditional brokers such as C.H. Robinson, Echo, and Landstar involve the freight apps' digitized, head-count-light infrastructure with no (or very few) salespeople or commissions, and limited carrier sourcing personnel. The large traditional brokers utilize a model combining technology, back office headcount, and highly proactive salespeople. The digital freight matching model depends on the development of a broad network of small carriers and lower-cost, lower-priced service. Freight apps will likely gain some traction in the years ahead, and they could prove to be a first step toward the application of blockchain technology in logistics longer term, but we don't think this spells disaster for moatworthy brokers.

The network effect, which supports the economic moats of several truck brokers we cover, provides context for framing the threat of digital freight-matching companies. At its heart, the network effect implies that the more parties (suppliers and customers) that use a logistics provider's network, the more powerful the network becomes and the harder it is to replicate. Large traditional brokers such as C.H. Robinson, Echo Global Logistics, and Landstar have each amassed an immense customer base of shippers that aggregates sufficient demand to attract substantial truckload capacity while bestowing robust buying power relative to small and midsize brokers and shippers. Along these lines, vast capacity relationships and deep lane experience have allowed C.H. Robinson and Echo to win highly service-

intensive price-committed business among large shippers over the years. Also, these firms are no slouches on the IT front—heavy investment has allowed them to monetize their deep reservoirs of market-transaction data, and we expect that to persist.

Sourcing capacity in the incredibly fragmented truckload market first requires freight density and numerous carrier-facing sales personnel to be in constant contact with small fleets, which make up most of the carrier base. The more that capacity tightens, the more a broker must work the phones to secure trucks to get freight moved. C.H. Robinson employs roughly 1,300 carrier-sourcing reps, while mobile-app based marketplace Convoy had around 120 total employees as of mid-2017. In theory, a blockchain-based rival would rely on a more organic (and most likely slower) method of growing the carrying capacity of the network.

Sales and service activity plays a role both in establishing network effects and generating intangible assets in the form of customer goodwill. To date, trucking activity requires human support, especially for manual oversight of location tracking, appointment scheduling, and exceptions like billing errors, cargo damage, and late arrivals. It will be some time before all of these activities can be automated.

Application: Marketplaces and Distributors
Companies Affected: Amazon, Alibaba, McKesson, Anixter

The most advantaged marketplaces and distributors benefit from economies of scale, and provide value-added services to customers, including technical expertise and logistics management.[1]

Exhibit 29 A Wide Variety of Marketplace Activities Can Be Moved Onto a Blockchain

Source: Morningstar

All types of marketplaces can, in theory, be moved to a blockchain. Already, internet marketplaces have managed to disintermediate all types of commerce—Amazon and Alibaba have disrupted dozens of industries by connecting buyers directly to sellers. However, these companies have done so by taking on

the role of "trusted third party." Blockchain technology and smart contracts—by solving the trust problem—can remove the need for these newer corporate intermediaries[24].

In general, the more commoditized the product or service, the more amenable to a move to the blockchain. Israel's LaZooz, for instance, already provides a decentralized transportation service like Uber's. OpenBazaar is ostensibly a rival to marketplaces such as eBay or Etsy. Even for companies that provide only a marketplace, existing network effects are difficult to break, and new networks are difficult to establish.

Morningstar covers a wide variety of industrial distributors, most of which provide value-added services in addition to serving as a marketplace. These supply chain and inventory-management services include customer-managed inventory programs, vendor-managed inventory programs, industrial vending, and a host of related solutions. These solutions can eliminate the need for in-house procurement professionals and reduce product consumption and leakage. Many distributors also have technical expertise and offer operational reviews that can save customers time and money. Many of these also maintain inventory, and benefit from buying power produced by economies of scale. Economies of scale are even more prevalent in the pharmaceutical distribution industry—three companies control 90% of the buying power, while end-providers are relatively small and fragmented. Pharmaceutical distributors provide franchising/network infrastructure, inventory management, reimbursement/payment management services, and group purchasing discounts to their customers. While smaller pharmacies rely on these services for essential operational needs, branded manufacturers also use AmerisourceBergen, Cardinal Health, and McKesson as their distribution and inventory management divisions. Instead of building internal logistical operations, manufacturers leverage the expertise, warehouse networks, and retail pharmacy relationships of the major distributors.

Morningstar recently conducted an assessment of distributor vulnerability to digital disruption[25], and we believe the results of this research are applicable to the blockchain threat. Companies that sell specialized products, utilize their scale to increase customer buying power, and provide value-added services should be resistant to the threat of new digital intermediaries, as well as the complete disintermediation of their businesses via blockchain.

We also note that Amazon itself has had more difficulty penetrating the business-to-business market, as specialization and service (intangible assets) are arguably as important as network effects. In the realm of office supplies (with fairly commoditized products), the FTC found that Amazon's limited request for proposal experience, lack of customer-specific pricing ability, and lack of control over third-party pricing and delivery hurt the retail giant's ability to compete with Office Depot and Staples. We further note that business-to-business distributors typically provide logistics expertise at least on part with Amazon's—a blockchain-based solution would be at a huge disadvantage on this front.

24 "Blockchain and Smart Contracts Will Eat Online Marketplaces," Dec. 1, 2016, Hicham Ezzahid, Medium.
25 "Industrials Observer: Middlemen in the Crosshairs: Which B2B Survivors Will Survive (and Thrive) in the Digital Age?" Dec. 14, 2017

Blockchain Limitations

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Beyond competitive considerations, there are some broad technical reasons blockchain technology may not be extremely disruptive in the near term. Despite the hype, major issues remain. There are tradeoffs among decentralization, scalability, and security.

Exhibit 30 Decentralization, Scalability, and Security Can Be Mutually Exclusive
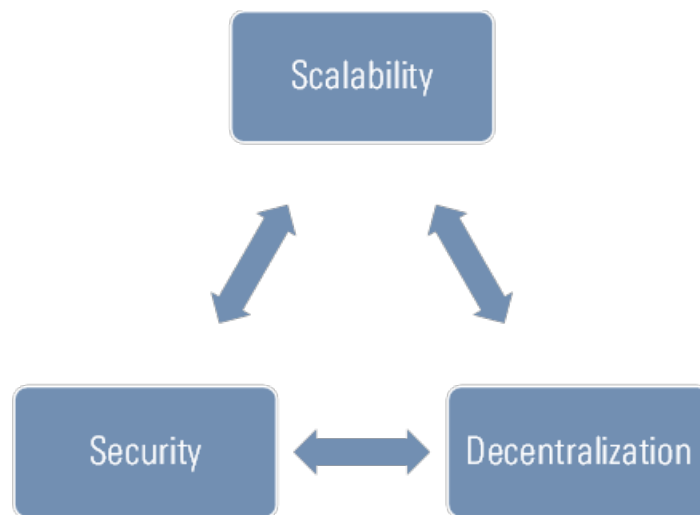

Source: Morningstar

It's important to remember that decentralization is not always better. Without a clear chain of command, disagreements can cause major problems. Already, major blockchains have experienced disputes and forks (disagreements that result in permanent splits of a chain and the efforts surrounding it). Indeed, the history of other open-source software efforts such as Linux is replete with variations and splits. Two such splits in the blockchain world involved Bitcoin and Bitcoin Cash and Ethereum/Ethereum Classic. The first of these involved a disagreement over how to solve the scalability problems facing bitcoins. Some developers and other participants chose to support an implementation of larger block sizes and thus, faster transaction speeds. Others essentially stuck with rules closer to the initial bitcoin implementation. The split created two communities and two digital assets—bitcoin and Bitcoin Cash. The other notable split stemmed from a successful hack related to "the DAO" experiment on Ethereum. A bug in the code governing "the DAO" allowed a hacker to divert the organization's funds to his own account. The Ethereum Foundation chose to introduce code disallowing any future transactions related to those funds—changing the rules midgame to punish an otherwise "legal" cheater. Those who rejected the change stuck with the asset now known as Ethereum Classic, while the bulk of users are

continuing on with the larger, updated Ethereum. Centralized control has its disadvantages, but the ability to quickly and efficiently resolve disputes is a major advantage over decentralization.

Scalability remains a major issue—typically, all nodes will process all transactions in parallel, which leads to enormous inefficiencies. Estimates from digiconomist.net indicate that the Bitcoin network alone is consuming close to 60 terawatt hours of electricity per year[26]. For comparison, the largest nuclear plant in the United States, the Palo Verde plant, produces about 3,937 megawatts at net summer capacity[27]. It would therefore take almost two of these plants operating at full capacity to power Bitcoin for a year. There are some potential solutions to the technology's problems. Reducing the need for parallel storage and processing is a key objective—ideally, enough nodes participate to produce the benefits of blockchain protocols, but not so many that time and cost begin to cause problems. Some actions can also be moved off the blockchain to better balance speed and security, but such solutions are in the early stages[28].

Exhibit 31 Bitcoin Power Consumption in Perspective
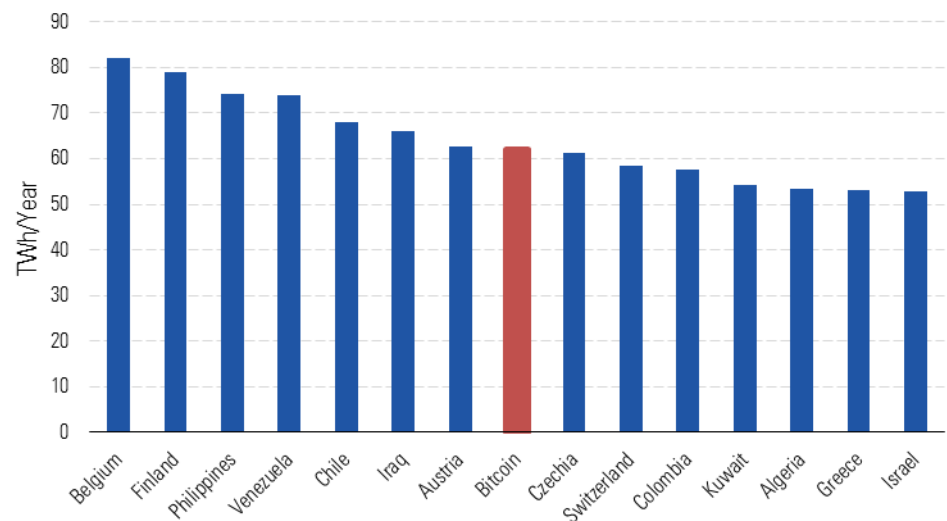
Source: CIA, Digiconomist.com. Data as of April 23, 2018.

Privacy and security concerns still exist in the blockchain world. While the system itself can be quite secure, individual accounts can be far more difficult to maintain. In the case of bitcoins, for instance, a lost private key—and the funds attached to it—can never be recovered. Fifty-one-percent attacks are not out of the realm of possibility. As bitcoin mining activities became both more profitable and more difficult, large miners began to centralize processing activity with the decentralized network. Selfish

26 https://digiconomist.net/bitcoin-energy-consumption

27 https://www.eia.gov/tools/faqs/faq.php?id=104&t=21

28 https://medium.com/l4-media/making-sense-of-ethereums-layer-2-scaling-solutions-state-channels-plasma-and-truebit-22cb40dcc2f4

mining can also create problems[29]. This strategy involves a pool of miners temporarily "hiding" the longest chain from the network's honest nodes. The rogue miners can thus establish a lead, generating more legitimate blocks and rewards while the honest nodes waste resources attempting to catch up. This also gives honest miners the incentive to turn rogue and join the selfish pool until rogue miners dominate the network.

Perhaps more important, a plethora of individual targets offsets the lack of a central target for hackers. Theft or loss of a bank card is now a relatively small, manageable problem. Unfortunately, the loss of a private key can result in massive, irreversible losses. Responsibility for safety and security falls on the individual. Some participants prefer this philosophically, but in practice many will depend on third parties for storage and custody of valuable information, effectively recreating the existing financial system.

Bugs can also present massive problems due to the irreversibility of transactions. In a simple example, a code vulnerability led to a dispute and hard fork between Ethereum and Ethereum classic. As smart contracts become more prevalent, users must ensure the software and smart contracts they are using are bug-free, replacing trust in humans with trust in code. If "code is law," then ignorance of the code is no excuse. M

Cryptoeconomic Considerations

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It's worthwhile to distinguish among the multiple types of digital assets ("tokens") that can be stored on a blockchain. Payment tokens, like bitcoins, are transferrable stores of value. Utility tokens are needed to pay for usage of a blockchain application. For example, Ether pays for computing processing on the Ethereum network. Security tokens represent a traditional financial asset in digital form (securities such as equities can also be tokenized and transacted via blockchain).

Unlike traditional stocks and bonds, there no cash flows associated with ownership of a utility token, no economic profits to be had, and no economic moat sources. However, that does not mean that such cryptocurrencies have no value. Bitcoin, for instance, is a type of digital money[30]. Money is any good that is widely accepted as payment for goods and services[31]. It serves as a store of value, a unit of account, and a medium of exchange. Bitcoin is clearly not a perfect currency—its volatility versus other currencies has been too high during its short history to be confident in its ability to hold value over a long time period. On the other hand, its limited supply—only 21 million units will ever be produced—is an attractive feature. It's not widely used to purchase goods and services, but it is increasingly accepted for that purpose. At least to some extent, bitcoins can be used as a medium of exchange, and for some transactions—those conducted outside the purview of authorities—it is clearly more useful than other types of currency.

Bitcoin's value is therefore driven by its utility (the digital asset is needed to utilize the payment network) and scarcity (the supply of bitcoins is limited). The same holds true for many other tokens—their utility gives them value. Much as oil is used to produce energy, or agricultural products are used for food, the functionality of utility tokens endows them with value. Unlike most commodities, however, the supply of many tokens is generally not replenished or used up on a regular basis. The annual production of bitcoins, for instance, is small in comparison to the total supply, making it more like gold than oil[32]. As in the case of commodities, supply (determined by developers) and demand (created by users) drive the price of tokens. Growing demand therefore leads to value creation at the token level—to the extent that the supply does not increase at the same time. Limited supply and growth in demand have clearly fueled the appreciation of bitcoins, for example (although abrupt changes in demand have contributed to

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30 Three basic types of money exist. Commodity money has value due to its utility. For example, cigarettes and precious metals can be used as money for this reason. Representative money can be exchanged for a useful commodity. A certificate entitling the bearer to a quantity of gold is a form of representative money. Finally, fiat money gains its value via government decree. If a government declares something (like a paper dollar) is acceptable for commerce (and the decree is widely accepted), an otherwise useless item like a $20 paper bill can be exchanged for goods and services.

31 https://www.stlouisfed.org/education/economic-lowdown-podcast-series/episode-9-functions-of-money

32 https://www.ft.com/content/fd892dda-bce0-11e0-bdb1-00144feabdc0

extreme volatility). Even in cases where supply is limited, demand may turn out to be transient. Some observers[33] have rightfully pointed out that many blockchain services may eventually be interchangeable, leading to commoditization. Interestingly, this could already be happening in the case of bitcoins. Alternatives such as litecoin and Monero have arisen, offering similar—and arguably better—functionality than the original bitcoins. Rivals to Ethereum, like Lisk, have sprung up as well.

Olaf Carlson-Wee, founder of Polychain Capital, points out[34] that unlike networks like Facebook (where the value created by users accumulates to owners), and a variety of open-source projects (where value is altruistically transferred from creators to users), participants in blockchain networks will actually receive a portion of the value they contribute. This phenomenon, which provides an incentive for participation, can also blur the lines between some tokens and traditional securities[35]. The SEC's Howey Test defines "investment contracts" and involves four key principles: an investment of money, an expectation of profits, a common enterprise, and the efforts of a third party. Some pure currencies (like bitcoins) arguably do not involve the expectation of profits, and many tokens entail some form of participation, rather than the efforts of a third party.

Blockchain technology has thus introduced an entirely new way of conducting economic activity. Creators of a new application receive tokens—rather than dollars—in exchange for their efforts. Investors might also buy tokens, helping to fund development. Users must then obtain the tokens in order to make use of the application. As demand for the application grows, the price of the associated utility token should rise.

Vitalik Buterin of Ethereum provides a useful cryptoeconomic analysis[36], outlining a few factors that contribute to the demand for a token, which we believe can be summarized into two categories. The first of these are technical benefits—security, stability, and developer ecosystem. The second are market-related benefits—liquidity, market depth, and standardization. In other words, a potential user of a decentralized application would clearly prefer a well-supported, secure technology associated with an easily marketable token. In order to gather users, developers must be enticed to ensure a useful, stable, secure technology—the "chicken-and-egg" problem inherent in all nascent networks. In the case of decentralized applications, the promise of increasing demand for tokens (and a commensurate increase in value) is of prime importance to initial network participants.

Furthermore, we believe the ability of a utility token to create sustained user demand depends on two key criteria. First is its ability to create economic value for users—is the functionality provided by the token actually useful and desired? The second, and often neglected, is the lack of viable alternatives to its use. Unless a utility token benefits from durable competitive advantages over both centralized and

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33 https://www.evanvanness.com/post/166666272011/theres-no-such-thing-as-fat-protocols

34 https://techcrunch.com/2017/01/08/the-future-is-a-decentralized-internet/

35 https://www.coinist.io/the-howey-test-the-sec-and-ico/

36 https://blog.ethereum.org/2014/11/20/bitcoin-maximalism-currency-platform-network-effects/

other decentralized competitors, it's unlikely to experience long-lasting gains in value. Rising participation in a project and increased demand might drive up prices in the short run, but without actual utility to end users and durable advantages over competitors, such gains are likely to be short-lived.

Exhibit 32 Decentralization Can Create a Virtuous Circle
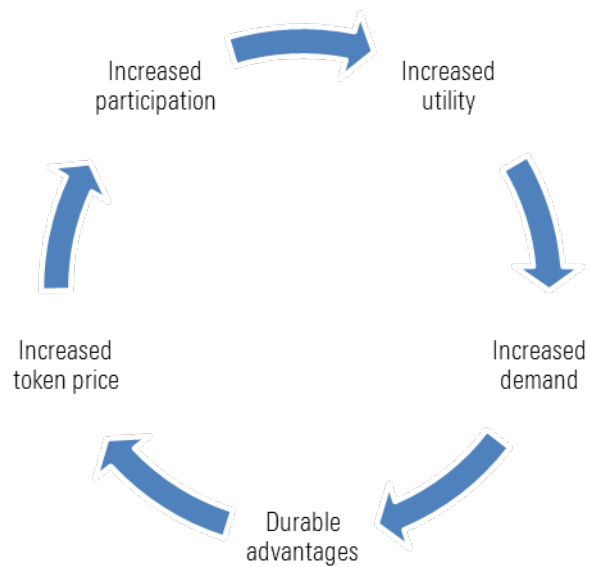
Source: Morningstar

Top Picks

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Because of the established economic moats of incumbents and the headwinds to complete disintermediation by blockchain technology, we believe there are long-term opportunities in the stocks of several companies providing centralized services. These are payment networks (American Express), social networks (Facebook), and marketplaces and distributors (Anixter, TripAdvisor, and McKesson). Our theses on each firm are briefly articulated below, with valuation summaries in the Appendix.

Exhibit 33 Top Picks Among Intermediaries

Name/Ticker	Economic Moat	Moat Trend	Currency	Fair Value Estimate	Current Price	Uncertainty Rating	Morningstar Rating	Market Cap(Bil)
American Express AXP	Wide	Stable	USD	112.00	99.48	High	★★★	86.23
Anixter AXE	Narrow	Stable	USD	107.00	59.65	Medium	★★★★★	2.01
Facebook FB	Wide	Stable	USD	198.00	172.76	High	★★★★	504.95
McKesson MCK	Wide	Stable	USD	210.00	158.18	Medium	★★★★	31.77
TripAdvisor TRIP	Narrow	Stable	USD	55.00	37.39	High	★★★★	5.20

Source: Morningstar

American Express by Jim Sinegal

Wide-moat American Express is once again experiencing a tailwind from the growth of digital payments as pricing and competitive pressures recede. The company's cost-cutting programs have experienced early success, and we think management is wise to refocus the company's growth strategy on its strengths in corporate spending and differentiated rewards. Competitors including Mastercard are already monetizing customer data, and JPMorgan Chase is attempting to build its own closed-loop network, yet we see American Express as best-positioned in both of these areas.

American Express should resume an aggressive repurchase program in 2019, and we believe the company has a huge opportunity ahead of it to provide more value to both merchants and cardholders. We still see a long growth runway as the use of cash declines, and American Express trades at a discount to both our fair value estimate and to peer multiples.

Facebook by Ali Mogharabi

We view the recent downturn in Facebook's stock, driven by the Cambridge Analytica data scandal, as a buying opportunity for investors. We think the firm is likely to endure the short-term impact of the scandal, and we do not expect a significant long-term headwind to Facebook's platform, operations, or moat sources.

We think Facebook can overcome the most recent data issue, as over time, and we expect it to regain user trust around data security and privacy. Thus we don't see users walking away from Facebook properties or otherwise negating the firm's network effect moat source. Plus, Facebook owns the two largest (and perhaps most valuable) social networking properties, and any migration of users or usage away from Facebook may simply shift toward its Instagram platform. In addition, we believe future regulations stemming from the latest data breach are likely to strengthen barriers to entry in this space, helping Facebook maintain its attractiveness to advertisers compared with other social networks such as Twitter or Snap.

With its access to data on over 2 billion users, we think Facebook will continue to enhance its social networks by offering even more relevant content to its users. This virtuous cycle may increase usage and creates an even more valuable intangible asset of user data, which only Facebook and its advertising partners can monetize. The value of such data (and advertisers' willingness to use it) has been demonstrated historically by the 65% average annual growth of Facebook's average ad revenue per user during the past five years, which we view as indicative of the price that advertisers pay Facebook for ad placement. We don't see the data scandal disrupting these trends and still project overall advertising average revenue per user rising at an 8% average annual pace over the next five years, with U.S. and Europe ARPU rising at a low teens rate. We think the market is too bearish in assuming only mid-single-digit ARPU growth or perhaps even annual declines in monthly average users going forward.

Anixter International by Brian Bernard, CFA
Narrow-moat Anixter International has recently transformed itself, and we think shareholders will be rewarded with consistent earnings growth and occasional outsize dividends over at least the next few years.

Over the past three years, Anixter has completed three transactions that have bolstered its market presence, growth potential, and operating flexibility. After acquiring Tri-Ed, selling its capital-intensive OEM supply fastener business, and purchasing HD Supply's utility distribution business, Anixter is now the global leader in network and security distribution, a major player in electrical distribution, and the leading utility power solutions distributor in North America. Anixter's focus on value-added technical and supply chain services across a global platform differentiates the firm from many of its competitors. In many cases, Anixter is not the low-cost leader, but its value-added services can provide its customers with the lowest cost of ownership.

We see key growth drivers for each of Anixter's segments over the next five years. With the addition of Tri-Ed, Anixter's network and security solutions segment are set to gain share with midsize system integrators and in residential end markets. This segment should also benefit from cross-selling security products to utilities customers as they invest in security solutions to comply with regulatory standards. Growth in wireless and cloud-related products should augment network and security growth. Anixter's electrical and electronic solutions business has suffered from industrial end-market weakness, and has been generating depressed EBITDA margins. As industrial end markets recover, we expect this segment to return to growth and normalized profitability. The acquisition of HD Supply's power solutions business

created the utility power solutions segment, which has industry-leading scale and should benefit from market share gains and improving utility capital spending.

Anixter's capital-allocation strategy has favored returning cash to shareholders through special dividends and share repurchases. Once Anixter achieves its targeted leverage ratio of 2.5–3 times EBITDA, which we think will happen in 2018, we expect it to resume returning cash to shareholders.

McKesson Corp. by Vishnu Lekraj

Despite major near-term headwinds, McKesson will remain an essential link in the pharmaceutical supply chain. Several headwinds have pressured the firm's operations and stock. The potential loss of the Rite Aid contract, slowing drug price inflation, and increased competition for small/independent pharmacy market share have formed a confluence of negative variables that have built in significant near-term uncertainty for the drug distributor. However, we believe these are near-term issues and McKesson will be able to power through the recent volatility as it is a critical partner to both retail pharmacy clients and drug suppliers. This has given investors an opportunity to acquire shares of a wide-moat company at a material discount.

While there are some remaining headwinds associated with potential contract losses, we believe McKesson will be able to offset this issue effectively, win its share of contracts in the future, and thrive in the long term. Additionally, we believe near-term drug price inflation trends should not have any material impact on McKesson's valuation, given that we expect generic inflation to remain close to 0% and brand inflation to remain close to 5% over the long term. McKesson has also positioned itself as a critical player in the lucrative specialty pharmaceutical market niche, bolstering its wide economic moat.

TripAdvisor by Dan Wasiolek

We see a sufficient margin of safety for investors looking to take a position in this narrow-moat company, despite near-term headwinds (Booking's pullback in performance advertising spending) and intermediate challenges (increasing metasearch competition from Google, higher TV advertising spending from Booking, and incremental investment into international and vacation rental markets by Expedia). We see the company's intact and powerful network advantage, along with recent initiatives, leading to sales acceleration to low-double-digit annual growth in 2019–24 from a roughly 3% lift in 2018.

TripAdvisor's network advantage is evident from its leading traffic and mobile application downloads, eclipsed only by Booking.com, which is owned by Booking Holdings. Further, TripAdvisor has the number-one online supply of attractions, bookable restaurants, and reviews, along with a leading presence in accommodations. We expect the company to see improving conversion on its leading network over the next 10 years, driven by a new user interface and TV campaign launch, which should aid user awareness and satisfaction, leading to improved monetization over time. M

Appendix

Valuation Summary

American Express (AXP)

Market Cap: $86.5B		Sector: Financial Services		Industry: Banks			Stewardship: Standard

Five-Star Price	$	66.96	Economic Moat	Wide	Valuation Multiples (2018 Estimates)	
Fair Value Estimate	$	111.60	Moat Trend	Stable	Price/Earnings (2018)	15.40
One-Star Price	$	172.98	Uncertainty	High	Price/Book	5.34
					Price/Tangible Book	5.34
Market Price	$	99.92	Estimated COE	9.00%	Dividend Yield	-0.01
Price/Fair Value Estimate	0.90					

FY Ends: December

	3-Yr Historical CAGR/AVG	2015	2016	2017	Forecast 2018	2019	2020	2021	2022	5-Yr Projected CAGR/AVG
All values (except per share amounts) in millions										
Income Statement										
Revenue (net of Provisions)		30,830	30,093	30,712	32,160	33,700	35,011	36,147	38,353	
Net Interest Income		5,922	5,771	6,441	6,993	7,047	6,898	6,804	6,764	
Operating Income		7,938	8,096	7,414	8,137	8,660	8,900	8,968	9,871	
Net Income		5,063	5,285	2,634	6,326	6,734	6,921	6,974	7,678	
Adjusted EPS		5.05	5.65	2.97	7.14	8.15	9.04	9.88	11.89	
Growth										
Revenue (net of Provisions)	-0.1%	-4.4%	-2.4%	2.1%	4.7%	4.8%	3.9%	3.2%	6.1%	3.9%
Net Interest Income	2.8%	8.2%	-2.5%	11.6%	8.6%	0.8%	-2.1%	-1.4%	-0.6%	3.0%
Operating Income	-2.3%	-	2.0%	-8.4%	9.8%	6.4%	2.8%	0.8%	10.1%	-
Net Income	-19.6%	-13.3%	4.4%	-50.2%	140.2%	6.4%	2.8%	0.8%	10.1%	6.5%
Adjusted EPS	-16.2%	-9.1%	12.0%	-47.4%	140.2%	14.2%	10.8%	9.3%	20.3%	7.4%
Profitability										
Net Interest Margin (NIMs)	4.8%	4.8%	4.7%	5.0%	5.0%	4.9%	4.8%	4.8%	4.8%	4.8%
Efficiency Ratio	69.3%	69.8%	68.5%	69.6%	67.9%	67.3%	67.1%	66.8%	66.1%	66.1%
Net Margin	14.2%	16.4%	17.6%	8.6%	19.7%	20.0%	19.8%	19.3%	20.0%	
ROA	2.7%	3.2%	3.4%	1.6%	3.4%	3.5%	3.6%	3.6%	3.9%	3.9%
ROE	21.7%	24.8%	26.3%	14.0%	33.2%	33.7%	34.2%	34.2%	37.4%	30.7%
ROIC	20.0%	22.6%	22.7%	14.7%	30.0%	30.9%	30.8%	31.4%	33.0%	28.8%
Leverage										
Tangible Equity/Tangible Assets	11.9%	12.8%	12.9%	10.1%	10.5%	10.5%	10.5%	10.5%	10.5%	
Tier 1 Capital	8.1%	0.0%	12.3%	11.9%	-	-	-	-	-	
Cash Flow										
Dividends Per Share		0.72	0.72	0.86	1.01	1.42	1.76	2.46	2.81	
FCFE		5,063	5,457	4,908	4,653	(81)	(542)	(1,160)	(1,246)	

Source: Morningstar. Data as of April 26, 2018.

Valuation Summary

Anixter International (AXE)

★★★★

Last Price	Fair Value		Uncertainty	Stewardship		Economic Moat	Moat Trend		Morningstar Credit Rating		
85 USD	107 USD		Medium	Standard		Narrow	Stable		N/A		

Analyst	Bernard, CFA, CPA		Five-Star Price	74.90		Estimated COE	9.0%		Adjusted P/E	13.0	16.3
Phone & Email	312-696-6084		Fair Value Estimate	107.00		Pre-Tax Cost of Debt	6.5%		EV / Adjusted EBITDA	9.0	10.7
brian.bernard@morningstar.com			One-Star Price	144.45		Estimated WACC	8.0%		EV / Sales	0.5	0.6
Sector	Industrials		Market Price	85.00		ROIC*	14.2%		Price / Book	1.8	2.2
Industry	Electronics		P/FVE	0.79		Adjusted ROIC*	10.7%		FCF Yield	4.8%	3.8%
	Distribution					* 5-Yr Projected Average			Dividend Yield	1.8%	1.4%
									(2018 Estimates)	(Price)	(Fair Value)

All values (except per share amounts) in: USD Millions	3-Yr Historical CAGR/AVG	**Forecast**						5-Yr Projected CAGR/AVG
		2017	2018	2019	2020	2021	2022	
Income Statement								
Revenue		7,927	8,284	8,701	9,139	9,527	9,890	
Gross Profit		1,571	1,643	1,722	1,828	1,942	2,013	
Operating Income		321	359	393	436	476	490	
Net Income		109	198	231	261	304	328	
Adjusted Income		175	224	257	287	331	355	
Adjusted EPS		5.16	6.56	7.48	8.36	9.62	10.32	
Adjusted EBITDA		404	446	483	530	576	595	
Growth (% YoY)								
Revenue	12.9%	4.0%	4.5%	5.0%	5.0%	4.2%	3.8%	4.5%
Gross Profit	8.2%	1.5%	4.6%	4.8%	6.1%	6.3%	3.6%	5.1%
Operating Income	0.4%	2.6%	11.9%	9.3%	10.9%	9.4%	2.9%	8.8%
Net Income	-17.6%	-9.5%	81.8%	16.5%	13.1%	16.5%	7.9%	24.7%
Adjusted EPS	-1.3%	4.7%	27.3%	14.0%	11.8%	15.0%	7.3%	14.9%
Adjusted EBITDA	3.2%	2.2%	10.6%	8.3%	9.7%	8.6%	3.3%	8.1%
Profitability (%)								
Gross Margin	20.6%	19.8%	19.8%	19.8%	20.0%	20.4%	20.4%	20.1%
Operating Margin	4.4%	4.1%	4.3%	4.5%	4.8%	5.0%	5.0%	4.7%
Net Margin	1.7%	1.4%	2.4%	2.7%	2.9%	3.2%	3.3%	2.9%
Adjusted EBITDA Margin	5.4%	5.1%	5.4%	5.6%	5.8%	6.0%	6.0%	5.8%
Return on Equity	9.6%	7.9%	12.8%	13.6%	14.2%	15.0%	14.7%	14.0%
Adjusted ROIC	9.0%	9.0%	9.5%	10.1%	10.8%	11.5%	11.7%	10.7%
Adjusted RONIC	25.5%	9.8%	27.0%	51.9%	59.7%	73.3%	24.3%	47.2%

Source: Morningstar. Data as of April 26, 2018.

Valuation Summary

Facebook, Inc. (FB)

★★★★

Last Price	Fair Value
168.1 USD	198 USD

				Economic Moat	Moat Trend
Uncertainty		**Stewardship**		**Economic Moat**	**Moat Trend**
High		Standard		Wide	Stable

Morningstar Credit Rating
N/A

Analyst	Ali Mogharabi
Phone & Email	312-696-6056
li.mogharabi@morningstar.com	
Sector	Technology
Industry	Internet Content & Information

Five-Star Price	118.80
Fair Value Estimate	198.00
One-Star Price	306.90
Market Price	168.10
P / FVE	0.85

Estimated COE	9.0%
Pre-Tax Cost of Debt	5.5%
Estimated WACC	9.0%
ROIC *	38.9%
Adjusted ROIC *	32.1%
* 5-Yr Projected Average	

	(Price)	(Fair Value)
Adjusted P / E	23.6	27.8
EV / Adjusted EBITDA	13.9	16.6
EV / Sales	8.3	9.9
Price / Book	5.3	6.2
FCF Yield	2.9%	2.5%
Dividend Yield	0.0%	0.0%
(2018 Estimates)		

All values (except per share amounts) in: USD Millions	3-Yr Historical CAGR/AVG	2017	Forecast 2018	2019	2020	2021	2022	5-Yr Projected CAGR/AVG
Income Statement								
Revenue		40,653	54,768	66,720	79,780	93,718	109,009	
Gross Profit		35,199	46,553	56,712	67,015	77,786	90,477	
Operating Income		20,203	24,372	29,690	35,502	42,407	49,872	
Net Income		15,934	21,059	25,664	30,712	36,718	43,224	
Adjusted Income		15,934	21,059	25,664	30,712	36,718	43,224	
Adjusted EPS		5.39	7.13	8.70	10.43	12.49	14.72	
Adjusted EBITDA		26,951	32,683	38,931	45,574	53,232	61,413	
Growth (% YoY)								
Revenue	48.3%	47.1%	34.7%	21.8%	19.6%	17.5%	16.3%	21.8%
Gross Profit	50.6%	47.6%	32.3%	21.8%	18.2%	16.1%	16.3%	20.8%
Operating Income	59.3%	62.6%	20.6%	21.8%	19.6%	19.5%	17.6%	19.8%
Net Income	75.7%	56.0%	32.2%	21.9%	19.7%	19.6%	17.7%	22.1%
Adjusted EPS	69.7%	54.3%	32.3%	22.1%	19.9%	19.7%	17.8%	22.3%
Adjusted EBITDA	49.8%	49.8%	21.3%	19.1%	17.1%	16.8%	15.4%	17.9%
Profitability (%)								
Gross Margin	85.6%	86.6%	85.0%	85.0%	84.0%	83.0%	83.0%	84.0%
Operating Margin	43.1%	49.7%	44.5%	44.5%	44.5%	45.3%	45.8%	44.9%
Net Margin	32.2%	39.2%	38.5%	38.5%	38.5%	39.2%	39.7%	38.8%
Adjusted EBITDA Margin	64.5%	66.3%	59.7%	58.4%	57.1%	56.8%	56.3%	57.7%
Return on Equity	17.6%	23.9%	25.0%	24.0%	22.9%	22.0%	21.0%	23.0%
Adjusted ROIC	29.0%	35.0%	33.8%	31.6%	31.0%	31.4%	32.9%	32.1%
Adjusted RONIC	47.1%	62.3%	21.8%	26.8%	30.1%	40.0%	50.8%	33.9%

Source: Morningstar. Data as of April 26, 2018.

Valuation Summary

McKesson (MCK)   ★★★★

Last Price	Fair Value
150 USD	210 USD

		Uncertainty	Stewardship		Economic Moat	Moat Trend		Morningstar Credit Rating		
		Medium	Standard		Wide	Stable		N/A		
Analyst	Vishnu Lekraj	Five-Star Price	147.00		Estimated COE	9.0%		Adjusted P / E	12.3	17.3
Phone & Email	312-244-7021	Fair Value Estimate	210.00		Pre-Tax Cost of Debt	6.5%		EV / Adjusted EBITDA	10.0	13.4
vishnu.lekraj@morningstar.com		One-Star Price	283.50		Estimated WACC	8.6%		EV / Sales	0.2	0.2
Sector	Healthcare	Market Price	150.00		ROIC *	15.0%		Price / Book	2.5	3.5
Industry	Medical Distribution	P / FVE	0.71		Adjusted ROIC *	31.9%		FCF Yield	8.5%	6.1%
					* 5-Yr Projected Average			Dividend Yield	0.8%	0.5%
								(2018 Estimates)	(Price)	(Fair Value)

All values (except per share amounts) in: USD Millions	3-Yr Historical CAGR/AVG	2017	Forecast 2018	2019	2020	2021	2022	5-Yr Projected CAGR/AVG
Income Statement								
Revenue		198,533	206,170	210,072	220,693	232,843	243,759	
Gross Profit		11,271	11,479	11,294	10,990	11,673	12,210	
Operating Income		3,446	2,858	3,154	3,419	3,807	4,100	
Net Income		5,070	1,268	2,005	2,187	2,452	2,663	
Adjusted Income		5,070	2,583	2,720	2,687	2,852	3,063	
Adjusted EPS		22.74	12.15	12.92	13.24	14.67	16.56	
Adjusted EBITDA		4,356	3,768	4,064	4,329	4,717	5,010	
Growth (% YoY)								
Revenue	13.0%	4.0%	3.8%	1.9%	5.1%	5.5%	4.7%	4.2%
Gross Profit	10.7%	-1.3%	1.8%	-1.6%	-2.7%	6.2%	4.6%	1.6%
Operating Income	13.3%	-2.8%	-17.1%	10.3%	8.4%	11.4%	7.7%	3.5%
Net Income	58.9%	124.5%	-75.0%	58.1%	9.1%	12.1%	8.6%	-12.1%
Adjusted EPS	61.3%	134.6%	-46.6%	6.3%	2.5%	10.8%	12.9%	-6.1%
Adjusted EBITDA	12.4%	-1.7%	-13.5%	7.8%	6.5%	9.0%	6.2%	2.8%
Profitability (%)								
Gross Margin	6.0%	5.7%	5.6%	5.4%	5.0%	5.0%	5.0%	5.2%
Operating Margin	1.8%	1.7%	1.4%	1.5%	1.5%	1.6%	1.7%	1.6%
Net Margin	1.5%	2.6%	0.6%	1.0%	1.0%	1.1%	1.1%	0.9%
Adjusted EBITDA Margin	2.2%	2.2%	1.8%	1.9%	2.0%	2.0%	2.1%	2.0%
Return on Equity	31.7%	50.7%	10.6%	15.6%	16.9%	19.1%	21.5%	16.7%
Adjusted ROIC	33.2%	39.6%	28.7%	29.7%	30.4%	34.8%	36.2%	31.9%
Adjusted RONIC	-32.1%	-88.5%	150.1%	12.3%	-20.3%	-4840.3%	47.7%	-930.1%

Source: Morningstar. Data as of April 26, 2018.

Valuation Summary

TripAdvisor (TRIP) ★★★★

Last Price	Fair Value
43.82 USD	55 USD

Uncertainty	Stewardship
High	Standard

Economic Moat	Moat Trend
Narrow	Stable

Morningstar Credit Rating
N/A

Analyst	Dan Wasiolek	
Phone & Email	312-696-6822	
dan.wasiolek@morningstar.com		
Sector	Consumer Cyclical	
Industry	Leisure	

Five-Star Price	33.00
Fair Value Estimate	55.00
One-Star Price	85.25
Market Price	43.82
P / FVE	0.80

Estimated COE	9.0%
Pre-Tax Cost of Debt	10.0%
Estimated WACC	9.0%
ROIC *	31.2%
Adjusted ROIC *	133.1%
* 5-Yr Projected Average	

	(Price)	(Fair Value)
Adjusted P / E	38.5	48.3
EV / Adjusted EBITDA	16.6	21.2
EV / Sales	3.5	4.4
Price / Book	5.0	6.3
FCF Yield	3.6%	2.9%
Dividend Yield	0.0%	0.0%
(2018 Estimates)		

Disclaimer: 2017 CF/BS Est until 10K

All values (except per share amounts) in: USD Millions	3-Yr Historical CAGR/AVG	2017	Forecast 2018	2019	2020	2021	2022	5-Yr Projected CAGR/AVG
Income Statement								
Revenue		1,556	1,594	1,780	1,975	2,222	2,487	
Gross Profit		1,484	1,522	1,701	1,888	2,133	2,400	
Operating Income		124	136	160	228	337	484	
Net Income		(19)	80	116	169	253	368	
Adjusted Income		144	156	212	257	329	422	
Adjusted EPS		1.03	1.14	1.59	1.95	2.56	3.42	
Adjusted EBITDA		331	333	364	444	564	733	
Growth (% YoY)								
Revenue	7.7%	5.1%	2.5%	11.6%	11.0%	12.5%	11.9%	9.8%
Gross Profit	7.2%	5.3%	2.6%	11.7%	11.0%	13.0%	12.5%	10.1%
Operating Income	-28.6%	-25.3%	10.0%	17.1%	42.7%	47.8%	43.8%	31.3%
Net Income	-143.8%	-115.2%	-519.2%	45.7%	45.5%	50.0%	45.1%	NM
Adjusted EPS	-12.8%	-28.4%	10.7%	39.7%	22.8%	30.9%	33.8%	27.2%
Adjusted EBITDA	-10.9%	-6.0%	0.6%	9.4%	21.8%	27.0%	30.0%	17.2%
Profitability (%)								
Gross Margin	95.6%	95.4%	95.5%	95.6%	95.6%	96.0%	96.5%	95.8%
Operating Margin	11.6%	8.0%	8.6%	9.0%	11.5%	15.2%	19.5%	12.7%
Net Margin	6.8%	-1.2%	5.0%	6.5%	8.6%	11.4%	14.8%	9.3%
Adjusted EBITDA Margin	25.4%	21.3%	20.9%	20.5%	22.5%	25.4%	29.5%	23.7%
Return on Equity	7.6%	-1.3%	6.2%	9.7%	13.6%	19.4%	28.0%	15.4%
Adjusted ROIC	121.8%	133.4%	85.1%	74.3%	112.2%	162.8%	231.1%	133.1%
Adjusted RONIC	-51.3%	-47.3%	-9.6%	-28.2%	-212.1%	-621.2%	-791.9%	-332.6%

Source: Morningstar. Data as of April 26, 2018.

Research Methodology for Valuing Companies

Overview

At the heart of our valuation system is a detailed projection of a company's future cash flows, resulting from our analysts' research. Analysts create custom industry and company assumptions to feed income statement, balance sheet, and capital investment assumptions into our globally standardized, proprietary discounted cash flow, or DCF, modeling templates. We use scenario analysis, in-depth competitive advantage analysis, and a variety of other analytical tools to augment this process. Moreover, we think analyzing valuation through discounted cash flows presents a better lens for viewing cyclical companies, high-growth firms, businesses with finite lives (e.g., mines), or companies expected to generate negative earnings over the next few years. That said, we don't dismiss multiples altogether but rather use them as supporting cross-checks for our DCF-based fair value estimates. We also acknowledge that DCF models offer their own challenges (including a potential proliferation of estimated inputs and the possibility that the method may miss short-term market price movements), but we believe these negatives are mitigated by deep analysis and our long-term approach.

Morningstar's equity research group ("we," "our") believes that a company's intrinsic worth results from the future cash flows it can generate. The Morningstar Rating for stocks identifies stocks trading at a discount or premium to their intrinsic worth—or fair value estimate, in Morningstar terminology. Five-star stocks sell for the biggest risk-adjusted discount to their fair values, whereas 1-star stocks trade at premiums to their intrinsic worth.

Morningstar Research Methodology

Economic Moat	Stewardship	**Morningstar Fair Value**	Price / Fair Value	**Morningstar Rating™ For Stocks**
Financial Health	Moat Trend		Uncertainty	★★★★★
Fundamental Analysis		*Valuation*	*Margin of Safety*	
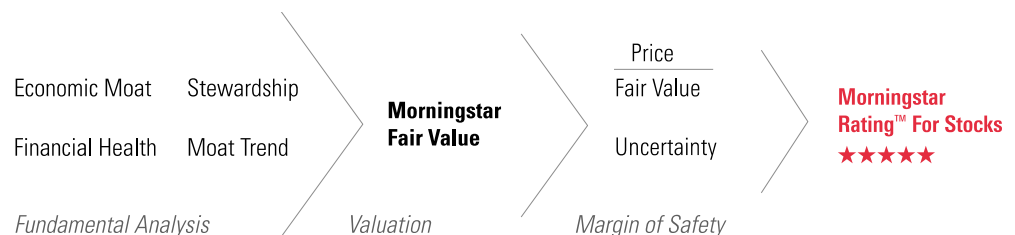
Source: Morningstar.

Four key components drive the Morningstar rating: (1) our assessment of the firm's economic moat, (2) our estimate of the stock's fair value, (3) our uncertainty around that fair value estimate, and (4) the current market price. This process ultimately culminates in our single-point star rating.

Economic Moat

The concept of an economic moat plays a vital role not only in our qualitative assessment of a firm's long-term investment potential, but also in the actual calculation of our fair value estimates. An economic moat is a structural feature that allows a firm to sustain excess profits over a long period of time. We define economic profits as returns on invested capital (ROIC) over and above our estimate of a firm's cost of capital, or weighted average cost of capital (WACC). Without a moat, profits are more susceptible to competition. We have identified five sources of economic moats: intangible assets, switching costs, network effect, cost advantage, and efficient scale.

Companies with a narrow moat are those we believe are more likely than not to achieve normalized excess returns for at least the next 10 years. Wide-moat companies are those in which we have very high confidence that excess returns will remain for 10 years, with excess returns more likely than not to remain for at least 20 years. The longer a firm generates economic profits, the higher its intrinsic value. We believe low-quality, no-moat companies will see their normalized returns gravitate toward their cost of capital more quickly than companies with moats.

To assess the sustainability of excess profits, analysts perform ongoing assessments of the moat trend. A firm's moat trend is positive in cases where we think its sources of competitive advantage are growing stronger, stable where we don't anticipate changes to competitive advantages over the next several years, or negative where we see signs of deterioration.

Estimated Fair Value

Combining our analysts' financial forecasts with the firm's economic moat helps us assess how long returns on invested capital are likely to exceed the firm's cost of capital. Returns of firms with a wide economic moat rating are assumed to fade to the perpetuity period over a longer period of time than the returns of narrow-moat firms, and both will fade slower than no-moat firms, increasing our estimate of their intrinsic value.

Our model is divided into three distinct stages:

Stage I: Explicit Forecast

In this stage, which can last 5 to 10 years, analysts make full financial statement forecasts, including items such as revenue, profit margins, tax rates, changes in working capital accounts, and capital spending. Based on these projections, we calculate earnings before interest, after taxes (EBI) and net new investment (NNI) to derive our annual free cash flow forecast.

Stage II: Fade

The second stage of our model is the period it will take the company's return on new invested capital—the return on capital of the next dollar invested (RONIC)—to decline (or rise) to its cost of capital. During the Stage II period, we use a formula to approximate cash flows in lieu of explicitly modeling the income statement, balance sheet, and cash flow statement as we do in Stage I. The length of the second stage depends on the strength of the company's economic moat. We forecast this period to last anywhere from one year (for companies with no economic moat) to 10–15 years or more (for wide-moat companies). During this period, cash flows are forecast using four assumptions: an average growth rate for EBI over the period, a normalized investment rate, average return on new invested capital (RONIC), and the number of years until perpetuity, when excess returns cease. The investment rate and return on new invested capital decline until a perpetuity value is calculated. In the case of firms that do not earn their cost of capital, we assume marginal ROICs rise to the firm's cost of capital (usually attributable to less reinvestment), and we may truncate the second stage.

Stage III: Perpetuity

Once a company's marginal ROIC hits its cost of capital, we calculate a continuing value, using a standard perpetuity formula. At perpetuity, we assume that any growth or decline or investment in the business neither creates nor destroys value and that any new investment provides a return in line with estimated WACC.

Because a dollar earned today is worth more than a dollar earned tomorrow, we discount our projections of cash flows in stages I, II, and III to arrive at a total present value of expected future cash flows. Because we are modeling free cash flow to the firm—representing cash available to provide a return to all capital providers—we discount future cash flows using the WACC, which is a weighted average of the costs of equity, debt, and preferred stock (and any other funding sources), using expected future proportionate long-term, market value weights.

Uncertainty Around That Fair Value Estimate

Morningstar's uncertainty rating captures a range of likely potential intrinsic values for a company and uses it to assign the margin of safety required before investing, which in turn explicitly drives our stock star rating system. The uncertainty rating represents the analysts' ability to bound the estimated value of the shares in a company around the fair value estimate, based on the characteristics of the business underlying the stock, including operating and financial leverage, sales sensitivity to the overall economy, product concentration, pricing power, and other company-specific factors.

Analysts consider at least two scenarios in addition to their base case: a bull case and a bear case. Assumptions are chosen such that the analyst believes there is a 25% probability that the company will perform better than the bull case and a 25% probability that the company will perform worse than the bear case. The distance between the bull and bear cases is an important indicator of the uncertainty underlying the fair value estimate.

Our recommended margin of safety widens as our uncertainty regarding the estimated value of the equity increases. The more uncertain we are about the estimated value of the equity, the greater the discount we require relative to our estimate of the value of the firm before we would recommend the purchase of the shares. In addition, the uncertainty rating provides guidance in portfolio construction based on risk tolerance.

Our uncertainty ratings for our qualitative analysis are low, medium, high, very high, and extreme.

► Low: Margin of safety for 5-star rating is a 20% discount and for 1-star rating is a 25% premium.

► Medium: Margin of safety for 5-star rating is a 30% discount and for 1-star rating is a 35% premium.

► High: Margin of safety for 5-star rating is a 40% discount and for 1-star rating is a 55% premium.

► Very high: Margin of safety for 5-star rating is a 50% discount and for 1-star rating is a 75% premium.

► Extreme: Margin of safety for 5-star rating is a 75% discount and for 1-star rating is a 300% premium.

Morningstar Equity Research Star Rating Methodology
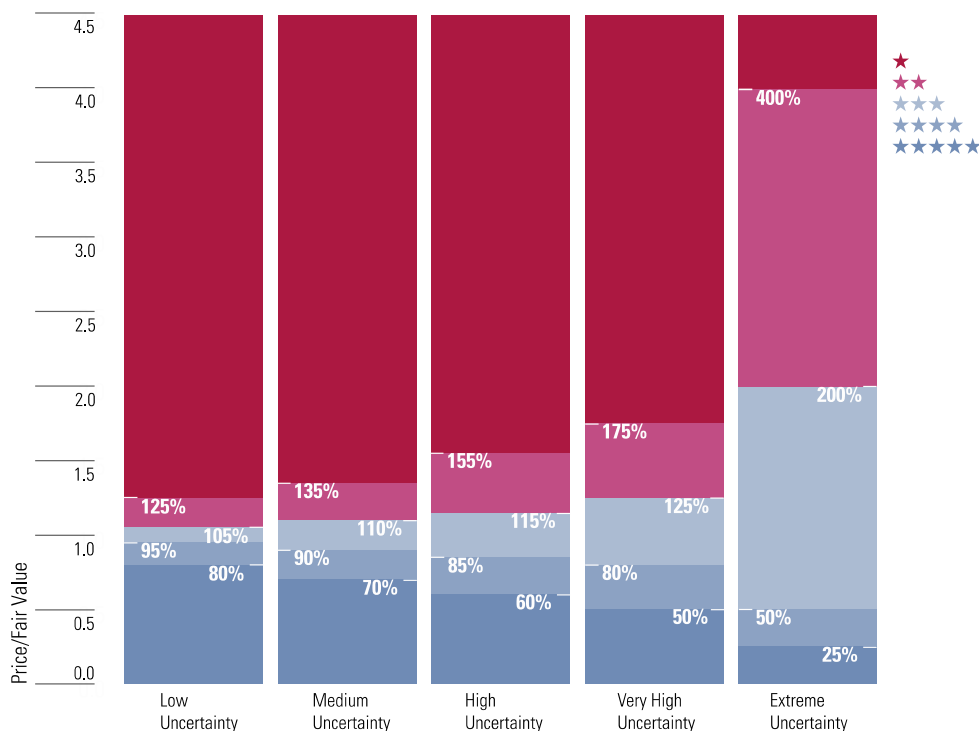
Market Price
The market prices used in this analysis and noted in the report come from the exchange on which the stock is listed, which we believe is a reliable source.

For more details about our methodology, please go to https://shareholders.morningstar.com.

Morningstar Star Rating for Stocks
Once we determine the fair value estimate of a stock, we compare it with the stock's current market price on a daily basis, and the star rating is automatically recalculated at the market close on every day the market on which the stock is listed is open. Our analysts keep close tabs on the companies they follow and, based on thorough and ongoing analysis, raise or lower their fair value estimates as warranted.

Please note, there is no predefined distribution of stars. That is, the percentage of stocks that earn 5 stars can fluctuate daily, so the star ratings, in the aggregate, can serve as a gauge of the broader market's valuation. When there are many 5-star stocks, the stock market as a whole is more undervalued, in our opinion, than when very few companies garner our highest rating.

We expect that if our base-case assumptions are true, the market price will converge on our fair value estimate over time, generally within three years (although it is impossible to predict the exact time frame in which market prices may adjust).

Our star ratings are guideposts to a broad audience, and individuals must consider their own specific investment goals, risk tolerance, tax situation, time horizon, income needs, and complete investment portfolio, among other factors.

The Morningstar Star Ratings for stocks are defined below:

★★★★★ We believe appreciation beyond a fair risk-adjusted return is highly likely over a multiyear time frame. Scenario analysis developed by our analysts indicates that the current market price represents an excessively pessimistic outlook, limiting downside risk and maximizing upside potential.

★★★★ We believe appreciation beyond a fair risk-adjusted return is likely.

★★★ Indicates our belief that investors are likely to receive a fair risk-adjusted return (approximately cost of equity).

★★ We believe investors are likely to receive a less than fair risk-adjusted return.

★ Indicates a high probability of undesirable risk-adjusted returns from the current market price over a multiyear time frame, based on our analysis. Scenario analysis by our analysts indicates that the market is pricing in an excessively optimistic outlook, limiting upside potential and leaving the investor exposed to capital loss.

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