

# **Blockchain's Democratic Promise?**

The state of blockchain and the future of its application to public policy

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## **Introduction and Potential Implications of Blockchain**

Blockchain is a new technology functioning as a distributed database of records, or a public ledger of all transactions or digital events that have been executed and shared among participating parties (Crosby, Pattanayak, Verma, & Kalyanaraman, 2016). Using technological features including decentralization, cryptographic hashes, chronological timestamps, and smart contracts, blockchain has the potential to improve quality of life through public sector use. These applications could revolutionize how humans interact with one another, our relationship with our government, and our methods of commercial exchange. Such applications include quicker and lower-cost transactions and remittances (money), notary services, electronic medical records, asset protection, digitized land registries, and more.

Intense debate exists regarding the benefits and drawbacks of blockchain technology. For citizens, blockchain's positive potential centers around limiting government and corporate exploitation through improved transparency and data security measures. For example, by reducing the costs associated with sending remittances, blockchain could grant citizens improved financial agency.

For governments, the positive promises made by blockchain could fundamentally change how the public sector operates and serves citizens. Three examples of such change include building trust, protecting sensitive data, and improving efficiency. Blockchain could build trust between governments and citizens. Considering that just 18% of Americans claim to trust their government to do what is right the majority of the time, room for improvement clearly exists in this department ("Public Trust in Government: 1958-2017", 2017). Blockchain facilitates trust

through decentralization, which enables participating parties (citizens and federal officials) the ability to view and verify data (Boeding, Czerwinski & McConkie, n.d.). Blockchain-based land registries represent one such data management example. By relocating land registries to the blockchain, governments could more easily track land transfers and verify associated property data. Sweden, Estonia, and Georgia are all experimenting with blockchain-based land registries for these very reasons (Boeding, Czerwinski & McConkie, n.d.).

Second, blockchain could help protect sensitive data through the properties of cryptography, auditability, decentralization, immutability, and secrecy (Niranjanamurthy, Nithya, & Jagannatha, 2018). Considering that governments act as society's record keepers, they are often the target of hacks, such as the 2015 US Office of Personnel Management hack which resulted in the stolen background information of 21.5 million Americans (Zetter, 2015). Blockchain's security measures could strengthen data structures by decreasing the 'single-point-of-failure' risk of hacking breaches (Boeding, Czerwinski & McConkie, n.d.).

Third, blockchain might improve the efficiency of federal processes by limiting redundancy, streamlining workflows, decreasing the burden of auditing, and ensuring data integrity (Boeding, Czerwinski & McConkie, n.d.). For example, the General Services Administration of the US government, which manages incoming proposals from vendors, requires 40 days of processing. However, it is estimated that blockchain integration could reduce processing time to 10-days and lower analysis costs by nearly 80% (Goldstein, 2018).

The gravity of these changes places intense urgency on governments to explore blockchain's potential applications, as ignoring the technology could leave them behind and leave their citizens comparatively disadvantaged.

However, limits exist on blockchain's technical capacity. For citizens, doubts loom over the proposed security of the technology. An individual's data could be susceptible to attacks despite the technology's decentralized nature. For example, if a hacker controls over 50% of a blockchain's mining hashrate, they can modify the data associated with that blockchain. For governments, this unproven security could not only expose their citizens' data, but could also result in international security attacks threats.

Though blockchain may not reshape lives in the next five years, it may very well reshape those of future generations. As a result, individuals should be aware of the morality of its potential impacts. This thesis will explore three main areas: blockchain's technical capacity, the necessary conditions which must exist for a government to consider blockchain adoption for public policy use, and how receptive users would be to adopting blockchain technology.

Considering the nascency of blockchain, the video and terms below are included to help readers understand its technical concepts. By understanding these concepts, blockchain's policy implications will become more accessible to readers.

## *Background Video*

*Figure 1: What is Blockchain?*



*Source: <https://www.youtube.com/watch?v=3xGLc-zz9cA&feature=youtu.be>*

## *Definitions*

- *51% Attack*: a potential attack on the blockchain network whereby an organization is somehow able to control the majority of the network mining power (hashrate). If the majority of miners are controlled by a single entity, they would have the power to (at least attempt to) decide which transactions get approved or not. This would allow them to prevent other transactions, and allow their own transactions to be spent multiple times—a process called double spending (Ksherti, 2017).
- *Bitcoin*: the most popular, decentralized, peer-to-peer digital currency which runs on blockchain technology (Crosby, Pattanayak, Verma, & Kalyanaraman, 2016).
- *Chronological Timestamp*: the process of securely keeping track of the creation and modification time of a document (Parker, 2015).

- *Cryptographic Hash*: an algorithm that can be run on a piece of data to produce a value called a checksum to verify the authenticity of that data (Fisher, 2018).
- *Cryptography*: the process of converting ordinary plain text into unintelligible text and vice-versa. It is a method of storing and transmitting data in a particular form so that only those for whom it is intended can read and process it. Cryptography not only protects data from theft or alteration, but can also be used for user authentication (Economic Times, 2018).
- *Decentralization*: blockchains are politically decentralized (no one controls them) and architecturally decentralized (no infrastructural central point of failure) but they are logically centralized (there is one commonly agreed state and the system behaves like a single computer) (Buterin, 2017).
- *Digital Signature*: a signature which guarantees the authenticity of an electronic document or message in digital communication and uses encryption techniques to provide proof of original and unmodified documentation. Digital signatures are used in e-commerce, software distribution, financial transactions and other situations that rely on forgery or tampering detection techniques (Techopedia, 2018).
- *Distributed Database*: when storage devices are not all attached to a common processing unit such as the CPU, but are spread across a network (Meunier, 2016).
- *Distributed Ledger Technology*: a generic description of a distributed database that often holds transaction records (i.e. a ledger) (Chang, 2017).
- *Mining Hashrate*: the unit that measures how much power a blockchain network is consuming to be continuously functional (Khatwani, 2018).

- *Smart Contracts*: self-executing contracts with the terms of the agreement between buyer and seller being directly written into lines of code. Smart contracts permit trusted transactions and agreements to be carried out among disparate, anonymous parties without the need for a central authority, legal system, or external enforcement mechanism. They render transactions traceable, transparent, and irreversible (Investopedia, 2018).
- *Under Banked*: having a bank but using alternative financial services in the past 12 months. (Folknishteyn, Lennon, & Reilly, 2015).

### ***Main Question***

Under what conditions, if any, would it be favorable for a government to adopt blockchain technology for public sector use?

## **Contextual Overview of Blockchain's Applicability**

Blockchain technology may be a foreign concept to the everyday citizen—with our main exposure to the technology coming from Bitcoin and other cryptocurrencies. However, the technology underlying these currencies may have incredible potential for public policy use. This potential is contingent upon the existence of appropriate government conditions and a receptive population of potential users.

Controversy over blockchain's technical capacity is understandable. On one hand, blockchain offers improved protection and security through cryptography and digital signatures (Crosby, Pattanayak, Verma, & Kalyanaraman, 2016), while also offering efficiency through chronological timestamps, minimal transactions fees, and relatively quick processing speeds (Folknishteyn, Lennon, & Reilly, 2015). On the other hand, the technology has been criticized as its anonymity, security, and transparency may not be guaranteed (Chang, 2017). Additionally, a blockchain is not unhackable. Possible security attacks include altering data inside a block (rendering the information no longer trustworthy) and a "51% attack" (which includes control of the majority of a blockchain's mining hashrate)(Gupta, Patel, Gupta, & Gupta, 2017). Perhaps the most famous blockchain hack came in 2014, when the then largest cryptocurrency exchange platform "Mt. Gox" was hacked—leading to the theft of 850,000 Bitcoins, then worth roughly \$473 million (Pollock, 2018). How? The hacker (someone who had access to the company's internal database) temporarily deflated the value of Bitcoin, transferred currency from customer accounts, then reset the value. This devaluation allowed for changes to balances to go temporarily undetected. (Norry, 2018).

To assess blockchain's technical strengths and quality of life applications, current and potential uses of the technology were reviewed. Currently, companies like BitPesa are leveraging blockchain technology in the private sector and disrupting legacy industries in the process.

BitPesa, a privately-operated, Kenyan foreign exchange and payment platform (similar to Venmo), has facilitated over 560,000 transactions with zero transfer fees (BitPesa, 2018). This has drastically reduced the time and cost of remittances for those sending money across borders to loved ones (Folknishteyn, Lennon, & Reilly, 2015).

Blockchain also has the ability to empower marginalized communities by improving security and transparency. Blockchain's disintermediary quality lends itself to improvements upon current systems for securing asset and property rights. Non-blockchain-based efforts to secure asset and property rights have already proven beneficial in Vietnam and Argentina, promoting investment and reducing fertility rates respectively (Deininger & Goyal, 2012). Blockchain's introduction could be the logical next step in further facilitating these benefits, bridging the poverty gap. In fact, DeSoto predicts that the value of global dead capital (including land) in which people do not have legal title to equals \$20 trillion (Shin, 2017). This empowerment extends into other realms, including healthcare data validation (Angraal, Krumholz, & Schulz, 2017), avoiding predatory loan institutions to improve earning power (Folknishteyn, Lennon, & Reilly, 2015), and reducing insurance and risk management costs for businesses through increased access to trade and supply chain financing (Kshetri, 2017).

But the technical strengths and quality of life applications of blockchain are only helpful if governments and citizens are willing and able to utilize them. Therefore, if these aforementioned strengths outweigh the risks and limitations, government conditions and

population receptiveness can be explored to pinpoint specific nations and user demographics which have the most to gain from blockchain's public policy implementation.

As for a government's ability to integrate blockchain, some nations exhibit a historical propensity to accept technological innovation and/or a current orientation toward creating the necessary conditions for technological adoption. In this thesis, several nations were evaluated according to the Global Information Infrastructure's five conditions for building an interconnected technological nation. These conditions include private sector investment, promoting competition, providing open access to the network for all information providers and users, creating a flexible regulatory environment that can keep pace with rapid technological and market changes, and ensuring universal service (Gore & Brown, 1996).

The Global Information Infrastructure conditions were chosen as a metric for determining favorable government conditions for two main reasons. First, these principles were established in order to guide nations toward technological partnership, rather than zero-sum competition. Second, these conditions are collectively encompassing, meaning they are inclusive of all the information needed to assess a nation's propensity to adopt new technologies, as they address the private sector, the public sector, government legislation, individual citizens access, and overall flexibility to change (Gore & Brown, 1996). The degree to which a nation fulfilled these conditions indicated their propensity to employ blockchain technology in pursuit of benefits for all involved parties.

Given blockchain's nascent nature, it is crucial to gauge a population's willingness to use the new technology. Willingness to adopt was predicted based on attitudes of prospective users and demographic information of current users. This information was collected from existing

surveys, with most information available in the cryptocurrency space. For example, according to surveys from 2013-2015, 39% of Bitcoin users are young adults (25-34 years old), over 90% are male, 61% are non-religious, and 23.9% have a yearly household income between \$50-100K per year (Stray, 2017).

After completing the literature review and better understanding the environment surrounding blockchain-based technologies, it became evident that three potential scenarios could play out following this research investigation:

1. Blockchain technology, in its current form, is not inherently superior to or more secure than other forms of existing technology.
2. Blockchain technology, in its current form, presents viable improvements upon other forms of technology, but a nation's conditions do not satisfy the requirements for building an interconnected technological infrastructure.
3. Blockchain technology, in its current form, presents viable improvements upon other forms of technology and a nation's conditions satisfy the requirements for building an interconnected technological infrastructure.

Hypothesis #1 would stem from findings which display weaknesses in blockchain's technical capacity. In other words, the proposed improved efficiency, security, and transparency of blockchain would be invalidated or outweighed by security concerns. Implications of this hypothesis would include a recommendation against blockchain's public policy use regardless of

a nation's conditions, as well as, a warning to current blockchain users surrounding the shortcomings and insufficiencies which might put them and their data at risk.

Hypothesis #2 would arise from the discovery that the supposed benefits of blockchain outweigh its security concerns, and that a given nation fails to exhibit a propensity to employ blockchain technology in accordance with the five Global Information Infrastructure conditions. Implications of this hypothesis would include a recommendation to delay blockchain adoption in such nations, as well as, a recommendation to encourage these nations to create a more open, equitable technological infrastructure so as to eventually benefit their citizens with blockchain technology.

Hypothesis #3 would be satisfied if the benefits of blockchain technology outweigh the security concerns and if a given nation displays a propensity to employ blockchain technology in accordance with the five Global Information Infrastructure conditions. Implications of this hypothesis would include a recommendation for blockchain adoption in these nations, as well as, a proposal to gather demographic information with respect to a population's willingness to utilize the technology.

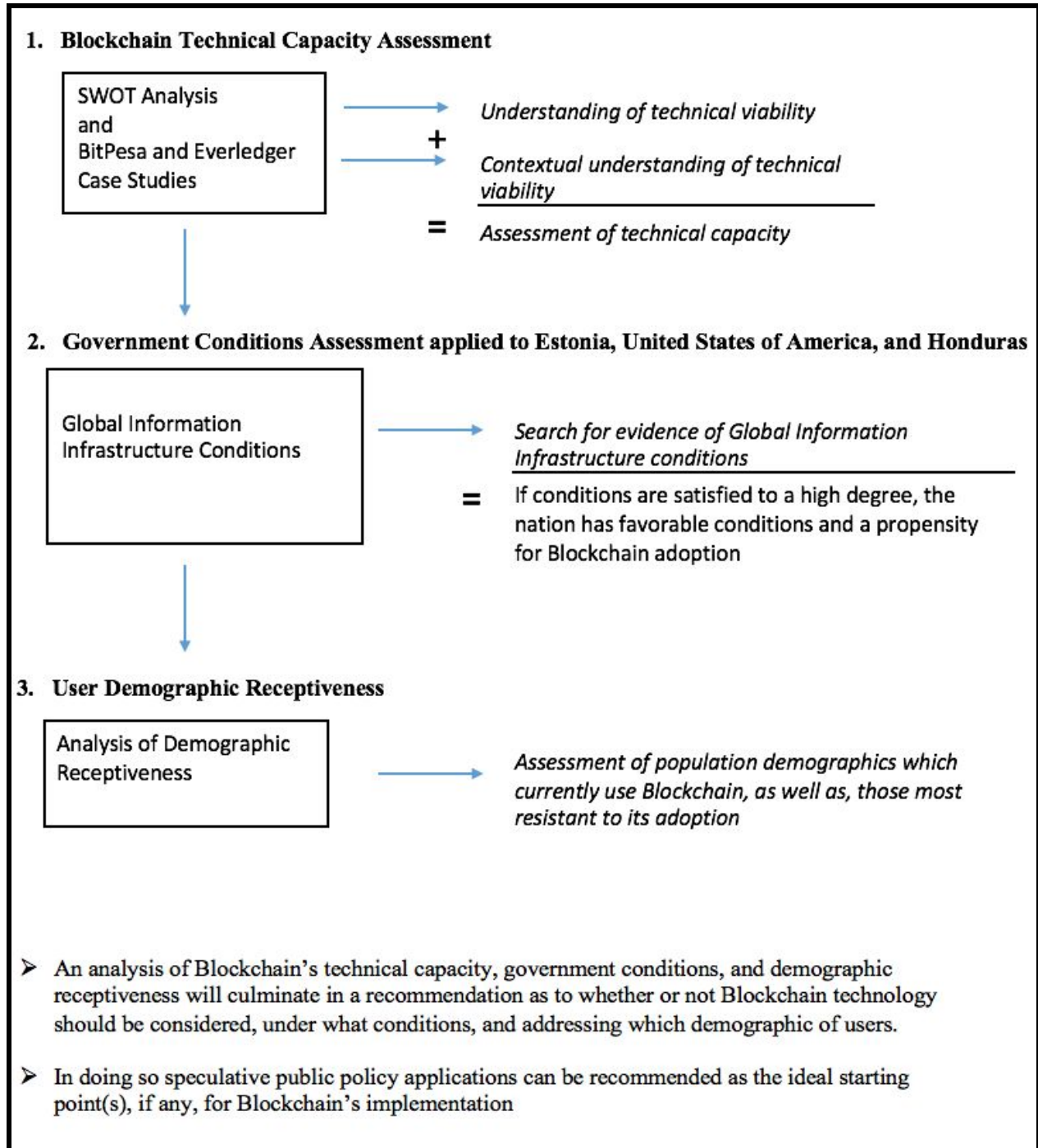
Given the chronological nature of research required in reaching these hypotheses, the methodology of this thesis is best expressed as a flowchart of outcomes. Figure 2 outlines this chronological process, which served as the guiding mechanism for empirical research and consequent conclusions.

The components to this methodology seek to answer three questions. At the most basic level, these questions ask: 1) is blockchain useful?; 2) could governments use it?; and 3) which citizens are likely to use it? If the answer to any of these three questions is "no" (or "none" for

question 3), then blockchain might not be adopted for public policy purposes within the nation being examined. Moreover, each question is contingent upon the findings of preceding questions. Thus, if blockchain is not useful, questions 2 and 3 become irrelevant, as blockchain's public policy viability would be rejected. Furthermore, if blockchain is useful but governments are unable or unwilling to adopt it, then question 3 also becomes useless, as blockchain's public policy viability is, again, rejected.

## Methodology Overview

Figure 2: Methodology Overview



## **Methodology**

This thesis was structured as a comparative case study with three chronological components: blockchain's technical capacity, government conditions, and user demographic receptiveness.

To assess blockchain's technical capacity, a SWOT (strengths, weaknesses, opportunities, and threats) analysis was performed, utilizing research from existing studies. This included an assessment of blockchain's unique technical benefits, such as cryptography, chronological timestamps, and smart contracts and blockchain's technical drawbacks, including concerns over anonymity, confidentiality, and immutability.

To provide additional context, two current blockchain-based company case studies were explored—BitPesa and Everledger. BitPesa is an online payment platform that leverages blockchain to significantly lower the cost and increase the speed of business payments to, from, and within sub-Saharan Africa (BitPesa, 2018). Everledger is a global startup that uses blockchain's smart contracts to assist in the reduction of risk and fraud for banks, insurers, and open marketplaces (media.everledger.io, 2018). These case studies were chosen because they highlight different aspects of blockchain's functionality. Analyzing BitPesa provided an understanding of the functionality of blockchain's reduced transaction fees and times, as well as the benefits of cutting out the middleman. Everledger allowed for an understanding of blockchain's ability to track provenance, chronological timestamps, and smart contracts.

The combination of a SWOT analysis and company case studies allows for a holistic understanding of the technology's viability. Here viability is defined as blockchain's ability to function successfully both on its own and in comparison to existing technologies.

Second, three comparative case studies were performed to assess whether or not the government conditions in Estonia, the United States of America, and Honduras exhibited a propensity to adopt blockchain technology. Here, comparative case studies were the best route for research as they revealed key differences in government infrastructure and policy. These differences effectively differentiated which nations are equipped to adopt blockchain technology, and which are not. Additionally, an experimental design was not feasible for this research question as blockchain technology has yet to be implemented and evaluated at the national level.

These nations—Estonia, the United States of America, and Honduras—were specifically selected as they maintain key differentiating qualities. Estonia displays high openness to technological innovation, possesses a relatively uniform population, and currently experiments with blockchain technology on a small scale. The United States of America has an incredibly disuniform population, uses a complicated legal framework for adoption and implementation, and possesses immense technological capacity. Honduras maintains a weak technological infrastructure, and contains citizens who stand to gain the most from blockchain.

This thesis investigated whether or not these three nations satisfied the Global Information Infrastructure's conditions for building an interconnected technological infrastructure. These conditions included private sector investment, promoting competition, providing open access, creating a flexible regulatory environment, and ensuring universal service to all citizens (Gore & Brown, 1996).

Lastly, existing data sets were leveraged to best understand which population demographics would be most open to blockchain adoption, based on both sentiment and current use of blockchain technology. These data sets were most easily and reliably collected in relation

to cryptocurrency, as the space represents the largest population segment engaged with blockchain technology. Three specific data sets were used—a Reddit based self-report data set on attitudes toward Bitcoin, a +2,000 person U.S.-based self-report survey on age-dependent attitudes toward Bitcoin, and Blockchain Wallet demographic data based on Google Trends analytics. By combining both self-report and empirical data sets, an understanding of both micro-level individual attitudes as well as macro-level trends of current blockchain usage became clear. Worth noting, cryptocurrency represented the focal point of these three surveys, which is just one application of blockchain-based technology. Adjusting for that fact, this data may help inform governments as to which population segments would be most willing to incorporate blockchain technology into their lives, as well as, which population segments would be most resistant.

Following these three chronological components, the three nations examined clearly fell into the aforementioned potential hypothesis categories. Additionally, conclusions were drawn as to whether or not blockchain technology should be considered, under what conditions, and addressing which demographic of users. In doing so, potential immediate public policy applications and key discussion points moving forward were highlighted.

## **Part One: Blockchain Technical Capacity Assessment**

Blockchain technology includes a host of features which influence its users in distinct ways. At its core, blockchain's distinguishing technological characteristic is decentralization—information and data are transmitted, recorded, and stored on multiple networks, eliminating the need for one central authority. To put this in perspective, when you send a text message to your mother, the information must be first be transmitted through a central cell tower, acting as a medium between your phone and your mother's phone. Blockchain's decentralized nature allows your text message to go from your phone to your mother's, without the need for a medium of exchange.

Before diving into a technical assessment of blockchain, it is worth noting that the ensuing analysis represents a snapshot of blockchain in its current form—not an analysis of blockchain over its lifetime impact on humanity. While it is true that technology can and has had a sweeping impact on society, it would be unfair to compare blockchain to technologies like the printing press, the internet, etc. Rather, blockchain must be analyzed for what it is today, not what it will realistically, or even optimistically will be in the future.

A SWOT (strengths, weaknesses, opportunities, and threats) analysis of blockchain technology, drawing upon existing research, is a helpful tool in determining technical viability. There are countless categories which can be distinguished as strengths, weaknesses, opportunities, and threats when analyzing a potentially globally impactful and complex new technology. There is no qualification for what constitutes a strength, weakness, opportunity, or threat. Rather, the standard for categorization has been subjectively constructed based on consistency in literature as well as my own interpretation. As a result, overarching buckets have

been created to best group and contextualize blockchain’s technical tenants and their associated impacts. These buckets are as follows:

Figure 3: SWOT Overview

<p><b>Strengths</b></p> <ul style="list-style-type: none"> <li>1. Security</li> <li>2. Access</li> <li>3. Efficiency</li> </ul>	<p><b>Weaknesses</b></p> <ul style="list-style-type: none"> <li>1. Computational Complexity</li> <li>2. Security</li> </ul>
<p><b>Opportunities</b></p> <ul style="list-style-type: none"> <li>1. Security</li> <li>2. Access</li> </ul>	<p><b>Threats</b></p> <ul style="list-style-type: none"> <li>1. Resistance to Adoption</li> <li>2. Scalability</li> </ul>

As one may notice, security presents itself as a strength, weakness, and opportunity. This is not an accident. When delving into blockchain’s technical capacity, it quickly becomes clear that security can function as the “make-or-break” component to its overall viability.

The purpose of this SWOT analysis is twofold. First, a SWOT analysis allows us to best understand the categorical elements which compose blockchain’s value proposition. In doing this, the goal is not to compare the importance of strengths vs. weaknesses or opportunities vs. threats, but rather to lay them out and understand the landscape holistically. The case studies which follow serve to test the hypotheses developed in this SWOT analysis. The degree to which these case studies confirm positive elements, including strengths and opportunities, and/or negative elements, including weaknesses and threats, helps construct an overall picture of blockchain’s technical capacity.

## ***Strengths***

Blockchain's three main strengths are security, access, and efficiency.

In terms of security, blockchain technology allows for disintermediation, removing the need for a centralized database. In this sense, blockchain acts as its own consensus mechanism, ensuring that transactions are verified and processed independent of one another. This presents a security advantage because a centralized database is only as secure as the third party which maintains it (Niranjanamurthy, Nithya, & Jagannatha, 2018) (Gatteschi, Lamberti, Demartini, Pranteda, & Santamaría, 2018). Next, transferring data on a blockchain is transparent, meaning as information changes, those who can view the information can track its changes, preventing intentional false reporting (Niranjanamurthy, Nithya, & Jagannatha, 2018). Third, a blockchain's records are immutable, meaning a record made on a blockchain is maintained forever. For a record to change, or for its original state to be muted, an individual with control over the majority of a node must do so (Niranjanamurthy, Nithya, & Jagannatha, 2018). The last major security strength that blockchain presents is secrecy—the underlying contents of a data transfer or transaction are anonymous to the public (Niranjanamurthy, Nithya, & Jagannatha, 2018).

Another major strength of blockchain technology is access. A blockchain ledger is “open source”, meaning blockchain systems are open to everyone and may be checked publicly. This open access to blockchain is not to be confused with a lack of privacy. Anyone can verify a blockchain transaction to confirm that data exists, but the underlying data is encrypted, and, thus, only those who should be able to understand it can (Niranjanamurthy, Nithya, & Jagannatha, 2018).

The third and final category of blockchain's technical strength is efficiency. Blockchain's potential to improve efficiency is primarily associated with business, but these tenants apply to individuals and governments as well. To start, blockchain inherently ensures a degree of data quality. blockchain data must be complete, consistent, and accurate, otherwise its incorrectness will be detected automatically (Niranjanamurthy, Nithya, & Jagannatha, 2018). Next, transactions on a blockchain are both fast and inexpensive. Transactions between traditional banks can take days for wiring, clearing, and settlement, as they rely on the working hours of individuals. Blockchain transactions can take minutes and processing occurs around the clock (Niranjanamurthy, Nithya, & Jagannatha, 2018). Additionally, the overhead costs associated with processing and exchanging assets within traditional frameworks can, with blockchain, be removed (Niranjanamurthy, Nithya, & Jagannatha, 2018). Other efficiency improvements which blockchain affords include the management of record sharing and smart contracts. Record sharing is made more efficient on the blockchain because blockchains allow various parties within an economic ecosystem the ability to access the individual live copies of a shared record system. Smart contracts are a function enabled by blockchain to create contextually-aware transactions. In this sense, if a transaction is meant to be paid over time, or upon any other cadence, a contract can recognize these dependencies and execute accordingly (Niranjanamurthy, Nithya, & Jagannatha, 2018). Finally, blockchains are auditable and traceable, meaning transactions on the blockchain allow for confidence in record collection and the consequent ability for parties to authenticate and trace assets. This is a particularly useful tool in supply chain management (Niranjanamurthy, Nithya, & Jagannatha, 2018).

## ***Weaknesses***

Despite the strengths which have people around the globe excited about blockchain, several clear weaknesses present themselves. It is possible that as the technology improves these weaknesses could become less glaring. As of now, these key weaknesses include computational complexity and security.

Considering the nascency of blockchain, it makes sense that computational complexities would prohibit its rapid dissemination. Many technologies were once far more inefficient and impractical than they became upon widespread adoption. Blockchain's computational complexity includes concerns over transaction speed. Seemingly contradictory to the strengths section, blockchain transactions, on a technological level, are slower than centralized databases. Where blockchain's technology presents an opportunity to save time comes at a human level, removing the reliance on human processing, verification, etc. Blockchain's disadvantage in time performance stems from the additional burdens it carries which centralized databases can avoid. These burdens include: signature verification, consensus mechanisms, and redundancy. For signature verification, all transactions must be digitally signed by the sender and receiver of a transaction due to the peer-to-peer nature of blockchain. Generating and verifying such signatures requires a large amount of computational power. Centralized databases, on the other hand, require a one-time connection for a type, or category, of transaction, rather than each individual transaction (Niranjanamurthy, Nithya, & Jagannatha, 2018). Next, consensus mechanisms introduce computational complexity because a large amount of computational energy must be spent in order to maintain the back-and-forth communication necessary for data consensus to be maintained between all nodes of a blockchain (Niranjanamurthy, Nithya, &

Jagannatha, 2018). Third, blockchain transactions are redundant—every node of a blockchain must process transactions independently, while a centralized database requires a one-time process (Niranjanamurthy, Nithya, & Jagannatha, 2018).

In terms of security, a blockchain is not immune to hacking—hackers may still exploit weaknesses in blockchain’s code to steal data from users. An example of this exploitation occurred in June 2016, when \$60 million was stolen on the blockchain network “Ethereum.” While the specific hacking mechanisms are complex, the technology’s failure in this regard serves as a threat to its ability to gain trust and deliver upon its technological strengths (Gatteschi et al., 2018). Under the broader umbrella of hacking, specific challenges to blockchain’s security include practices such as user identity theft, asset/node theft/impersonation, injection of malicious code, and fictitious blockchain applications (Niranjanamurthy, Nithya, & Jagannatha, 2018).

### ***Opportunities***

Blockchain presents an opportunity to advance the interests of marginalized communities around the globe by granting new degrees of security (to owned assets) and access (to a repository of information).

In terms of security, blockchain technology may allow for a future in which individuals’ assets are registered on a distributed ledger which cannot be tampered with by corrupt governments or strong-arming corporations. One example of this is land ownership—time and time again, corrupt regimes have forced poor families off of their land for political or economic gain. India's non-blockchain-based computerization of land registries points to how securing

property rights could reduce the need for individuals to spend resources on protecting their rights. This computerization has allowed for increased self-assessed land values, greater investment in housing and female empowerment, and allowed former squatters to join labor markets rather than staying home to guard their land (Deininger & Goyal, 2012). Land security has also proven beneficial in Vietnam by prompting higher investment and in Argentina by helping reduce fertility rates and leading to increased investment in children's human capital (Deininger & Goyal, 2012). As previously stated, it is estimated that the value of global dead capital (including land) in which people do not have legal title to equals \$20 trillion (Shin, 2017). Blockchain could be the logical next step in granting billions of individuals access to their legitimately owned assets. Next, blockchain's potential security superiority could create end to end auditable voting systems which would be more time efficient (Gupta, Patel, Gupta, & Gupta, 2017). This security could also improve business to business trade by increasing access to trade and supply chain finance, while reducing costs and improving insurance and risk management systems (Kshetri, 2017).

As for access, the blockchain could become a hub of verifiable information used for data analytics across multiple sectors, contributing to a decrease in informational friction and serving as an opportunity for assisting human development (Gatteschi et al., 2018). Access to such a repository of information could have implications across all sectors. In healthcare, blockchain has the potential to save the industry up to \$20 billion annually by improving data validation, auditing, and authorization of medical records (Angraal, Krumholz, & Schulz, 2017). This type of access via the blockchain can also create financial avenues to bridge the poverty gap, including reductions in remittance costs (Satara, 2017). Blockchain could also save consumers

from predatory loan institutions, improving earning power for the average person (Folknishteyn, Lennon, & Reilly, 2015).

These opportunities could, however, come with disproportionate impacts. Some fear that blockchain could decrease quality of life as the technology may favor urban and/or high income areas. Computerization in India showed that positive effects of land security disproportionately favored urban dwellers (Deininger & Goyal, 2012). Additionally, electronic voting in the 2007 Estonian election disproportionately yielded a higher voter turnout in high income areas, leading to concerns about a growing digital divide perpetuated by blockchain's introduction (Gupta, Patel, Gupta, & Gupta, 2017).

### ***Threats***

Threats to the success of blockchain technology fall into two main categories—resistance to adoption and scalability.

Resistance to the adoption of blockchain technology is not a unique obstacle to blockchain, but rather characteristic of the obstacles which stand in the way of any new technology in the modern era. This resistance is driven by technical limitations, regulatory status, concerns over ease of integration, and cultural adoption. First, before gaining the trust of widespread users, blockchain must first improve upon its technical limitations including transaction speed, the verification process, and data limitations (Niranjanamurthy, Nithya, & Jagannatha, 2018). Next, blockchain's legal standing has been in a state of flux, depending on both application and location. As a result, organizations are wary of dedicating resources toward creating an infrastructure for blockchain, as financial institutions and governments have not yet

issued blanket laws over its legality (Niranjanamurthy, Nithya, & Jagannatha, 2018). Third, blockchain must conquer integration concerns. To adopt blockchain, significant changes and/or replacements must be made to existing technological systems. This process is often labor and capital intensive (Niranjanamurthy, Nithya, & Jagannatha, 2018). Lastly, individual users must be willing to incur the qualitative and quantitative switching costs associated with the mental and physical switch to blockchain-based systems (Niranjanamurthy, Nithya, & Jagannatha, 2018). Considering that resistance to adoption is a historical technological phenomenon, the community which supports blockchain can look to past technological successes as blueprints for overcoming such resistance.

Scalability is also a threat to blockchain. Currently very few blockchain transactions can be handled at any given time due to computational power restrictions. In order to overcome the threat of scalability, blockchain platforms must reduce the complexity of Block validation. A failure to decrease these computational requirements poses a threat to blockchain's expansion (Gatteschi et al., 2018). For context, Bitcoin, the most widely traded cryptocurrency on the blockchain, requires over 170 GB of storage per network node (Bitinfocharts, 2018). As a result, the associated hardware is expensive—roughly \$6 per transaction. Many companies are currently developing processes to bring these energy storage and hardware expense figures down (Stilgherrian, 2018). For comparison's sake, it takes roughly 17 megajoules of energy to mine (regulate and verify) a \$1 Bitcoin transaction, while it takes just five megajoules of energy to physically mine \$1 of gold (Hern, 2018). Moreover, it is estimated that the Bitcoin network alone uses 30.14 terawatt hours of energy per year, which surpasses 19 European nations' yearly energy usage (Hern, 2017)!

In an effort to contextualize applications of blockchain technology and test its technical viability, two companies—BitPesa and Everledger were explored. BitPesa is an online payment platform that leverages blockchain settlement to significantly lower the cost and increase the speed of business payments to, from, and within sub-Saharan Africa (BitPesa, 2018). Everledger is a global startup that uses the best of emerging technology including blockchain, smart contracts and machine vision to assist in the reduction of risk and fraud for banks, insurers and open marketplaces (media.everledger.io, 2018).

These two case studies were selected because they underscore different aspects of blockchain technology. BitPesa highlights the functionality of reduced transaction fees and times, reduced remittance costs, and third party circumnavigation. Everledger highlights the use of chronological timestamps and smart contracts in order to leverage blockchain for personal, business to business, and government contract and asset security.

The findings in these case studies were linked back to the SWOT analysis of blockchain's technical viability in order to scrutinize the application of blockchain's proposed strengths and opportunities, as well as, evaluate its practical weaknesses and threats.

### ***BitPesa Case Study***

BitPesa may be thought of as similar to the common payment platform Venmo. Both platforms reduce friction and facilitate financial transactions. The key difference between the two is that BitPesa acts as a currency exchange. Users upload their home currency into a mobile wallet, convert it to Bitcoin (or another digital currency), send it to a family member or friend

(domestically and/or internationally), then the receiver converts the Bitcoin into **their** home currency, allowing that individual to withdraw it from their banking institution (BitPesa, 2018).

BitPesa's value resides in its ability to accomplish two goals:

1. Send and collect business payments between Africa and the globe
2. Place and execute a financial trade within minutes

(Bitcoin Exchange Guide, 2015).

These goals are especially important on the African continent to facilitate trading between importers and exporters, and to open Africa's markets to new investors by simplifying the process for trade. Additionally, BitPesa's ability to reduce transactional friction has served individuals interested in sending remittances home to support their family and friends. BitPesa reduces remittance costs and the time involved in a foreign exchange transaction. Whereas wire transfers take days, BitPesa takes just a few minutes (Bitcoin Exchange Guide, 2015). BitPesa's ability to open markets to new entrants represents blockchain's opportunity of "access" in that it creates new financial channels toward wealth creation for businesses, while simultaneously reducing costs for individual transactions. Advocates of blockchain's implementation in foreign exchange argue that any cryptocurrency security issues would only result from the services built on top of the blockchain network, not the underlying technology itself (Jackson, 2015). Moreover, currency exchanges, such as BitPesa, are not susceptible to the volatility of cryptocurrency markets, as communication between sender and receiver can ensure exchange within minutes (Jackson, 2015).

BitPesa is fulfilling on its promise, as it has lowered the cost of transferring money internationally in the countries it operates in by 75% and has reduced the settling time between

currencies from 12 days to under 2 hours (Haig, 2017). BitPesa has also been able to effectively scale its model; moving on from Kenya, BitPesa now operates across 85 countries, has served over 23,000 users, and has processed over 560,000 transactions (BitPesa, 2018). BitPesa's ability to effectively scale underscores the blockchain strength of "efficiency", reducing transaction time as compared to traditional financial institutions, while simultaneously reducing overhead costs and thus enabling a less expensive transaction process for the end-user. This scaling also discredits the threat of "scalability" in blockchain based processing platforms.

Though not categorically outlawed, the Kenyan Central Bank publically discouraged the use of cryptocurrency in 2015. In its statement, the bank said, "Financial institutions are expressly advised not to open accounts for any person dealing in virtual currencies such as Bitcoin. Failure to comply with the directive will lead to appropriate remedial action from the Central Bank" (Banking Circular No 14 of 2015). While the Central Bank has since softened its stance on BitPesa and similar operations, such defiance calls the threat of "resistance to adoption" of new technology into play.

Exploring the purpose, execution, and limitations of BitPesa uncovered opportunities, strengths, and threats respectively. By opening African markets to foreign and/or domestic investment, BitPesa creates opportunity by enabling new access to financial markets and reducing remittance costs by up to 75%. Next, BitPesa's rapid and successful scaling highlights blockchain's strength in "efficiency" for both businesses and consumers alike. Finally, BitPesa's opposition, as issued by the Central Bank, presents a real-world application in which the threat of "resistance to adoption" nearly foiled a blockchain-based technology's trajectory.

### ***Everledger Case Study***

Everledger is able to create supply chain transparency via an immutable digital ledger, leveraging blockchain technology to “build trust and drive sustainability in global markets, industry and production” (media.everledger.io, 2018). The company was named amongst the *World Economic Forum’s* 61 most promising Technology Pioneers of 2018 (media.everledger.io, 2018).

The problem which Everledger is solving pertains to the insurance industry at large. A 2012 study from the *Association of British Insurers* notes that 65% of fraudulent claims go undetected, producing a market failure of £2bn to insurance companies each year in London’s diamond industry. Diamonds serve as one example of this market failure, as there has not been an easy way to detect if diamonds have been stolen and, if so, determining proof of ownership can be nearly impossible due to an imperfect paper-based system (Caffyn, 2015). Blockchain’s ability to track provenance better than paper documents is truly a breakthrough in that it is more secure and easily accessible to the public. Moreover, insurance companies can save on the costs incumbent with paying out claims (Lomas, 2015). This solution reflects blockchain’s strengths in “access” and “efficiency”, creating a publically accessible ledger and business efficiencies, respectively.

Everledger is able to ameliorate supply chain/fraud issues by giving transactional parties (including police and insurers) access to 40 data points on any given diamond. In this way, investigators can track who owned a stolen diamond and, consequently, where to return it to. While this sort of tracking and identification system has proven effective for cloud-based systems, Everledger has pioneered its use for diamonds and other luxury goods. Beyond helping solve issues surrounding the black market for diamonds, Everledger technology could be useful for e-retailers like Amazon and eBay,

as well as for other luxury good markets including handbags, fine art, etc. (Caffyn, 2015). These online marketplaces are often where individuals dump counterfeit goods at discount prices (Lomas, 2015).

The degree to which Everledger is able to create a robust solution to the diamond provenance problem is contingent upon the scale they can build. Everledger has taken a global approach, partnering with major certification houses in America, India, Israel, and Belgium. In addition to these global stakeholder successes, Everledger has already “digitized” over 1.2 million diamonds on its private blockchain (Gutierrez, 2017). Everledger’s ability to successfully scale serves as an example of overcoming the threat of “scalability”. This scaling success reinforces that of BitPesa.

Everledger is also a prime example of the value proposition blockchain presents in terms of “security”. Everledger leverages a system called “LinuxONE” to protect its database of information. LinuxONE provides blockchain-specific security measures including “Protection against misuse of privileged user credentials, malware protection, protection of peers from one another, key safety, and a highly auditable operating environment” (Gutierrez, 2017).

The principal threat which surfaced in the case study of Everledger was not inherent to Everledger, but rather targeted toward traditional insurance companies. Everledger, and blockchain-based companies in general, present a business threat by changing the cost-advantages which insurers traditionally held (Lorenz et al., 2016). This could pose a “resistance to adoption” spurred by private interests. For example, large insurance companies could begin lobbying governments for legislation creating heightened barriers to entry for blockchain-based companies. To date, this resistance has not been seen. Whether or not this development is viewed as a threat is open to an individual’s interpretation of capitalistic innovation at large. While traditional insurance companies may be weakened (and jobs potentially lost) due to Everledger, and others’ innovation, many believe this is

simply the natural cycle of innovation, replacing present jobs with new jobs, and providing a better product or service to the end consumer.

Everledger's ability to deliver "access" and "efficiency", supported by improved "security" techniques, serves as a model for building on blockchain's unique technical strengths. Moreover, Everledger's ability to overcome the threat of "scalability" proves that such a threat can be strategically defeated. Finally, it is yet to be determined whether or not "resistance to adoption" in the insurance industry will curb Everledger's progress, but the threat alone cannot be used to discredit the company's progress.

## **Part Two: Government Conditions Assessment**

Chronologically it made sense to assess government conditions following the SWOT analysis because, if the SWOT analysis provided evidence against blockchain's technical capacity, an analysis of government conditions would be futile. Blockchain's technical capacity was a universal exploration, as the technology can impact countries on opposite ends of the globe in the very same ways. As a result, it made sense to start most broadly (with the technology itself) then become more specific, by diving into the governments which could adopt the technology.

The goal in this section is to search for evidence of the Global Information Infrastructure conditions—whether or not a government's conditions are favorable for blockchain adoption was assessed based on these conditions. The conditions for building an interconnected technological infrastructure are as follows (Gore & Brown, 1996):

- (i) Encouraging private sector investment
- (ii) Promoting competition
- (iii) Providing open access to the network for all information providers and users
- (iv) Creating a flexible regulatory environment that can keep pace with rapid technological and market changes
- (v) Ensuring universal service

So long as the Global Information Infrastructure standards were satisfied to a high degree, the conditions in such a nation were considered favorable for blockchain technology

adoption. If one or more of the conditions were not satisfied, such a nation would not be considered favorable.

The use of these five conditions is justified because they are both mutually exclusive and collectively exhaustive. In other words, these five conditions are neither overlapping in content, nor do they fail to comprehensively cover all facets of a government’s posture toward the private sector’s role in building a technological infrastructure which blockchain could fit into.

This methodology was applied to Estonia, the United States of America, and Honduras. These nations were carefully selected due to their clear differences.

*Figure 4: Country Comparison*

	<i>Population Size</i>	<i>Regional Cohesion</i>	<i>Ease of Lawmaking</i>	<i>Technical Capacity</i>
<i>Estonia</i>	Low	High	High	High
<i>United States</i>	High	Low	Low	High
<i>Honduras</i>	Medium	Low	Low	Low

Estonia is a small country in Northern Europe—a region known for its openness to technological innovation. Given Estonia’s small and uniform population, the country serves as a case study for how technology is impacted by easily managed populations. In fact, the Estonian population is only 1.3 million and only 2 languages are regularly spoken (Estonian and Russian) (BBC News, 2018). Given these parameters, Estonian law can be passed swiftly, citizens can be communicated with easily, and nationwide technological experiments can be carried out with little friction. In fact, Estonia’s high technical capacity is proven by its position as one of the only nations to have tested electronic voting with their 2007 political election (Gupta, Patel, Gupta, & Gupta, 2017). Moreover, Estonia has already exhibited a propensity for blockchain

experimentation within their nationwide data registries including health, judicial, legislative, security, and commercial code systems (E-estonia.com, 2018).

Unlike Estonia, the United States of America operates more independently, rather than in the context of its region. The United States of America has a far larger population at 316 million and a high degree of variability in state laws. At the same time, the United States of America represents a nation with immense technical capacity, amongst the world's leaders in technology and global economic impact. As a result, the United States of America serves as a case study for how technology is impacted by a large, disparate population with a government possessive of immense technical capacity. Furthermore, the United States of America maintains a complicated legal structure defined by conflicting interests of lawmakers and constituents alike (BBC News, 2018).

Honduras lacks both a strong regional coalition in Central America, and the independent strength of the United States of America. Instead, Honduras's history of military rule, corruption, poverty, and crime, has left it with high wealth inequalities and, consequently, a weak technical capacity. In terms of demographics, Honduras's population is mid-sized, at 9 million. Honduras's population is also diverse, with many indigenous languages spoken, as well as Spanish and English. Lawmaking in Honduras has become complicated by political pressure groups and guerilla groups which both seek to push political agendas through fear tactics (BBC News, 2018). Of important consequence, Honduras's historical violence and present hardships render its citizens amongst those with most to gain from blockchain's strengths and opportunities in security, access, and efficiency.

### ***Case Study: Estonia***

An analysis of Estonia's government conditions exhibited overwhelming evidence of the Global Information Infrastructure conditions including encouraging private sector investment, promoting competition, providing open access, a flexible regulatory environment, and universal service.

**Encouraging Private Sector Investment:** Estonia is currently in the investment-driven stage of economic development. The Estonia government has done well to channel funds for research, as well as establish a bureaucratic framework to capitalize on such funds. This bureaucratic framework includes the "Eesti Teadusfond"—the Estonian Science Foundation (which distributes scientific grants for research and competition)—as well as the "Ettevõtluse Arendamise Sihtasutus—the EAS - Enterprise Estonia (which distributes grants for innovation). Not only has the Estonian government set up these organizations, but they have also delivered on their intended promises. Specifically, the EAS implemented 150 innovation audit programs, specifically focused on technology development (Friedrich and Looga, 2016).

**Promoting Competition:** Evidence of Estonia's ability to promote competition resides in its economic openness and policy of "Smart Specialization." In terms of economic openness, 90% of Estonia's GDP is attributable to exports and imports, rendering the nation amongst the highest globally in import/export contribution to GDP (Kappeler, 2015). Next, Estonia's government has instituted a policy framework, "Smart Specialization," wherein industrial, educational, and innovation policies are reimagined and combined in an effort to promote growth opportunities through competition (Kappeler, 2015). Strategically, this policy framework has manifested itself in a document titled "The Estonian Entrepreneurship Growth Strategy

2014-20.” This document underscores Estonia’s economic policy initiatives, which seek to improve competition by increasing productivity, stimulating entrepreneurship, and encouraging innovation (Estonian Entrepreneurship Growth Strategy 2014-2020, 2013).

**Providing Open Access:** Estonia’s ability to provide open access to government services extends beyond its own borders and simultaneously highlights the nation’s commitment to utilizing technology to provide access to services more seamlessly. In an unprecedented decision, Estonia became the first nation to offer “e-residency” to citizens outside of its borders, allowing these e-residents benefits including, but not limited to: the ability to incorporate a company, set up bank accounts, and access the EU market. As of November 2014, over 10,000 people have applied for Estonian e-residency. At the same time, it was estimated that Estonia would have 10 million e-residents by 2025 (Drysdale, 2014). The Estonian government has demonstrated its extreme commitment to open access to government services by pioneering e-residency beyond its own borders.

**Flexible Regulatory Environment:** Estonia’s Entrepreneurship Growth Strategy 2014-2020 includes the construction of co-operation networks, funded by the public sphere, with the goal of addressing “important challenges to the state, increase synergy with international initiatives and to create preconditions for their adoption and implementation at the national level” (Estonian Entrepreneurship Growth Strategy 2014-2020, 2013). The state funding such an endeavor is evidence of a willingness to use policy in order to create the conditions by which existing business and academic sectors may identify synergies and create economic opportunity thereafter. In this sense, the Estonia government has embedded a flexible regulatory policy

within the very document which it claims to be it's "most important strategic document" (Estonian Entrepreneurship Growth Strategy 2014-2020, 2013).

**Universal Service:** Estonia has exhibited a commitment to providing universal service to its citizens through the provision of several nationwide mobile services. To highlight two important examples, mobile transport ticketing services, as well as mobile positioning services were explored. Mobile transport ticketing refers to a program which grants commuters the opportunity to buy transportation tickets with their mobile phones. Practically speaking, this is accomplished by sending an SMS text, creating immense convenience for users. Mobile positioning services refers to Estonia's "enhanced112" emergency call center. Similar to the United States's 911 option, Estonian citizens can text 112 and receive emergency assistance through location-based services (Rannu, 2003). For both mobile transport ticketing and mobile positioning services, the Estonian government has effectively created a universal solution for its citizens, improving accessibility and ease of use, while reducing the time and effort required to obtain the same service.

*Figure 5: Estonia Results*

<i>Conditions</i>	<i>Encouraging Private Sector Investment</i>	<i>Promoting Competition</i>	<i>Providing Open Access</i>	<i>Flexible Regulatory Environment</i>	<i>Universal Service</i>
<i>Estonia</i>	Present	Present	Present	Present	Present

### ***Case Study: United States of America***

The United States of America produced mixed results with regard to the Global Information Infrastructure conditions. Given its presence as an global superpower, it is not surprise that it the United States of America has some of the necessary conditions for blockchain's implementation. However, the nation's lack of homogeneity, specifically with regard to its government's ability to provide services, holds it back from making a convincing argument for its preparedness to equitably distribute the benefits of blockchain technology to its citizens.

**Encouraging Private Sector Investment:** The United States of America has convincingly demonstrated a commitment to private sector technology investment. This year alone, the nation has made great strides by building spectrum policy through its "5G Summit." Recent National Telecommunications and Information Administration (NTIA) strides in spectrum policy include spectrum sharing and bi-directional spectrum leasing. In a recent NTIA policy forum, Assistant Secretary of Commerce for Communication and Information, David Redl, highlighted these successes and noted a policy outlook inclusive of "building the sustainable policy frameworks that are supporting 5G rollout and other important uses of spectrum we have, and will continue to need" (NTIA, 2018).

**Promoting Competition:** The United States of America's Bureau of Competition, in conjunction with the Federal Trade Commission (FTC) takes a firm stance toward protecting consumers by promoting competition. Competition is promoted in four key areas: preventing mergers, stopping business practices which maintain high prices, promoting economic opportunity, and tracking emerging trends and innovative products. The FTC prevents mergers

by reviewing competitive landscapes and taking action if they believe a merger may eliminate a crucial competitor (Lipsky, 2017). In 2015, the FTC stopped a merger between two foodservice distributors—Sysco and U.S. Foods. The merger would have led to unnaturally high food costs nationwide (Lordan, 2015). Next, the FTC works to stop business practices which maintain high prices by tracking monopolies which create prohibitive barriers to market entry, then taking action to prevent such barriers (Lipsky, 2017). For example, the FTC cracked down on Mallinckrodt, a drug company which violated antitrust laws by acquiring exclusive rights to develop a competitive drug for treating infants in 2017 (Federal Trade Commission, 2017). In terms of promoting economic opportunity, the FTC recently created a task force for economic liberty, with the mission of increasing “occupational licensing regulations that may limit job opportunities, especially for low-income workers and military families who move frequently” (Lipsky, 2017). Lastly, the FTC tracks emerging trends in order to push new products to consumers. The FTC does so by hosting workshops on innovation inclusive of key stakeholders such as industry experts and consumer groups. Topics of recent innovation workshops include home-mounted solar panels and self-driving cars (Lipsky, 2017). The Federal Trade Commission’s demonstrated action across these four areas confirms the United States of America’s commitment to promoting competition.<sup>1</sup>

**Providing Open Access:** The 2009 American Recovery and Reinvestment Act exhibits a commitment to providing open access by granting \$4 billion to the NTIA in order to increase broadband access in underserved parts of the country. As of November 2016 the NTIA successfully replaced over 117,000 network miles and connected over 25,000 institutions

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<sup>1</sup> The Federal Trade Commission is the authority over specific technology policy issues, but not all. It is illustrative, but not exhaustive, of national technology policy attitudes in the United States of America.

(schools, libraries, hospitals, etc.) (Ntia.doc.gov, 2016). While the American Recovery and Reinvestment Act was well intentioned, there were failures in its execution which raise doubts over the United States of America's ability to provide open technological access. In fact, according to Politico, half of the roughly 300 approved broadband projects had not drawn their promised funding by July 2015—six years later. Additionally, over 40 of the projects funded by the American Recovery and Reinvestment Act were not followed through within this same timeframe (Romm, 2015).

**Flexible Regulatory Environment:** The United States of America's treatment of net neutrality indicates a failure in creating a flexible regulatory environment, while the Federal Communications Commission's (FCC) Strategic Plan 2018-2022 indicates an aspiration to create a more flexible regulatory environment. The United States of America has a reputation for inflexible policy decisions as a result of bifurcated political party voting. Such strong contradictory ideologies can lead to flip-flopping on policy decisions. The Trump administration repealed rulings which upheld Obama's defense of net neutrality. These changes allow internet service providers to discriminate according to internet user. As a result, companies including AT&T and Verizon are able to throttle (slow down) certain products and services (Reardon, 2018). For example, AT&T was caught selectively throttling Apple's FaceTime service in order to damage the experience of non-paid AT&T users (Kravets, 2017). Beyond the flip-flop in decision making from one administration to the next, a lack of net neutrality grants competitive advantages to large-scale service providers, representing a failure in promoting competition through inflexible policy. On the flip side, the FCC is aware and in support of flexible policies, despite this case study on net neutrality. In the FCC's Strategic Plan 2018-2022, two key

objectives indicate a commitment to flexible policy. These include removing “regulatory burdens and barriers to infrastructure investment, and providing opportunities for innovation in broadband services and technologies by developing a flexible approach that will modernize, reform, and simplify the Universal Service Fund (USF) programs” and reducing “the digital divide, creating incentives for providers to connect consumers in hard-to-serve areas...bringing the benefits of communications services to all Americans by developing and implementing flexible, market-oriented policies related to the assignment and use of spectrum” (Federal Communications Commission, 2018).

**Universal Service:** In 2015 President Obama created the Broadband Opportunity Council with the goal of increasing “broadband deployment, competition, and adoption” (Ntia.doc.gov, 2017). While this initiative is well intentioned, key findings from the 2016 Broadband Progress Report indicate a failure in delivering universal service with regard to broadband telecommunications. These findings note that 39% of rural Americans lack access to 25 Mbps/3 Mbps, 66% of Americans living in U.S. territories lack access to 25 Mbps/3 Mbps, and 41% of schools lack the connectivity needed to meet the target goal of 100 Mbps per 1,000 individuals (Federal Communications Commission, 2016).

Figure 6: United States of America Results

<i>Conditions</i>	<i>Encouraging Private Sector Investment</i>	<i>Promoting Competition</i>	<i>Providing Open Access</i>	<i>Flexible Regulatory Environment</i>	<i>Universal Service</i>
<i>USA</i>	Present	Present	Insufficient	Insufficient	Insufficient

## ***Case Study: Honduras***

Military conflict in the 1980s and Hurricane Mitch's devastation in 1998 have left Honduras in a state of economic and political transition which continues to this day (BBC News, 2018). Across the spectrum of the Global Information Infrastructure conditions, with the exception of encouraging private sector investment, Honduras fails to provide sufficient evidence. Positive commitments in pursuit of many of these conditions are in place and/or in progress, yet their lack of existence at present renders the nation incapable of blockchain adoption for public policy use.

**Encouraging Private Sector Investment:** In the Aftermath of Hurricane Mitch, Honduras's government recognized a need for reforms to reduce poverty, develop human resource potential, and support environmental protection (OPEC, 2002). Years later, in 2016, the nation re-stated its commitment to private sector investment by launching "Honduras 20/20"—an economic development program which aims to create 600,000 jobs through a \$13 billion investment in tourism, textiles, manufacturing, and business support services (Economic Survey, 2017).

**Promoting Competition:** Promoting competition can be aptly explored through the case study of "mobile number portability", which refers to the ability of an individual to switch telecom carrier without switching phone numbers. This service is important because without it, high switching costs enable service providers to strangle competition (Rouse, 2010). Government-provided mobile number portability has become a precedent in the 21st century. Considering that the Global Information Infrastructure conditions are comparative by nature, it is logical to compare the timing of Honduras's adoption of mobile number portability to other

nations'. Upon closer examination, it was found that Honduras was the last Central American country to pass a law on mobile number portability. In 2013 Honduras passed the "Number Portability Act", creating a more level playing field for an oligarchical telecom landscape dominated by Tigo, Claro, and Hondutel (Central America Data, 2013). While this act serves as a victory for consumers by promoting competition, its timing weakens any argument in favor of Honduras taking a proactive, rather than reactive, approach to promoting competition.

**Providing Open Access, Universal Service:** In the case of Honduras, internet diffusion rates reject the presence of the conditions of providing open access and universal service. In a recent study on Latin America and sub-Saharan Africa, greater internet diffusion was positively correlated with an improved democratic voice and government accountability and negatively correlated with government corruption (Kock and Gaskins, 2014). If open access and universal service are key drivers of democracy and accountability, then governments have an obligation to ensure high internet penetration rates. At 12% Honduras ranked amongst the lowest in Central America for internet penetration rate in 2010 (Salzman and Albarran, 2011). To put this in perspective, the cumulative internet penetration rate in 2010 for the Latin American/Caribbean region was 35.7% (Internet World Stats, 2011). The relationship between internet diffusion and democracy, accountability, and corruption, coupled by Honduras's comparatively low internet diffusion rates, rendered insufficient evidence in the case of Honduras providing open access and universal service to its citizens.

**Flexible Regulatory Environment:** Honduras's president, Juan Orlando Hernandez, is practically synonymous with crime. On the campaign trail in 2013, Hernandez embezzled \$90 million from the Honduran Social Security Institute to support his campaign. Since then, his

administration has embezzled a further \$300 million from the social security institute. Blatantly corrupt leaders typically create inflexible regulatory environments. By illegally influencing Honduras’s Supreme Court with party affiliates, Hernandez has done just that. In 2015 Hernandez championed the unconstitutional vote to allow elected officials the ability to run for a second consecutive term, planning to prolong his power. Honduran citizens have said their piece on the state’s regulatory environment—in 2014 Honduras ranked 125th in terms of citizen perception of corruption, amongst the world’s worst (Fiorini, 2017).

*Figure 7: Honduras Results*

<i>Conditions</i>	<i>Encouraging Private Sector Investment</i>	<i>Promoting Competition</i>	<i>Providing Open Access</i>	<i>Flexible Regulatory Environment</i>	<i>Universal Service</i>
<i>Honduras</i>	Present	Insufficient	Insufficient	Insufficient	Insufficient

### **Part Three: User Demographic Receptiveness**

After laying out the conditions which the government case studies were driven by, it became possible to transition to understanding the populations within these nations which might be receptive to the adoption of blockchain technology. Keeping with the common thread of increased specificity in answering this thesis question, it makes sense to move on from a government conditions assessment to a user demographic receptiveness assessment. There would be limited use in understanding which demographic of citizens would be receptive to blockchain adoption, without first understanding the nations which are willing and able to adopt the technology. Thus, the user demographic receptiveness section follows the government conditions assessment, as this study seeks one more level of specificity in an effort to draw conclusions about the viability of blockchain technology in public policy.

The goal of this section is to use data in order to best understand who would use blockchain technology and who currently uses blockchain technology. This thesis has already dived into the switching costs associated with new technology in the threats section of the SWOT analysis. Therefore, for the purposes of this section, data, rather than hypothetical speculation, was focused on exclusively. This section is divided into two main categories of evidence—self-report measures and Blockchain Wallet demographic information.

Self-report data on attitudes toward blockchain was most readily available through existing studies on Bitcoin, given that Bitcoin is the widest, most well known application of blockchain technology, inclusive of all of blockchain's technical tenants. In a survey published

on a Bitcoin related reddit stream with over 300,000 readers, researchers sought to understand attitudes toward the popular cryptocurrency. Considering the reddit stream is only used by those already interested in the technology, the researchers were able to filter for the technology's potential user demographic from the onset. 50 participants took the study. Three key demographic insights were collected regarding gender, age, and frequency of use. Ninety-two percent of participants in this study were male, while 4% were female, and 4% chose not to disclose (Pajunen, 2017). Next, it was revealed that 48% of participants were aged 20-29 and 28% were aged 30-39. With 76% of participants falling within just a 20-year age range, the target audience became more clear (Pajunen, 2017). Third, survey results indicated that 22% of participants would be open to using blockchain technology on a daily basis, 38% on a weekly basis, 34% on a monthly basis, and 6% on an annual basis (Pajunen, 2017). The key finding here, from a public policy perspective, was that 94% of users would be open to using blockchain technology on a monthly basis, or more frequently. Considering public policy applications of blockchain would likely not require frequent use, (i.e. voting, taxes, car registration, etc.) this finding indicates that those willing/interested in blockchain would be open to a frequency of use encompassed by its likely public policy applications.

While it is clear from this survey that males aged 20-39 are the most interested users of blockchain technology, efforts to understand attitudes on a more granular level were needed to delineate why certain population demographics show more support for the new technology than others. In a survey of over 2,000 U.S. adults aged 18+, researchers uncovered attitudes on Bitcoin. Results of this survey indicated that 42% of millennials are aware of Bitcoin as compared to 15% of individuals aged 65+ (Bogart, 2017). Perhaps more importantly, millennial

attitudes toward Bitcoin indicated a distrust toward traditional institutions and an optimism toward the new technology's potential. In fact, 27% of millennials believe that using Bitcoin is more trustworthy than using traditional banks (Bogart, 2017). This figure's importance stems not from whether it is a majority or minority, but rather that a significant proportion of millennials are seeking a more trustworthy financial service. Furthermore, millennials are 10-times more likely than those aged 65+ to positively view Bitcoin, with 48% of millennials holding the opinion that Bitcoin is a positive innovation (Bogart, 2017). Considering the nascency of blockchain technology, this substantial support (particularly from millennials) serves to indicate a potential willingness for adoption. It is worth noting that this survey exclusively included U.S. participants and cannot stand to represent a global audience.

While self-report measures provided valuable insights, empirical data on current blockchain-based technology use served as a vital supplement to this analysis. Considering blockchain's newness, the ability to measure demographic information as related to public policy use is limited. However, insights were gained based on the most widely used blockchain application to date—cryptocurrency exchange. In order for individuals to trade cryptocurrencies, they must own a "Blockchain Wallet." Blockchain Wallets allow anyone to store, trade, and request cryptocurrencies. These wallets are tied to unique addresses and, of course, all transactions occur via the blockchain ("Blockchain Wallet", 2018). At this very moment, on October 24th, 2018, 29,532,610 individuals own Blockchain Wallets. To give a sense of timing and momentum, by the end of 2012, less than 500 people had owned Blockchain Wallets ("Blockchain Wallet Users", 2018). By examining who exactly owns Blockchain Wallets, self-report data was able to be contextualized. Coin Dance, a community-driven Bitcoin statistics

site, utilizes real-time Google Trends to track demographic breakdowns for Blockchain Wallets. The site reported that 91.22% of owners are male and 8.78% are female (“Bitcoin Statistics”, 2018). Additionally, 48.93% of these users are aged 25-34 and 24.96% are aged 35-44 (“Bitcoin Statistics”, 2018).

This evidence on Blockchain Wallets overwhelmingly confirmed the self-report data, with breakdown by gender nearly exactly the same in both scenarios. Simultaneously, despite age range breakdowns not lining up perfectly, it is clear that individuals aged between 20 and 45 represent the heaviest users of Blockchain Wallets, a result which would likely carry over into blockchain-based technology use at large. Moreover, by both isolated and comparative standards, millennials share positive feelings toward Bitcoin and a distrust for traditional financial institutions.

Given these demographic findings, the public sector services which would be more or less likely to be shifted onto the blockchain became more clear. For example, any service which requires young individuals to register personal information for the first time, such as voting, getting one’s driver’s license, and registering for healthcare, could become blockchain-driven. This is because these young individuals have a comparative predilection for, and awareness of, blockchain, and because they will not need to switch from a legacy system. Conversely, services which related exclusively to the elderly and/or women would face increased resistance. In the United States of America, these include programs such as Social Security and Medicare, as well as, maternity-care and abortion-related services.

A key limitation to this section concerns the narrow scope of research—that all three studies focused on financial applications of blockchain technology. Thus, such data is

understandably limited in the extent to which it addresses receptiveness to public policy applications of blockchain technology.

## Conclusion

Three potential scenarios presented themselves as hypotheses to this research. First, that blockchain technology, in its current form, is not inherently superior to or more secure than other forms of existing technology. Given a mixed, yet encouraging SWOT analysis and two overwhelmingly positive company-based case studies, such a hypothesis can be initially ruled out. Findings from this portion of research support the argument that governments would be foolish to ignore blockchain's potential public policy applications. Given the results from blockchain's technical capacity assessment, several types of government services emerge as potential uses of blockchain. These services include, but are not limited to, information management, transaction facilitation, provenance tracking, and workflow efficiency. Land registries serve as an example of how blockchain-based information management could empower citizens, unlocking formerly dead capital. BitPesa's success in reducing the time and cost of transactions underscores how governments could apply the same processes to transactions such as individual and corporate taxes. Everledger's ability to reduce market failures by tracking the diamond supply chain surfaces the idea that governments could employ similar strategies to track the supply chain of exports and imports, perhaps through agencies like the Food and Drug Administration in the United States of America. Workflow efficiencies which might be enabled by improved data integrity, record sharing, and the replacement of human labor could streamline expensive, inefficient government services, such as the provision of nationwide healthcare.

The second hypothesis was that blockchain technology, in its current form, presents viable improvements upon other forms of technology, but a nation's conditions do not satisfy the requirements for building an interconnected technological infrastructure. Two of the three

government conditions case studies completed this hypothesis—the United States of America and Honduras. The United States of America exhibited both an encouragement of private sector investment and a promotion of competition, but failed to provide open access, display a flexible regulatory environment, and ensure universal service to its citizens. The Honduran government successfully provided evidence of its encouragement of private sector investment, but failed across all other Global Information Infrastructure conditions. Accordingly, the resulting recommendation for the governments of the United States of America and Honduras is to delay blockchain adoption and to accelerate efforts to create a more open, equitable technological infrastructure.

The third and final hypothesis was that blockchain technology, in its current form, presents viable improvements upon other forms of technology and a nation's conditions satisfy the requirements for building an interconnected technological infrastructure. Of the three government conditions case studies, only Estonia realized this hypothesis. Estonia proved to encourage private sector investment, promote competition, provide open access, create a flexible regulatory environment, and ensure universal service. Accordingly, the recommendation for the Estonian government is to gather demographic receptiveness information within their home nation. Following this, the Estonian government would be wise to adopt blockchain for specific public policy purposes with receptive target demographics, and to educate resistant citizens regarding the benefits of the technology's applications.

The data collected during the demographic receptiveness portion of my empirical section thus serves to inform nations like Estonia, on which segments of their population (predominantly young males) would be most open to adopting blockchain-based technologies for public policy

use. Moreover, this demographic information may inform the Estonian government, and others, as to which public policy avenues should be most aggressively supported in pursuit of their potential blockchain transformation.

The varying results exhibited by the three national case studies indicate a spectrum of government preparedness, along which all global nations will find a place. The failure of the United States of America across the majority of Global Information Infrastructure conditions indicates the high standards required for a nation to be willing and able to introduce blockchain in an equitable manner.

These findings thus confirm the ongoing battle which both the blockchain community and individual nations face in order to reap the benefits of blockchain technology. The technology itself must improve, particularly with regard to security and computational complexity. In parallel, nations themselves must embrace progressive policy measures, some of which were pioneered by Estonia. These include open-border systems of innovation as well as a commitment to the equitable distribution of benefits to citizens. Delivering on such policies becomes increasingly complicated with the introduction of large, disparate populations and non-democratic structures.

### ***Blockchain Technical Capacity Assessment***

In order to form conclusions based on this SWOT analysis, it became necessary to separate the analysis according to what is unique to blockchain and what is true of new technologies in general.

Blockchain's strengths and opportunities presented uniqueness. In terms of strengths, blockchain's introduction of technological disintermediation, open source quality, and newfound efficiencies are unlike any previous achievement. The common thread in these strengths is a new degree of democratization. With blockchain, no longer are intermediary forces necessary. As a result, blockchain's adoption could represent a complete transformation of the global economic system, spreading control more widely, for example, giving content creators more autonomy over their material. Blockchain's opportunities are also unique, particularly with regards to security. Blockchain's potential protection and legitimization of assets could, for the first time, allow the world's poor to collateralize land and animals—assets currently institutionally unrecognized (in many countries) and thus unriskable. The ability to risk one's possessions is crucial for one's ability to take out a loan, build a more promising financial future, and climb out of poverty.

On the other hand, blockchain's weaknesses and threats are not exclusive to the technology. Specifically, blockchain's computational complexity and security concerns should not be seen as deterrents to the technology's promise. Let us not forget that the first computers filled entire rooms and were incomprehensibly inefficient in comparison to today's. As for security, blockchain's imperfect present state can be paralleled to hacking on the internet. As time passes, hacking information on the internet becomes harder, but the act of doing so never quite goes extinct. A similar future for blockchain should not be seen as a failure, but rather an iterative process for distributed technological systems. Lastly, threats to blockchain—including resistance to adoption and scalability—are not unique to this technology. There are always a

small group of early adopters for a product, new laws addressing emerging fields, and upfront costs associated with new technological integration.

Overall, separating what is common to all emerging technology and what is unique to blockchain provides clarity over the technology's viability. Despite the commonality of blockchain's weaknesses and threats, these issues must first be solved before blockchain's strengths and opportunities can be actualized. Perhaps most crucially, blockchain's colossal energy usage raises the question, are the potential benefits of blockchain worth the guaranteed opportunity cost of its energy consumption? If, and only if, the blockchain community can ensure to the public and to businesses that its weaknesses and threats have been thwarted, then widespread adoption could become possible and prove successful.

Case Studies - BitPesa and Everledger: Both BitPesa and Everledger successfully supported key technical strengths and opportunities of blockchain. For BitPesa, access to new financial markets and improvements in business and consumer efficiencies bolstered the argument for blockchain's strength in access and efficiency, as well as an opportunity in access. Everledger's success touched on every strength and opportunity underscored in the SWOT analysis, as its robust solution to luxury good provenance and fraud issues solves problems for a number of stakeholders while introducing sophisticated security measures. Both BitPesa and Everledger did well to dispel the threat of scalability, as each company is growing with a global scope. The opposition BitPesa experienced from the Kenyan Central Bank, and the potential opposition which Everledger could face from traditional insurance companies serves to threaten their respective growth through a resistance to adoption. Given the relaxed, current state of these

forces of resistance, it would be unfair to attribute their existence as critical to the respective companies' success. Overall, these case studies provided overwhelming support in favor of blockchain's technical viability, whilst overcoming threats along the way.

### ***Government Conditions Assessment***

Case Study Estonia: Estonia's public sector has a clear and well defined commitment to executing upon the Global Information Infrastructure conditions as proven by current conditions, as well as, policies which are in progress. It is clear that Estonia's government views investment, competition, access, flexibility, and universality as paramount to economic and social prosperity. Moreover, the nation has found itself to be a pioneer in the utilization of technology in order to fulfill the Global Information Infrastructure conditions. As a result, there should be little doubt in Estonia's sentiment toward adopting blockchain for public policy use, provided the nation's leaders are satisfied by its technical capacity.

Case Study United States of America: The results of the United States of America's case study indicated that being a prosperous economic nation is not enough to satisfy the Global Information Infrastructure conditions to a sufficient extent. The presence of conditions including encouraging private sector investment and promoting competition are strongly tied to conditions found in economic superpowers, as they are preconditions to an ever-growing gross domestic product. Conversely, the United States of America's insufficiency across conditions including providing open access, a flexible regulatory environment, and universal service align with the

difficulty in equitably treating a large, disparate population through a divided political party structure.

Case Study Honduras: In totality, Honduras failed to holistically meet the Global Information Infrastructure conditions. While private sector investment following the wrath of Hurricane Mitch is encouraging, the Honduran government fails to promote competition, provide open access, create a flexible regulatory environment, or deliver universal service. Promoting competition, providing open access, and granting universal service can all be considered failures by comparative metrics. Honduras's slowness in delivering mobile number portability, as well as, its low internet penetration rate, fails to create government accountability, democratic voice, and an empowered/informed population. Hernandez's continued corruption and unconstitutional influence over Honduras's Supreme Court creates an inherently inflexible regulatory environment, as confirmed by the sentiment of Honduran citizens.

Synthesis of Government Case Studies: The case studies of Estonia, the United States of America, and Honduras indicate that those nations with the most to benefit from technologies which can offer security and an improvement in quality of life for citizens, are the least equipped to disseminate such technologies. In this instance, Honduras serves as that example. Next, these case studies indicate that just because a nation is economically strong does not mean it is equipped to create equitable solutions for its citizens. The United States of America has a political system which supports the private sector financially and promotes competition, yet fails to provide the open access, universal service, and flexible regulatory environment required to create equitable blockchain-based policy solutions. Finally, Estonia serves as an example of

having both the present conditions, as well as the future aspirations necessary to maintain the Global Information Infrastructure conditions. From this case study, it became obvious that Estonia’s government not only values such conditions as crucial to its economic prosperity, but has pioneered collaborative policies in an effort to help its citizens benefit from domestic and international innovation. Estonia’s conditions may have been made easier by its relatively small, homogenous population, which undoubtedly simplifies the implementation of its nationwide policies.

*Figure 8: Government Conditions Synopsis*

<i>Conditions</i>	<i>Encouraging Private Sector Investment</i>	<i>Promoting Competition</i>	<i>Providing Open Access</i>	<i>Flexible Regulatory Environment</i>	<i>Universal Service</i>	<i>Conclusion</i>
<i>Estonia</i>	Sufficient	Sufficient	Sufficient	Sufficient	Sufficient	<b>Sufficient</b>
<i>USA</i>	Sufficient	Sufficient	Insufficient	Insufficient	Insufficient	<b>Insufficient</b>
<i>Honduras</i>	Sufficient	Insufficient	Insufficient	Insufficient	Insufficient	<b>Insufficient</b>

### *User Demographics Receptiveness*

The empirical section on user demographic receptiveness provided overwhelming patterns of user behavior through self-report measures and the current use of blockchain-based technologies. One key confounding variable in this analysis is the notion that Bitcoin trading was used to collect data. While Bitcoin is a blockchain-based technology, it may not predict user demographic receptiveness at a public policy level. Regardless, the two self-report measures and one use-case study can be synthesized across three main demographic categories—gender, age,

and frequency of use. Two of these measures accounted for gender, with both revealing that over 90% of survey participants or users (of Blockchain Wallets) are men. All three surveys collected data regarding age's impact on blockchain sentiment and/or use. In one study, 76% of participants were aged between 20-39. In another study, 73.89% of Blockchain Wallet users were aged between 25-44. These two studies indicate a remarkable skew within just a 25 year age range. The third study focused on attitudes toward Bitcoin, revealing that millennials are nearly 3-times more aware of the technology than individuals aged 65+. Moreover, 27% of millennials believe Bitcoin is more trustworthy than traditional banks, and millennials are 10-times more likely to view the technology positively as compared to those aged 65+. Lastly, one study collected data regarding frequency of use, indicating that 94% of potential blockchain-based technology users would be open to using the technology on, at a minimum, a monthly basis. This measure is crucial in that it reveals a receptiveness to potential integration for most major public policy applications, such as voting, taxes, car registration, etc. In total, these three studies provided a clear indication that men aged 20-45 are the heaviest current users of blockchain-based technology and likely the most receptive moving forward. Moreover, an overwhelming willingness to engage with blockchain-based technology on a frequent basis (once a month or more) bodes well for public policy adoption prospects.

## **Observations, Discussion, and Recommendations**

General Trends and Patterns: Given the brief timeframe of this research, the scope of these findings are limited, yet promising. At the most macro level, several questions were answered with regard to blockchain's legitimate claim for public policy potential. Additionally, conclusions were drawn regarding government conditions which can be extrapolated to consider regions of the world and timing of potential adoption. Finally, current and prospective user demographics of the technology were identified, allowing for an understanding of the most immediate potential public policy uses of blockchain in general. The direction that governments may take blockchain in the future, however, is not the question at hand in this exploration. Rather, several key findings have been made and delineated throughout this exploration, which indicate arguments for and against, as well as contextualize, blockchain's public policy viability moving forward.

Blockchain Technical Capacity Assessment: The SWOT analysis on blockchain created two clear distinctions which helped clarify the technology's uniqueness. First, that blockchain's weaknesses and threats concern the processes built on top of the distributed ledger. A good way to visualize this concept would be to compare it to fraudulent websites being built on the internet. The website may have scammed you, but the internet did not. This conclusion raises the question: would the processes built on top of a blockchain for public policy use be secure? This comes down to the degree to which you trust your government, or governments around the world. If blockchain for public policy is meant to ameliorate the negative impacts of corrupt governments, what purpose would it serve if it was set up by such corrupt institutions? The

answer might lie in a more detailed understanding of the ways in which blockchain-based processes can be manipulated by their makers. Would unethical manipulations be easily detected? If so, would governments be incentivized to enact processes with integrity? Further research on government manipulation through technological innovation may be necessary to answer these questions. Privacy concerns within the United States of America represent a clear example of this complex matter at hand.

The second discussion point from the SWOT analysis is that blockchain's strengths and opportunities are unique to itself (the technology), while its weaknesses and threats are common to all emerging technologies. Technological tenants including computational complexity, security concerns, public adoption, and education have been weaknesses and threats to all emerging technologies. Today, everything humans do relies (in part) on the internet, which also shared these same concerns. Thus, it is important to decrease the weight placed on these weaknesses and threats as we can empirically confirm that they are not insurmountable.

Case studies on BitPesa and Everledger did well to highlight blockchain's technical viability and potential government threats. Perhaps more importantly, they remind us that blockchain is already influencing industries and individuals. This impact, at scale, leaves governments and companies with no choice but to 'adapt or die' as the meritocratic nature of innovation commands. This evolution may unfold over many years, but a current inability for governments to keep pace with technological innovation foreshadows blockchain's potential misalignment with government regulations in the near future. This is not to say that governments must be in complete command of the technology's influence on citizens, but in order to

effectively provide services for their citizens, governments must act proactively, not reactively. Those who act most proactively, provided the technology is an improvement on previous methods, will thus be considered the best servants to their populations. On the flip side, should early adopters' efforts to improve the lives of their citizens backfire, such nations and political entrepreneurs may face backlash. This risk of failure has and will continue to keep governments slow, waiting until evidence is absolutely conclusive before changing the technological infrastructure of national services.

Government Conditions Assessment: Case studies of Estonia, the United States of America, and Honduras indicate the irony of technologically-driven innovation at the government level. Much of the global hype around blockchain concerns its ability to serve the needs of marginalized, disenfranchised, and underprivileged populations. However, the overwhelming failure in Honduras's preparedness to integrate blockchain-based technology for public policy use (according to the Global Information Infrastructure conditions) dispels the notion that blockchain, at least currently, can fulfill on its promise of empowerment for those who need it most. On the opposite end of the spectrum, Estonia's willingness and ability to take calculated risks with technological innovation bolsters the notion that governments can truly improve the lives of their citizens through a proactive approach to the public policy adoption of promising technology. Estonia can be expected to be a leader in blockchain-based technological adoption for public policy use based on these findings.

This analysis of governments conditions raises moral and methodological questions. Morally, should a country like the United States of America, which has the ability to disseminate

blockchain technology but has not proven that it can do so equitably, be able to? On one hand, it will improve the lives of some citizens, which is better than none. Conversely, it is simply not fair for a government to provide unequal services to its citizens on the basis of convenience and ease. In the event that a government, such as that of the United States of America, were to adopt blockchain-based services only for those with specific access to them (presumably the rich), this would effectively be an unjust, unequal distribution of resources. It is thus imperative that governments carry out the due diligence necessary to ensure that any public policy use of blockchain-based technology does not disproportionately benefit one population demographic over another.

Methodologically, searching for evidence of specific government conditions may have been less effective than searching for evidence against certain government conditions in this part of the empirical section. This is because there are many possible examples which serve as evidence for the presence of certain government conditions, yet they are not all equally important. A government's ability to provide universal broadband access is likely more important than a government's ability to provide mobile number portability, as the former has more of a positive impact on an individual's life than the latter. Thus, while both of these examples pertain to the condition of universal access, they are not equally important. Therefore, carrying out case studies on predetermined technology topics, such as broadband access, may better control for analyzing differences between countries on technology policy issues. By making this methodological change, one could effectively standardize for importance of topic, as well as control for the technology topics which matter most.

User Demographic Receptiveness: It is important not to extrapolate observations from this area of the empirical section too far, as the use purpose of blockchain being explored here was largely tied to financial services, not public policy. The degree to which demographic findings hold true when concerning public policy use cases hedges largely on a government's ability to successfully educate a given population and minimize the switching costs associated with adopting new processes.

It is conceivable that attitudes and behaviors pertaining to age and use case may remain unchanged. In this sense, it seems reasonable to assume that millennials (particularly those aged 20-45) would continue to represent the most willing and able adopters of blockchain-based governments services. It is also reasonable to assume that these individuals would continue to be open to using the technology, at a minimum, on a monthly basis, as government services are usually mandatory and would thus require little additional effort.

However, it is possible that the large gender skew with regards to participation in blockchain-enabled financial services would become less dramatic through the introduction of public policy applications. Perhaps men own more Blockchain Wallets because they are more risk-tolerant and thus willing to trade volatile cryptocurrency assets. Or, perhaps the earliest adopters of Blockchain Wallets were men, and network effects may have contributed to this skew. Regardless, it is worth noting that the specific public policy uses of blockchain-based technology will strongly impact the demographics which are educated and receptive to its continued use.

Thus, more research should be conducted regarding sentiment on blockchain's public policy introduction, rather than on its holistic presence as chiefly associated with Bitcoin and

cryptocurrencies. This research would serve to inform the most effective use cases for blockchain from a public policy perspective.

Closing Statement: Despite blockchain's nascency, it is clear that it is technically viable and that some governments are both interested and equipped to adopt it for public policy purposes. It is less clear which population demographics would be most receptive to its introduction into their lives, given a difficulty in extrapolating tangentially related demographic data. Several obstacles must be overcome in order for blockchain to deliver upon its promises of empowerment and democratization. While it is possible that traditionally slow governments may act swiftly in order to leapfrog other nations in the adoption of blockchain-based technologies, it is likely that these nations are not equipped. Thus, it will likely require proof-of-concept from entrepreneurially minded governments, such as Estonia, in order to perpetuate global adoption. This process would certainly be slow, but ultimately beneficial provided that the technical capacity of blockchain continues to be supported over time. The degree to which this process is beneficial is understandably contingent upon the specific ways in which governments utilize blockchain.

There is a Martin Luther King Jr. quote which states, "The arc of the moral universe is long, but it bends toward justice." With regards to blockchain's public policy viability following the research conducted in this thesis, I believe that "The arc of innovation is long, but it bends toward democratization."

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