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Making Sense of Blockchain Opportunities

- **A blockchain taxonomy for investors.** Blockchain technology is being used in a growing diversity of applications, offering a complex array of investment opportunities. While the technology is so new that any investment in it is speculative, patterns of use are emerging. In this report, we propose a taxonomy to enable investors to more quickly and effectively understand individual blockchain applications' key attributes and to assess how blockchain technology will be used in the near and medium term. To illustrate use of the taxonomy, we apply the indicators to several blockchain applications that range in investment, purpose, and launch date, including Bitcoin, EOS, Tezos, Ethereum and Provenance.

Figure 1: Blockchain taxonomy

Activity:	Transaction	⟷	Ownership
Governance:	Fixed	⟷	Flexible
Technology functionality:	Stateless	⟷	Stateful
Transparency:	Public	⟷	Permissioned
User status:	Expert	⟷	Amateur

Source: Cornerstone Capital Group

- **What does the taxonomy tell us**?
  - We find that recent blockchain applications are shifting blockchain's original structural and philosophic pillars (i.e., ex-ante rule setting and radical transparency) toward applications with flexible governance structures and private access. Many applications broadly align with the original blockchain application, Bitcoin, but deviate on one or two indicators to address some potential user need.
  - Current blockchain applications are focused on expert users, which suggests that blockchain remains a product for technology innovators/developers and is yet not targeting the mass market. The wider success of blockchain does depend on adoption by amateur users.

- **Our view.** We remain skeptical about the ability for blockchain to replace existing non-digital transaction processes without clearer demonstrations of benefits to a wide range of users. However, blockchain is gaining traction within communities and marketplaces focused on the technology-enabled.

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Executive Summary

Blockchain technologies have garnered increased media attention and fund-raising from both technological experts and the broader public over the past few years. Approximately $1.4 billion was invested in blockchain technology in 2016 alone[1]. However, the technology itself is still nascent, as are the business models it supports.

While the technology is so new that any investment is speculative, a taxonomy of blockchain applications can help investors identify risks and opportunities

Many people associate blockchain technology with its original use, the cryptocurrency Bitcoin, but the technology is being used in a growing diversity of applications. At the same time, patterns in how blockchain technology is used are emerging, with associated risks and opportunities. While the technology is so new that any investment is speculative, a taxonomy of blockchain applications can help investors identify risks and opportunities as a first step towards researching possible investment opportunities.

In this report, we lay out a preliminary framework for investors to more quickly and effectively understand an application's key attributes and to refine their theses on the future of blockchain. We outline five indicators, each based on a spectrum of characteristics:

- **Activity:** *transaction* applications facilitate the consumption of or trade in goods and services, while *ownership* applications digitize legal assets or identities.
- **Governance:** *fixed* applications require that the rules are previously and immutably coded, while *flexible* governance applications allow users to adapt governance structures.
- **Technology functionality:** *stateless* applications process transactions without retaining data beyond the validity of the transaction, while *stateful* applications retain data surrounding the transaction.
- **Transparency:** *public* applications allows all users on the blockchain to see every transaction, while *permissioned* applications enable private channels.
- **User status:** applications geared towards *experts* are focused on users who are technologically enabled, while applications geared towards *amateurs* require little understanding of blockchain technology itself.

[1] https://www.cryptocoinsnews.com/pwc-expert-1-4-billion-invested-blockchain-2016/

Blockchain's Many Futures

Proponents see the scope of the technology ranging from securing payment systems to replacing existing institutions in order to level the playing field for disadvantaged populations

Blockchain technology and associated business models represent potentially sweeping economic changes, as we discussed in our June 2017 report Governance and the Ungovernable: Implications of Blockchain Proliferation. Proponents of blockchain propose that the technology can remove third-party intermediaries from transactions. They see the scope of the technology ranging from securing payment systems to replacing existing institutions in order to level the playing field for disadvantaged populations. This could have a wide range of end results, from affecting global financial flows to enabling new political structures. Investors in the blockchain space could reap significant benefits if they are involved in applications that achieve some of these aims.

However, there are diverging views about the technology's reach, as the blockchain ecosystem is still in its infancy. It will be important for investors to understand the range of futures to understand how individual applications are positioned.

Initial blockchain technology was based on two pillars:

- **Ex-ante rule setting:** All interactions through the blockchain platform are pre-programmed and immutable. Once an event happens or certain conditions are met, the transaction is executed as per the programming in the code, without involvement of lawyers, financiers, or judges.
- **Radical transparency:** The platform is public and validation of transactions is decentralized, meaning a single individual or institution does not control it. Instead, each user has a copy of the public record, and transactions are validated by each user's copy in order to be accepted.

However, the blockchain ecosystem is still developing and volatile. For instance, applications are emerging that allow users to change the program by voting or through jury systems. Because this process is pre-programmed into the code, it does not violate the condition of ex-ante rule making, but could be viewed as violating the principle.

At this stage of the technology's development, we consider two types of future uses for blockchain technology: a "blockchain world" and "our world with blockchain." In "a blockchain world," the technology enables novel ways of creating and managing economic, social, and political systems. The most fervent blockchain supporters envision eliminating the need for government and third-party corporations, as the technology explicitly does not require their involvement. If fully integrated into society, the technology is envisioned to replace existing economic and political systems.

In "our world with blockchain," the technology is a tool to increase the transparency and security of transactions, leading to significant efficiency gains much like any other new form of technology. Systems that are increasingly complex could benefit from the radical transparency that blockchain offers (e.g., supply chains). At the same time, blockchain offers transactional security to individuals and institutions concerned about hacking, data safety or unnecessary intermediaries (e.g., financial payments). However, it is unclear in some applications whether blockchain technology offers a value-add relative to other information-management systems.

The debate around future uses of blockchain is important given the range of outcomes and implications for the economy and society. The future use of blockchain is highly uncertain, which is both attractive and concerning for investors. Investors can benefit from frameworks that categorize and improve understanding of the range of blockchain applications as the ecosystem continues to evolve.

Blockchain Taxonomy

Framework for investors to compare different types of blockchain applications

We propose a blockchain taxonomy to provide a framework for investors to compare different types of blockchain applications. A taxonomy is a useful tool during periods of technology proliferation, as it classifies technologies across attributes without bias. Our goal is to help investors:

- More quickly and effectively understand individual applications' key attributes; and
- Assess how blockchain technology will be used in the near and medium term.

The taxonomy focuses on the structural characteristics and user differences associated with the range of blockchain applications and can be used as an assessment framework while the blockchain ecosystem is developing.

Figure 1: Blockchain taxonomy

Activity:	Transaction	Ownership
Governance:	Fixed	Flexible
Technology functionality:	Stateless	Stateful
Transparency:	Public	Permissioned
User status:	Expert	Amateur

Source: Cornerstone Capital Group

We use examples of blockchain applications to provide context for each indicator on the taxonomy (Figure 2).

Figure 2: Application examples

Application	Functionality	Investment as of 9/8/2017[1]
Arcade City	Mobile-based taxi service, self-described as an "Uber alternative"	Funding of $620,000[2]
Bitcoin	Cryptocurrency	Market cap of $70.1 billion
Bitland	Records and digitizes land deeds	Market cap of $4.0 million
Blockstack	Encrypts users' data to keep their internet use private	Funding of $5.4 million[3]
EOS	Helps launch and run applications, with rules based on a constitution	Market cap of $272.1 million
Ethereum	Helps launch and run other applications	Market cap of $27.8 billion
Hyperledger	Open-source application to help develop applications	Funded by the Linux Foundation[4]
Provenance	Monitors supply chains by tagging and tracking goods with digital tokens	Funding of $865,000[5]
Ripple	Financial payments application	Market cap of $8.1 billion
Tezos	Provides other applications the ability to amend rules and coding via a voting system	Funding of $232 million[6]

Source: Cornerstone Capital Group

Activity: Transaction ⇔ Ownership

Distinction

Examples:
***Transaction* – Arcade City**
***Ownership* – Bitland, Blockstack**

Transaction applications facilitate the consumption of or trade in goods and services, including the transfer of cryptocurrencies. Investing in transaction applications represents either interest in using the application or speculation of its future, as the application only has value because other people are willing to use it.

An *ownership* application enables a fundamentally different activity as it digitizes legal ownership. It assigns unique and private digital identification codes to real assets or to individuals, which can then be used to confirm status, vote, or register. Some applications overlap, as they might require an identification code to confirm a trade.

Uses

Transaction applications create value by eliminating third-party institutions in interactions and by defraying the costs of trade. They also appeal to service-based applications that want to standardize on a single, non-fiat currency for simplicity or security. Arcade City, for example, aims to eliminate the corporation

[1] Blockchain applications raise capital and then "go public" and trade. For applications that are trading, we use the website https://coinmarketcap.com/ to price their market caps. We use the funding amount for applications that are not trading, or do not have significant levels of trading.
[2] https://cointelegraph.com/news/arcade-city-parts-ways-with-controversial-founder-raises-almost-620000
[3] https://www.crunchbase.com/organization/blockstack-inc#/entity
[4] https://www.linuxfoundation.org/news-media/announcements/2016/02/linux-foundation-s-hyperledger-project-announces-30-founding
[5] https://www.crunchbase.com/organization/provenance#/entity
[6] https://www.forbes.com/sites/omribarzilay/2017/07/15/tezos-232-million-ico-may-just-be-the-beginning/#21fcdecb4c52

necessary to run taxi services like Uber or Lyft and to make payments more secure through cryptocurrencies.

Ownership applications offer opportunities to secure registries (e.g., Bitland is currently running a pilot program to register property rights in Ghana) and for users to ensure their digital information is private (e.g., Blockstack's goal is to allow internet users to own their own data and keep their data private). Applications that become the key digital identity or asset application should benefit from significant network effects (i.e., more users will increase its usefulness for existing users).

Challenges

Transaction applications could be solutions looking for a problem if they do not enhance users' experience—in other words, even if blockchain technology works at facilitating the transaction, users may not receive any benefits or reduced costs. For instance, the blockchain technology behind Arcade City may function appropriately, but if current Uber users are not concerned about Uber's level of payment security or the speed of transactions, there is limited reason to shift from Uber to Arcade City.

Ownership applications face risks from two stakeholder categories:

- Governments: ownership-based applications can require government involvement if they are substituting for a function managed by the government. Bitland's pilot program required working with local communities to digitize owners' property rights[1].
- Users: the users must be comfortable with transferring identities and assets to blockchain technologies. This might require a more educated understanding of blockchain than transaction applications do, given that ownership applications like Blockstack deal with security of personal information. In addition, the digitizing of any physical assets is still likely to require interaction with existing regulators and sovereign entities.

The fundamental question for investors is whether blockchain technology provides a step-change in benefits or a reduction in costs for users or service providers. We see the development of specific use cases for blockchain as critical to further adoption.

[1] http://www.bitland.world/about/

Governance: Fixed ⇔ Flexible

Examples:
***Fixed* – Bitcoin**
***Flexible* – Tezos**

Distinction

A *fixed* governance system requires that the rules are previously and immutably coded. Users know and agree to the outcomes of a transaction before completing a transaction. Blockchain purists argue that the technology can revolutionize governance structures by replacing governmental and legal processes with pre-programmed computation.

On the other side, some have developed blockchain technologies with more *flexible* governance structures. Applications can pre-program the ability to vote or to decide by jury into the computation. Rather than being a new form of governance, this overlays existing governance systems onto blockchain technology.

A further analysis of these two sides is available in our June 2017 report, Governance and the Ungovernable: Implications of Blockchain Proliferation.

Uses

Fixed governance systems could provide greater equality and efficiency, as every user would know and agree to the outcome of their transactions before entering the agreement. When one user pays another on Bitcoin, both understand the necessary steps to complete the payment as well as the outcome of the payment. In addition, when investors buy bitcoins to speculate, they have information about the number of bitcoins that will exist, as the computation has limited the supply.

Blockchain applications with *flexible* governance structures, like voting or a jury system, can be changed by agreement among its users. This avoids the situation where unforeseen circumstances require a new version of the application to be created, and all the users of the old application uploaded onto the new system. For instance, Tezos' developers built the initial application to be "simple by design, but its self-amending nature means that the rules governing the network can be improved over time."[1] This could possibly make the application more secure, as it can be updated for security breaches, and avoids growth slowdowns.

Challenges

Fixed applications face challenges because the initial code is immutable, but there may be problems or mistakes in the code that only arise after the code is finalized. For instance, the application may not be able to update security protocols even if there is a security breach. A disagreement among users could

[1] https://www.tezos.com/static/papers/Tezos_Overview.pdf

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limit the functionality without any mediation policy written into the code. At the time of this report's publication, there is internal debate within the Bitcoin community about the scalability of the application. There is limited structure within Bitcoin to facilitate agreement between the two sides, and it is possible that one side might develop and move to a new Bitcoin application[1].

Blockchain technologies that overlay *flexible* governance structures may not adequately integrate real-world governance experience and face challenges similar to those of real-world governance. Tezos' users receive voting rights in proportion to how much of the application they own, with the ability to pass along voting rights to delegates. If most of the voting power sits with a few people, the application can adapt to that governance choice[2]. This makes the application vulnerable to power inequalities within the system. Additionally, users will have to be knowledgeable about the rules and programming changes each time there is vote, which may involve significant time and effort.

Both governance systems face large challenges from society. *Fixed* applications remove governmental and legal process completely, while *flexible* applications remove the structures created to advise, act as experts, and help those disadvantaged by the system. For instance, if Bitcoin replaces fiat currencies, individuals and communities with limited computing power might be disadvantaged, without any governmental structures to access for support. New forms of discrimination against minorities could develop without any means of recourse, and new structures of power could be formed around technology processing capabilities.

Technology Functionality: Stateless ⇔ Stateful[3]

Distinction

Examples:
***Stateless:* Bitcoin**
***Stateful:* Ethereum**

A *stateless* application processes transactions without retaining data beyond the fact that the transaction has taken place and is valid. In contrast, a *stateful* application captures information specific to the transaction, like contracts or information about the users. The implication is that stateless applications behave similarly to cash, while stateful applications are able to retain significantly more information about the transaction, similar to transfers between bank accounts.

[1] https://www.coindesk.com/bitcoins-battle-segwit2x-begun/
[2] https://techcrunch.com/2017/07/12/behind-the-scenes-with-tezos-a-new-blockchain-upstart/
[3] This section draws heavily upon Colin Platt's article "Thoughts on the taxonomy of blockchains & distributed ledger technologies," https://medium.com/@colin_/thoughts-on-the-taxonomy-of-blockchains-distributed-ledger-technologies-ecad1c819e28. Platt uses the terms "stateless" and "stateful" to describe where blockchain sits in an interaction. *Stateless* interacts with just the final interaction (e.g. records the validity of the transaction), while *stateful* interacts with more (e.g. records information on the counterparties).

Uses

The core appeal of a *stateless* application is the relative simplicity of its processing. It keeps business logic external to the application and limits the computer power necessary to keep the program running. For example, Bitcoin only processes the validity of a transaction, i.e., that two users have agreed to a transaction and have sufficient bitcoins to complete the transaction. In addition, the anonymous nature of the transactions may be attractive to a range of users.

Stateful applications create value by the inverse. The application processes all the information related to the transaction (e.g. contracts, user information), which means the business logic is validated as well as the transaction. This allows applications like Ethereum to facilitate almost any type of function, which means Ethereum can "host" other applications. Stateful applications are also the only way for the blockchain to begin to digitize transactions that are more complex than the exchange of money (e.g., organizing delivery of goods or transferring the deed of property to another party).

Challenges

Stateless applications face challenges similar to those of fiat currency. It is difficult to add additional types of functions to stateless programs, as changing the function would require the approval of all users. It is therefore very unlikely that Bitcoin will ever facilitate any transaction other than the trading of bitcoins. In addition, any logic more complex than the agreement to trade bitcoins must be done outside the application.

The major risk from a societal point of view is that there is no trace of why the transaction occurred, which means that the application can be used to pay for goods and services that are illegal in the users' countries. Bitcoin, for instance, has been used to pay hackers' extortion demands[1].

Stateful applications face structural and strategic risks. They are slower and require more data storage because more information must be processed. There are also more entry points for security breaches. Additionally, it is not clear that a stateful application, consisting of computer code, can capture the complexity of the obligations involved in a transaction. For instance, stateful applications may be unable to make sure that a product which is purchased has been delivered to the recipient or that a service has been rendered as promised.

[1] https://www.bloomberg.com/news/articles/2017-05-12/ransom-hack-racking-up-victims-with-hospitals-most-at-risk

Transparency: Public ⇔ Permissioned

Distinction

A core pillar of original blockchain applications is that there is radical transparency. The ledger is public, which allows every user to see every transaction. However, some applications are built as permissioned blockchains, allowing users to have private channels. Once admitted to a permissioned blockchain, users can still audit the data.

Examples:
Public: **Bitcoin**
Permissioned: **Hyperledger**

Uses

As the public increasingly demands transparency from corporations and governments, *public* blockchains could face growing demand. They are "auditable" to the public, which could have the added benefit of reduced corruption. Bitcoin's ledger is public, traceable, and permanently stored, allowing anyone with a computer to access the ledger and view all the payment histories.

On the other side, *permissioned* blockchains allow for personal and business transactions to be kept private. Users who are concerned that their transactions could lead to discrimination, or businesses who require private transactions for strategic purposes, may be more inclined to use a permissioned blockchain. Hyperledger allows "competing business interests, and any groups that require private, confidential transactions, to coexist on the same permissioned network"[1].

Challenges

Public blockchains face concerns around personal privacy and the sharing of business transactions. Users may be wary of any large-scale transactions that have personal or strategic implications. Currently, public blockchain applications like Bitcoin are anonymous through its stateless nature but participants know how many bitcoins are in existence. However, *public stateful* applications may concern some users given the availability of transaction data on public ledgers.

Permissioned blockchains also face risks. There is a practical concern of reduced scalability and security in creating many permissioned blockchains, but also a theoretical concern of removing the radical transparency that blockchain technology was, in part, created to ensure. Internal stakeholders within the blockchain community might push back against relaxed transparency and security measures. In addition, private blockchains seem to conflict with the equitable and inclusive nature of the original blockchain idea.

[1] http://hyperledger-fabric.readthedocs.io/en/latest/capabilities.html

User Status: Expert ⬄ Amateur

Examples:
Elite: **Ethereum**
Amateur: **Provenance**

Distinction

We use *expert* to describe individuals with technological expertise and at least some experience in blockchain. They are technology-enabled, knowledgeable about coding, and have connections within the blockchain ecosystem. *Amateur* users possess little understanding of the technology itself, but gain value from the applications.

Uses

Applications that are geared towards *experts* are more likely to grow a user base in the short term, as most current blockchain users are experts. Given the nascent nature of the technology, we would expect technological experts to be the primary market for blockchain applications as 'early adopters' in the technological adoption curve. Also, expert users can contribute to the development of the application and to the larger blockchain ecosystem. For instance, Ethereum helps launch new applications, and some of the largest applications since Ethereum's own launch in 2014 are based on Ethereum.

In the medium term, *amateur* users are going to provide the large user base that generates significant investment returns. These users will be aware that the service or application operates on a blockchain, but will be focused on the benefits of the service such as efficiency or security. Users of Provenance, for instance, use the application to see the supply chain of a good, not how the application keeps track of the supply chain.

Challenges

Blockchain applications employ technologies, structures, and vocabulary that are relatively incomprehensible for large segments of the population. An application that requires a broad user base may never gain traction if the technology is unable to develop user-friendly interfaces and service amateur users.

A large group of amateur users who do not fully understand the technology could also disrupt the usefulness of an application. For instance, if most users are amateurs in an application with a governance structure that allows for voting to decide on changes in code, suboptimal choices could result. In addition, amateur users who do not understand the coding could be cheated. This risks defeating one of the intended purposes of blockchain, which is to be able to trust the technology and not rely on the integrity of the other users.

Applying the Blockchain Taxonomy

We use a number of examples to illustrate how investors can use the blockchain taxonomy to evaluate where an application may fall on the continuum of indicators. Figure 3 is based on our qualitative assessment rather than a quantitative analysis.

Figure 3: Applying the blockchain taxonomy

Activity:	***Transaction***	Bitcoin EOS Ethereum Ripple		Provenance	***Ownership***
Governance:	***Fixed***	Bitcoin EOS Ethereum		Provenance Ripple	***Flexible***
Technology functionality:	***Stateless***	Bitcoin Provenance Ripple		Ethereum EOS	***Stateful***
Transparency:	***Public***	Bitcoin Ethereum Provenance Ripple		EOS	***Permissioned***
User status:	***Expert***	EOS Ethereum	Bitcoin Ripple	Provenance	***Amateur***

Source: Cornerstone Capital Group

Key Takeaways

We note the following application-specific conclusions from the applied taxonomy above.

- **User status is the only indicator that is not binary.** All the other indicators divide the applications into either end of the spectrum, which is expected at this early stage of development. User status instead suggests that users of blockchain applications have a range of technology levels. For instance, users of Bitcoin do not need to be experts in terms of understanding the code, but most likely find it helpful to understand blockchain vocabulary and coding basics.
- **Bitcoin, the first use of blockchain technology, stands out in comparison to more recent applications.** This is likely a function of the fact that newer applications are looking to differentiate from Bitcoin and address real or perceived inflexibility and governance issues.
- **We do not see a relationship between applications' governance structure and technology functionality.** For instance, both Ethereum and Bitcoin have fixed governance, but Ethereum is stateful while Bitcoin is stateless. In contrast, Provenance has flexible governance and stateless functionality. We note that the two indicators specify different aspects of applications' structures: governance categorizes applications' management, while functionality determines what transaction information is retained.
- **There is some overlap between activity and user status** (e.g., of our examples, Provenance is the only application that has an ownership activity and the only application geared towards amateurs). Provenance, in our view, is the most 'real-world' targeted application of the group with its focus on developing improved supply chain tracking using Blockchain. We would expect ownership-based applications to be focused on amateurs, flexible, and public to support mass market uptake and government partnerships.
- The application EOS, launched in June 2017, is in part built as a more scalable version of Ethereum[1]. We note that that the two applications fall into the same categories for each indicator except for transparency. EOS allows for permissioned channels, while Ethereum is a public blockchain application. **We would view any move from Ethereum to EOS as a suggestion that blockchain integration into society requires more privacy than the public nature of older blockchain applications allows.**

[1] http://www.lendacademy.com/eos-google-of-blockchain/

At a higher level, the taxonomy identifies a few key indications of where the blockchain ecosystem could be moving:

- **Most blockchain applications that have received high levels of investment to date are transaction applications.** We note that ownership applications require either buy-in from large stakeholders like governments or user acceptance of blockchain applications digitizing personal information. As the blockchain ecosystem is still developing, it is understandable that ownership applications have not yet bridged these stakeholder concerns. We view any funding move towards ownership applications as a suggestion that society is moving towards blockchain integration. We also see ownership applications as being less vulnerable to competition due to the network effect and likely government partnerships.
- **Recent blockchain applications are adapting the original blockchain pillars of immutable and public code**. This includes applications with flexible governance structures and permissioned channels. These applications are more marketable, but also move away from blockchain's original philosophy and toward current understandings of governance structures. While there are early signs of investor interest in flexible arrangements (e.g., funding for Tezos), the significant market value growth of Bitcoin suggests there are many users who value immutability.
- **Stateful applications are now receiving more investment than stateless ones.** We recognize that stateful applications are key to the blockchain's ability to digitize more parts of transactions than just the exchange of money. However, we observe that Bitcoin, the original blockchain application, monopolizes the investment in stateless applications. This indicates that the blockchain ecosystem may only require one stateless cryptocurrency.
- **Most applications are geared towards expert users** by providing new coding environments and sub-routines for the developer groups to use, which suggests that blockchain is still a product for technology innovators. Technology innovators represent a small market with low customer loyalty. Mass market focused applications represent greater market access, but we do not see the technology as sufficiently advanced yet to be able to reduce the level of understanding needed to use it with confidence.

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