BEYOND BITCOIN:
A LITERATURE REVIEW OF BLOCKCHAIN TECHNOLOGY

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This dissertation was submitted in part fulfillment of requirements for the degree of MSc Information and Library Studies

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ABSTRACT

Blockchain, the technology that underlies the first and most widely known cryptocurrency Bitcoin, is a shared digital ledger that records transactions occurring across a distributed or peer-to-peer network. However, despite its potential for domains outside of finance, much confusion still exists surrounding both the technology and its applications. The overarching aim of this extended literature review is to identify current and emerging application domains and their requirements for blockchain technology, including potential observed challenges.

The incorporation of both academic sources and 'grey' literature yield a diverse variety of results with applications found in the fields of finance, government, healthcare, and the sharing economy. The text does not intend to provide an overly technical perspective, but instead offers an accessible foundation in key terms and concepts relevant to discussions of blockchain technology and its applications. The role of the information professional as an advocate for the understanding of new technological advances is also considered. With misinformation rife surrounding the use of blockchain technologies, information professionals may serve as one trusted and reliable outlet for public discourse surrounding new media.

It was discovered that the current literature exhibits a number of core similarities in application purpose such as the movement of assets, new modalities of verification, proof of ownership and/or traceability, and interrelationships with the concept of identity. However, noticeably lacking are cohesive frameworks and methodologies to evaluate the success of both technical blockchain applications and their wider social applicability. Recommendations include the implementation of social education campaigns for widespread uptake and acceptance, the need for governments and social leaders to work cohesively when advocating for, and regulating, potentially disruptive technologies such as the blockchain, and the role of academic and journalistic media outlets in providing information that is concise and accessible to a wide audience.

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Dedicated to Warren, who I know would have loved this topic.

TABLE OF CONTENTS

CHAPTER 1: INTRODUCTION

1.1 OVERVIEW

Blockchain, the technology that underlies the first and most widely known cryptocurrency Bitcoin, is a shared digital ledger that records transactions occurring across a distributed or peer-to-peer network. Public or private in nature, enhanced cryptography validates and 'chains' data blocks creating immutable record of transactions. As Howley (2016, p. 14) describes: "It is a piece of software that enables a minor miracle: the ability to create value in an open setting (open to participants from the world at large) but in a completely secure, mutually inter-conscious environment". However, despite current hype, the blockchain concept is mired in misinformation and technical jargon, making it "one of the most misunderstood technologies of 2017" (R. Das, 2017).

While much of the current literature centers on the use of blockchain within financial transactions, new applications are emerging within a wide variety of domains. Iansiti and Lakhani envision the potential for blockchain technologies:

> With blockchain, we can imagine a world in which contracts are embedded in digital code and stored in transparent, shared databases, where they are protected from deletion, tampering, and revision. In this world every agreement, every process, every task, and every payment would have a digital record and signature that could be identified, validated, stored, and shared. Intermediaries like lawyers, brokers, and bankers might no longer be necessary. Individuals, organizations, machines, and algorithms would freely transact and interact with one another with little friction. This is the immense potential of blockchain (Iansitia and Lakhani, 2017).

Platforms such as Ethereum and Bitcoin aim to provide development support to blockchain applications, while major global data infrastructure firms and corporations are embracing the technology within new domains such as government, healthcare, and the sharing economy (Ethereum, 2017; Bitcoin, 2016). Such advancements are reflected in the recent literature surrounding blockchain technology, and merit further scholarly exploration as provided by an extended literature review.

1.2 RESEARCH QUESTIONS

Webster and Watson (2002, p. 13) note an effective literature review "creates a firm foundation for advancing knowledge. It facilitates theory development, closes areas where a plethora of research exists, and uncovers areas where research is needed". As such, this review seeks to address the following primary questions:

- What are the current application domains for blockchain technology?
- What are the requirements of such domains for blockchain technology?
- What potential challenges must be overcome within such domains for wider applicability of blockchain technology?

And, if supported by the literature:

- What is the potential impact of blockchain technology to library practice?

In discussing the breadth of domain applicability of blockchain technologies, Swan observes:

> We should think about the blockchain as another class of things like the Internet – a comprehensive information technology with tiered technical levels and multiple classes of applications for any form of asset registry, inventory, and exchange, including every area of finance, economics, and money; hard assets (physical property, homes, cars); and intangible assets (votes, ideas, reputation, intention, health data, information, etc) (Swan, 2015, p. vii).

The research questions are supported by a number of objectives including: working to categorize themes relevant to the current literature surrounding blockchain technology and its application, identifying models or frameworks for further analysis, and determining gaps within the literature for additional exploration.

The overarching aim seeks to "assemble the literature being reviewed for a given concept into a whole that exceeds the sum of its parts" (Levy and Ellis, 2006, p. 200).

Therefore, the primary learning outcome for the reader will be to not only identify current practices focused on financial transactions and the predominance of Bitcoin within the body of knowledge, but to identify facets of literature that address blockchain technology as a new paradigm for organization with applications across multiple disciplines. Further outcomes include identifying common themes present through all domains, the identification of gaps for further exploration within the literature, and a reflection on the role of the information professional as it relates to such emerging technologies.

1.3 REPORT

This review is divided into the following subsequent chapters:

Chapter 2 provides an overview of the methodologies used during the literature review, including rationale for inputs, outputs, and processing as recommended by Levy and Ellis (2006). Issues of citation and formatting are also discussed.

Chapter 3 introduces a brief technical foundation of blockchain technologies. This chapter aims to bridge the gap between commercially available definitions that are uninformative and the overly technical jargon of computer science specialists and blockchain developers.

Chapter 4 discusses the role of blockchain within its most widely cited domain – cryptocurrency. However, consideration is also given to applicability within the wider financial sphere and subsequent regulatory and legislative issues.

Chapter 5 reviews the use of blockchain within government applications, including identity documents, land registries, and voting technologies.

Chapter 6 provides an overview of blockchain technologies within the domain of healthcare. Current trends exhibit application for multiple facets of healthcare management, medical research, and fraud detection within the pharmaceutical industry.

Chapter 7 explores the relationship and applicability of the blockchain to the sharing economy. Examples from within the literature will draw on a wide variety of subdomains including social media, the retail industry and exchange of goods and services, and the

role of libraries as new technology mediators.

Chapter 8 offers final conclusions, recommendations, and personal reflections. This includes: identification of common themes across domains, recognized gaps in public education and development of both regulatory frameworks and scientific methodologies, and potential implications to the role of information professionals.

In the interest of advancing the knowledge of subsequent researchers, the sole enclosed appendix is compiled of an annotated bibliography for all references within the review. These records detail access sources, search strategies, keywords, and other relevant particulars that may be of use to future blockchain related research endeavors.

CHAPTER 2: METHODOLOGY

2.1 RATIONALE

Levy and Ellis (2006, p. 181) observe: “The need to uncover what is already known in the body of knowledge prior to initiating any research study should not be underestimated”. Exploratory literature reviews of an extended nature allow for a synthesis of material that may yield results outside of widely cited disciplines, such as the potential applicability of blockchain technology to domains extending beyond cryptocurrencies. Levy and Ellis (2006, p. 208) advocate a sequential method of inputs, processing, and outputs, which aim to “decompose the task of the literature review into the three manageable stages”. Oliver (2012) and Jesson *et al.* (2011) further support sequential stages as a means of mitigating potential risks to the novice researcher within the literature review process. What follows is the methodology used for this review, including a system of processing academic and grey literature inputs to reach a final literature review output including associated risk considerations.

2.2 INPUTS

The intended primary source of input for this literature survey was peer-reviewed material as published in a variety of academic journals available via the University of Strathclyde. Davison, Vreede and Briggs (2005, p. 969) note the peer review process is essential as it allows the novice researcher to “use published work with confidence, and use the works of others as stepping stones and corner stones for advancing new concepts and insights”. However, academic standards vary widely by publication and discipline. The University of Strathclyde LibGuides, composed by subject librarians, were consulted to ensure quality of access within each domain.

As Oliver notes of exploratory areas for development:

> The advantage of a new topic is that it is likely to be a relatively under-research area, and therefore offers new opportunities. On the other hand, with new topics it is not always easy to identify research samples when there is not a great deal of existing previous research to act as a model” (Oliver, 2012, p. 17).

As a result, “grey material” as described by Oliver (2012) including government reports,

white papers, conference proceedings, and other sources of journalistic literature have also been sourced and evaluated for their contribution to the overall body of knowledge.

Keyword searching provided the inaugural method of sourcing input, although ”keyword search should be just the initial, not the main step for a literature search” (Levy and Ellis, 2006, p. 190). Keyword searching alone yielded limited depth and scope of blockchain technology and was used in conjunction with backwards and forwards searching methodologies. Backwards searching utilizes the cited references of academic writings to source additional literature, while forward searching seeks new publications by previously identified authors. A combination of all three approaches provides a scope beyond buzzwords, providing additional insights to future developments within the literature.

Jesson *et al.* (2011) emphasize the importance of a detailed search log during the initial input stage; Levy and Ellis (2006) further propose the use of annotated bibliographies during the search process. For the purposes of this review, Microsoft Access has been used to create a hybrid of both search log and annotated bibliography (see Appendix 1); this was used to create a simple database system within the search process, allowing for a complete capture of records that can further be queried for specific inputs.

REFERENCE:	Lemieux, V. (2016) ‘Trusting records: is Blockchain technology the answer?’, *Records Management Journal*, 26(2), pp. 110-139.
DATE ACCESSED:	March 8, 2017
ACCESS SOURCE:	Emerald Insight
KEYWORDS/STRATEGY:	Reliability, Authenticity, Risk, Digital preservation, Blockchain, Trusted digital repository
OTHER:	Cited by Morabito, V. (2017)

Lemieux (2016) provides one example in which blockchain technology has been implemented to ensure trustworthiness of digital records within the land registry system of the Honduran government (utilizing Factom, a leader in data infrastructure). Lemieux’s findings “suggest that Blockchain technology can be used to address issues associated with information integrity in the present and near term, assuming proper security architecture and infrastructure management controls. It does not, however, guarantee reliability of information in the first place, and would have several limitations as a long-term solution for maintaining trustworthy digital records” (p. 110).

Fig.1: Example database record from Appendix 1

Leedy and Ormrod (2015, p. 190) note: “the search is near completion when one discovers that new articles only introduce familiar arguments, methodologies, findings, authors, and studies”.

2.3 PROCESSING

Oliver (2012) describes processing the literature as a combination of selecting appropriate literature for inclusion within the review, and analysis and categorization of such literature for final output. Of the former, appropriate literature was evaluated by a number of means including perceived validity (often based on a peer review process or citations of the work by additional scholars), methodologies within the literature yielding replicable or scientifically valid outputs, cohesive writing including efficacy of arguments, and the objectivity of scholars in identifying potential limitations of their writings. The recency of writings was of less concern to the topic of blockchains, as the technology has risen to prominence within the last decade.

Categorization and critical analysis of the literature for common themes was conducted using the qualitative software NVivo. NVivo was used to identify patterns and themes within the current blockchain literature based on concept nodes and utilizing keyword queries. This further highlighted gaps in the body of knowledge, and assisted in weeding material sourced during the input stage. Jesson *et al.* (2011) argue that a process of codification of literature can also assist in comparing and contrasting scholarly material during the final output stage.

2.4 OUTPUTS

The final output as a result of inputs and processing is the literature review itself. In evaluating literature and the writing process Booth, Colomb and Williams (2008, p. 112) provide a helpful nuance for argumentation theory noting an effective review can provide a “[claim] because of [reason] based on [evidence]”. Jesson *et al.* (2011, p. 88) encourage the novice researcher to “dare to have an opinion” on the synthesized literature, as a rote recitation of findings does not encourage further scholarly discussion or attempt to bridge gaps in the current body of knowledge. In merit of this suggestion, a final reflection on the part of the researcher has been included at the end of the review. The final conclusions and recommendations aim to compare and contrast results across domains as a means of contributing further to applicable academic discourse.

It should be noted that referencing throughout the review follows Harvard style citation as recommended by the University of Strathclyde from Pear and Shields (2016). As per the Department of Computer and information Sciences PGT Dissertation Handbook for the academic year 2016/17, quotes in excess of approximately two lines have been indented with the reference placed in quotations at the end of the quotation.

2.5 RISK ANALYSIS

Bem (1995, p. 172) observes, “authors of literature reviews are at risk for producing mind-numbing lists of citations and findings that resemble a phone book – impressive case, lots of numbers, but not much plot”. While this may be true of blockchain technologies within cryptocurrencies and finance, the proposed topic remains a relatively innovative concept to many other disciplines and cross-disciplines. While it was anticipated this may cause difficulty in sourcing appropriate academic material to further the body of knowledge within identified gaps, ultimately the ‘grey literature’ included for review provided source material that was as relevant as the date of final submission. It would have been a disservice to the review to exclude journalistic content as it can provide debatable merit and lively discussion for a continually evolving domain such as blockchain technologies.

Appropriate referencing and citation is also of the utmost importance throughout the literature review process. Levy and Ellis (2006) caution that unethical use of referencing, whether material taken out of intended context or misquoted, may damage not only individual reputation but also the integrity of a field as a whole. Unethical referencing was avoided through a carefully devised search log and series of annotations, in addition to the use of qualitative software such as NVivo for further tracking.

Finally, the topic of blockchain and its applications may be perceived as overly complex to those without a computer science background. The aim in writing will be to present core technical concepts with limited scientific jargon, creating an accessible means of understanding for those without an in-depth background to the topic at hand.

CHAPTER 3: A BLOCKCHAIN PRIMER

3.1 INTRODUCTION

Ambiguity exists within the literature as the term **blockchain** can refer to a data structure, algorithm, a group of technologies, and/or as a definition used for distributed peer-to-peer systems with a common application system (Drescher, 2017, p. 33). A data structure is a means of organizing information, with blockchain referring to data in 'blocks' that are connected to one another not unlike a chain. Blockchain as an algorithm refers to a series of computation instructions that "negotiates the informational content of many blockchain-data-structures in a purely distributed peer-to-peer system" (Drescher, 2017, p. 34). As a group of technologies, the term blockchain can encompass both data structures and algorithms, in addition to cryptographic and security measures that seek to maintain integrity within distributed systems. Finally, blockchain may refer to peer-to-peer systems of **ledgers** that implement blockchain technologies including data structures, algorithms, and cryptographic measures. What follows is a simplified discussion of blockchain basics, including frequently cited terminology and a preliminary overview of the how, what, and why of current and potential blockchain industry.

3.2 HOW DOES BLOCKCHAIN TECHNOLOGY WORK?

In discussing blockchain technology Drescher (2017) first suggests a brief analysis of software systems in terms of **layers** (application versus implementation) and **aspects** (functional versus non-functional). The application layer refers to the needs of the user, while the implementation layer consists of the technical elements required to fulfil such needs. The functional aspects of a system are the most obvious as they serve the face value needs of the user (what is done) while the non-functional aspects work 'behind the scenes' (how things are done). Drescher (2017) utilizes the example of a mobile phone to illustrate both layers and aspects, as illustrated in Figure 2.

Layer	Functional Aspects	Non-functional Aspects
Application	• Taking photos • Making phonecalls • Sending e-mails • Browsing the Internet • Sending chat messages	• The graphical user interface looks beautiful • Easy to use • Messages are sent fast
Implementation	• Saving user data internally • Connecting to the nearest mobile network • Accessing pixels in the digital camera	• Stores data efficiently • Saves energy • Maintains integrity • Ensures user privacy

Fig.2: Layers and aspects of mobile phone
Adapted from Drescher (2017)

Not unlike a mobile phone, blockchain also offers multi-dimensional layering to ensure a number of essential aspects. Gibson (2011) notes: “Most IT security practices are focused on protecting systems from loss of confidentiality, loss of integrity, and loss of availability. These three together are referred to as the security triad, the CIA triad, and the AIC triad”. The security triad is composed of the following, as described by Gibson (2011):

1. Confidentiality: set of rules that limits access to information
2. Integrity: assurance that the information is accurate and trustworthy
3. Availability: reliable access to the information by authorized persons or users

The way in which system components are related to one another and organized is known as software architecture. Baran (1964) is often cited as first to describe the major architectural approaches for software systems, namely: centralized, decentralized, and distributed. As Szmigielski illustrates in Figure 3 of a centralized network:

> A centralized network is depicted as a star. Every node is connected to a central node. It is clear that by taking out the center node, the network breaks down. Examples could include any structure where there is a central authority and everyone reports to it (Szmigielski, 2015).

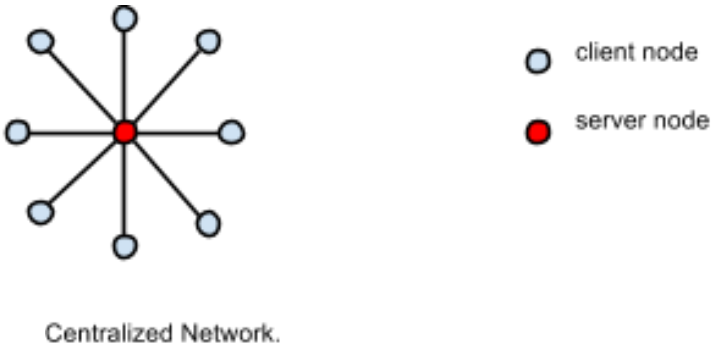

Fig.3: Centralized network
Szmigielski (2015)

Szmigielski goes on to further describe decentralized networks, as seen in Figure 4:

> [...] a decentralized network, there is no obvious center. In order to break this network completely the four red nodes would have to be destroyed. Or the highlighted communication links would need to be taken out. Note that taking out the links segments the network into smaller subnetworks (Szmigielski, 2015).

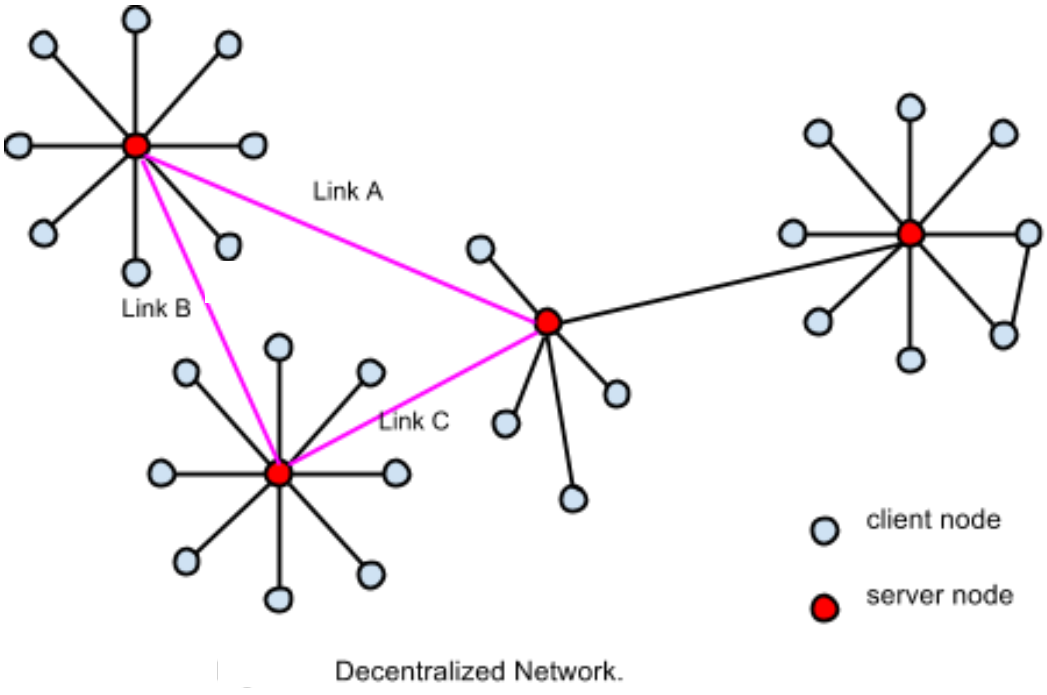

Fig.4: Decentralized network
Szmigielski (2015)

Drescher (2017) observes that decentralized networks offer advantages in terms of

tolerance to faults, efficacy in creating network links, and difficulty in shutting down the entire network. Finally, Szmigielski discusses distributed systems as seen in Figure 5:

> But what if we want a network that is almost impossible to destroy. All that is needed is for each node to have multiple connections to as many other nodes as possible, and the ability to forward traffic on its way to some destination. The result will be a distributed network[...]In a distributed network a node has as many connection as possible to other nodes. Therefore disrupting communication amounts to almost destroying every node or every link. Every node is now capable of forwarding communication from other nodes. It acts as a server for others, and of course as a client for itself (Szmigielski, 2015).

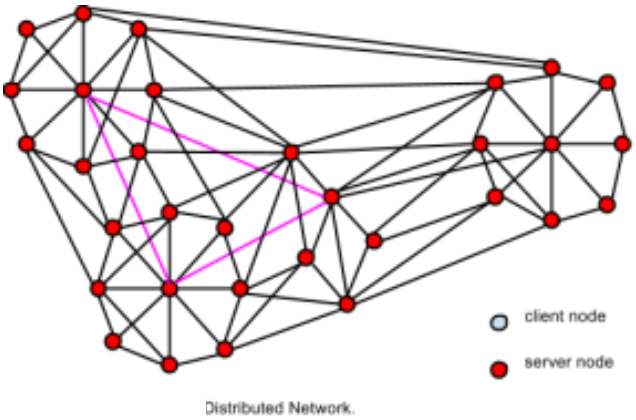

Fig.5: Distributed system
Szmigielski (2015)

Szmigielski (2015) observes there is often confusion in discussing distributed versus decentralized systems: “The main difference is that in truly distributed networks each node has multiple connections and can act as a server”. With this in mind, the blockchain operates on a distributed system that offers several advantages including increased computing power and the ability for the system to grow organically (Frances, 2015). Computing power is a product of all connected computers on the system, which lends to reliability as the network can continue to operate should a single point of failure occur. As more computers are connected to the system, power can be increased incrementally allowing the system to naturally grow in scope (Gupta, 2017).

A **peer-to-peer** (often cited as P2P) network is a type of distributed system that allows individual computers the ability to share their computational resources with other

members of the network without the need for a central point of coordination (i.e. – decentralized) (Gupta, 2017). Individual computers are also known as nodes, with each node acting as both a supplier and consumer of resources within the system (Gupta, 2017). Architectural models can also be mixed in nature, offering elements of both a centralized and distributed system (see Figure 6). Software architecture may be selected based on available resources, desired implementation to a previously existing system, or as an innovative means of change.

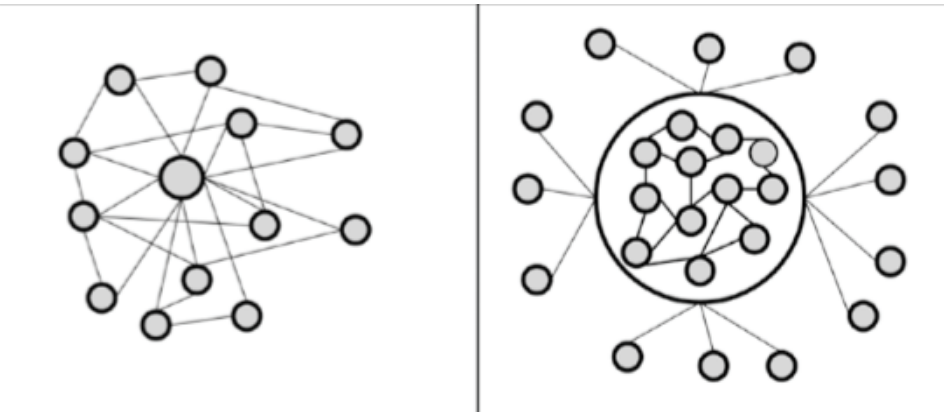

Fig.6: L: Central component within a distributed system, R: Internal distributed system connected to external centralized system
Drescher (2017)

Recall the security triad described by Gibson:

> If a system suffers loss of confidentiality, then data has been disclosed to unauthorized individuals[...]Loss of integrity means that data or an IT system has been modified or destroyed by an unauthorized entity[...]Availability ensures that data and systems are up and operational when they are needed (Gibson, 2011).

To achieve and maintain the security triad there must also be an element of **trust,** both in users and the system. As Drescher (2017, p. 31) describes: “The core problem to be solved by the blockchain is achieving and maintaining integrity in a purely distributed peer-to-peer system that consists of an unknown number of peers with unknown reliability and trustworthiness”. An oft-cited metaphor for this quandary is Lamport, Shostak, and Pease’s 1982 Byzantine Generals’ Problem.

In this scenario a group of generals, each commanding one faction of a Byzantine army, surround a city or castle. Some generals may wish to attack, while others prefer to retreat. Traitorous generals who selectively vote for a suboptimal strategy (i.e. – indicating a retreat vote to one group of parties, and a vote to attack to others) complicate the problem further, creating possible detrimental results due to a lack of cohesive strategy. The generals are also physically separated and must rely on messengers, whom may or may not prove trustworthy, failing to deliver votes or providing false information. This metaphor reflects a key issue within computing – the coordination and decision of action through unreliable or suboptimal links or means of communication.

One means of solving the Byzantine Generals' Problem using the blockchain is through a concept known as proof of work. Proof of work validates transactions submitted to the blockchain through a collective process known as 'mining' in which miners must solve a mathematical puzzle derived from the transaction's header before a new block can be added to the chain. Keyser (2017) provides an illustrative example of the blockchain process (see Figure 7). As transactional blocks are created miners "take the information in the block, and apply a mathematical formula to it [creating] a far shorter, seemingly random sequence of letters and numbers known as a hash" (CoinDesk, 2014). This unique hash is stored with each block, and also incorporates the hash of the preceding block in the chain, creating a definitive time-stamping process. The most widely used secure hash algorithm (or SHA) is SHA-256, which produces a unique fixed-size 256-bit hash.

As a hash is a one-way function that cannot be unencrypted, it is used to link transactional records making it "impossible to modify the blockchain without those changes being immediately apparent" (Delahaye, 2017). Hashing is a one-way function that does not derive original data, but only proves it existed (Gupta, 2017). Often called a 'digital fingerprint', hashing compresses input of any length to create a fixed size output. Each block on the blockchain is hashed, and if the block were changed, the hash value would differ.

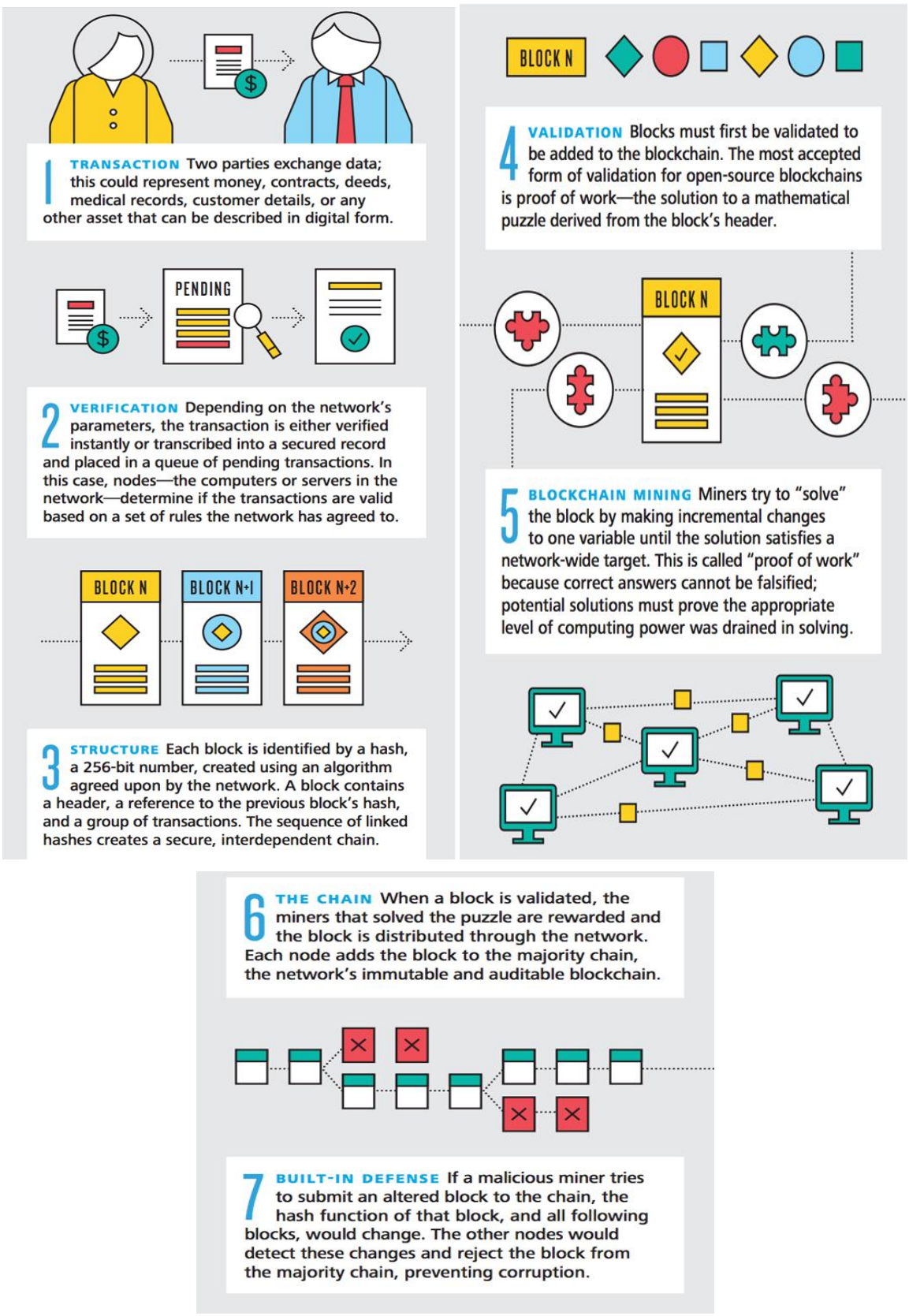

Fig.7: Blockchain process, Keyser (2017)

3.3 WHAT CAN THE BLOCKCHAIN DO?

In understanding how the blockchain functions, it is relevant to note:

> […]ledgers have been at the heart of commerce since ancient times and are used to record many things, most commonly assets such as money and property…now, for the first time algorithms enable the collaborative creation of digital distributed ledgers with properties and capabilities that go far beyond traditional paper-based ledgers" (Walport, 2016, p. 5).

As blockchain ledgers are maintained through distributed networks, their relationships can be one to one or one to many, with differing levels of permissibility. The UK Government Office for Science cites Birch (2016) to simplify the distributed ledger taxonomy, as seen in Figure 8 below.

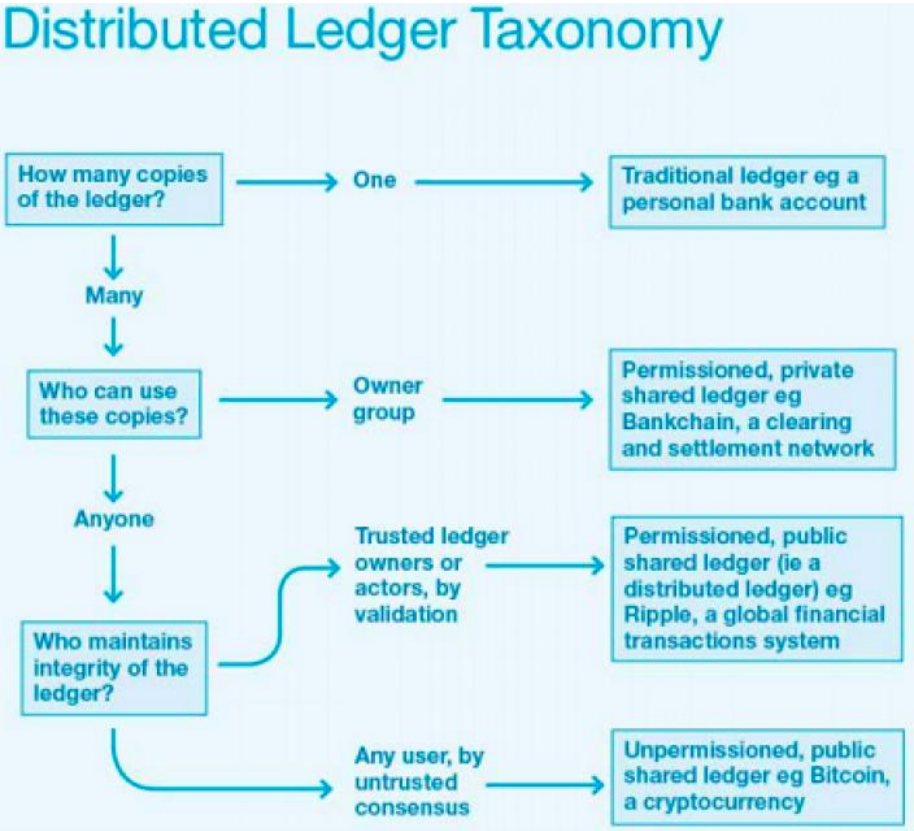

Fig. 8: Distributed ledger taxonomy
UK Government Office for Science (2016)

Key to the concept of ledgers is ownership. Specifically, the owner of an object, the object itself, and a mapping of the relationship between the two as recorded via ledger.

A ledger may also record transfers of ownership. When only one ledger exists, there is a risk of forgery or irreparable damage. Blockchains can facilitate ownership transactions, which are then stored and maintained on the nodes of a peer-to-peer system. As Drescher explains:

> […]the blockchain-algorithm is responsible for letting the individual nodes collectively arrive at one consistent version of the state of ownership on which the final verdict is based…integrity in this system is its ability to make true statements about ownership" (Drescher, 2017, p. 46).

Cryptographic keys aim to protect data from unauthorized entities; these digital keys utilize encrypted data known as cypher text, which appears as a random assortment of letters and numbers. This data can only be unencrypted with a corresponding key. A public key is typically distributed or made readily available, while only authorized users keep a private key confidential. Known as asymmetric cryptography, data can flow in either direction when using public and private keys and is utilized within blockchain to identify accounts and authorize transactions (Gupta, 2017; see Figure 9). As Bauerle describes:

The main purpose of this component of blockchain technology is to create a secure digital identity reference. Identity is based on possession of a combination of private and public cryptographic keys. The combination of these keys can be seen as a dexterous form of consent, creating an extremely useful digital signature. In turn, this digital signature provides strong control of ownership (Bauerle, 2017).

Public to private transactions can be likened to a mailbox; anyone can submit a letter (public key) but only the owner can open the box (private key). Private to public transactions are similar to a noticeboard where everyone who has a copy of the public key can read the messages, but only the owner of the private key can create and post (Drescher, 2017).

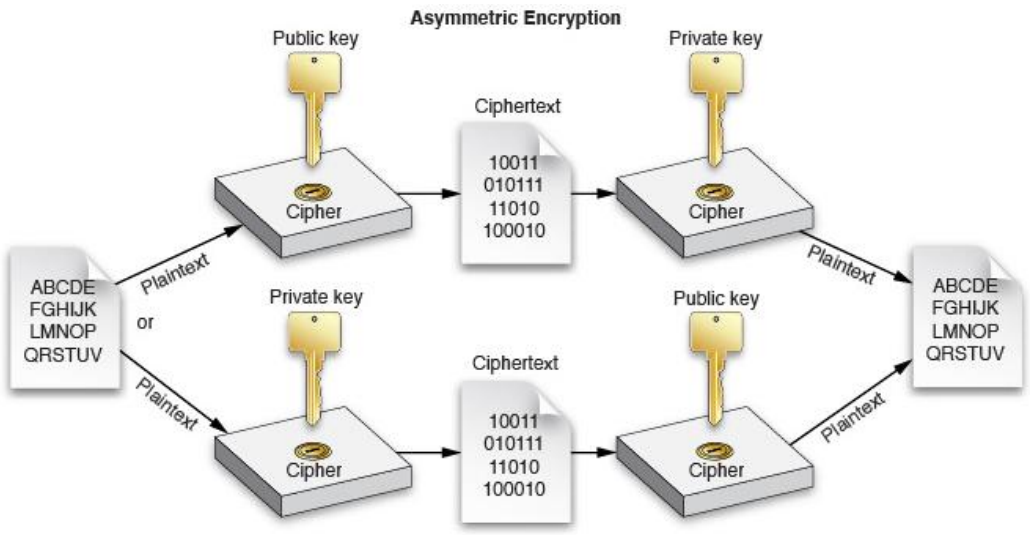

Fig. 9: Asymmetric encryption
Apple Developer (2012)

Recall Drescher's (2017) earlier example of the layers and aspects of a mobile phone. A similar analogy can now be applied to the layers and aspects of the blockchain (see Figure 10).

Layer	Functional Aspects	Non-functional Aspects
Application	• Clarifying ownership • Transferring ownership	• Reliable • Open • Pseudoanonymous • Secure • Resilient • Maintains integrity
Implementation	• Ownership logic • Transaction security • Transaction processing logic • Storage logic • Consensus logic • Peer-to-peer architecture	

Fig. 10: Layers and aspects of the blockchain
Adapted from Drescher (2017)

3.4 WHY DO WE NEED BLOCKCHAIN?

Blockchain creates immutable data by storing historical transactions in a way that even the slightest manipulation to its content is noticeable via hashing, and by ensuring manipulating data blocks is both time consuming and cost prohibitive. In seeking to provide all users the ability to add new transactional data while preserving integrity, the blockchain allows all nodes of the system to "act as supervisors of their peers and

reward them for adding valid and authorized transactions and for finding errors in the work of others" (Drescher, 2017, p. 155).

In functional aspects, blockchain seeks to clarify ownership and provide an immutable means of transference often through enhanced cryptography such as asymmetric key systems. In non-functional aspects, the blockchain is constantly evolving entity with no downtime and continuous availability; unlike centralized models, which are reliant on the availability of a core node, distributed networks exhibit resiliency through no such singular reliance. The level of integrity offered by blockchain technologies is unparalleled within open networks, including the concept of 'smart' contracts. As Stark observes of smart contracts:

> Sometimes the term is used to identify a specific technology – code that is stored, verified and executed on a blockchain…other times, the term is used to refer to a specific application of that technology: as a complement, or substitute, for legal contracts (Stark, 2016).

Most often, a smart contract is an agreement between parties posted to the blockchain for automated execution. The smart contract lifecycle is summarized by Marvin (2016) (see Figure 11), and is seen throughout the literature to have a wide breadth of applicability within multiple domains.

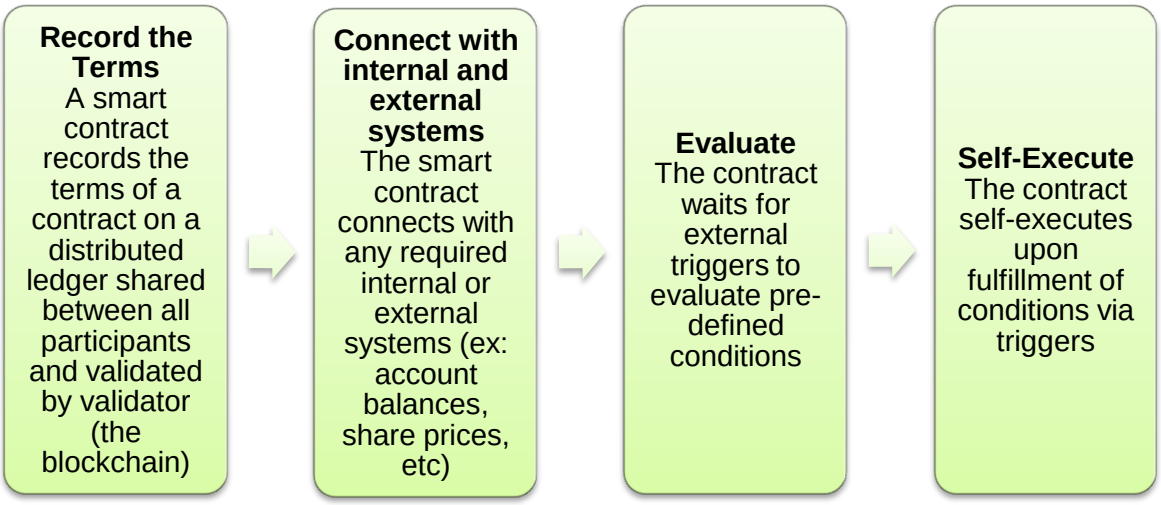

Fig. 11: Smart contract life cycle
Adapted from Marvin (2016)

Blockchain platforms include often cited competitors such as Bitcoin, Ethereum, LiteCoin, Blockstream, and etc. each with their own systems for rapid prototyping and application development. Bitcoin dubs itself “a worldwide cryptocurrency and digital payment system” while Ethereum focuses heavily on smart contracts self-describing as: “[...] a decentralized platform for applications that run exactly as programmed without any chance of fraud, censorship or third-party interference” (Bitcoin, 2016; Ethereum, 2017). LiteCoin functions in a similar fashion to Bitcoin, but offers a different proof-of-work algorithm intended to accelerate mining capabilities (LiteCoin, 2017). Finally, Blockstream’s “primary area of innovation is in sidechains, a technology invented to extend the capabilities of Bitcoin's blockchain[...]sidechains allow digital assets to be moved from one blockchain to another” (Blockstream, 2017).

3.5 SUMMARY AND ANALYSIS

Peer-to-peer distributed systems have the potential to revolutionize industry through disintermediation where “direct interactions occur between contractual partners instead of indirect interactions through a middleman, hence, there is less processing time and lower costs” (Drescher, 2017, p. 22). Systems of payment, and/or cryptocurrencies, are often cited as the primary industry for blockchain technology. Financial systems consist of “simple intermediation between supplies and consumers of money, which mainly exists as digital or immaterial good” (Drescher, 2017, p. 25). As Drescher (2017) observes: “The excitement about the blockchain is based on its ability to serve as a tool for achieving and maintaining integrity in purely distributed peer-to-peer systems that have the potential to change whole industries due to disintermediation” (p. 25).

Blockchain, like any emerging technology, is not without its challenges. From a technical perspective Yii-Huumo *et al*. (2016) note that the security offered by blockchain is still susceptible to elements of sophisticated piracy or hacking, with a need for further support of software development as the technology enters the mainstream. This is further supported by Walport (2016) who observes: “[…]ensuring the security of distributed ledgers is an important task and part of the general challenge of ensuring the security of the digital infrastructure on which modern societies now depend” (p. 6). Scaleability of the blockchain is also cited throughout the literature as an area of concern. As Macdonald, Liu-Thorrold, and Julien observe:

> Much discussion currently surrounds Bitcoin's blocksize limit, which restricts blocks to 1Mb of transaction and header data. As blocks are mined every 10 minutes this limits the number of transactions per second (TPS) to a theoretical limit of 7 TPS [7]. As Blockchain became more popular and more nodes joined the network, the number of transactions increased and this limit became a significant problem. If the transaction creation rate increases too much it could surpass the rate at which transactions are added to the blockchain, creating a backlog of transactions (Macdonald, Liu-Thorrold and Julien, 2017).

While the Bitcoin community at large has yet to decide on a suitable solution, suggestions include amending block size or a possible 'forking' of the chain where "a blockchain diverges into two potential paths forward — either with regard to a network's transaction history or a new rule in deciding what makes a transaction valid" (Castor, 2017). For example, a hard fork "is a software upgrade that introduces a new rule to the network that isn't compatible with the older software" while a soft fork "is any change that's backward compatible" (Castor, 2017). This can ultimately result in the creation of two separate blockchain histories, such as this August when "bitcoin experienced a high-profile hard fork when a subset of the community split off the software and created a new version called bitcoin cash. The contention came from bitcoin's move toward a certain scaling upgrade, one which the bitcoin cash contingent was against" (Bennington, 2017). As Benning (2017) observes, this has created "two competing and incompatible 'bitcoin' blockchains and 'bitcoin' assets" with the long-term ramifications still yet to be seen.

Yeoh (2017) posits on global implications of blockchain technology, including the eventual need for collaboration among varying international jurisdictions of law and commerce. Huckle *et al*. (2016) discuss the difficulties of creating shared economies where acceptance and misinformation are critical to uptake. For example, in the case of smart contracts:

> […]lawyers often look at smart contracts and see marginally improved legal agreements, without appreciating the fuller potential of blockchain-code to extend beyond law's reach…developers, on the other hand, consider smart contracts

> and see the limitless possibilities of software, without appreciating the subtleties and commercial realities reflected in traditional legal agreements (Stark, 2016).

As a relatively new concept, the blockchain will continue to undergo “variations in its implementation, improving efficiency, improving scalability, and conceptual advances” (Drescher, 2017, p. 248).

CHAPTER 4: CRYPTOCURRENCIES AND THE FINANCIAL SPHERE

4.1 INTRODUCTION

In late 2008, a now infamous concept paper titled 'Bitcoin: A Peer-to-Peer Electronic Cash System' was distributed online through a cryptography mailing list (and later reiterated on *Bitcoin.org*). Published under the pseudonym Satoshi Nakamoto, the paper posited "a peer-to-peer, client-based, completely distributed currency that does not depend on centralised issuing bodies (a 'sovereign') to operate[…]value is created by users, and the operation is distributed using an open source client that can be installed on any computer or mobile device" (Guadamuz and Marsen, 2017). Dubbed 'Bitcoin', the autonomous P2P networking system was first released in early 2009 utilizing enhanced cryptographic practices and "a distributed leger, known as the blockchain, [to] maintain a public record of all transactions" (Delahaye, 2017). The term 'Bitcoin' is widely cited within the literature and may refer to: the blockchain platform itself, the protocol initiated on such a platform to facilitate transfer of assets, and/or as the moniker for the first and largest global cryptocurrency (Swan, 2015). Since its inception, Bitcoin now competes with over seven hundred alternate currencies (or 'altcoins',) the majority of which also employ blockchain technologies and platforms (Delahaye, 2017). What follows is a brief summary of the functional role of blockchain within cryptocurrencies, a survey of subsequent criticisms surrounding both shortcomings and future applications of the blockchain within the wider financial sphere, and a discussion of the legalities surrounding Bitcoin and its alternates.

4.2 CRYPTOCURRENCIES AND BLOCKCHAIN

The terms 'cryptocurrency' and 'altcoins' or 'altcurrency' can be used interchangeably to "describe platforms that rely on the blockchain and on double-key cryptography and employ a peer-to-peer structure, to 'issue digital cash', usually called 'coin', with the aim of transmitting economic value across the Internet' (Papadopoulos, 2015, p. 155; see Figure 12). Or, in other terms provided by Grant:

> Bitcoins are generated by using an open-source computer program to solve complex math problems in a process known as mining[…]each Bitcoin is defined by a public address and a private key, which are long strings of numbers and

> letters that give each a specific identity. This means that Bitcoin is not only a token of value but also a method for transferring that value (Grant, 2014).

Modern forms of currency have evolved from a literal backing of gold held in trust to the overall multi-faceted economic prosperity of a country: “In the traditional economic model, all currency is issued and controlled by the state; only they are permitted to issue the coin of the realm and the advent of a widely accepted alternative would threaten the monopoly of power” (Flint, 2014, p. 61). Proponents of Bitcoin claim that exhibits a real-world value, derived from computing power. As Guadamuz and Marsden describe:

> […]the only way to create new coins is by allocating distributed CPU power through computer programs named “miners”. The miners create a block after a period of time that is worth an ever-decreasing amount of bitcoins in order to ensure scarcity. Each bitcoin consists of 100 million smaller units, with each unit called a satoshi. The operations performed to mine are precisely to authenticate other transactions, so the system both creates value and authenticates itself[…]once created, each Bitcoin (or 100 million satoshis) exists as a cryptographic address that is part of the block that gave birth to it. The person who mined the coin owns the address, and can transfer it by sending value to another address, which is a “wallet” file stored in a computer (Guadamuz and Marsden, 2015).

The bitcoin protocol specifies that each hash exhibit certain characteristics through a proof of work scheme. As the writers at CoinDesk.com describe:

> Miners aren’t supposed to meddle with the transaction data in a block, but they must change the data they’re using to create a different hash. They do this using another, random piece of data called a ‘nonce’. This is used with the transaction data to create a hash. If the hash doesn’t fit the required format, the nonce is changed, and the whole thing is hashed again. It can take many attempts to find a nonce that works, and all the miners in the network are trying to do it at the same time. That’s how miners earn their bitcoins (CoinDesk, 2014).

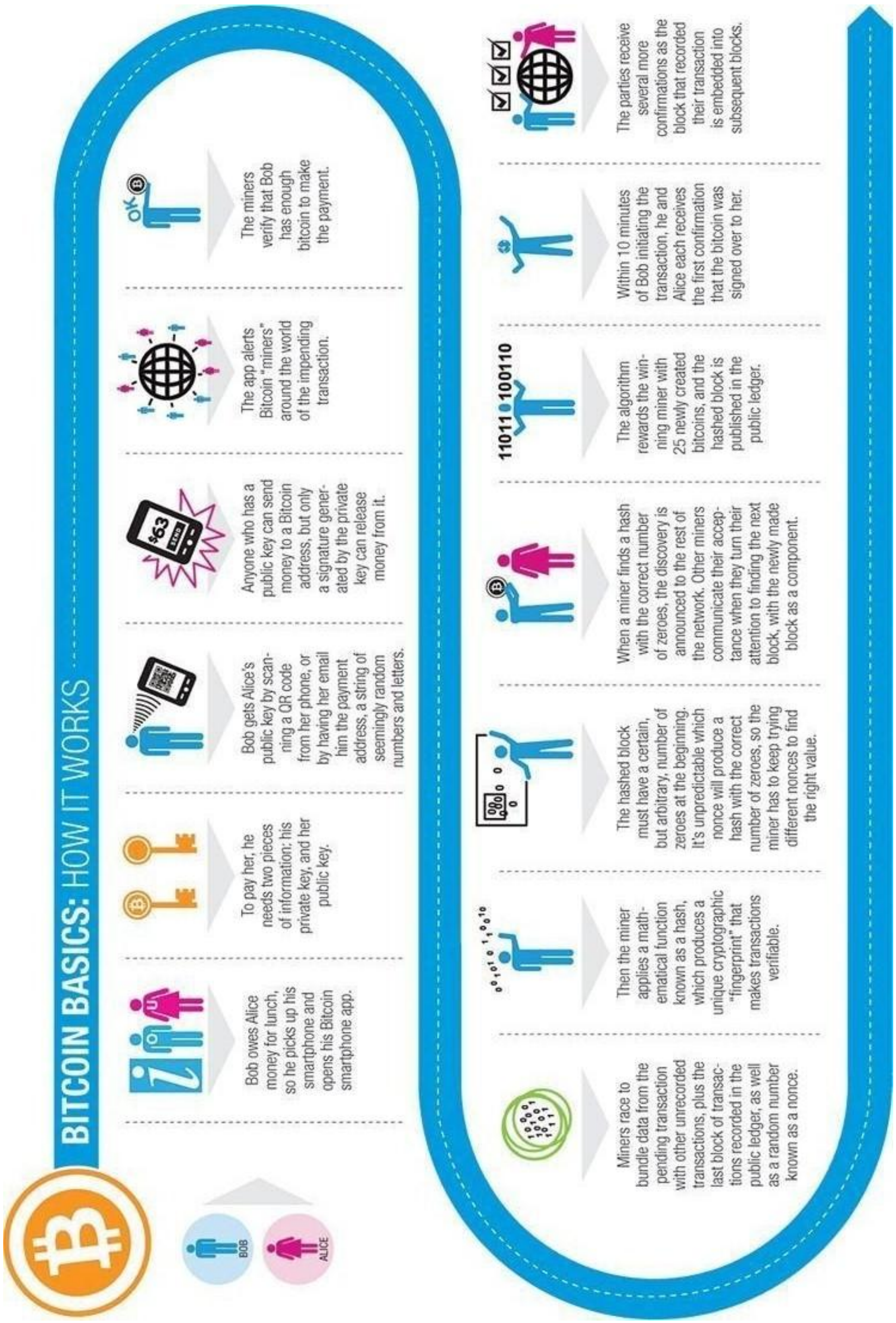

Fig. 12: How bitcoin works, Hochstein (2015)

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Gervais *et al*. (2016, p. 3) note: "Proof of Work (PoW) powered blockchains currently account for more than 90% of the total market capitalization of existing digital cryptocurrencies". Alternative systems to proof of work also exist, such as proof of stake. Unlike proof of work, the creator of the next block in the chain is chosen through deterministic means dependent on account wealth (also defined as 'stake'; see Figure 13). While proof of stake schemes are far more energy efficient than proof of work, the literature notes that incorporation of account wealth may inadvertently create a centralized system where those with the most stake are continually forging currency to the disadvantage of others (Hertig, 2017).

Proof of Work	Proof of Stake
• Proof of Work (PoW) is defining an expensive computer calculation called mining blocks • A reward is given to the first who solves each block calculation • Miners compete with computer power to be the first to find a solution	• In Proof of Stake (PoS) the 'miner' of a new block in the blockchain is chosen in a detereministic way depending on wealth (stake) • The miners do not receive a block reward but collect network fees as the reward • This mechanism make PoS mining much more energy efficient

Fig.13: PoW vs. PoS
Adapted from Nem (2017)

Current technical literature discusses varying security concerns of cryptocurrencies backed by PoW powered blockchains including: double spending, selfish mining, and the risk of eclipse attacks. Karame *et al*. (2015) have shown that in the time required to create a new transactional block a user could potentially 'double spend' bitcoins by

authorizing multiple payment transactions, proving that “accepting transactions without requiring blockchain confirmations is insecure” (Gervais *et al.,* 2016, p. 4). Eyal and Sirer (2013) discuss the risk of selfish mining in which “Bitcoin protocol requires a majority of the miners to be honest; that is, follow the Bitcoin protocol as prescribed. By construction, if a set of colluding miners comes to command a majority of the mining power in the network, the currency stops being decentralized and becomes controlled by the colluding group”. Finally, Heilman *et al.* (2015) observe that the bitcoin peer-to-peer network is susceptible to adversarial nodes seeking to disrupt the mining and consensus system. Known as an eclipse attack “[…]an adversary control[s] a sufficient number of IP addresses to monopolize all connections to and from a victim bitcoin node”, allowing for further manipulation via double-spending and/or selfish mining (Heilman *et al.,* 2015, p.1).

A scarcity paradigm exists within the Bitcoin market as the algorithms used to produce coins “increase[s] the amount of processing power necessary to create each new block, so producing new coins is more difficult. This difficulty is built into the system in order to keep the total amount of Bitcoins at a maximum of 21 million[…]an individual cannot hope to have the processing power to develop new coins, and this can only be done currently through pool mining CPU resources” (Guadamuz and Marsden, 2015). Both Guadamuz and Marsden (2015) and Flint (2014) note this creates an economic disadvantage for late adopters, many of who may only be able to acquire bitcoins through market exchange. The cryptocurrency index CRIX was launched in 2016 to follow the market development of cryptocurrencies, and is a collaborative effort between the Humboldt University of Berlin, Singapore Management University and the enterprise CoinGecko (CoinGecko, 2017). As of August 2017, one bitcoin exhibited fluctuating value of approximately $3500 USD (CoinGecko, 2017). In comparison, popular competitor altcoins Ether (Ethereum) valued approximately $300 USD and LiteCoin at $46 USD (CoinGecko, 2017). Bitcoin has ultimately provided the source code for additional cryptocurrencies, offering a “prototype for the management, the organization, and the business model for the other altcoins” (Papadopoulous, 2015, p. 158).

4.3 THE FINANCIAL SPHERE

While most widely known for use in cryptocurrencies, blockchain technologies exhibit multiple applications - such as smart contracts - for potential use in a variety of financial

domains. As Swan (2015, p. xi) observes: “The economy that blockchain enables is not merely the movement of money, however; it is the transfer of information and the effective allocation of resources that money has enabled in the human-and corporate-scale economy”. Smart contracts, often dubbed ‘blockchain 2.0’, “can be stored on a blockchain (i.e., a decentralized, replicated and shared public ledger used to record and verify transactions), interact with external data feeds, and then self-execute payments, shipment of products or other actions/processes (including remedies in the case of breach) based on conditional logic (programmed as traditional ‘if-then’ statements) and agreed verifiable proof of performance or other trigger events” (Herzfeld, 2016).

Prisco (2017b) notes that while smart contracts are currently used to execute a cryptocurrency payment within a blockchain, they can’t yet be applied to “self-execute a payment in fiat money from a bank account to another”. Prisco (2017b) argues this is an important limitation to the application of blockchain within the financial sphere for two reasons: first, contracts executed on a blockchain are not yet consistently recognized by national or intentional jurisdictions of law, creating discord with systems of legal protection and enforcement. Second, “the real business world will continue to be based on fiat money for many years to come,” suggesting the gap between technological hype and realistic implementation may be wide at best (Prisco, 2017b). Despite such cautions, blockchain technology applications for the financial sector, including the use of smart contracts, is steadily emerging within the literature surrounding the trade finance industry, loans and mortgages, and stock trading platforms, among others.

Silitschanu describes the trade finance industry as referring to:

> […] financial transactions, both domestic and international, which relate to trade receivables finance and global trade. These trade finance transactions include lending, issuing letters of credit, factoring, export credit and insurance. These transactions make up an enormous portion of global trade – approximately 80 to 90 percent of world trade relies on trade finance. Essentially, almost any time goods or services are bought or sold across any border, there is some form of trade finance involved (Silitschanu, 2017).

IBM has recently been hired by seven of the world’s largest banks, including HSBC and Deutsch Bank, to develop a blockchain based platform for trade finance. As Kelly (2017)

observes: “trade finance transactions typically involve a complicated paper trail that requires international courier services, is vulnerable to document fraud, and can take as long as a month to be completed”. In a June 2017 interview, Hubert Bdenoot, general manager of trade finance for one of the seven banks, KBC, noted initial platform offerings will focus on financing and risk coverage including “a track-and-trade system so that buyers and sellers can follow the physical transfer of the goods” (Kelly, 2017). The Mizuho Financial Group based in Japan recently completed a blockchain-backed trial between “Marubeni Corporation, a Japanese trading conglomerate, and domestic insurer Sompo Japan Nipponkoa Insurance Inc. During the test, information was transmitted between Japan and Australia, with ‘all trade-related processes, from issuing the letter of credit to delivering trade documents, [being] completed entirely via a digital platform using blockchain” (Higgins, 2017). Mizuho noted overall success, specifically the “digitization of the process cut the amount of time it takes to create and disseminate trade finance-related documentation, as well as reduce the human labor required” (Higgins, 2017).

Loans provide another area of the financial market where blockchain technology could soon play a key role in streamlining traditional practices. In today’s current system of mortgage lending “every time a transaction moves between ledgers, someone confirms that move. Blockchain could address this issue by updating ledgers immediately, automatically, transparently, and with traceability” (PwC, 2016). Financial and legal conglomerate PricewaterhouseCoopers (PwC) goes on to describe the role blockchain technology could play at every stage of the mortgage cycle:

> At origination, blockchain might help establish more accurate recordkeeping. At fulfillment, it could provide immutable proof that loan estimates were sent within three business days. Smart contracts would speed up settlement flows. In the mortgage servicing process, blockchain could track the movement of payments. And in the secondary markets, it might provide transparency about the ownership of underlying assets (PwC, 2016).

However, Delahaye (2017) notes of loans in general “if a user lends money to another user who defaults on the loan, the lender cannot force repayment using the blockchain.

One deterrent for defaulting is the automatic publication of the information, validated by the blockchain, and the prospect of reputational damage for the borrower".

Finally, sharemarket trading provides a prime example of the blockchain already at work in the financial sector. As Lee and Hong (2016) describe, the use of blockchain allows for trades to be settled by "participants confirming transactions through the peer to peer network" and bypassing the need for traditional third party clearing houses. Blockchain technology offers trading platforms the ability to seamlessly "record the buyer and selling participants, the number of shares traded, price of shares, time of exchange and the exchange of funds" (Lee and Hong, 2016). In late 2015 NASDAQ's "Linq blockchain ledger had issued securities to an unnamed private investor, proving the concept of share trades through a decentralised ledger, and removing the need for a middleman such as a clearing house" (Dakers, 2015). In 2016 retail conglomerate Overstock began trading its shares over the Bitcoin blockchain, and 2017 has yielded a new collaboration between IBM and the London Stock Exchange to "create a distributed shared registry containing a record of all shareholder transactions, and […] to open up new opportunities for trading and investing" (Aitken, 2017). As Aitken (2017) observed, a 2016 survey of 200 global banks by the IBM Institute for Business Value indicated that 65% "said they expected commercial blockchain solutions and technology to be in production in three years".

4.4 REGULATION – CRYPTOCURRENCIES, BLOCKCHAIN, & BEYOND

Kethineni, Cao, and Dodge (2017) observe that cryptocurrencies differ from traditional financial systems through their use of blockchain as "there is no central authority or third party, neither the payer nor the payee needs to go to a bank to open an account and reveal his or her identity". Papadopolous further supports Kethineni, Cao, and Dodge (2017):

> Anyone who holds altcoins also has the exact copy of the blockchain, making all transactions visible to the users of the system, eliminating the information asymmetries that characterize the traditional hierarchical system of financial intermediation, and enhancing the security of the public ledger of the transactions (Papadopolous, 2015, p. 156).

Greenberg (2016) notes “transactions are recorded only as addresses, which aren’t necessarily tied to anyone’s identity—hence Bitcoin’s use for anonymous and often illegal applications”. The pseudo-anonymity provided by the blockchain “acts as a powerful motivation for people to resort to criminal activity” with the roots of Bitcoin historically linked to peer-to-peer ‘darknet’ markets which require special software for access, typically to facilitate illegal goods and activity. One of the most infamous examples is the now defunct Silk Road – founded in 2011. The United States Federal Bureau of Investigation (FB) shut down the darknet market in late 2013, arresting founder and owner Ross Ulbricht on multiple charges of money laundering, computer hacking, narcotic trafficking, and attempted assassination (Levin, O’Brien, and Zuberi, 2015). As the exclusive currency of the Silk Road, the FBI and United States Department of Justice “seized over 170,000 Bitcoins” and raised early concerns regarding cryptocurrency regulations and the anonymity offered by the blockchain as copycat networks began to appear (Levin, O’Brien, and Zuberi, 2015, p. 335).

The current literature on cryptocurrency regulation, and the use of blockchain technologies within such legalities, offers a breadth of yet unanswered questions. Cryptocurrency lawyer Santorini (2017) reflects on early questions of regulation: “Was crypto prohibition on the horizon? Would bitcoin be deemed contraband? Would the government classify our clients – bitcoin businesses – as entities of primary money laundering concern?”. More importantly for the blockchain, “all this made corporations weary to even consider taking Bitcoin seriously. And very happy when the term ‘blockchain’ came around and gave them a chance to talk about the core invention without having to pronounce ‘Bitcoin’” (Diedrich, 2016, p. 274). As Barre (2015, p. 338) asks: “since Bitcoin is primarily used in e-commerce transactions, there is no singular body that takes primary responsibility for its overall regulation. So if it is indeed determined that there should be some degree of regulation over Bitcoin transactions, who should do it?”. Levin, O’Brien, and Zuberi (2015, p. 356) note that while regulators intend to “protect the public from fraudulent schemes that make use of virtual currencies”, ultimately “the fact that Bitcoin has been used by parties as part of a fraud does not mean virtual currencies are inherently fraudulent or flawed”. Kethineni, Cao, and Dodge (2017) observe a need for further “additional expertise” in blockchain backed

cryptocurrency fraud, as “there is no central authority for identifying abnormalities in transactions”.

Yeoh (2017) argues that the regulation of cryptocurrencies such as Bitcoin, currently determined at varying national levels, must be developed with consideration for the wider implications of the underlying blockchain technology in all domains of social application. A lack of international uniformity is captured in the spectrum of regulatory approaches, as summarized by Nian and Kuo Chuen (2015, p. 314) in Figure 14. Nian and Kuo Chuen (2015, p. 312-313) posit that international jurisdictions, however, do exhibit commonality in identified regulated risks, including: 1) counterparty risk in a virtual, decentralized system (and the fulfillment of smart contracts), 2) consumer protection (loss and theft), 3) financial crime, and 4) risk of facilitating money laundering and terrorist financing.

Restrictive➔Permissive

Restrictive Regulation	Participation discouraged	Regulate under existing structures	Encouragement with self-regulation	Active engagement for coexistence	Laissez-fair or no regulation
China Russia	European Banking Authority	United States Canada Singapore	United Kingdom	Ireland	Australia Brazil

Fig.14: Spectrum of regulatory approaches as identified by Nian and Kuo Chen (2015)

Finally, Flint (2014, p. 60) writes: “Law should be technology and application neutral; no higher standard or restriction should be placed on commerce merely because it is effected by a specific medium”. However, as cryptocurrency continues to serve as the most widely used medium of blockchain technology, the literature overwhelming concludes that regulation of both its use and underlying architecture will be among the first to see formal, unified international agreements creating new legal precedent and regulatory status quo. As Yeoh (2017) concludes, case precedent from the financial sector may serve as a model for further cross-disciplinary regulation of blockchain technologies and should ideally be developed with consideration to both short and long term outcomes.

4.5 SUMMARY & ANALYSIS

Much of the academic literature surrounding blockchain focuses on cryptocurrency

applications, specifically Bitcoin, which originally sought to disintermediate features of traditional banking systems. However, Diedrich (2016, p. 303) notes the financial sphere is merely a precursor to further blockchain activity, in which “special-purpose blockchains will, also, not be blockchains but will be employing, recycling and re-dressing great ideas that have come to the fore in the wake of blockchains”. The use of cryptocurrencies is not without concern, as evidenced through potential double spending, selfish mining, and eclipse attacks. Furthermore, Diedrich (2016, p. 131) notes account numbers within the blockchain are not verified: “People have lost million meanwhile by sending money to wrong accounts – accounts that the blockchain assumes exist, and so accepts the transaction as valid – but that no one has a private key for[…]And yes, the transactions are irrevocable”. The literature suggests that blockchain technologies will continue to surpass their Bitcoin origins within the public sphere, and in doing so, distance themselves from widely held beliefs of cryptocurrency use within nefarious or illegal market practices.

Despite such challenges, PwC (2016) argue the lack of current cohesive blockchain regulation within the financial sector allows for an unprecedented “opportunity to learn about the technology while processes are still fluid”. For example, Diedrich (2016, p. 12) observes: “The nature of making legal contracts will likely change dramatically and litigation might take a back seat to prevention: because a blockchain gives you the guarantee that a contract will execute – including moving assets and money – exactly as cod(ifi)ed”. Emerging within the literature are discussions surrounding the legal implications of monetary transactions backed by blockchain technologies – i.e., what and how is accepted as the status quo for currency. As more proof of concepts emerge within the financial sector organizational legacy schemes will also need to be considered, alongside challenges associated with the migration of longstanding data systems.

CHAPTER 5: BLOCKCHAIN AND GOVERNMENT

5.1 INTRODUCTION

The use of blockchain within government aims to "provide services traditionally provided by nation-states in a decentralized, cheaper, more efficient, personalized manner" (Swan, 2015, p. 44). Douglas (2017) observes that blockchain technologies offer innovative solutions for two of the most persistent problems currently faced by governments – the establishment of identity records, and the creation of trust in digital environments. Such elements are crucial to the success of nation-states, as:

> […]untrustworthy civil registration entries may mean that citizens are unable to prove their identities as a necessary precondition of accessing social protection benefits, or that opportunities for identity fraud emerge that undermine a country's immigration policies and national security" (Lemieux, 2016, p. 110).

Three emerging areas within the literature surrounding blockchain implementation include identity records and the case of e-Estonia, land registry systems in both the Western and developing world, and emerging theories on the potential use for democratic elections and other third-party voting systems.

5.2 IDENTITY RECORDS

Chester (2017) observes of the majority of nations: "In the offline world, you update your proof of identity every few years, receiving a drivers license, ID card, or maybe a passport if you travel internationally". With the onset of evolving digital technologies, electronic identity documents and records (e-identities) may soon become the status quo, with the possibility of blockchain technology as the means of authorization. A progressive leader in digital identity, Estonia first implemented e-identification for residents in 2014 through a:

> […]cryptographically secure digital identity card (powered by a blockchain-like infrastructure on the backend) that allows an Estonian to access public services, financial services, medical and emergency services as well as to drive, pay taxes online, e-vote, provide digital signatures, and travel within the EU without a passport" (Shen, 2016).

The Estonian ID card, or public key infrastructure (PKI) card, does not operate directly on a blockchain system. Instead, the "card carries embedded files, and using 2048-bit public key encryption, it can be used as definitive proof of ID in an electronic environment" (e-Estonia, n.d.). With the success of electronic resident identification cards the Estonian government further partnered with Bitnation, a blockchain based virtual state offering "DIY Governance Services", in 2015 to create a new program of e-Residency (BitNation, 2015).

With just 1.3 million physical residents, e-Residency offers a transnational digital identity in which "an individual can establish a location-independent online business registered in Estonia and with access to digital services similar to those accessible by Estonian citizens and Estonian based businesses" (Shen, 2016). E-residency provides revenue to the country through administrative fees and subsequent business ventures, while allowing otherwise foreign business access to the markets of the European Union. In early 2017 NASDAQ released a proof-of-concept that would also utilize the blockchain to allow proxy shareholder votes for e-residents (NASDAQ, 2017). E-residents are liable to pay taxes only in their home jurisdiction, and through the Bitnation Public Notary system "e-residents, regardless of where they live or do business, will be able to notarize their marriages, birth certificates, business contracts, and much more on the blockchain" (Bitnation, 2015). However, Sullivan and Burger (2017) note the literature at present gives few to no details on Bitnation's technical platform for implementation in Estonia, despite the interest of additional nations in creating their own e-Residency programs. Furthermore, while Bitnation seeks to exist outside the sphere of current legal practice, the use of blockchain for notary services raises issue of national data protection legislation and international rights to identity (Sullivan and Burger, 2017).

On October 5, 2014 the world's first blockchain recorded marriage occurred at Disneyworld in Florida (Swan, 2015). As an online public registry, the marriage was "submitted to the Bitcoin blockchain…the vows were transmitted in the text annotation field, embedded in a Bitcoin transaction of .01 Bitcoins ($32.50) to appear permanently in the blockchain ledger" (Swan, 2015, p. 46). Connell lists several examples in which the blockchain has provided a marriage contract between citizens of differing nations, eliminating a possible need for multiple citizenships and lengthy governmental processes to proclaim such a transaction as valid:

> […]two people who love each other must spend thousands of dollars, months or even years of time and lots of paper to two governments for the privilege of moving across imaginary lines. Not only that, but the marriage is only legal in the country you file (Connell, 2017).

Through blockchain, smart contracts could also be executed to include pre- and post-nuptial agreements and childcare contracts. Further to their work in Estonia, Bitnation announced ‘Smart Love’ in November of 2016, a propriety blockchain application to address multiple agreements traditionally linked to marriage such as asset sharing (Memória, 2016). However, at present, “none of the transactions registered by Bitnation have any legal standing, unless also recognized by a real sovereign nation…no one will recognize a ‘wedding’ registered at Bitnation that is not also recognized by some other state” (Sullivan and Burger, 2017, p. 476).

While the success of Estonian digital identities has garnered much interest from other nations, Sullivan and Burger (2017, p. 475) ultimately question the scalability of blockchain noting this “is reportedly an issue for Bitcoin, the first application built on top of blockchain, with reports that the chain is reaching capacity”. Estonia has proven a unique platform for uptake of blockchain technologies following the collapse of the Soviet Union, as leaders circumvented traditional governing methodologies in favour of progressive laws surrounding digital signatories and innovative mobile solutions (Walt, 2017). As Walt notes:

> Since no Estonian had ever had a checkbook, once the Soviets were gone the country simply skipped past pen and paper and issued bank cards. It was a money saver, but had another benefit: It pushed Estonians to get online fast (Walt, 2017).

By enabling access to identity information, the “blockchain is said to be able to prove a person exists at a certain time and place, based on verification by a group of people. In effect, their consensus constitutes reality. In other words, if the consensus says that it is so then it is so” (Sullivan and Burger, 2017, p. 475). The concept of a self-sovereign identity is one that merits further consideration in wider transnational contexts, as each

nation will differ in its ability and capacity to support blockchain infrastructure and its associated legalities.

5.3 LAND REGISTRY

A land registry typically refers to the means by which a government agency records matters of ownership and rights to land; this may include evidence of title, and the facilitation of possession transactions, with the intent to prevent unlawful or fraudulent activities. In February of 2017, the Republic of Georgia became the first government to secure land titles using blockchain technology (Shin, 2017). Originally launched as a pilot project in April of 2016, the National Agency of Public Registry (NAPR) is working with BitFury, a blockchain technology conglomerate, to implement a "transparent, secure ledger to manage land titles, and, if successful, cut property registration fees by up to 95%, increase transparency of land ownership, and reduce fraud" (Underwood, 2016, p. 17). A custom blockchain solution was devised for integration with NAPR's current system of digital record keeping:

This private, permissioned blockchain is anchored to the Bitcoin blockchain through a distributed digital timestamping service. Distributed digital timestamping allows NAPR to verify and sign a document containing a citizen's essential information and proof of ownership of property" (Prisco, 2017a). From February of 2017 to April of 2017, Valery Vavilov, CEO of BitFury, reported more than 100,000 property registrations in the Republic of Georgia utilizing their blockchain solution (Smerkis, 2017).

The advantages of blockchain in this instance are twofold. First, creating an accessible land registry utilizing blockchain technology allows citizens a new means of participation – in both registering assets, and in verifying legitimacy of current land titles. With transactions placed on a private blockchain, the subsequent cryptographic hash is:

> […]made public on the Bitcoin blockchain to verify the authenticity of certificates. The hash serves as a digital fingerprint allowing anyone to verify that the data matches what is on the blockchain without actually seeing the data itself (Coleman, 2017).

Second, a land registration transaction in the Republic of Georgia historically requires at least 24 hours processing time with a fee of $50-200 USD, paid in-person by a buyer or seller to a registry house; under the blockchain system, fees to buyers and sellers are “in the range of $.05-$.10[USD]” with subsequently reduced processing timeframes (Shin, 2016). Originally tested on land title registrations, the new agreement further expands to “purchases and sales of land titles, registration of new land titles, demolition of property, mortgage and rentals, as well as notary services” (Shin, 2017). Underwood (2016) posits this is particularly significant for those citizens at economic disadvantage, as proof of ownership would allow land to be used as collateral asset in other financial transactions.

The success of the Georgian land registry pilot program has largely been credited to a low incidence of previous registry fraud, and existing software infrastructure for integration of blockchain technology (S. Das, 2017). In 2015, a project between Factom, an alternate blockchain service provider, and the government of Honduras reached a temporary stall. Despite new laws surrounding land administration within the country, the Honduran land registry database was subject to fraudulent hacking resulting in “concerns about the reliability of the information in the Honduran land registry system…[and] about ongoing authenticity of Honduran land registrations” (Lemieux, 2016, p. 122). In economies already subject to corruption the use of blockchain alone is not sufficient, as no framework has been established to test for the reliability and authenticity of previously existing records for transfer. As Lemieux (2016, p. 122) observes: “Security of land tenure in Honduras is essential for the economy to grow and to reduce poverty levels”. Lemieux (2016) proposes management and digital preservation standards as set by the Association of Records Managers and Administrators (ARMA) be used to evaluate pre-existing files before transfer to the blockchain.

Despite the advances offered to developing countries, Coleman (2017) observes that the use of blockchain is not without challenges; in the instance of Georgia, “processes for verifying information accuracy on the ledger [have] yet to be established”. Land registry systems utilizing blockchain are also under development in Ghana, Sweden, and the United States, each with their own unique assets and challenges. In Ghana, blockchain conglomerate Bitland is focusing on educational initiatives preceding the introduction of new technologies, as blockchain “benefits often fail to resonate due to the markets

targeted and the way in which they are communicated" (Aitken, 2016). Sweden currently exhibits a highly developed, corruption-free land registry system; however, the Swedish government has recognized the cost saving implications of blockchain which "could save the Swedish taxpayer over €100 million ($106 million) a year by eliminating paperwork, reducing fraud, and speeding up transactions" (Wong, 2017).

While still in its infancy, the Swedish government is working with blockchain startup ChromaWay, technology consultancy firm Kairos Future, and national banks (SBAB and Landshpotek) to create a customized private blockchain system that may set industry standard for developed nations where resistance to change is not uncommon (Keane, 2017). Finally, in the United States, land registry systems vary across state lines; through a partnership with real estate technology startup Velox.re, "Chicago's Cook County will test the use of the Bitcoin blockchain for transferring and tracking property titles and other public records. The Cook County Recorder's Office is the second largest such office in the United States, and it will be the first in the country to experiment with blockchain technology" (Torpey, 2016). The International Blockchain Real Estate Association (IBREA) is also involved in the closed pilot project, and aims to develop best practices and "identify new standards that will be needed to operate with a blockchain paradigm" within the collaborative nature of real estate transactions (IBREA, 2017).

5.4 ELECTIONS

Noizat identifies the key problem of current electronic voting systems:

> They are proprietary, that is, centralized by design, meaning there is a single supplier that controls the code base, the database, and the system outputs and supplies the monitoring tools at the same time. The lack of an open-source, independently verifiable output makes it difficult for such centralized systems to acquire the trustworthiness required by voters and election organizers" (Noizat, 2015, p. 453).

In lieu of current paper-based systems of voting, blockchain offers a solution in conjunction with the use of i-voting (where votes can be cast using a web browser) and/or e-voting (electronic votes tallied at a polling station). The aims of digital voting

systems utilizing blockchain are twofold: first, to provide an unprecedented level of voter privacy, and second, to ensure each voter is unique and able to ensure their vote is tallied as cast. In considering the efficacy of such suggested digital systems, several social assumptions are made: that a country or jurisdiction utilizes a system of constituency based voting, that all voters have been assigned a unique identifier or other form of reference, and in the case of e-voting, a reliable network connection must be present at all polling stations (Barnes, Brake and Perry, 2016).

In 2007, Estonia became the first nation to utilize i-voting in Parliamentary elections (Estonian Government, 2017). Barnes, Brake and Perry (2016) discuss the potential issues of i-voting within Estonia's current system of digital democracy, and propose how blockchain technology could solve potential security concerns. As noted, the Estonian national identity card is encrypted with files that allow the user to perform a range of digital functions, including i-voting where ballots are cast online. The Estonian government describes the process as:

> […]a designated pre-voting period, [where] the voter logs onto the system using an ID-card or Mobile-ID, and casts a ballot. The voter's identity is removed from the ballot before it reaches the National Electoral Commission for counting, thereby ensuring anonymity" (Estonian Government, 2017).

As Barnes, Brake and Perry (2016, p. 6-7) found, ballots are forwarded to a secure server where they are encrypted and stored until the end of the election, "then the vote has all identifying information cleaned from it and is transferred by DVD to a vote count server which is disconnected from all networks. This server decrypts and counts the votes and then outputs the results". However, the authors note that the presence of malware on the device used by the individual voter may monitor the vote placed and later change the ballot to a different outcome (Barnes, Brake and Perry, 2016, p. 7).

Barnes, Brake and Perry instead theoretically propose a:

> […]geographically distributed network comprising of machines from both government and public infrastructure; this infrastructure houses two distinctly separate blockchains, one for voter information such as who has voted and the

> other for vote information such as what has been voted. These blockchains are held completely separately to remove any threat to link votes for certain parties back to individual voters while maintaining the ability to track who has voted and how many votes are actually present" (Barnes, Brake and Perry, 2016, p. 13).

The voter registration process comprises of either electronic or paper based forms, noting elements of identification such as a national identity number, postal address, e-mail, and creation of a unique password. A transaction is created on the user blockchain when an individual 'registers', and a second transaction is created on the same chain when a "government miner authorizes the user's right to vote" (Barnes, Brake and Perry, 2016, p. 9). Ballots would be sent in both hardcopy and electronic format, including a randomly generated password to use at polling stations (Barnes, Brake and Perry, 2016, p. 8-9).

Votebook, abstractly proposed by Kirby, Masi and Mayim (2016) offers a differing solution – the authors do not condone remote interaction, noting that as voting may no longer occur in a secure environment the element of coercion or duress may exist. This also addresses the threat of malware on the individual's computer, as discussed by Barnes, Brake and Perry (2016). The authors' solution, *Votebook*, is a "permissioned blockchain" wherein a distributed database with consensus for change and no retroactive edits is employed without a proof of work mechanism. As Kirby, Masi and Mayim observe:

> Proof of work channels brute computing power to limit permission within a *trustless* system; however, elections are not trustless – they are restricted to their electorate…we determined that the best leverage of trust would be to allow a centralized authority to oversee the distribution of encryption keys to the nodes in the election network – hence the term 'permissioned blockchain'. Nodes must have prior permission from the central authority to make changes to the ledger" (Kirby, Masi and Mayim, 2016, p. 3).

Several issues remain present in the literature surrounding blockchain and electronic voting systems; for example, as voting may no longer occur in a secure environment, the potential element of coercion can be viewed as prohibitive to the social uptake of new systems. The Estonian government sought to circumvent this problem, noting voters are

able to “log on and vote as many times as they want during the pre-voting period. Since each vote cancels the last, a voter always has the option of changing his or her vote later” (Estonian Government, 2017). Individuals who choose to abstain from voting also prove problematic, creating the possibility of using uncast votes fraudulently. *Votebook* theoretically allows voters the option to abstain from casting a ballot through an on-screen keyboard, a solution the authors posit will deter from the possibility of using uncast votes fraudulently through timestamping and multiple validation segments (Kirby, Masi and Mayim, 2016). Data must also be held privately until the end of the voting process in jurisdictions that prohibit the publication of interim voting results; Kirby, Masi and Mayim note in theory:

> […] a ledger and the set of public keys for each voting machine can be released to the public at large, at which point any voter will be able to verify that her own vote was counted once and may even examine the integrity of each block, but will not be able to decipher the hashes representing the identities of other voters” (Kirby, Masi and Mayim, 2016, p. 7).

5.5 SUMMARY AND ANALYSIS

Within the limited, but emerging, literature on the use of blockchain for government services it is not unreasonable to posit that the “blockchain could become both the mechanism for governing in the present, and the repository of all of a society’s documents, records, and history for use in the future – a society’s universal record-keeping system” (Swan, 2015, p. 44). However, such implementation is not without challenges – among them the differing financial and political states of nations. Underwood (2016, p. 15) supports the claims of Lemieux (2016) in noting blockchain technology “could empower people in developing countries with recognized identity, asset ownership, and financial inclusion”. However, implementation may require initial capital and commitment from governments and leaders to explore the potential of blockchain technologies. Strategies for implementation can be prototyped using “proofs of concept, sandboxes and small projects that do no harm” (Mougayar, 2016). Available literature on technical aspects of blockchain system development are limited, as many partnerships and pilot projects are closed in nature and subject to contractual agreements of privacy.

Mougayar (2016) argues that small cities and municipalities are the ideal for implementing blockchain technologies, as “it is a lot easier to implement solutions at smaller scales first, in jurisdictions that have between five to 300,000 citizens, instead of larger cities of more than a million inhabitants”. However, embedding blockchain solutions within government are not without risk; in the case of both essential identification services and elections, the legalities of both national and international standards are yet to be tested. This includes responsibility for data stored on blockchains, and the emergence of blockchain nation-states like BitNation that adhere to no central system of government yet lay claim to many of the same essential services. Swan (2015) posits that informed citizenship is key to reaching a critical mass where the shifting nature of the nation-state will require blockchain technologies as the future of identity systems and associated functions, including proof of ownerships.

CHAPTER 6 – BLOCKCHAIN AND HEALTHCARE

6.1 INTRODUCTION

The current literature surrounding blockchain and the healthcare industry indicates "promise in simplifying an array of healthcare data transactions on both the business and clinical sides of healthcare--from claims adjudication to precision medicine" (Conn, 2016, p. 14). Centered at the core of such discussions is the concept of interoperability across a range of stakeholders. As Krawiec *et al.* (2016, p.10) note: "Capitalizing on this technology has the potential to connect fragmented systems to generate insights and to better assess the value of care". What follows is an overview of blockchain applications, both in practice and theory, as presented in the wider domains of healthcare management, medical research, and pharmaceutical fraud detection.

6.2 HEALTHCARE MANAGEMENT

Blockchain technology offers several advancements in the field of healthcare management including the cross-institutional unification of electronic medical/health records (EMRs or EHRs) and personal health records (PHRs). Healthcare institutions with centralized databases typically manage EMRs or EHRs with little or no individual access. PHRs would allow patients primary access to their collective health records, with the ability to authorize the transfer of secure medical information and input additional basic health statistics such as height, weight, blood pressure and etc. As Swan (2015) observes, the medical field could benefit greatly from systems in which multiple parties (physicians, healthcare institutions, allied health professionals and etc.) can access unified and continually updated patient records via the blockchain. Taylor (2016) further supports this premise, noting "the amount of media disruptions involved during the treatment of a patient (e.g., change of communication media, various medical health records, incompatible IT interfaces, etc.) can lead to time-consuming and resource-intensive authentication and information processes for all medical stakeholders involved".

Recall Estonia's system of e-identification, where residents are issued an electronic identification card capable of storing and executing multiple personal data commands. In 2016, the Estonian Government's e-Health Foundation (EGeHF) partnered with Guardtime, a software security systems company, to integrate patented blockchain

based Keyless Stystems Infrastructure (KSI) technology with current digital record keeping systems (EGeHF, 2017). Aru writes:

> The Estonian eHealth Foundation will integrate Guardtime's KSI blockchain into its Oracle database engine[…]it will provide real-time visibility into the state of electronic systems and lifecycle management of patient records. KSI-instrumented records, based on a hash function cryptography, will be mathematically irrefutable (Aru, 2016).

Residents are able to manage their medical information through an integrated ID e-portal allowing for management of PHR information and view which healthcare providers have accessed their files (EGeHF, 2017). As e-Estonia describes of the system:

> Each person in Estonia that has visited a doctor has an online e-Health record that can be tracked[…]functioning very much like a centralized, national database, the e-Health Record actually retrieves data as necessary from various providers, who may be using different systems, and presents it in a standard format via the e-Patient portal. A powerful tool for doctors that allows them to access a patient's records easily from a single electronic file, doctors can read test results as they are entered, including image files such as X-rays even from remote hospitals. For assuring the integrity of retrieved electronic medical records as well as system access logs, blockchain technology is used (EGeHF, 2017).

At present, more than 1 million patient records are backed using Guardtime's Keyless Systems Infrastructure (KSI), which will further be implemented at "all levels of Estonian Government infrastructure through a frame cooperation agreement with the Estonian Information Systems Authority (RIA)" (Aru, 2016).

Roehrs, da Costa and da Rosa Righi (2017) propose a hypothetical blockchain-based architecture known as OmniPHR for the integration and interoperability of PHRs. In this model, OmniPHR "divide[s] the patient's health records into datablocks, which are a logical division of the patient's health datasets, such as laboratory data, drug-related dataset, X-ray dataset and others" (Roehrs, da Costa and da Rosa Righi, 2017, p.73). OmniPHR datablocks can be created and digitally signed by both patients and medical

professionals. A P2P network allows authorized users or institutions the “ability to maintain and locate datablocks of PHR when required” while the contents of each data block are validated via time-stamping protocols (Roehrs, da Costa and da Rosa Righi, 2017, p.75). The authors observe that this level of architecture is not without limitations, including human error in the consistency of data entry standards to yield appropriate recall, and/or the duplication of source input data by multiple healthcare professionals.

Gem, a blockchain startup based in the United States, proposes a similar architecture to Roehrs, da Costa and da Rosa Righi (2017) for use in healthcare financial claims systems. As R. Das (2017) describes of Western health schemes: “an estimated 5-10% of healthcare costs are fraudulent, resulting from excessive billing or billing for non-performed services”. Self-described as “connecting the ecosystem to universal infrastructure”, the Gem Healthcare Network seeks to address “the lack of real-time transparency into health claims transactions involving providers and payers [and] the amount of time it takes for providers to get paid for their service” (Allison, 2017). Not unlike PHRs, a single unified blockchain is created per claim, allowing real-time distribution of data across numerous stakeholders. Attribution created through blockchain time stamping may greatly decrease the risk of fraudulent transactions and provide a reliable and transparent means of tracking information throughout the claims cycle. Gem also notes the possibility of integrating smart contracts could allow for the automation of payment processing activities which would “eliminate the need for intermediaries and reduce the administrative costs and time for providers and payers” (R. Das, 2017).

Yue *et al.* (2016) discuss the benefits of mobile computing for PHRs, noting that blockchain technology may best be enabled at the patient level through user-friendly applications. The authors propose a smartphone application titled Healthcare Data Gateway (HGD) with “architecture based on blockchain to enable patient to own, control and share their own data easily and securely without violating privacy” (Yue *et al.,* 2016). Smartphones offer a low barrier to adoption given their prevalence, computing power, and current availability of mobile wireless networks. The hypotheses made by Yue *et al.* (2016) surrounding mobile computing are supported by recently launched Patientory, a “cybersecurity blockchain-based distributed electronic medical record network” that offers a cohesive medical tracking application backed by blockchain technology for use

by healthcare providers and patients alike. As of May 2017, Patientory has begun proof of concept testing within the United States with further plans to expand to an international network. The company cited recent global ransomware attacks on the UK's National Health Service as evidence of the need for blockchain based PHRs readily accessible by mobile device to provide "patients with an easy and hassle free way of tracking doctor visits, medical bills, personal medical information, insurance, immunizations and pharmacy medications" (Patientory, 2017).

6.3 MEDICAL RESEARCH

Transparency, as both concept and practice, has been a longstanding issue within the field of medical research. While global information sharing may yield medical breakthroughs, differing information privacy laws result in retracted or withheld patient data influencing the efficacy of both international and domestic clinical trials. Nugent, Upton and Cimpoesu (2016) note that the World Health Organization (WHO) has advocated making both methodologies and results of clinical trials readily available. While the UK Medicines and Healthcare products Regulatory Agency (MHRA) support this view, the authors observe it remains to be seen how effectively such statements can be enforced given a lack of cohesive reporting legislation across varying jurisdictions:

> For example, while the United States Food and Drug Administration (FDA) regulations require that methods and results of all clinical trials be made available, a recent study suggests that more than half of trials have failed to do so. Clearly, legislation alone will not solve these problems. Technological solutions such as the use of blockchains for record management may therefore provide an alternative strategy with which to address these challenges (Nugent, Upton, and Cimpoesu, 2016).

In their 2016 study Nugent, Upton and Cimpoesu employed a private Ethereum based blockchain "used to record synthetic data representing clinical trials of Tamiflu, an influenza drug stockpiled by the British government at a cost of £424m". The authors observed: |

> […]were able to query the number of trials underway, the number of subjects recruited to each one, the address of the transaction sender (resolvable to a [Contract Research Organisation]) and the timestamp at which the transaction

> was processed. Due to the append-only nature of blockchains, we were also able to query the state of the data at any historic block (Nugent, Upton and Cimpoesu, 2016).

The authors note in their methodology the use of scripts to connect to local networks, where “a script is provided to read all the data from the blockchain, providing a summary of each trial, and details of each subject and data points that have been added, with full timestamping” (Nugent, Upton and Cimpoesu, 2016). The authors also suggest the use of smart contracts within clinical trial blockchains as a means of automating procedures for informed patient consent. This concept is further discussed by Benchoufi, Porcher and Ravaud who advocate for the implementation of:

> […]a process allowing the collection of patients’ informed consent, which is bound to protocol revisions, storing and tracking the consent in a secure, unfalsifiable and publicly verifiable way, and enabling the sharing of this information in real time (Benchoufi, Porcher and Ravaud, 2017).

The authors cite several incidences where patient re-consent was not sought during modifications of clinical trials resulting in adverse side effects and in extreme cases, death. A mock clinical trial was conducted with staff volunteers at the Hospital Hôtel Dieu in Paris, France. Using the Bitcoin network, pseudo patients were sent a link to a consent form by e-mail; each digital signature was recorded to the blockchain via script, which “allows grouped network request validation, which preserves the Blockchain network from computation overload, and allows to scale our method to a large patient cohort” (Benchoufi, Porcher and Ravaud, 2017). In a follow-up piece, Benchoufi and Ravaud note that smart contracts would allow for each phase of a clinical trial to be reliant on the transparency of its predecessor, ensuring a rigorous methodology has been adhered to:

> Smart Contracts enable the validation of a step with the only condition that every preceding step has been fully validated. For example, the chain of successive blocks could verify that the designed methodology has been followed, and the material presented to publishers would consist of the publication itself and the set of blocks that constitute the Smart Contract, whose correct execution indicates proof that the study was well conducted (Benchoufi and Ravaud, 2017).

However, further methodologies for implementation of blockchain technologies within medical research are also needed as evidenced by the recent retraction of Irving and Holden (2017). The authors originally claimed to have "confirm[ed] the use of blockchain as a low cost, independently verifiable method to audit and confirm the reliability of scientific studies" (Irving and Holden, 2017). However, their methodology was later deemed unreliable as issues of appropriate cryptography were raised during the peer review process. Consideration must also be given to ongoing innovations in source technology as Irving and Holden (2017) utilized the Blockchain platform while Nugent, Upton and Cimpoesu (2016) cite Ethereum's far superior speed per transaction (i.e. – proof of stake versus proof of work) as a contributor to the success of their findings.

6.4 PHARMACEUTICALS AND FRAUD DETECTION

Not unlike cryptocurrency transactions, blockchain technology can be used in a similar fashion to monitor the production and distribution of pharmaceutical drugs. Mettler (2016) notes that in 2010 the World Health Organization estimated "[10%] of drugs are counterfeit worldwide" with increases as high as 30% in developing countries. Pharmaceutical products include lifestyle supplements and "also drugs for the treatment of cardiovascular disorders and cancer, antibiotics, painkillers, contraceptives and other[s]". The World Health Organization notes that counterfeit pharmaceuticals often include the correct active ingredient in a higher or lower than stated dose, causing adverse or undesired reactions (WHO, 2010).

Mackey and Nayyar (2017) address the need for technology-based solutions that are innovative and meet with current trends in global pharmaceutical supply and demand. The cross-industry Hyperledger network, which works to converge varying blockchain applications, has proposed several counterfeit drug prevention and detection schemas that would use "blockchain tracking and time stamps to make it easy to establish exactly when and where a medicine was produced" (Taylor, 2016). Hyperledger (2017) observes that current solutions include electronic pedigrees (e-pedigrees) in the United States and mobile pedigrees (mPedigrees) in West Africa, which use systems of product tagging to authenticate the description and life history of a product. The Office of the National Coordinator for Health Information (ONCHI) in the United States notes that both instances are not unlike the blockchain infrastructure, wherein:

> […]movements are logged and include signed certificates that establish a life history of the shipped products, entered in multiple business process systems. In West Africa there is mPedigree, whereby the provider or consumer scratches the package to reveal a code that they send to a toll-free telephone number and receive a return text message confirming whether or not the product is genuine (ONCHI, 2016, p.7).

However, within existing solutions "there is still a central authority that can be compromised and documents that can be faked" (ONCHI, 2016, p.7). The ONCHI suggests that if current e-pedigree systems could be modified to incorporate blockchain technologies "enable[ing] anti-tampering capabilities during manufacturing, the supply and dispensation system could make drug counterfeiting a non-issue" (ONCHI, 2016, p.7).

Thomson discusses the need for blockchain technologies as digital pharmacies become the status quo, notably in the United States:

> A number of leading sites such as Snapdeal Medidart, Buydrug and Meramedicare have installed safety features, requiring users to upload prescriptions for prescribed drugs while placing orders, and extra checks on vendors. However, the World Health Organization estimates that more than 50 percent of medications purchased from online vendors in which the doctor's name is concealed are counterfeit (Thomson, 2015).

As healthcare management applications such as The Gem Health Network and Patientory have suggested, fraud can be reduced through a blockchain backed portal for confirming authenticity of physician engagement. As Patientory (2017) suggests, this could include the management of prescriptions and pharmaceutical purchases, creating a new level of transparency within both industries of supply and distribution.

6.5 SUMMARY AND ANALYSIS

Systems built utilizing blockchain technology offer medical professionals the ability to "make better-informed decisions that have the potential to reduce both patient risk and

the financial strain placed on health services that data manipulation issues contribute to" (Nugent, Upton, and Cimpoesu, 2016). R. Das (2017) argues that cohesive frameworks spanning across national and international jurisdictions will be key to blockchain implementation within healthcare domains, as "trust and governance within a blockchain network or consortium will be the critical success factors for implementation". However, while these solutions may be within reach of the developed world, inequality and funding pose problematic for those countries or organizations without the appropriate financial means to engage with new technologies.

Uptake of new technologies must also resonate with users. Mobile computer solutions may provide one means of engaging with blockchain technology that is both user-friendly and readily accessible given the prominence of smartphones in digitally advanced societies. An element of education on the part of blockchain technology developers is also needed to engage in meaningful dialogue with healthcare stakeholders and system users, not unlike the Ghanian land registry project approach exhibited in Chapter 5. As Krawiec *et al.* note:

> […]further support may be needed to encourage organizations to adopt the technology and participate in a shared network. While some organizations are already testing the technology to verify and track medical records and claims internally, blockchain will be more powerful when the number of users on the shared network increases (Krawiec *et al.*, 2016, p.8).

The regulatory and legal ramifications of blockchain technologies within healthcare are largely unknown, as much of the literature exists only as hypotheses. Integration with current healthcare systems, many of which are self-contained entities, also poses significant challenges in the implementation of widespread blockchain use. The use of blockchain offers potential solutions to many of healthcare's most pressing issues including: interoperability of patient data, creating user-centric models of data control, and transparency within a wide variety of medical transactions. However, as R. Das (2017) astutely concludes: "Despite the current euphoria, we need to understand and decode the hype cycle for blockchain technology and its realistic healthcare applications".

CHAPTER 7: BLOCKCHAIN AND THE SHARING ECONOMY

7.1 INTRODUCTION

While the term ‘sharing economy’ has received much hype in recent years, its definition remains debatable. For the interest of this chapter, it can best be defined by Killeen (2015, p. 489) who simplifies it to a “network of collaborative consumption and/or collaborative creation” which results in increased efficacy for users. Shared economies may embody third-party institutions, or as is more often seen in the case of blockchain technologies, be inclusive of distributed systems where peer-to-peer transactions occur directly without third party mediation. Davis *et al.* (2017) note both the disruptive yet transformative potential of shared economies including: unprecedented control of personal data, the ability to engage in peer-to-peer transactions for goods and services, and the means to definitely attribute creative works. As the sharing economy is vast in scope and nature, the examples that follow offer an intentional breadth of discussion within the literature surrounding the use of blockchain in social media, retail industry, and the role of libraries as new technology mediators.

7.2 SOCIAL MEDIA

Within the last decade the onset of popular social media sharing sites such as Twitter, Facebook, and Reddit have yielded multiple questions of user privacy, right to free speech and sharing of information, and the monetary value of curated social content. In 2016 Steem, or Steemit.io, became one of the first social media ventures to integrate blockchain technology with blockchain-based startups AKASHA and Synereo quick to follow (Steemit, 2017; AKASHA, 2017; Synereo, 2017). As De Filippi observes of such new platforms:

> Instead of relying on a centralized organization to manage the network and stipulate which content should be displayed to whom (often through proprietary algorithms that are not disclosed to the public), these platforms are run in a decentralized manner, aggregating the work of disparate groups of peers, which coordinate themselves, only and exclusively, through a set of code-based rules enshrined in a blockchain (De Filippi, 2017).

The integration of blockchain technologies offers a new paradigm for social media with unprecedented levels of personal data control, lack of current censorship regimes, and due compensation for contributions through varying forms of digital currency.

In the case of Steem, currency may be either social or monetary. Larimer *et al*. (2016, p. 2) describe the platform as: "[…]a blockchain database that supports community building and social interaction with cryptocurrency rewards". Steem encourages posting and upvoting of content to the site by rewarding users with "digital currency [Steem Dollars] that can be exchanged for real cash via Bitcoin or reinvested into 'Steem Power', a token that represents how much influence a person has on the Steemit platform" (Rosencrance, 2017). The more 'Steem Power' a user holds, the greater the value of their shared content and upvotes. A 2016 white paper published by Steem sought to expand on the intricacies of the custom-based blockchain solution, however, Quentson (2016) observes that the writings are "bereft of any technical explanation" leaving much unanswered about the susceptibility of the platform to vote rigging. Technicalities withstanding, Steem provides two working instances of the potential of blockchain integration to social media. First, blockchain timestamping allows content creators the ability to show proof of attribution: "in a circumstance where a creator would like to address those who have re-shared without permission or attribution, blockchain-based records provide public proof that the content was posted by a particular user at a particular time" (Larimer *et al*., 2016, p. 43). Second, Larimer *et al.* (2016, p. 42) advocate that censorship is all but nil within the decentralized network, as user actions are publically recorded on the blockchain and mined by users across the globe creating an environment where "no single entity can censor content that is valued by STEEM holders". At the time of writing, Steem held record of 40,000 active and unique user accounts (Steemit, 2017).

Competitor AKASHA operates in a similar fashion to Steem by storing user created content on the Ethereum blockchain; "votes are bundled with Ethereum microtransactions, so users can earn some Ethereum if their content is good and other users vote for it" (Rosencrance, 2017). A product of Ethereum co-founder Mihai Alisie, AKASHA seeks to rectify the current problems of the modern world wide web which "relies on a centralized distribution model…if a server goes down for any technical or commercial reason, or is taken down by the authorities, all the web pages stored on that

server disappear" (Prisco, 2016). AKASHA operates in conjunction with the InterPlanetary File System (IPFS), a P2P distributed file system that "connects all participating nodes with the same file system and permits building versioned file systems, blockchains, all the way to a permanent distributed Web" (Prisco, 2016). AKASHA operates solely on a P2P network without the use of servers and employs a series of smart contracts on the Ethereum blockchain to assist with "identity, verification, voting and transactions" (Silva, 2017). In a 2017 interview, Alisie noted that instead of producing a white paper, AKASHA moved directly to "alpha pre-release that allows for rapid iteration and experimentation for everything", although the number of users is the pre-release is not readily available (Silva, 2017). Still in the early stages of development, the social media aspects of AKASHA are intended as a precursor to an alternative world wide web where content could be stored and managed on a blockchain, with additional system stacking such as the IPFS.

In a blog post dated April of 2017, blockchain startup Synereo introduced Qrator as the first "attention economy app" that puts "[c]reators and [c]urators on top of the Internet's monetary food chain" (Synereo, 2017). Currently in initial user testing, Qrator uses a browser extension that tracks movement through social media sites where users can "**amp**lify content [they] appreciate (or simply think is going to generate a lot of attention) using AMPs – Synereo's cryptocurrency" (Synereo, 2017). The user chooses how many AMPs to invest, with Qrator generating a unique link for distribution on social media networks. As the link gains traction via the user's social network, subsequent traffic is directed to the Qrator site "with the option to Amplify and share it as well. If they choose to do so, a share of the AMPs invested by them will be credited to [the user] and to the [original] Curator" (Synereo, 2017). In doing so, both content creators and curators are monetarily compensated for their efforts through altcurrency. As Rosencrance (2017) observes: "With Qrator, the company is looking to develop a cross-platform social graph, laying the groundwork for a fully-decentralized social content app based on blockchain and distributed storage technologies that will be built on the Qrator foundation later this year". Synereo's Qrator capitalizes on the growing distrust found within current social media networks, and with a blockchain cryptocurrency at its core, Qrator offers users the ability to "capitalize on human nature as it manifests online" (Reutzel, 2016).

While many platforms are still in their infancy, or lack transparency in technical details,

the use of blockchain is currently “advancing a dialogue about how social media platforms can be more user-centric and sustainable” (Reutzel, 2016). A key area for further development within the literature will be the discussion surrounding blockchain transactional fees and initial buy-in for participations within new platforms. For example, the Steem white paper briefly addresses this issue by stating that a truly transparent social media platform should be fee-free to encourage organic growth; however, user account creation requires a minimum balance of altcoins and a further maintenance of balance to conduct transactions on the blockchain (Latimer *et al*., 2016). For users with little to no experience of cryptocurrencies this may prove a problematic barrier to entry that requires further investigation.

7.3 RETAIL INDUSTRY: THE EXCHANGE OF GOODS & SERVICES

Much of the current blockchain literature focuses on establishing systems of trading for non-physical assets, be they digital or financial. However, emerging trends also exhibit a natural evolutional interest in a decentralized marketplace for both goods and services. OpenBazaar, the first of its kind, offers a blockchain backed decentralized market of a global scale with tens of thousands of items for sale (OpenBazaar, 2017). As Sundararajan describes:

> If you have an item for sale, you list it on the OpenBazaar client (a program or app you download to your device), along with a product description, and a price (in bitcoin). Once you confirm listing the item, this listing is broadcast to all the other clients on OpenBazaar (Sundararajan, 2016, p. 91-92).

Search features are enabled on the blockchain through distributed hash tables that index items within the network. Smart contracts offer buyer protection; when an item arrives as described, funds can be released to the seller through executable code. In 2016, “one of the most common things people [bought] on OpenBazaar is actually ‘dangerously spicy’ hot sauce”; however, “because transactions on OpenBazaar are completely peer-to-peer, the platform cannot get more accurate data on what and how much exactly is being bought and sold” (Scott, 2016).

With roots in the ‘dark market’ in which illegal products can be exchanged, OpenBazaar faces significant challenges in changing widespread perception of both transactional

safety and its user base. However, OpenBazaar developers Leon and Hoffman note the wide applicability of blockchain technology to the decentralized marketplace:

> New templates for more advanced contracts are being designed by the OpenBazaar team and it will be possible to do things like Insurance Policies, P2P Insurance (think now that instead of getting insurance from one provider, you could have thousands of underwriters distributing your risk in very small chunks), Crowdlending, Crowdfunding, P2P renting (decentralized Uber, decentralized AirBnb), Whole sellers trading directly with retailers across the world and being able to find each other and transact without incurring listing fees or currency exchange inefficiencies making global trade more efficient than ever[…] (Reyes, 2014).

While transportation enterprises such as Uber and Lyft market themselves as ride sharing, "ultimately they are really taxi apps because drivers make trips that they would not otherwise be making in exchange for a fee. For that reason, many have argued that we shouldn't even consider them part of the sharing economy" (Cassano, 2015). In contrast, Lazooz (also cited as La'Zooz) is a "decentralized, community-owned transportation platform that turns a vehicles unused space into a variety of smart transportation solutions" (Lazooz, 2017). Backed by Bitcoin's blockchain technology, Schneider wrote of the platform:

> Rather than Bitcoin's 'proof of work' method of generating new tokens, which requires enormous computational power, La'Zooz generates new tokens—called 'zooz'—with 'proof of movement.' Basically, turn on your La'Zooz-enabled phone and drive. As you drive, you earn zooz tokens. Then, when you want a ride from someone else in the community, you can pay in zooz (Schneider, 2015).

Lazooz founders Matan Field and Shay Zluf acknowledge the challenges of creating a critical mass within a shared economy, citing the token system of 'zooz' as incentive for participation as both service provider and user (Schneider, 2015). The Lazooz mining application was released on Android in 2015, and as of 2017, continues to reward users with zooz tokens as mobile phones create a network of locational data: "The purpose of the mining app is to obtain the critical mass of movement needed for the collaborative transportation web to become operational, as well as to create and fairly distribute zooz

tokens among the community" (Lazooz, 2017). Lazooz's movement-based mining app seeks to not only distribute zooz tokens fairly among participants, but also to encourage local growth needed to reach critical mass for launch of full application features (Lazooz, 2017).

However, sharing economies of retail nature are not without faults. Arcade City, a similar application to Lazooz, recently split into two factions: the original titled entity, and a subsequent ridesharing venture, Swarm City (Arcade City, 2017; Swarm City, 2017). When the founder of the Arcade City project, Christopher David, stepped away from the venture due to claims of cryptocurrency fraud it became unclear as to whom the original investors of the project were, in addition to their proposed subsequent shares of Arcade City altcoins (Valenzuela, 2017). Backed by Ethereum, both Arcade City and Swarm City continue to seek legal control over issues of branding, as "having control over the brand is necessary to execute the white paper" (Valnezuela, 2017). A lack of trust in application developers, particularly when cryptocurrencies backed by blockchain have a nefarious history of illegal activity, does little to instill public confidence in projects intended for collaborative purposes.

7.4 LIBRARIES, E-BOOKS, & THE FUTURE OF LITERARY LENDING

Howley (2016, p. 14) provides an interesting discourse on the role of libraries as digital mediator, noting that blockchain "stands to be even more revolutionary through the humanizing power of libraries and librarians". Howley (2016) hypothesizes that libraries could serve as mediator between new technologies, including the blockchain, and wider public uptake and acceptance. Touted as the "trusted guide" at the heart of communities, libraries offer users of all socioeconomic backgrounds the ability to engage with, and learn from, new forms of digital media (*Glasgow Life*, 2015). This claim is further supported by the earlier work of Hellman (2010, p. 22) who posited that libraries "attract voracious new competition with every technological advance", creating demand for innovative service delivery and continual change within the role of the information professional. Black (2011, p. 2), citing McMenemy (2009), wrote that "the future of the public library is the subject of continuing, strenuous debate…the institution is struggling in its quest to delineate a modern mission in the age of the Internet and the citizen consumer". Remaining "at the heart of the digital revolution, and staking…claim in this network world, are among the most significant challenges currently facing library and

information workers" (Simmonds, 2003, p. 169). Simmonds (2003) noted that flexibility and adaptability of information professionals to receive, process, and further disseminate new forms of digital information will be crucial to the success of new opportunities like blockchain within the wider public sphere. What follows is a brief discussion of a hypothesized blockchain-based model of library lending, and discourse surrounding digital e-books backed by blockchain technology. The role of the library and/or information professional should not be discounted when considering the success of public blockchain education in both hypotheses.

In a 2017 case competition sponsored by technology conglomerate Atos IT, Cabello, Janßen, and Mühle (2016, p.1) hypothesized on a blockchain-based model of library lending in which "patrons can lend library books directly to other patrons without bringing [them] back to the library first" . Titled *LibChain*, the authors aim to "remove bureaucratic obstacles for both the users and providers of library services" through a decentralized lending system (Cabello, Janßen and Mühle, 2016, p. 2). Using the example of library patrons 'Alice' and 'Bob', Cabello, Janßen and Mühle offer the following example scenario:

> […] let us consider that Alice wants to borrow a book from library A (LibA) and she is registered with library B (LibB). LibA and LibB cooperate through our system. LibA can, without knowing Alice's real identity, trust her request and verify the entitlement of the action. Therefore, Alice can proceed to borrow the book with the loan's transaction being stored on the blockchain. After a week, Bob, who is registered with library C (LibC), wants to borrow the same book Alice currently has. Bob can contact Alice through the system – without knowing Alice's real identity – to ask whether she could give him the book. As Alice does not need it anymore, she can use the system to make a transaction on the blockchain to transfer the loan with its obligations to Bob. She can meet and give the book directly to Bob without bringing it back to the library (Cabello, Janßen and Mühle, 2016, p. 2).

The proposed Ethereum-backed blockchain architecture would stack with existing library systems, facilitating the ability for both user-to-user loans and library-to-users loans. Not unlike ride-sharing applications, one of the largest barriers to entry of such a system is trust in meeting an otherwise unknown party for the exchange of goods or services. As

noted with Lazooz's use of blockchain, as the network of users grows over time "the risk becomes comparatively much less[…]since the network itself makes it obvious who you can and cannot trust" (Harrison, 2017).

Finally, use of blockchain within e-books is challenging the concepts of borrowing and ownership within literary spheres. At present, one of the most widely cited examples is T.L. Uglow's *A Universe Explodes*. A limited edition e-book existing in only 100 digital copies accessed through a web or mobile browser, "each owner is recorded on the blockchain after they have dedicated the book to a new owner" (A Universe Explodes, 2017). A collaborative venture between Google (of which Uglow is an employee) and London-based publish Visual Editions, *A Universe Explodes* is "an experiment in what it means to own a digital book" and raises such questions as: "Does physical possession constitute ownership? […] Does there have to be an exchange of money?" (Stinson, 2017). In 'dedicating' the book to the new owner, users must "remove two words and add one to every page, creating a personalized limited edition of the book" until the book as it began no longer exists (Stinson, 2017). While the literature surrounding the potential of blockchain and e-books is limited, *A Universe Explodes* provides a unique and readily understood visual example that challenges ideas of ownerships and how creative endeavors can be recorded and preserved using blockchain technology. As Miller (2017) astutely observes: "It's also an attempt to deepen the relationship between a reader and a digital book, to see if it's possible to make the same emotional investment—to feel a sense of ownership and connection, and to have the impulse to lend and borrow—that many do with physical books… if nothing else, it's an accessible way to think about a complicated technology like blockchain".

7.5 SUMMARY AND ANALYSIS

De Filippi (2017) observes: "it is important not to confuse [shared economies] with the traditional model of 'crowd-sourcing,' where people contribute to a platform but do not benefit from the success of that platform". Through blockchain users are platform contributors and shareholders alike, ultimately creating a redistribution of wealth to the benefit of all. Also dubbed "platform cooperativsm", shared economies offer varying means of compensation for effort and contribution, be they through monetary or social gain. A 'bottom-up' approach to community building allows for new discourse on what a

‘shared’ economy truly embodies as it is “a term frequently incorrectly applied to ideas where there is an efficient model of matching supply with demand, but zero sharing and collaboration involved” (Botsman, 2015). As evidenced through examples of social media, retail endeavors, and the library as a space of digital dissemination, the role of blockchain within shared economies varies widely yet offers innovative solutions to pressing issues such as forward transparency and due compensation.

However, despite proposed benefits, education surrounding blockchain technology and its advantages within sharing economies remains an area for further development in both the literature and in practice. As Watson (2010, p.21) notes of continued development within information domains: “It is not sufficient to just have an experience; you need to reflect on that experience and evaluate it, and then apply that knowledge to another experience or activity”. This is evident in examples such as ridesharing application Lazooz, where the importance of education as a facet of critical mass will either lead to the success or failure of the general launch. Blockchain offers the means to disintermediate social monopolies, and as Botsman (2015) suggests: “[p]erhaps we should be working towards a certification system that recognizes true ‘sharing,’ ‘collaborative,’ and ‘peer’ platforms”, allowing for an additional means of trust within new social dichotomies”.

CHAPTER 8: CONCLUSIONS, RECOMMENDATIONS AND REFLECTION

8.1 CONCLUSIONS

A number of common themes emerge within the literature surrounding blockchain technology as it applies to the identified domains of cryptocurrencies and finance, government, healthcare, and the sharing economy.

First, the secure movement of digital assets is a core tenant of blockchain technologies. Originally developed as the architecture for cryptocurrencies such as Bitcoin, the transfer of funds from one entity to another is evident in all manner of financial transactions including “rollovers, trusts, estates, insurance and other transactions where assets are moved between parties or contracts are executed” (EYGM Limited, 2017). Smart contracts offer the ability to enable direct payments upon satisfaction of conditions, creating potential for autonomous systems of asset movement. The domain of finance overlaps in hypothesized blockchain use within areas of government and healthcare, including payment for national billable services. The movement of digital assets using the blockchain is already at work in the sharing economy as evidenced through altcurrencies on new social media sites and potential ride-sharing applications.

Second, the praised element of verification exists in differing capacities across all domains. As Mougayar (2017) observes, discussion of verification within blockchain literature may take many forms and refer to “licenses, proofs of records, transactions, processes or events” and asks key example questions such as: “Did this event take place? Was this service performed on this piece of equipment? Does this person have the right permit?”. For example, a verified financial transaction may differ in its technical backing than the verification of a clinical trials process, however, both may utilize blockchain technology to attest that certain conditions have been met before an immutable transaction is executed. That transaction can then be verified again in perpetuity using additional blockchain features such as time stamping.

Third, blockchain technologies offer an absolute chain of custody to prove ownerships and the traceability of physical items. The literature surrounding land registries, the tracking of pharmaceuticals for fraud prevention, and even the lending of objects such as library books can be recorded and traced using the blockchain. Digital assets intended to be immovable without compensation, such as social media content production or

curating, also benefit from attribution within the blockchain creating innovative standards for proof of ownership in new media creation.

Fourth, the interrelationship between blockchain and identity is present throughout the literature. In contrasting facets, blockchain technologies can serve as a means of secure personal identification while still offering pseudo-anonymity among transactions. The nation of Estonia has proven that blockchain technologies offer residents a host of personal data management benefits, such as healthcare administration and voting capabilities. In creating transparent systems of verified identity, systems of blockchain technology must also offer pseudo-anonymity in scenarios where personal information must be shared among multiple stakeholders. For example, new healthcare applications seek to be user friendly and offer cohesive access to medical records; however, collected data can be made largely anonymous for the consented use of third party groups.

8.2 RECOMMENDATIONS

Several gaps exist within the literature surrounding blockchain technologies and potential application across varying domains. As an emerging technology, it comes as no surprise that hype, buzzwords, and misinformation surrounding the highly technical topic can lead to confusion as to its core structural components and their potential use. In the analysis of each chapter it is evident that public education will be a key tenant to the success or failure of widespread blockchain technologies. For example, the nation of Estonia created digital smart campaigns specifically targeted at residents to fully explain the benefits of personalized data management and the role of blockchain in securing government services. The current e-Estonia website is largely free of technical jargon, opting for clear and simple statements with simplified illustrations.

As noted in the example provided by Aitken (2016), the nation of Ghana is pursuing a campaign of social education before launching a blockchain backed land registry system citing communication as a key barrier to wider social uptake and acceptance. Mobile computing, discussed largely within the domain of healthcare, offers a potential solution for educating user groups on the benefits of blockchain technology as barriers to entry are low given the prevalence and adoption of smartphone capabilities. The visual nature of smartphone applications may aide in illustrating otherwise complex concepts such as

transactional chains, with industry example Patientory offering interactive blockchain graphics within both their desktop and mobile websites. Educational consortiums, such as the Blockchain Education Network (BEN), are only beginning to emerge and offer educational programs to students across a variety of international university networks (BEN, 2017).

Yeoh (2017) observes that governments will also play an important role in the education of their constituents surrounding blockchain domains. This statement is furthered by Mougayar (2017) who posits that government leaders should: “Get up to speed on the blockchain by understanding it first, and committing to exploring its potential” and, in doing so, “[d]evelop new and more progressive ideas that are increasingly ambitious, and touch the lives of the citizens they are serving”. Information professionals, and hubs of community information sharing such as the library, should also be considered in strategies of blockchain education. These roles are often multi-faceted and diverse, ranging from grassroots communications to higher echelons of policy development and widespread social media management.

The work of government does not end with public education, as few regulatory or legislative frameworks exist within the literature to support the development of blockchain technologies in varying domains at both the national and international level. As the technical scalability of blockchain platforms, such as Bitcoin, are currently under scrutiny, there are also limited methodological frameworks for measuring efficacy of blockchain networks themselves. As with any potentially disruptive technology, communication between the technical and social aspects of blockchain advancements will be fundamental to the development of associated laws and case precedent. For example, what constitutes the concept of ‘identity’ may vary greatly between national and international jurisdictions when applied to blockchain verification. Differing political bodies will need to seek consortia on the implications of blockchain technologies on all domains of finance, governance, healthcare, and wider social applications.

Finally, the role of academia should also be considered in the validity of statements surrounding the applicability of blockchain technologies. The product of an emerging industry, much of the current information stems from ‘grey literature’. Media outlets reporting on current trends may also have a vested interest in domains such as

cryptocurrencies; for example, writers of the frequently cited CoinDesk may self-identify within the preface of a published article if they have an established interest or affiliation with a particular topic. These practices are important to note as they indicate some level of journalistic transparency, which is advantageous given blockchain's nefarious cryptocurrency roots in illegal 'darknet' activities. Yii-Huumo *et al.* (2016) suggest that while systematic literature reviews offer a comprehensive overview of technical findings for a given period, they may prove inadequate in addressing the continually evolving global nature of blockchain technologies and agreements. Findings that have undergone peer review may be best sourced from publications that circulate frequently, and/or with instant access or preview access available online.

8.3 REFLECTION

With misinformation rife surrounding the use of blockchain technologies, the role of the library and information professional may serve as one trusted and reliable outlet for public discourse surrounding new media. Webster wrote of the typical librarian stereotype:

> There is also a frequent evocation of librarians being hopelessly out-of-date. Even if this is presented as quaint ('you must love books'), or as enviable ('so lucky to have time to do all that reading'), there is a widespread sense that librarians just don't get it. They don't understand the world of the Information Age, the world of computers, the world of instantaneity, where people can get information at the touch of a keyboard (Webster, 2005, p. 283).

However, the role of the library and information professional as we know it today is constantly evolving. New technologies such as the blockchain and its multiple applications continually challenge perceptions of what it means to engage with, educate on, and disseminate new forms of information. While a library may serve as a physical hub for a community at large, information professionals are found within all domains utilizing blockchain technology.

The challenge in conducting a literature of this scope was twofold; first, a lack of familiarity with technical jargon is a continued point of need for further education. While blockchain technologies have been shown to exhibit a variety of applications, much of

the literature focuses exclusively on the technical infrastructure required to establish a blockchain network and leaves nary discussion of social implication or wider reach. As Simmonds (2003, p. 169) notes: “Keeping your skills, knowledge and expertise current and up to date is vital – so that you remain flexible and adaptable to change, and well placed to make the most of the opportunities change always brings”. While a challenging topic to pursue with little technical background, assessing the domains and impacts of blockchain technology has left the research with a renewed interest in the scope of information sciences and the futures they may offer. In the scope of library sciences, further research may be necessary in the concepts of ownership, plain language communication, and visual literacy as a means of communicating complex concepts such as blockchain technology and its applications.

Second, conducting a literature review that incorporates a large proportion of ‘grey literature’ requires a constant evaluation of source material quality and the varying use of buzzwords or phrases. For example, an oft-cited quality of blockchain is anonymity; however, as demonstrated throughout review, blockchains are only pseudo-anonymous. While Davison *et al.* (2005, p. 969) note the academic peer review process is essential as it allows the novice researcher to “use published work with confidence, and use the works of others as stepping stones and corner stones for advancing new concepts and insights”, ultimately emerging domains such as blockchain may not yet have a consensus standard regarding academic standards and rigor. Reuters, “which sells data, news and other information”, proposes one interesting solution to the issue of reliable source data through the recent release of application BlockOne IQ which “allows customers to plug its market data into systems that run on the digital ledger technology known as blockchain” (Platiau, 2017). Writing for Reuters, Platiau (2017) notes BlockOne IQ allows “two different technologies to communicate with one another”, also known as “Oracle”, creating a means for consumer validity testing and cross-comparison within the domain of information sharing.

While this review aims to give a general overview of domains for blockchain application, ultimately further research is required on the state of knowledge as it applies to the wider social sphere.

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APPENDIX 1 – ANNOTATED REFERENCE LIST

REFERENCE:	A Universe Explodes (2017) *A blockchain book*. Available at: https://a-universe-explodes.com (Accessed: 1 August 2017).
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ACCESS SOURCE:	Website (see link in reference)
KEYWORDS/STRATEGY:	Blockchain book, blockchain library
OTHER:	Cited by Miller, M. (2017)

Limited edition e-book existing in only 100 digital copies accessed through a web or mobile browser, "each owner is recorded on the blockchain after they have dedicated the book to a new owner" (A Universe Explodes, 2017). Collaborative venture between Google (of which writer/creator Uglow is an employee) and London-based publish Visual Editions.

REFERENCE:	Aitken, R. (2017) 'IBM's blockchain securities collaboration with LSE heralds new trading opportunities', *Forbes*, 19 July 2017. Available at: https://www.forbes.com/sites/rogeraitken/2017/07/19/ibms-blockchain-securities-collaboration-with-lse-heralds-new-trading-opportunities/ (Accessed: 1 August 2017).
DATE ACCESSED:	August 1, 2017
ACCESS SOURCE:	Forbes (see Aitken, 2016)
KEYWORDS/STRATEGY:	Blockchain trading economy, blockchain stocks
OTHER:	

Overview of new partnership between IBM and the London Stock Exchange; discusses use of blockchain within major trading platforms. Sourced from Aitken's Forbes page (see 2016 reference, below). Not overly technical; does require some knowledge of financial terminology.

REFERENCE:	Aitken, R. (2016) 'Bitland's African blockchain initiative putting land on the ledger', *Forbes*, 5 April 2016. Available at: https://www.forbes.com/sites/rogeraitken/2016/04/05/bitlands-african-blockchain-initiative-putting-land-on-the-ledger/ (Accessed: 16 July 2017).
DATE ACCESSED:	July 16, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Blockchain land registry Africa
OTHER:	Search idea suggested by Lemieux (2016, re: Honduras)

Use of the blockchain as a tool to end land registry corruption in West Africa (Ghana); partnership with Bitland, currently in white paper stage development. Focus on educational outcomes for wider public acceptance. Brief discussions of micro-loans, and possibility of blockchain use for wider business outside of land registries.

REFERENCE:	AKASHA (2017) *The AKASHA project*. Available at: https://akasha.world/ (Accessed: 14 August 2017).
DATE ACCESSED:	August 14th, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	AKASHA project
OTHER:	Added at request of supervisor

Homepage of the AKASHA social media project, using blockchain as a means of verified consensus; project is not yet full realized.

REFERENCE:	Allison, I. (2017) 'Gem shows off first blockchain application for health claims', *International Business Times*, 20 May. Available at: http://www.ibtimes.co.uk/gem-shows-off-first-blockchain-

	application-health-claims-1622574 (Accessed: 6 June 2017).
DATE ACCESSED:	June 6, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Platforms for blockchain healthcare
OTHER:	See Gem (2017) for more details

Operation OS that seeks to address "the lack of real-time transparency into health claims transactions involving providers and payers [and] the amount of time it takes for providers to get paid for their service"; first blockchain product of this nature (presented in May 2017, USA).

REFERENCE:	Apple Developer (2012) *Encrypting and hashing data*. Available at: https://developer.apple.com/library/content/documentation/Security/Conceptual/cryptoservices/GeneralPurposeCrypto/GeneralPurposeCrypto.html (Accessed: 14 August 2017).
DATE ACCESSED:	August 14, 2017
ACCESS SOURCE:	Google Images
KEYWORDS/STRATEGY:	Asymmetric Encryption
OTHER:	

Used for presentation of asymmetric encryption images; small accompanying summary from the Apple Developer training website.

REFERENCE:	Arcade City (2017) *Ridesharing for the people*. Available at: https://arcade.city/ (Accessed: 14 August 2017).
DATE ACCESSED:	August 14, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Arcade City
OTHER:	Added at request of supervisor; see recent controversy regarding Arcade City/Swarm City and cryptocurrency fraud in Valenzuela (2017)

Homepage of the Arcade City ridesharing project.

REFERENCE:	Aru, I. (2016) 'Estonian government adopts blockchain to secure 1 mln health records', *Coin Telegraph*, 9 March 2016. Available at: https://cointelegraph.com/news/estonian-government-adopts-blockchain-to-secure-1-mln-health-records (Accessed: 1 August 2017).
DATE ACCESSED:	August 1, 2017
ACCESS SOURCE:	Google search
KEYWORDS/STRATEGY:	Estonian e-health records
OTHER:	Further information sought after reading e-estonia/Estonian Government Healthcare Network information on health records management

Details the relationship between blockchain securities firm Guardtime and the Estonian Government Healthcare Network; use of KSI blockchain technology to secure healthcare records and further partnerships at all level of government within Estonia.

REFERENCE:	Baran, P. (1964) 'On distribute communications', *The Rand Corporation*, August. Available at: https://www.rand.org/content/dam/rand/pubs/research_memoranda/2006/RM3420.pdf (Accessed: 14 August 2017).
DATE ACCESSED:	August 14, 2017
ACCESS SOURCE:	Google/The Rand Corporation
KEYWORDS/STRATEGY:	

OTHER:	

Seminal paper on the division of centralized, decentralized, and distributed networks and their benefits/drawbacks. Frequently cited in other areas of the literature, including images of aforementioned.

REFERENCE:	Barnes, A., Brake, C., and Perry, T. (2016) 'Digital voting with the use of blockchain technology', *The Economist*, 25 September 2016. Available at: http://www.economist.com/sites/default/files/plymouth.pdf?as_qdr=y15 (Accessed: 16 July 2017).
DATE ACCESSED:	July 16, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Blockchain voting
OTHER:	

Discusses the potential issues of i-voting within Estonia's current system of digital democracy, and propose how blockchain technology could solve potential security concerns through a geographically distributed network.

REFERENCE:	Barre, T. (2015) 'Bitcoin: a pedagogical guide for the college classroom', *Journal of Education for Business*, 90, pp. 335-339.
DATE ACCESSED:	July 14, 2017
ACCESS SOURCE:	EBSCOhost Business Source Complete
KEYWORDS/STRATEGY:	Regulation of blockchain, blockchain education
OTHER:	Sourced from Strathclyde Education LibGuide

Brief semantic piece on teaching business students the basics of blockchain, including key focus questions of regulation: ex: "…if it is indeed determined that there should be some degree of regulation over Bitcoin transactions, who should do it?".

REFERENCE:	Bauerle, N. (2017) 'How does blockchain technology work?', *CoinDesk*, n.d. Available at: https://www.coindesk.com/information/how-does-blockchain-technology-work/ (Accessed: 14 August 2017).
DATE ACCESSED:	August 14, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	How does blockchain technology work
OTHER:	

General primer document provided by CoinDesk on blockchain technologies; easy to understand, free of jargon.

REFERENCE:	Bem, D. (1995) 'Writing a review article for psychological bulletin', *Psychological Bulletin*, 118(2), pp. 172-177.
DATE ACCESSED:	July 14, 2017
ACCESS SOURCE:	EBSCOhost PsycARTICLES
KEYWORDS/STRATEGY:	Literature review, successful arguments
OTHER:	Sourced from Strathclyde Psychology LibGuide

Bem provides key arguments and guidance for writing successful review of literature, including critiques and considerations of one's own writing bias.

REFERENCE:	Benchoufi, M., Porcher, R., and Ravaud, P. (2017) 'Blockchain protocols in clinical trials: Transparency and traceability of consent', *F1000Research*, 6(66). Available at: https://f1000research.com/articles/6-66/v1 (Accessed: 8 June

	2017).
DATE ACCESSED:	June 8, 2017
ACCESS SOURCE:	DOAJ Directory of Open Access Journals
KEYWORDS/STRATEGY:	Blockchain and clinical trials
OTHER:	See follow-up piece by Benchoufi and Ravaud (2017)

The authors advocate for the use of blockchain in informed consent medical protocols; cite several incidences where patient re-consent was not sought during modifications of clinical trials resulting in adverse side effects and in extreme cases, death. A mock clinical trial was conducted with staff volunteers at the Hospital Hôtel Dieu in Paris, France to support the successful implementation of blockchain used on the Bitcoin platform.

REFERENCE:	Benchoufi, M. and Ravaud, P. (2017) 'Blockchain technology for improving clinical research quality', *Trials*, 18(334). Available at: https://trialsjournal.biomedcentral.com/articles/10.1186/s13063-017-2035-z (Accessed: 1 August 2017). doi: 10.1186/s13063-017-2035-z
DATE ACCESSED:	August 1, 2017
ACCESS SOURCE:	Google Scholar
KEYWORDS/STRATEGY:	Blockchain and clinical trials
OTHER:	See Benchoufi, Porcher, and Ravaud (2017)

Further discusses the use of smart contracts within clinical trials; Benchoufi and Ravaud note that smart contracts would allow for each phase of a clinical trial to be reliant on the transparency of its predecessor, ensuring a rigorous methodology has been adhered to.

REFERENCE:	Bennington, A. 'What the fork? why bitcoin tech changes impact price', *CoinDesk*, 14 August 2017. Available at: https://www.coindesk.com/bitcoin-forks-easy-introduction-investors/ (Accessed: 14 August 2017).
DATE ACCESSED:	August 14, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Blockchain forks, bitcoin fork
OTHER:	

Summary of impact of recent Bitcoin 'fork' on market prices; volatility was expected, but so far has not yet been displayed. Provides brief introduction to forks, and the Bitcoin fork scenario.

REFERENCE:	Bitcoin (2016) *What is Bitcoin?* Available at: https://www.bitcoin.com/getting-started/ (Accessed: 2 June 2017).
DATE ACCESSED:	June 2, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Bitcoin
OTHER:	

Homepage of Bitcoin, explaining the origins and uses of both the cryptocurrency and development platform including current means of engagement through mining processes.

REFERENCE:	BitNation (2015) *Estonia e-residencies program & BitNation DAO public notary partnership*. Available at: https://bitnation.co/blog/pressrelease-estonia-bitnation-public-notary-partnership/ (Accessed: 17 July 2017).
DATE ACCESSED:	July 17, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Bitnation and e-estonia, Bitnation and blockchain
OTHER:	source re-direct from e-estonia residencies homepage

Press release from BitNation detailing partnership with Estonian government for identity services, including new notarization procedures for a variety of identity (and other) documents.

REFERENCE:	Black, A. (2011) 'We don't do public libraries like we used to: attitudes to public library buildings in the UK at the start of the 21st century', *Journal of Librarianship and Information Science*, 43(1), pp. 30-45.
DATE ACCESSED:	July 2, 2017
ACCESS SOURCE:	Sage Premier 2017
KEYWORDS/STRATEGY:	Saved reference from previous I&LS readings
OTHER:	

Discussion surrounding the role of the public library and the information professional in the 21st century; interesting note on need for continual technical skills.

REFERENCE:	Blockchain Educational Network (2017) *Join the network*. Available at: https://blockchainedu.org/ (Accessed: 14 August 2017).
DATE ACCESSED:	August 14, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Blockchain education, blockchain students, blockchain grassroots learning
OTHER:	

BEN is a grassroots organization of colleges and universities (worldwide) that aim to promote blockchain development and learning opportunities for students both within and outside of the computer science field.

REFERENCE:	Blockstream (2017) *Our vision: an ecosystem of financial networks*. Available at: https://blockstream.com/about/ (Accessed: 14 August 2017).
DATE ACCESSED:	August 14, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Blockstream
OTHER:	Blockstream frequently mentioned as competitor to major development platforms (Bitcoin, Ethereum)

Homepage of Blockstream; blockchain technology specializing in 'sidechains' "…a technology invented to extend the capabilities of Bitcoin's blockchain[...]sidechains allow digital assets to be moved from one blockchain to another".

REFERENCE:	Booth, W., Colomb, G., and Williams, J. (2008) *The craft of argument*. Chicago: University of Chicago Press.
DATE ACCESSED:	May 1, 2016
ACCESS SOURCE:	Strathclyde Library
KEYWORDS/STRATEGY:	Literature review development, literature reviews
OTHER:	

Describes successful strategies for creating a convincing argument within all manners of reviews and debates.

REFERENCE:	Boritz, J. (2005) 'IS practitioners' views on core concepts of information integrity', *International Journal of Accounting Information Systems*, 6(4), pp. 260-279.
DATE ACCESSED:	June 30, 2017
ACCESS SOURCE:	Elsevier ScienceDirect
KEYWORDS/STRATEGY:	Reverse search from Drescher (2017)

OTHER:	Cited by Drescher (2017)

Describes three principles of integrity useful to discussions surrounding information systems securities; somewhat overly technical perspective.

REFERENCE:	Botsman, R. (2015) 'Defining the sharing economy: what is collaborative consumption, and what isn't?', *Fast Company*, 27 May 2015. Available at: https://www.fastcompany.com/3046119/defining-the-sharing-economy-what-is-collaborative-consumption-and-what-isnt (Accessed: 1 August 2017).
DATE ACCESSED:	August 1, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Sharing economy, sharing economy definition
OTHER:	

Concise overview of arguments for and against definitions of the sharing economy, including frameworks for further development.

REFERENCE:	Cabello, Janßen, and Mühle (2016) 'LibChain: distributed library management system based on the blockchain technology', *AtosIT*, 23 November 2016. Available at: https://www.atositchallenge.net/wp-content/uploads/2016/11/LibChain-Atos-IT-Challenge-2017.pdf (Accessed: 1 August 2017).
DATE ACCESSED:	August 1, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Blockchain and libraries, blockchain for library environment, libraries as distributed management systems
OTHER:	

Proposed distributed management system for libraries based on blockchain technology; interesting case example with clear language and references.

REFERENCE:	Cassano, J. (2015) 'Could La'Zooz be the ride-sharing app we've been waiting for?', *Fast Company*, 27 January 2015. Available at: https://www.fastcompany.com/3041403/could-lazooz-be-the-ride-sharing-app-weve-been-waiting-for (Accessed: 2 August 2017).
DATE ACCESSED:	August 2, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	La'Zooz, Lazooz, blockchain ridesharing
OTHER:	

Discussion of Lazooz, the blockchain ridesharing app, as it compares to competitors such as Uber and Lyft. Arguments for why these competitors are not truly part of the 'shared' economy.

REFERENCE:	Castor, A. (2017) 'A short guide to bitcoin forks', *CoinDesk*, 27 March 2017. Available at: https://www.coindesk.com/short-guide-bitcoin-forks-explained/ (Accessed: 14 August 2017).
DATE ACCESSED:	August 14, 2017
ACCESS SOURCE:	CoinDesk search
KEYWORDS/STRATEGY:	Bitcoin forks, blockchain forks
OTHER:	

Discussion surrounding hard and soft fork properties; reasons for forks, using recent bitcoin discussions as examples.

REFERENCE:	Chester, J. (2017) 'How the blockchain will secure your online identity', *Forbes*, 3 March 2017. Available at: https://www.forbes.com/sites/jonathanchester/2017/03/03/how-the-blockchain-will-secure-your-online-identity/2/#6cb8d7a83244 (Accessed: 14 July 2017).
DATE ACCESSED:	July 14, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Blockchain and identity, blockchain and identity records, blockchain and identity verification
OTHER:	

General discussion surrounding blockchain's identity properties, including discussion of the success of e-Estonia; draws general conclusions on the benefits and drawbacks of digital identities, a very helpful primer guide for further reading as it introduces key concepts with little technical jargon.

REFERENCE:	CoinDesk (2014) *How bitcoin mining works*. Available at: https://www.coindesk.com/information/how-bitcoin-mining-works/ (Accessed: 2 August 2017)
DATE ACCESSED:	August 2, 2017
ACCESS SOURCE:	CoinDesk search
KEYWORDS/STRATEGY:	Mining, bitcoin mining
OTHER:	No specific author cited

General primer from the CoinDesk writers on how bitcoin mining works; includes several helpful illustrations for visual reference.

REFERENCE:	CoinGecko (2017) *Overview of cryptocurrencies chart*. Available at: https://www.coingecko.com/en (Accessed: 14 August 2017).
DATE ACCESSED:	August 14, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Redirected from Wikipedia's page on crypto-indexes, CoinGecko
OTHER:	

The cryptocurrency index CRIX was launched in 2016 to follow the market development of cryptocurrencies, and is a collaborative effort between the Humboldt University of Berlin, Singapore Management University and the enterprise CoinGecko; good reference to check current market prices of bitcoin and competitors.

REFERENCE:	Coleman, L. (2017) 'Georgia expands project to secure land titles on the Bitcoin blockchain', *CryptoCoins: News*, 2 July 2017. Available at: https://www.cryptocoinsnews.com/republic-of-georgia-expands-project-to-secure-land-titles-on-the-bitcoin-blockchain/ (Accessed: 18 July 2017).
DATE ACCESSED:	July 18, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Blockchain and land registry, blockchain and Georgia
OTHER:	Suggested topic from Lemieux (2016)

Discusses the benefits to blockchain integrity and confidentiality as they could be applied to the land registry system in the Republic of Georgia.

REFERENCE:	Conn, J. (2016) 'Could blockchain help cure health IT's security woes?', *Modern Healthcare*, 46(45), p.14.
DATE ACCESSED:	June 2, 2017
ACCESS SOURCE:	EBSCOhost Business Source Complete

KEYWORDS/STRATEGY:	Used Strathclyde's Business LibGuide to find database; searched for blockchain and healthcare
OTHER:	

General discussion of the current drawbacks of modern healthcare challenges including patient records and insurance claims; focus on benefits to both patient and practitioners.

REFERENCE:	Connell, J. (2017) 'How humans now use the blockchain to declare love and marriage', *BitCoin*, 14 February 2017. Available at: https://news.bitcoin.com/cross-border-love-on-the-blockchain/ (Accessed: 18 July 2017).
DATE ACCESSED:	July 18, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Blockchain and marriage, blockchain and love
OTHER:	Concept redirect from *Digital Currency Handbook*

Interesting discussion of blockchain as marriage contract; includes discussion of regulatory issues, including the legalities of identification arrangement such as marriage and their recognition within current nation-states.

REFERENCE:	Dakers, M. (2015) 'Nasdaq makes first share trade using blockchain technology', *Telegraph*, 31 December 2015. Available at: http://www.telegraph.co.uk/finance/markets/12075825/nasdaq-blockchain-share-trade-bitcoin-technology.html (Accessed: 4 August 2017).
DATE ACCESSED:	August 4, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	NASDAQ and blockchain
OTHER:	

Discussion of NASDAQ's use of the blockchain; unclear if the Telegraph is a reputable source, but interesting colloquial musings and some factual backing such as the decentralization of clearing houses.

REFERENCE:	Das, R. (2017) 'Does blockchain have a place in healthcare?', *Forbes*, 8 May 2017. Available at: https://www.forbes.com/sites/reenitadas/2017/05/08/does-blockchain-have-a-place-in-healthcare/#7ce356a61c31 (Accessed: 1 August 2017).
DATE ACCESSED:	August 1, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Blockchain and healthcare
OTHER:	

General discussion of the applications of blockchain within modern healthcare; focus on benefits to practitioners, patients, and overall cost savings to governments.

REFERENCE:	Das, S. (2017) 'Republic of Georgia to introduce blockchain platform for real estate documents', *CryptoCoins: News*, 1 February 2017. Available at: https://www.cryptocoinsnews.com/republic-georgia-introduce-blockchain-platform-real-estate-documents/ (Accessed: 18 July 2017).
DATE ACCESSED:	July 18, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Blockchain and Republic of Georgia, blockchain and land registry

OTHER:	

Discussion of the use of blockchain to secure the land registry system within the Republic of Georgia, citing advantage of cost and trustless consensus.

REFERENCE:	Davis, A., *et al*. (2017) 'Sharing economies: moving beyond binaries in a digital age', *Cambridge Journal of Regions, Economy and Society*, 10, pp. 209-230. doi:10.1093/cjres/rsx005
DATE ACCESSED:	July 15, 2017
ACCESS SOURCE:	Oxford University Press 2017
KEYWORDS/STRATEGY:	Sharing economies, blockchain and the sharing economy
OTHER:	

Davis et al. (2017) note both the disruptive yet transformative potential of shared economies including: unprecedented control of personal data, the ability to engage in peer-to-peer transactions for goods and services, and the means to definitely attribute creative works.

REFERENCE:	Davison, R., Vreede, G., and Briggs, R. (2005) 'On peer review standards for information systems literature', *Communications of the Association for Information Systems*, 16(4), pp. 967-980.
DATE ACCESSED:	May 11, 2016
ACCESS SOURCE:	Google Scholar
KEYWORDS/STRATEGY:	Literature review, IS literature review
OTHER:	

Provides a framework for evaluation of information science literature reviews, including discussion of journal publication bias.

REFERENCE:	De Filippi, P. (2017) 'What blockchain means for the sharing economy', *Harvard Business Review*, 15 March 2017. Available at: https://hbr.org/2017/03/what-blockchain-means-for-the-sharing-economy (Accessed: 1 August 2017).
DATE ACCESSED:	August 1, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Blockchain and the sharing economy, blockchain shared economy implications
OTHER:	

Discussion of wider implications of blockchain to the sharing economy; "it is important not to confuse [shared economies] with the traditional model of 'crowd-sourcing,' where people contribute to a platform but do not benefit from the success of that platform". Through blockchain users are platform contributors and shareholders alike, ultimately creating a redistribution of wealth to the benefit of all.

REFERENCE:	Delahaye, J.P. (2017) 'Cryptocurrencies and blockchains', *Inference: International Review of Science*, 2(4). Available at: http://inference-review.com/article/cryptocurrencies-and-blockchains (Accessed: 3 August 2017).
DATE ACCESSED:	August 3, 2017
ACCESS SOURCE:	Google Scholar
KEYWORDS/STRATEGY:	Cryptocurrencies, blockchain and cryptocurrencies
OTHER:	

Discusses the ongoing development of popular cryptocurrencies, including technical backings such as hashing and the benefits/drawbacks to new forms of digital currency.

REFERENCE:	Diedrich, H. (2016) *Ethereum*. Wroclaw, Poland: Wildfire

	Publishing.
DATE ACCESSED:	June 2, 2017
ACCESS SOURCE:	Amazon.co.uk search for literature on blockchain not available through Strathclyde library sources
KEYWORDS/STRATEGY:	Blockchain, Ethereum
OTHER:	
Written by a key contributor to the Ethereum platform; aims not to be overly-technical (does not necessarily succeed, as a number of high level computing discussions are also included). Obviously skewed towards the Ethereum line of products, but provides useful overviews of some blockchain concepts in connection with wider trends and implications.	

REFERENCE:	Donnelly, J. (2016) 'Steemit bridges blockchain and social media, but how does it work?', *CoinDesk*, 13 August 2016. Available at: https://www.coindesk.com/steemit-blockchain-social-media-how-works/ (Accessed: 1 August 2017).
DATE ACCESSED:	August 1, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Blockchain and social media
OTHER:	
Overview of Steem's social media platform features; discussion of wider blockchain implications for social media and its users.	

REFERENCE:	Douglas, T. (2017) 'Blockchain a 'next big transformational technology' in government', *Government Technology Magazine*, 16 May 2017. Available at: http://www.govtech.com/security/Blockchain-a-Next-Big-Transformational-Technology-in-Government.html (Accessed: 4 July 2017).
DATE ACCESSED:	July 4, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Blockchain and government
OTHER:	
Key observations include blockchain technologies offering innovative solutions for two of the most persistent problems currently faced by governments – the establishment of identity records, and the creation of trust in digital environments.	

REFERENCE:	Drescher, D. (2017) *Blockchain basics*. USA: Apress Media.
DATE ACCESSED:	June 2, 2017
ACCESS SOURCE:	University of Strathclyde
KEYWORDS/STRATEGY:	Blockchain
OTHER:	
Concise book that aims to describe blockchain technology in a series of easy to digest steps including the use of analogies and illustrations for those with a non-technical background.	

REFERENCE:	e-Estonia (2017) *e-identity*. Available at: https://e-estonia.com/solutions/e-identity/id-card/ (Accessed: 8 July 2017). Estonian Government (2017) *i-voting*. Available at: https://e-estonia.com/solutions/e-governance/i-voting/ (Accessed: 14 August 2017). Estonian Government's e-Health Foundation (2017) *e-health*

	records. Available at: https://e-estonia.com/solutions/healthcare/e-health-record/ (Accessed: 14 August 2017).
DATE ACCESSED:	July 8, 2017 and August 14, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Redirected from continual mention of e-Estonia within wider literature
OTHER:	Sources pull from the same website, but with slightly different attributes to authors. To avoid confusion, one saved record has been created with three different (and correct) means of referencing for clarity within the literature review.
Outline of Estonian e-identity, i-voting, and e-health record procedures and systems.	

REFERENCE:	Ethereum (2017) *Ethereum: blockchain app platform*. Available at: https://www.ethereum.org/ (Accessed: 14 August 2017).
DATE ACCESSED:	August 14, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Ethereum
OTHER:	Added at request of supervisor
Homepage of the Ethereum suite of platforms; note Ethereum's key trait in opposition to Bitcoin is proof of stake versus proof of work, creating less energy output and faster creation of blocks.	

REFERENCE:	Eyal, I., and Sirer, E.G., (2014) 'Majority is not enough: bitcoin mining is vulnerable'. *International conference on financial cryptography and data security,* Christ Church, Barbados, 3-7 March. Available at: https://arxiv.org/pdf/1311.0243.pdf (Accessed: 2 August 2017).
DATE ACCESSED:	August 2, 2017
ACCESS SOURCE:	Google Scholar
KEYWORDS/STRATEGY:	Blockchain deficits, blockchain weaknesses, blockchain mining outcomes, blockchain mining concerns
OTHER:	
Discusses key pitfalls of the mining process including selfish mining.	

REFERENCE:	EYGM Limited (2017) *Blockchain innovation in wealth and asset management*. Available at: http://www.ey.com/Publication/vwLUAssets/Blockchain_in_wealth_and_asset_management/$File/ey-blockchain-innovation-wealth-asset-management.pdf (Accessed: 14 August 2017).
DATE ACCESSED:	August 14, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Blockchain and financial management, blockchain and financial resources
OTHER:	
ErnstYoung discuss transfer of funds from one entity to another as evident in all manner of financial transactions including "rollovers, trusts, estates, insurance and other transactions where assets are moved between parties or contracts are executed".	

REFERENCE:	Faraz, T. (2017) 'Synereo announces first attention economy app Qrator', *CoinReport: Global Digital Currency News*, 16 April 2017. Available at: https://coinreport.net/synereo-announces-qrator/ (Accessed: 1 August 2017).
DATE ACCESSED:	August 1, 2017

ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Blockchain and social media
OTHER:	Note: no specific website link for Qrator, included as part of the Synereo package of applications

Discusses the potential release of Qrator the first "attention economy app" that puts "[c]reators and [c]urators on top of the Internet's monetary food chain"; works by tracking movement through social media sites via browser plug-ins.

REFERENCE:	Flint, D. (2014) 'Computers and internet: are all modern currencies not virtual? – the bitcoin phenomenon', *Business Law Review*, 35(2), pp. 60-62.
DATE ACCESSED:	July 11, 2017
ACCESS SOURCE:	Kluwer Law International
KEYWORDS/STRATEGY:	Bitcoin virtual currency, digital currency, blockchain and cryptocurrency, cryptocurrencies
OTHER:	

Provides historical backing to the ideology of 'currencies' and how this notion is evolving in the wake of cryptocurrencies and exhibited digital counterparts.

REFERENCE:	Frances, P. (2015) *Understanding Bitcoin: Cryptography, engineering, and economics*. Chichester, West Sussex: Wiley.
DATE ACCESSED:	July 2, 2017
ACCESS SOURCE:	Strathclyde library
KEYWORDS/STRATEGY:	Bitcoin, cryptography, blockchain
OTHER:	

General text discussing ideas of cryptography and the development of associated apps; some discussion of ramifications to economies of scale and scope including the wider financial sphere and the cost associated with digital currency production.

REFERENCE:	Gem (2017) *GemOS*. Available at: https://gem.co/gemos/ (Accessed: 2 June 2017).
DATE ACCESSED:	June 2, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Gem
OTHER:	Cited by Allison, I. (2017)

Homepage of Gem (GemOS, Gem Healthcare Network) for further supporting documentation to Allison, I. (2017).

REFERENCE:	Gervais *et al.* (2016) 'On the security and performance of proof of work blockchains', *Proceedings of the 2016 ACM SIGSAC conference on computer and communications security,* Vienna, Austria, 24-28 October. Available at: https://eprint.iacr.org/2016/555.pdf (Accessed: 1 August 2017).
DATE ACCESSED:	August 1, 2017
ACCESS SOURCE:	Google Scholar
KEYWORDS/STRATEGY:	Blockchain proof of work
OTHER:	

Technical overview of proof of work mining schemes; "Proof of Work (PoW) powered blockchains currently account for more than 90% of the total market capitalization of existing digital cryptocurrencies".

REFERENCE:	Glasgow Life (2015) *A vision for Glasgow city libraries*. Available at: https://www.glasgowlife.org.uk/libraries/Documents/Vision%20Documents/Vision%20For%20Glasgow%20Libraries.pdf (Accessed: 16 July 2017).
DATE ACCESSED:	July 16, 2017
ACCESS SOURCE:	Previous coursework
KEYWORDS/STRATEGY:	N/A
OTHER:	

Used in previous coursework to introduce concept concept of the library as 'trusted heart' of a community; ties to the role of information professional as 'guide' to new technologies.

REFERENCE:	Gibson, D. (2011) 'Understanding the security triad (confidentiality, integrity, accessibility)', *Pearson IT Certification*, 27 May 2011. Available at: http://www.pearsonitcertification.com/articles/article.aspx?p=1708668 (Accessed: 14 August 2017).
DATE ACCESSED:	August 14, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Security triad, CIA triad
OTHER:	Strategy provided by supervisor

Discussion of the key points of the security triad for information security systems: confidentiality, integrity, and accessibility

REFERENCE:	Giulio, P. (2017) 'Smart contracts for real businesses and bank', *CryptoInsider*, 2 May 2017. Available at: https://cryptoinsider.com/smart-contracts-real-businesses-banks/ (Accessed: 2 August 2017).
DATE ACCESSED:	August 2, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Cryptocurrencies, cryptocurrencies and banking, cryptocurrencies for business
OTHER:	

Lists examples of the application of smart contracts to varying business and banking scenarios.

REFERENCE:	Grant, R. (2014) 'Bitcoin for idiots: an introductory guide', *VentureBeat*, 17 February 2014. Available at: https://venturebeat.com/2014/02/17/bitcoin-for-idiots-an-introductory-guide/ (Accessed: 1 August 2017).
DATE ACCESSED:	August 1, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Bitcoin for idiots (yes, I really searched this)
OTHER:	

Primer for bitcoin basics; however, some technical concepts remain unclear and require further details to be truly accessible (ex: distributed vs. decentralized networks)

REFERENCE:	Greenberg, A. (2013) 'Follow the bitcoins: how we got busted buying drugs on silk road's black market, *Forbes*, 5 September 2013. Available at: https://www.forbes.com/sites/andygreenberg/2013/09/05/follow-the-bitcoins-how-we-got-busted-buying-drugs-on-silk-roads-black-market/#8929d6aadf76 (Accessed: 3 August 2017).
DATE ACCESSED:	August 3, 2017

ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Silk Road, blockchain and the silk road
OTHER:	

Silk Road introduced in Digital Currency Handbook; interesting article following Forbes writing purchasing illegal drugs prior to the shut-down of the website and use of computer science methodologies to test for anonymity on the blockchain.

REFERENCE:	Guadamuz, A. and Marsen, C. (2015) 'Blockchains and bitcoin: regulatory responses to cryptocurrencies', *First Monday*, 20(12), [no pagination] http://dx.doi.org/10.5210/fm.v20i12.6198
DATE ACCESSED:	August 3, 2017
ACCESS SOURCE:	Google Scholar
KEYWORDS/STRATEGY:	Regulation of cryptocurrencies, regulation of blockchain, regulation of Bitcoin
OTHER:	

Excellent discussion of the scarcity paradigm within bitcoin production as the result of mining procedures; overall good definitions of bitcoin's origins and the Bitcoin whitepaper.

REFERENCE:	Gupta, M. (2017) *Blockchain for dummies*. Hoboken, N.J.: John Wiley & Sons.
DATE ACCESSED:	July 2, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Blockchain for dummies (yes, I really searched this)
OTHER:	

Intended primer for blockchain concepts; however, still very technical as produced by IBM blockchain developer.

REFERENCE:	Harrison, D. (2017) 'Chain changers: behind the scenes at Ethereum with Vitalik Buterin and friends', *Coin Speaker*, 28 May 2017. Available at: https://www.coinspeaker.com/2017/05/28/chain-changer-behind-scenes-ethereum-vitalik-buterin-friends/ (Accessed: 1 August 2017).
DATE ACCESSED:	August 1, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Ethereum founder, Ethereum news
OTHER:	

Interesting article detailing an interview with Vitalik Buterin of Ethereum from early May including ideologies of a truly 'trustless' system.

REFERENCE:	Hellman, E. (2010) 'Libraries, ebooks, and competition', *Library Journal*, 135(13), pp. 22-23.
DATE ACCESSED:	August 1, 2017
ACCESS SOURCE:	EBSCOhost Business Source Complete
KEYWORDS/STRATEGY:	Ebooks, blockchain books
OTHER:	

Discussion of changing technologies within libraries… "attract voracious new competition with every technological advance", creating demand for innovative service delivery and continual change within the role of the information professional".

REFERENCE:	Hertig, A. (2017) 'Rethinking proof of work: the quest to 'improve' bitcoin heats up', *CoinDesk*, 29 January 2017. Available at: https://www.coindesk.com/rethinking-proof-of-work-

	the-quest-to-improve-bitcoin-heats-up/ (Accessed: 14 August 2017).
DATE ACCESSED:	August 14, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Proof of stake, proof of work, proof of work versus proof of stake, benefits to proof of work, bitcoin proof of wrok
OTHER:	
Discussion on the drawbacks to proof of work schemes; presentation of alternate schemes, including proof of stake.	

REFERENCE:	Herzfeld, O. (2016) 'Smart contracts may create significant innovative disruption', *Forbes*, 22 February 2016. Available at: https://www.forbes.com/sites/oliverherzfeld/2016/02/22/smart-contracts-may-create-significant-innovative-disruption/#ac64648396a5 (Accessed: 3 August 2017).
DATE ACCESSED:	August 3, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Smart contracts, blockchain and smart contracts, future of smart contracts
OTHER:	
Discusses the disruptive potential of smart contracts to all manners of business applications; presents discussion for both benefits and drawbacks, and a need for regulatory approaches to address all aspects of smart contract implementation.	

REFERENCE:	Hielman, E. (2015) 'Eclipse attacks on bitcoin's peer-to-peer network', *24th USENIX security symposium*, Washington, USA, August 2015. Available at: https://eprint.iacr.org/2015/263.pdf (Accessed: 14 August 2017).
DATE ACCESSED:	August 14, 2017
ACCESS SOURCE:	Google Scholar
KEYWORDS/STRATEGY:	Bitcoin weaknesses, Bitcoin attacks
OTHER:	
Discusses eclipse attacks on bitcoin's peer-to-peer network in relatively simple terms, with further in-depth discussion for those with advanced technical background.	

REFERENCE:	Higgins, S. (2017) 'Mizuho completes blockchain finance trial', *CoinDesk*, 7 July 2017. Available at: https://www.coindesk.com/mizuho-completes-blockchain-trade-finance-trial/ (Accessed: 1 August 2017).
DATE ACCESSED:	August 1, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Blockchain and shares, blockchain and financial examples, blockchain finance trial
OTHER:	
Discussion of successful blockchain use in Japanese banking system; "during the test, information was transmitted between Japan and Australia, with 'all trade-related processes, from issuing the letter of credit to delivering trade documents, [being] completed entirely via a digital platform using blockchain"	

REFERENCE:	Hochstein, M. (2014) 'Why bitcoin matters for bankers', *American Banker*, 25 February 2014. Available at: https://www.americanbanker.com/news/why-bitcoin-matters-for-bankers (Accessed: 14 August 2017).

DATE ACCESSED:	August 14, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Bitcoin processes, bitcoin financial processes
OTHER:	

Excellent diagram and discussion of how a bitcoin transaction is processed; includes roadmap image detailing initial stages of request through mining to encrypted completion.

REFERENCE:	Holmes, B. (2016) 'e-Estonia initiative progresses with blockchain partnerships', *Brave NewCoin*, 4 March 2016. Available at: https://bravenewcoin.com/news/e-estonia-initiative-progresses-with-blockchain-partnerships/ (Accessed: 14 July 2017).
DATE ACCESSED:	July 14, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	e-estonia blockchain, e-estonia government blockchain
OTHER:	

General information on the use of blockchain within e-Estonian/the Estonian government and associated partnerships.

REFERENCE:	Howley, B. (2016) 'Blockchain, ledger legerdemain, and the public library', *Information Today*, 33(9), pp. 14-15.
DATE ACCESSED:	July 2, 2017
ACCESS SOURCE:	Gale Business Insights: Global
KEYWORDS/STRATEGY:	Blockchain and library, blockchain and libraries
OTHER:	

One of few articles on the potential of blockchain within the library domain; suggests the role of the information professional as a medium to disseminate new technologies.

REFERENCE:	Huckle, S. *et al*. (2016) 'Internet of Things, blockchain, and shared economy applications', *Procedia Computer Science*, 98, pp. 461-466.
DATE ACCESSED:	July 2, 2017
ACCESS SOURCE:	Elsevier Science Direct Open Access Journals
KEYWORDS/STRATEGY:	Internet of things and the blockchain, blockchain and sharing economy
OTHER:	

Raises interesting question as to if the IoT should be included with the sharing economy; discussion on the importance of public reception.

REFERENCE:	Hyperledger (2016) *Counterfeit drug prevention and detection*. Available at: https://wiki.hyperledger.org/requirements/use-cases/use-case-counterfeit-drug-prevention-and-detection (Accessed: 1 June 2017).
DATE ACCESSED:	June 1, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Blockchain and counterfeit medicine
OTHER:	

Hyperledger aims to provide a cross-platform means of tracking counterfeit pharmaceuticals, as outlined in this working methodology/case presentation.

REFERENCE:	Iansiti, M. and Lakhani, K. (2017) 'The truth about blockchain', *Harvard Business Review*, January-February. Available at: https://hbr.org/2017/01/the-truth-about-blockchain (Accessed: 2

	August 2017).
DATE ACCESSED:	August 2, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Blockchain and business
OTHER:	

Discusses the potential of blockchain to multiple domains; “with blockchain, we can imagine a world in which contracts are embedded in digital code and stored in transparent, shared databases, where they are protected from deletion, tampering, and revision. In this world every agreement, every process, every task, and every payment would have a digital record and signature that could be identified, validated, stored, and shared. Intermediaries like lawyers, brokers, and bankers might no longer be necessary. Individuals, organizations, machines, and algorithms would freely transact and interact with one another with little friction...”

REFERENCE:	International Blockchain Real Estate Association (2017) *Initiatives*. Available at: http://www.ibtcrea.org/initiatives/ (Accessed: 18 July 2017).
DATE ACCESSED:	July 18, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Blockchain and real estate
OTHER:	

IBREA seeks to provide a platform for consortia across real estate transactions utilizing the blockchain; currently based out of the United States, seeking international expansion. Lists several key examples of the use of blockchain within real estate.

REFERENCE:	Irving, G. and Holden, J. (2017) ‘How blockchain-timestamped protocols could improve the trustworthiness of medical science’, *F1000Research,* 5(222). Available at: https://f1000research.com/articles/5-222/v3 (Accessed: 1 June 2017).
DATE ACCESSED:	July 18, 2017
ACCESS SOURCE:	Google Scholar
KEYWORDS/STRATEGY:	Blockchain and clinic trials, blockchain and medicine
OTHER:	

Interesting example of an article redacted from publication; did not meet with consistent methodologies during the peer review process (no elaboration given).

REFERENCE:	Jesson, J. *et al.* (2011) *Doing your literature review: traditional and systematic techniques*. London: SAGE Publications Inc.
DATE ACCESSED:	May 1, 2017
ACCESS SOURCE:	Strathclyde Library
KEYWORDS/STRATEGY:	Literature review
OTHER:	

Guidebook to conducing a literature review; overview of both traditional and systematic techniques.

REFERENCE:	Karame, G. *et al.* (2015) ‘Misbehaviour in bitcoin: a study of double-spending accountability’, *ACM Transactions on Information and System Security (TISSEC)*, 18(1), pp. 2-32. doi: 10.1145/2732196
DATE ACCESSED:	August 1, 2017
ACCESS SOURCE:	ACM Digital Library
KEYWORDS/STRATEGY:	Issues with bitcoin, double-spending in bitcoin
OTHER:	

Details the potential of double-spending within bitcoin; highly technical, but with enough simple grounding to be of relevance to this review.

REFERENCE:	Keane, J. (2017) 'Why Sweden is taking a chance on blockchain land registry', *CoinDesk*, 24 April 2017. Available at: https://www.coindesk.com/sweden-taking-chance-blockchain-land-registry/ (Accessed: 17 July 2017).
DATE ACCESSED:	July 17, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Blockchain and land registry
OTHER:	

Discussion of Sweden's implementation of the blockchain system; provides an example of land registry use in a nation where corruption is of less key importance versus long-term outcomes.

REFERENCE:	Kelly, J. (2017). 'Banks blockchain consortium picks IBM for trade finance platform', *Reuters*, 26 June 2017. Available at: http://www.reuters.com/article/us-banks-blockchain-ibm-idUSKBN19H2M6 (Accessed: 1 August 2017).
DATE ACCESSED:	August 1, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Blockchain and trade finance
OTHER:	

Easy descriptions of trade finance in relation to blockchain: "trade finance transactions typically involve a complicated paper trail that requires international courier services, is vulnerable to document fraud, and can take as long as a month to be completed".

REFERENCE:	Kethineni, S., Cao, Y., and Dodge, C. (2017) 'Use of bitcoin in darknet markets: examining facilitative factors on bitcoin-related crimes', *American Journal of Criminal Justice*, 3 May 2017. doi: 10.1007/s12103-017-9394-6
DATE ACCESSED:	July 3, 2017
ACCESS SOURCE:	Springer Standard Collection
KEYWORDS/STRATEGY:	Bitcoin and crime, bitcoin and the darknet
OTHER:	

Clear discussion of how cryptocurrencies differ from status quo; call for additional expertise in creating frameworks as there is no benchmark for evaluating cryptocurrency fraud cases or detection.

REFERENCE:	Keyser, R. (2017) 'Blockchain: a primer for governments', *LinkedIn*, 22 February 2017. Available at: https://www.linkedin.com/pulse/blockchain-primer-governments-rachel-keyser (Accessed: 14 August 2017).
DATE ACCESSED:	August 14, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Governments and blockchain
OTHER:	

Text is from LinkedIn; questionable as a reliable source? However, excellent visuals to display general blockchain transaction processes.

REFERENCE:	Killeen, A. (2015) 'The confluence of Bitcoin and the global sharing economy', in Chuen, D. (ed.) *Handbook of digital currency: Bitcoin, innovation, financial instruments, and big data*. USA: Elsevier, pp. 485-503.

DATE ACCESSED:	July 3, 2017
ACCESS SOURCE:	Chuen, D. (ed.) *Handbook of digital currency: Bitcoin, innovation, financial instruments, and big data*. via Strathclyde
KEYWORDS/STRATEGY:	N/A
OTHER:	

Wider text covering a broad range of topics relating to cryptocurrency; interesting arguments for the shared economy, notably ride sharing apps and the use of social media.

REFERENCE:	Kirby, K., Masi, A., and Maymi, F. (2016) 'Votebook: a proposal for a blockchain based electronic voting system', *The Economist*, 6 August 2016. Available at: https://www.economist.com/sites/default/files/nyu.pdf (Accessed: 25 July 2017).
DATE ACCESSED:	July 25, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Blockchain and voting, blockchain and voting systems
OTHER:	

Working paper on hypothetical 'Votebook', a "permissioned blockchain" wherein a distributed database with consensus for change and no retroactive edits is employed without a proof of work mechanism.

REFERENCE:	Krawiec, R.J. *et al.* (2016) 'Blockchain: opportunities for healthcare', *Deloitte*, August 2016. Available at: https://www2.deloitte.com/content/dam/Deloitte/us/Documents/public-sector/us-blockchain-opportunities-for-health-care.pdf (Accessed: 1 August 2017).
DATE ACCESSED:	August 1, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Blockchain and healthcare
OTHER:	

Located when conducted preliminary searches for information on blockchain and healthcare; provides an overview of several key domains including healthcare management and patient records/insurance purposes.

REFERENCE:	Lamport, L., Shostak, R., and Pease, M. (1982) 'The Byzantine generals' problem', *ACM Transactions on Programming Languages and Systems,* July, pp. 382-401.
DATE ACCESSED:	August 14, 2017
ACCESS SOURCE:	ACM Digital Library
KEYWORDS/STRATEGY:	Byzantine Generals' Problem
OTHER:	

Cited widely throughout the literature; uses an example of Byzantine generals' at war and ensuing miscommunication to illustrate pitfalls of confidentiality and integrity within IT systems.

REFERENCE:	Larimer *et al*. (2016) 'Steem: an incentive, blockchain-based social media platform', *Steem.io*, March 2016. Available at: https://steem.io/SteemWhitePaper.pdf (Accessed: 31 July 2017).
DATE ACCESSED:	July 31, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	What is steem
OTHER:	

Steem's white paper on the use of blockchain within social media; some challenges in that few technical details are provided.

REFERENCE:	Lazooz. (2017) *A value system designed for sustainability*. Available at: http://lazooz.org (Accessed: 1 August 2017).
DATE ACCESSED:	August 1, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Lazooz
OTHER:	Added at request of supervisor

Homepage of the Lazooz ridesharing app detailing specifics of the application.

REFERENCE:	Lee, A. and Hong, K. (2016) 'How blockchain technology is about to transform sharemarket trading', *The Conversation*, 3 February 2016. Available at: http://theconversation.com/how-blockchain-technology-is-about-to-transform-sharemarket-trading-53807 (Accessed: 14 August 2017).
DATE ACCESSED:	August 14, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Blockchain and market trading, blockchain and sharing trading
OTHER:	

'The Conversation' is a magazine style resource; discussion surrounding the use of blockchain in market share trading seems credible as backed by other sources. The authors primarily note the use of blockchain allows for trades to be settled by "participants confirming transactions through the peer to peer network" and bypassing the need for traditional third party clearing houses.

REFERENCE:	Leedy, P. and Ormod, J. (2015) *Practical research: planning and design*. Harlow: Pearson Education Limited.
DATE ACCESSED:	May 4, 2017
ACCESS SOURCE:	Strathclyde Library
KEYWORDS/STRATEGY:	Literature review
OTHER:	

A literature review resource; details appropriate strategies for planning and implementation a large-scale extended review.

REFERENCE:	Lemieux, V. (2016) 'Trusting records: is Blockchain technology the answer?', *Records Management Journal*, 26(2), pp. 110-139.
DATE ACCESSED:	March 8, 2017
ACCESS SOURCE:	Emerald Insight
KEYWORDS/STRATEGY:	Reliability, Authenticity, Risk, Digital preservation, Blockchain, Trusted digital repository
OTHER:	Cited by Morabito, V. (2017)

Lemieux (2016) provides one example in which blockchain technology has been implemented to ensure trustworthiness of digital records within the land registry system of the Honduran government (utilizing Factom, a leader in data infrastructure). Lemieux's findings "suggest that Blockchain technology can be used to address issues associated with information integrity in the present and near term, assuming proper security architecture and infrastructure management controls. It does not, however, guarantee reliability of information in the first place, and would have several limitations as a long-term solution for maintaining trustworthy digital records" (p. 110).

REFERENCE:	Levin, R., O'Brien, A., and Zuberi, M. (2015) 'Real regulation of virtual currencies', in Chuen, D. (ed.) *Handbook of digital*

	currency: Bitcoin, innovation, financial instruments, and big data. USA: Elsevier, pp. 327-360.
DATE ACCESSED:	July 2, 2017
ACCESS SOURCE:	Chuen, D. (ed.) *Handbook of digital currency: Bitcoin, innovation, financial instruments, and big data* from Strathclyde Library
KEYWORDS/STRATEGY:	N/A
OTHER:	
Wider text covering a broad range of topics relating to cryptocurrency; interesting arguments for the regulation of virtual currencies backed by the blockchain, including a need for cohesive regulatory frameworks and an overview of current jurisdictional practices.	

REFERENCE:	Levy, Y. and Ellis, T. (2006) 'A systems approach to conduct an effective literature review in support of information systems research', *Informing Science Journal*, 9, pp. 181-211.
DATE ACCESSED:	May 15, 2017
ACCESS SOURCE:	DOAJ Directory of Open Access Journals
KEYWORDS/STRATEGY:	Literature review, literature review information science
OTHER:	
The authors propose several core ideals of a successful literature review for the information sciences, including deficits within the current published body of works.	

REFERENCE:	Litecoin (2017) *What is litecoin?* Available at: https://litecoin.org/ (Accessed: 14 August 2017).
DATE ACCESSED:	August 14, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Litecoin
OTHER:	Added at the request of supervisor
Homepage of Litecoin; LiteCoin functions in a similar fashion to Bitcoin, but offers a different proof-of-work algorithm intended to accelerate mining capabilities.	

REFERENCE:	Macdonald, M., Liu-Thorrold, L., Julien, R. (2017) 'The blockchain: a comparison of platforms and their uses beyond bitcoin', *ResearchGate*, February. Available at: https://www.researchgate.net/publication/313249614_The_Blockchain_A_Comparison_of_Platforms_and_Their_Uses_Beyond_Bitcoin (Accessed: 14 August 2017). doi: 10.13140/RG.2.2.23274.52164
DATE ACCESSED:	August 14, 2017
ACCESS SOURCE:	Google Scholar
KEYWORDS/STRATEGY:	Blockchain platforms, blockchain platforms comparison
OTHER:	
Overview of current blockchain platforms and their advantages/disadvantages; somewhat technical writing, but with enough accessible dialogue to engage readers of a non-scientific background. Platforms include major competitors such as Bitcoin, Ethereum, Blockstream, IBM, etc.	

REFERENCE:	Mackey, T. and Nayyar, G. (2017) 'A review of existing and emerging digital technologies to combat the global trade in fake medicines', *Expert Opinion on Drug Safety*, 16(5), pp. 587-602.
DATE ACCESSED:	July 3, 2017
ACCESS SOURCE:	Google Scholar
KEYWORDS/STRATEGY:	Blockchain and counterfeit drugs, blockchain and fake medicine

OTHER:	*Not available through Strathclyde, purchased temporarily for the purpose of this literature review

The authors provide an overview of technologies, including the blockchain, that can be used to counteract the global trade in fake medicines. This includes e-pedigrees and mpedigrees; the authors conclude with the need for technology-based solutions that are innovative and meet with current trends in global pharmaceutical supply and demand.

REFERENCE:	Marvin, R. (2016) 'Blockchain in 2017: the year of smart contracts', *PC Magazine*, 12 December 2016. Available at: http://uk.pcmag.com/feature/86618/blockchain-in-2017-the-year-of-smart-contracts (Accessed: 14 August 2017).
DATE ACCESSED:	August 14, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Blockchain and smart contracts
OTHER:	

Excellent summary of the smart contract life cycle from recording of terms through to self-execution in language that is accessible and free of technical jargon.

REFERENCE:	Memória, F. (2016) 'Bitnation introduces smart love, a blockchain marriage application', *BitCoin*, 17 November 2016. Available at: https://news.bitcoin.com/bitnation-smart-love-blockchain-marriage/ (Accessed: 18 July 2017).
DATE ACCESSED:	July 18, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Marriage on the blockchain, blockchain and love
OTHER:	See Connell, J. (2017)

Bitnation announced 'Smart Love' in November of 2016, a propriety blockchain application to address multiple agreements traditionally linked to marriage such as asset sharing (*similar to Connell, J).

REFERENCE:	Mettler, M. (2016) 'Blockchain technology in healthcare: the revolution starts here', *2016 IEEE 18th International Conference on e-Health Networking, Applications and Services (Healthcom)*. Munich, Germany, 14-17 September 2016. doi: 10.1109/HealthCom.2016.7749510
DATE ACCESSED:	July 4, 2017
ACCESS SOURCE:	Google Scholar
KEYWORDS/STRATEGY:	Blockchain and healthcare
OTHER:	

Mettler (2016) discusses a wider call for blockchain technologies within healthcare; specific applications are discussed, including prevention of counterfeit drugs noting in 2010 the World Health Organization estimated "[10%] of drugs are counterfeit worldwide" with increases as high as 30% in developing countries.

REFERENCE:	Miller, M. (2017) 'This disintegrating e-book cleverly shows how blockchains work', *Co.Design*, 9 May 2017. Available at: https://www.fastcodesign.com/90124578/this-disintegrating-e-book-cleverly-shows-how-blockchains-work (Accessed: 31 July 2017).
DATE ACCESSED:	July 31, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Blockchain and books
OTHER:	See *A Universe Explodes (2017)*

Discussion of '*A Universe Explodes*'; the author takes a particular stance on the concept of

ownerships, noting the “attempt to deepen the relationship between a reader and a digital book, to see if it’s possible to make the same emotional investment—to feel a sense of ownership and connection, and to have the impulse to lend and borrow—that many do with physical books… if nothing else, it’s an accessible way to think about a complicated technology like blockchain...”

REFERENCE:	Mok, K. (2017) ‘Cultureblocks: experimental blockchain ebook is a new kind of ever-evolving literature’, *The News Stack*, 4 June 2017. Available at: https://thenewstack.io/cultureblocks-experimental-blockchain-e-book-new-kind-ever-evolving-literature/ (Accessed: 1 August 2017).
DATE ACCESSED:	August 1, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Blockchain and books
OTHER:	

*no in-text citation in literature review due to similarity to Miller, M (2017)

REFERENCE:	Mougayar, W. (2016) ‘The blockchain is perfect for government services’, *CoinDesk*, 3 September. Available at: http://www.coindesk.com/blockchain-perfect-government-services-heres-blueprint/ (Accessed: 17 June 2017).
DATE ACCESSED:	June 17, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Blockchain and government
OTHER:	

Mougayar (2016) introduces several important concepts within government that also apply to wider themes such as transfer of assets, the use of blockchain for land registries, and a need for identification applications. Key questions include: “Did this event take place? Was this service performed on this piece of equipment? Does this person have the right permit?”.

REFERENCE:	Nakamoto, S. (2008) ‘Bitcoin: A peer-to-peer electronic cash system’, *BitCoin*. Available at: https://bitcoin.org/bitcoin.pdf (Accessed: 3 August 2017).
DATE ACCESSED:	August 3, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Bitcoin white paper
OTHER:	Cited on Bitcoin (2017)

In late 2008, a now infamous concept paper titled ‘Bitcoin: A Peer-to-Peer Electronic Cash System’ was distributed online through a cryptography mailing list (and later reiterated on *Bitcoin.org*). Published under the pseudonym Satoshi Nakamoto, the paper posited on a decentralized form of digital currency (see: Bitcoin, 2017).

REFERENCE:	NASDAQ (2017) *Is blockchain the answer to e-voting? NASDAQ believes so*. Available at: http://business.nasdaq.com/marketinsite/2017/Is-Blockchain-the-Answer-to-E-voting-Nasdaq-Believes-So.html (Accessed: 17 July 2017).
DATE ACCESSED:	July 17, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Blockchain and voting, blockchain and e-voting
OTHER:	

As related to the e-Estonia residency program, in early 2017 NASDAQ released a proof-of-concept that would also utilize the blockchain to allow proxy shareholder votes for e-residents; further work to follow.

REFERENCE:	Nem (2017) *What is proof of importance (POI) and why is it better and what is vesting?* Available at: https://blog.nem.io/what-are-poi-and-vesting/ (Accessed: 14 August 2017).
DATE ACCESSED:	August 14, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Proof of work, proof of stake
OTHER:	

Excellent visuals regarding the differences between proof of work and proof of stake.

REFERENCE:	Nian, L.P. and Kuo Chuen, D.L. (2015) 'A light touch of regulation for virtual currencies', in Chuen, D. (ed.) *Handbook of digital currency: Bitcoin, innovation, financial instruments, and big data*. USA: Elsevier, pp. 309-360.
DATE ACCESSED:	July 3, 2017
ACCESS SOURCE:	*Handbook of digital currency: Bitcoin, innovation, financial instruments, and big data*; Strathclyde Library
KEYWORDS/STRATEGY:	N/A
OTHER:	

A lack of international uniformity is captured by Nian and Kuo Chuen, who have developed a spectrum of regulatory approaches; commonalities can be identified in regulated risks, including: 1) counterparty risk in a virtual, decentralized system (and the fulfillment of smart contracts), 2) consumer protection (loss and theft), 3) financial crime, and 4) risk of facilitating money laundering and terrorist financing.

REFERENCE:	Noizat, P. (2015) 'Blockchain electronic vote', in Chuen, D. (ed.) *Handbook of digital currency: Bitcoin, innovation, financial instruments, and big data*. USA: Elsevier, pp. 453-461.
DATE ACCESSED:	July 3, 2017
ACCESS SOURCE:	*Handbook of digital currency: Bitcoin, innovation, financial instruments, and big data*; Strathclyde Library
KEYWORDS/STRATEGY:	N/A
OTHER:	

Discussion of blockchain as it applies to electronic voting systems; excellent discussion of the current status quo including their proprietary (centralized) nature; "no single supplies that controls the code base, the database, and the system outputs…"

REFERENCE:	Nugent, T., Upton, D., and Cimpoesu, M. (2016) 'Improving data transparency in clinical trials using blockchain smart contracts', *F1000Research*, 5(2541). Available at: https://f1000research.com/articles/5-2541/v1 (Accessed: 1 June 2017).
DATE ACCESSED:	June 1, 2017
ACCESS SOURCE:	Directory of Open Access Journals
KEYWORDS/STRATEGY:	Blockchain and clinical trials
OTHER:	

In their 2016 study Nugent, Upton and Cimpoesu employed a private Ethereum based blockchain "used to record synthetic data representing clinical trials of Tamiflu, an influenza drug stockpiled by the British government at a cost of £424m". What follows is successful use of blockchain to "query the number of trials underway, the number of subjects recruited to each one, the address of the transaction sender ... and the timestamp at which the transaction was processed".

REFERENCE:	Oliver, P. (2012) *Succeeding with your literature review: a handbook for students*. Maidenhead: Open University Press.
DATE ACCESSED:	May 6, 2017
ACCESS SOURCE:	Strathclyde Library
KEYWORDS/STRATEGY:	Literature reviews
OTHER:	

A handbook for students on writing literature reviews; outlines process from start to finish, including recommendations to avoid common pitfalls.

REFERENCE:	Office of the National Coordinator for Health Information (2016). *Blockchain: the chain of trust and its potential to transform healthcare*. Available at: https://www.healthit.gov/sites/default/files/8-31-blockchain-ibm_ideation-challenge_aug8.pdf (Accessed: 14 August 2017).
DATE ACCESSED:	August 14, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Blockchain and healthcare
OTHER:	

Includes further discussion on the use of blockchain to prevent counterfeit drug movements; the ONCHI suggests that if current e-pedigree systems could be modified to incorporate blockchain technologies “enable[ing] anti-tampering capabilities during manufacturing, the supply and dispensation system could make drug counterfeiting a non-issue”.

REFERENCE:	OpenBazaar (2017) *Online marketplace – peer to peer economy*. Available at: https://www.openbazaar.org/ (Accessed: 14 August 2017).
DATE ACCESSED:	August 14, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	OpenBazaar
OTHER:	Added at request of supervisor

OpenBazaar is cited at length in examples of blockchain based transactional economies; link above provides homepage access for further reading.

REFERENCE:	Papadapolous, G. (2015) ‘Blockchain and digital payments: an institutional analysis of cryptocurrencies’, in Chuen, D. (ed.) *Handbook of digital currency: Bitcoin, innovation, financial instruments, and big data*. USA: Elsevier, pp. 153-172.
DATE ACCESSED:	July 7, 2017
ACCESS SOURCE:	Chuen, D. (ed.) *Handbook of digital currency: Bitcoin, innovation, financial instruments, and big data*.; Strathclyde Library
KEYWORDS/STRATEGY:	N/A
OTHER:	

Easily understood description of altcoins and how they differ from traditional methods of currency; brief discussion of the advantages of blockchain for cryptocurrencies, with a particular focus on confidentiality.

REFERENCE:	Patientory (2017) *Blockchain app puts an end to medical records being held ransom.* Available at: https://patientory.com/2017/05/16/blockchain-app-puts-an-end-to-medical-records-being-held-to-ransom/ (Accessed: 1 August 2017).
DATE ACCESSED:	August 1, 2017

ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Blockchain healthcare apps
OTHER:	

Patientory is a “cybersecurity blockchain-based distributed electronic medical record network” that offers a cohesive medical tracking application backed by blockchain technology for use by healthcare providers and patients alike”. As of May 2017, Patientory has begun proof of concept testing within the United States with further plans to expand to an international network.

REFERENCE:	Pears, R. and Shields, G. (2016) *Cite them right: the essential referencing guide*. 10th edn. Basingstoke: Palgrave Macmillan.
DATE ACCESSED:	N/A
ACCESS SOURCE:	Strathclyde Department of Computer Science
KEYWORDS/STRATEGY:	N/A
OTHER:	

Recommended source guide for Harvard referencing/citation from the CIS department at the University of Strathclyde.

REFERENCE:	Platiau, C. (2017) ‘Thomson Reuters makes its market data blockchain-friendly’, *Reuters*, 14 June 2017. Available at: http://www.reuters.com/article/us-thomsonreuters-blockchain-idUSKBN1950RZ (Accessed: 14 August 2017).
DATE ACCESSED:	August 14, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Oracle, Reuters, trusted blockchain information
OTHER:	Suggested by supervisor

Reuters, “which sells data, news and other information”, proposes one interesting solution to the issue of reliable source data through the recent release of application BlockOne IQ which “allows customers to plug its market data into systems that run on the digital ledger technology known as blockchain”.

REFERENCE:	PricewaterhouseCoopers (2016) *What might blockchain mean for the mortgage industry?* Available at: https://www.pwc.com/us/en/financial-services/publications/assets/pwc-financial-services-qa-blockchain-in-mortgage.pdf (Accessed: 3 August 2017).
DATE ACCESSED:	August 3, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Blockchain and mortages, blockchain and financial institutions
OTHER:	

Loans provide another area of the financial market where blockchain technology could soon play a key role in streamlining traditional practices. In today’s current system of mortgage lending “every time a transaction moves between ledgers, someone confirms that move. Blockchain could address this issue by updating ledgers immediately, automatically, transparently, and with traceability”.

REFERENCE:	Prisco, G. (2017a) ‘BitFury, Republic of Georgia push ahead with land-titling project’, *BitCoin Magazine*, 8 February 2017. Available at: https://bitcoinmagazine.com/articles/bitfury-republic-georgia-push-ahead-blockchain-land-titling-project/ (Accessed: 24 July 2017).
DATE ACCESSED:	July 24, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Blockchain Republic of Georgia, blockchain land registry

OTHER:	

Additional resource on the Republic of Georgia and their partnership with BitFury to develop a blockchain-based system of land registry.

REFERENCE:	Prisco, G. (2017b) 'Smart contracts for real businesses and banks', *CryptoInsider*, 2 May 2017. Available at: https://cryptoinsider.com/smart-contracts-real-businesses-banks/ (Accessed: 5 August 2017).
DATE ACCESSED:	August 5, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Blockchain and smart contracts
OTHER:	

Prisco is an easy-to-read writer covering basic developments in the blockchain industry; discussion on the impact of smart contracts on banking and business transactions, including the disintermediation of current practices.

REFERENCE:	Prisco, G. (2016) 'Akasha project unveils decentralized social media networks based on Ethereum and IPFS', *BitCoin Magazine*, 6 May 2016. Available at: https://bitcoinmagazine.com/articles/akasha-project-unveils-decentralized-social-media-network-based-on-ethereum-and-ipfs-1462551273/ (Accessed: 1 August 2017).
DATE ACCESSED:	August 1, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	AKASHA project blockchain
OTHER:	

Follow-up to social media discussion found in *Digital Currency Handbook;* provides some further information on the use of Ethereum for AKASHA, including discussion of 'web 3.0' (a hype/buzzword lead?)

REFERENCE:	Quentson, A. (2017) 'Can Ethereum-based Akasha revolutionize social network?', *CryptoCoins: News*, 29 January 2017. Available at: https://www.cryptocoinsnews.com/can-ethereum-based-akasha-revolutionize-social-networks/ (Accessed: 31 July 2017).
DATE ACCESSED:	July 31, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	AKASHA project blockchain
OTHER:	

Follow-up to social media discussion found in *Digital Currency Handbook;* no in-text citation in literature review, similarity to Prisco (2016)

REFERENCE:	Quentson, A. (2016) 'Steem soars 1000%, bypassing LiteCoin, but can it work?', *CryptoCoins: News*, 13 July 2016. Available at: https://www.cryptocoinsnews.com/steem-soars-1000-bypassing-litecoin-can-work/ (Accessed: 1 August 2017).
DATE ACCESSED:	August 1, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Blockchain and social media, Blockchain and steem
OTHER:	

Quentson challenges the white paper writings of Steem noting they are "bereft of any technical explanation" leaving much unanswered about the susceptibility of the platform to vote rigging.

REFERENCE:	Reutzel, B. (2016) 'Is blockchain the key to user-controlled social media?', *CoinDesk*, 9 May 2016. Available at: https://www.coindesk.com/facebook-user-controlled-social-media-blockchain/ (Accessed: 1 August 2017).
DATE ACCESSED:	August 1, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Blockchain and social media
OTHER:	

Reutzel introduces a key interesting concept when discussing social media and the blockchain – the ability to "capitalize on human nature as it manifests online"; this is an interesting idea in combination with other social media and blockchain writings, particularly ideas of attribution and content creation.

REFERENCE:	Reyes, F. (2014) 'Decentralized markets kills e-commerce stars: OpenBazaar', *BitCoin Magazine*, 29 November 2014. Available at: https://bitcoinmagazine.com/articles/decentralized-markets-kills-e-commerce-stars-openbazaar-1417320255/ (Accessed: 1 August 2017).
DATE ACCESSED:	August 1, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	OpenBazaar and blockchain
OTHER:	

Reyes discusses the possibilities of OpenBazaar beyond a marketplace, including "new templates for more advanced contracts…it will be possible to do things like insurance policies, P2P insurance, crowdlending, crowdfunding, P2P renting…"; this may contribute to the legitimacy of cryptocurrencies and blockchain as a whole as further platforms develop.

REFERENCE:	Roehrs, A., da Costa, C, and da Rosa Righi, R. (2017) 'OmniPHR: A distributed architecture model to integrate personal health records', *Journal of Biomedical Informatics*, 71, pp. 70-81.
DATE ACCESSED:	July 3, 2017
ACCESS SOURCE:	Elsevier
KEYWORDS/STRATEGY:	Blockchain and healthcare records
OTHER:	

The authors propose a hypothetical blockchain-based architecture known as OmniPHR for the integration and interoperability of PHRs. In this model, OmniPHR "divide[s] the patient's health records into datablocks, which are a logical division of the patient's health datasets, such as laboratory data, drug-related dataset, X-ray dataset and others"; advantages include patient-controlled data with instantaneous updates to healthcare providers.

REFERENCE:	Rosencrance, L. (2017) 'The intersection of social media and blockchain', *NASDAQ*, 16 March 2017. Available at: http://www.nasdaq.com/article/the-intersection-of-social-media-and-the-blockchain-cm790115 (Accessed: 1 August 2017).
DATE ACCESSED:	August 1, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Blockchain and social media
OTHER:	

Discussion of Steem.io, and the logistics of the platform functions including a discussion of associated app Qrator.

REFERENCE:	Santorini, M. (2017) 'Silk Road goes dark: bitcoin survives its

	biggest market's demise', *CoinDesk*, 5 May 2017. Available at: https://www.coindesk.com/bitcoin-milestones-silk-road-goes-dark-bitcoin-survives-its-biggest-markets-demise/ (Accessed: 1 August 2017).
DATE ACCESSED:	May 5, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Silk road, blockchain and the silk road
OTHER:	

Not an overly robust article; Santorini discusses the longterm implications for cryptocurrencies resulting from the closure of the Silk road (particular note is given to copycat ventures, and more legal entities, such as OpenBazaar).

REFERENCE:	Schneider, N. (2015) 'La'Zooz: the decentralized, crypto-alternative to Uber', *Shareable*, 26 January 2015. Available at: http://www.shareable.net/blog/lazooz-the-decentralized-crypto-alternative-to-uber (Accessed: 1 August 2017).
DATE ACCESSED:	August 1, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Lazooz
OTHER:	

Shareable is an online magazine resource; Schneider discusses La'Zooz in a compare and contrast article to current app driver service Uber.

REFERENCE:	Scott, A. (2016) 'Top 5 things people are buying on OpenBazaar', *BitCoin: News*, 1 September 2016. Available at: https://news.bitcoin.com/top-5-products-openbazaar/ (Accessed: 1 August 2017).
DATE ACCESSED:	August 1, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	OpenBazaar and blockchain
OTHER:	

Interesting reference note on the top items purchased on OpenBazaar (I was curious).

REFERENCE:	Shen, J. (2016) 'e-Estonia: the power and potential of digital identity', *Thomson Reuters*, 20 December 2016. Available at: https://blogs.thomsonreuters.com/answerson/e-estonia-power-potential-digital-identity/ (Accessed: 17 July 2017).
DATE ACCESSED:	July 17, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Blockchain and e-estonia, e-estonia and digital identity
OTHER:	

Shen describes the e-estonia identity system: "as a cryptographically secure digital identity card (powered by a blockchain-like infrastructure on the backend) that allows an Estonian to access public services, financial services, medical and emergency services as well as to drive, pay taxes online, e-vote, provide digital signatures, and travel within the EU without a passport".

REFERENCE:	Shin, L. (2017) 'The first government to secure land titles on the Bitcoin blockchain expands project', *Forbes*, 7 February 2017. Available at: https://www.forbes.com/sites/laurashin/2017/02/07/the-first-government-to-secure-land-titles-on-the-bitcoin-blockchain-expands-project/#1edf4b004dcd (Accessed: 24 July 2017).
DATE ACCESSED:	July 24, 2017

ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Blockchain and land registry
OTHER:	

In February of 2017, the Republic of Georgia became the first government to secure land titles using blockchain technology; discusses the expansion of blockchain backed land registry including "purchases and sales of land titles, registration of new land titles, demolition of property, mortgage and rentals, as well as notary services".

REFERENCE:	Shin, L. (2016) 'Republic of Georgia to pilot land titling on blockchain with economist Hernando de Soto, BitFury', *Forbes*, 21 April 2016. Available at: https://www.forbes.com/sites/laurashin/2016/04/21/republic-of-georgia-to-pilot-land-titling-on-blockchain-with-economist-hernando-de-soto-bitfury/#7768b53844da (Accessed: 24 July 2017).
DATE ACCESSED:	July 24, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Land registry and blockchain, Republic of Georgia blockchain
OTHER:	

Shin (2016) discusses the benefits of blockchain based land registries in Georgia, noting land registration transaction in the Republic of Georgia historically requires at least 24 hours processing time with a fee of $50-200 USD, paid in-person by a buyer or seller to a registry house; under the blockchain system, fees to buyers and sellers are "in the range of $.05-$.10[USD]" with subsequently reduced processing timeframes.

REFERENCE:	Silitschanu, P. (2017) 'Streamlining trade finance with blockchain technology', *AmericanExpress*. Available at: https://www.americanexpress.com/us/content/foreign-exchange/articles/blockchain-technology-to-streamline-trade-finance/ (Accessed: 2 August 2017).
DATE ACCESSED:	August 2, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Blockchain and trade finance
OTHER:	

Excellent description of the trade finance industry: "[…] financial transactions, both domestic and international, which relate to trade receivables finance and global trade. These trade finance transactions include lending, issuing letters of credit, factoring, export credit and insurance. These transactions make up an enormous portion of global trade – approximately 80 to 90 percent of world trade relies on trade finance. Essentially, almost any time goods or services are bought or sold across any border, there is some form of trade finance involved".

REFERENCE:	Silva, L. (2017) 'Alpha in action: an interview with the AKASHA project', *EthNews*, 26 January 2017. Available at: https://www.ethnews.com/alpha-in-action-an-interview-with-the-akasha-project (Accessed: 1 August 2017).
DATE ACCESSED:	August 1, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	AKASHA project
OTHER:	

*Note: this is an interview with the founders of the AKASHA project, which is backed by Ethereum; however, this article has also been published on the EthNews network (issue of credibility?).

REFERENCE:	Simmonds, P. (2003) 'Continuing professional development and

	workplace learning 2: CPD and you – how CILIP is meeting the continuing professional development needs of its members', *Library Management*, 24(3), pp. 169-170.
DATE ACCESSED:	July 4, 2017
ACCESS SOURCE:	ProQuest (LISA)
KEYWORDS/STRATEGY:	Librarian professional development, librarians continuing professional development
OTHER:	

Simmonds (2003) discusses best practices for continual learning within the roles of library and information professionals; this includes a focus on technological advancements, as well as a willingness to engage with new media and educational opportunities.

REFERENCE:	Smerkis, V. (2017) 'Georgia records 100,000 land titles on Bitcoin blockchain: BitFury', *CoinTelegraph*, 20 April 2017. Available at: https://cointelegraph.com/news/georgia-records-100000-land-titles-on-bitcoin-blockchain-bitfury (Accessed: 23 July 2017).
DATE ACCESSED:	July 23, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Blockchain land registry, blockchain and Georgia
OTHER:	

Support article to the use of blockchain and land registries; sourced for facts such as: "From February of 2017 to April of 2017, Valery Vavilov, CEO of BitFury, reported more than 100,000 property registrations in the Republic of Georgia utilizing their blockchain solution".

REFERENCE:	Stanley, A. (2017) 'Trump's Obamacare overhaul could be blockchain adoption catalyst', *CoinDesk*, 1 May. Available at: http://www.coindesk.com/trumps-obamacare-overhaul-could-be-blockchain-adoption-catalyst/ (Accessed: 6 June 2017).
DATE ACCESSED:	June 6, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Blockchain and healthcare
OTHER:	

*Very specific to the United States, no in-text citation (seeking broader articles)

REFERENCE:	Stark, J. (2016) 'Making sense of Blockchain smart contracts', *CoinDesk*, 4 June. Available at: http://www.coindesk.com/making-sense-smart-contracts/ (Accessed: 6 June 2017).
DATE ACCESSED:	June 6, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Blockchain and smart contracts
OTHER:	

Simple definitions of smart contracts without technical jargon: "Sometimes the term is used to identify a specific technology – code that is stored, verified and executed on a blockchain…other times, the term is used to refer to a specific application of that technology: as a complement, or substitute, for legal contracts".

REFERENCE:	Steem (2017) *A blockchain-based social media platform*. Available at: https://steem.io/ (Accessed: 14 August 2017).
DATE ACCESSED:	August 14, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Steem

OTHER:	Suggested by supervisor

Homepage for Steem.io; additional support material to blockchain and social media articles.

REFERENCE:	Stinson, E. (2017) 'The bizarre digital book you must destroy before sharing', *Wired Magazine*, 14 April 2017. Available at: https://www.wired.com/2017/04/bizarre-digital-book-must-destroy-sharing/ (Accessed: 2 August 2017).
DATE ACCESSED:	August 2, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Blockchain and ebooks
OTHER:	See: A Universe Explodes (2017)

Stinson raises important questions of ownership in regards to literary lending, e-books, and blockchain: "Does physical possession constitute ownership? […] Does there have to be an exchange of money?"

REFERENCE:	Sullivan, C. and Burger, E. (2017) 'E-residency and blockchain', *Computer Law & Security Review*, 33(4), pp. 470-481.
DATE ACCESSED:	August 1, 2017
ACCESS SOURCE:	Science Direct
KEYWORDS/STRATEGY:	Blockchain e-residency
OTHER:	

Sullivan and Burger (2017) provide an in-depth article noting the challenges of Estonia's e-residency program, finding the literature at present gives few to no details on Bitnation's technical platform for implementation in Estonia, despite the interest of additional nations in creating their own e-Residency programs. Furthermore, while Bitnation seeks to exist outside the sphere of current legal practice, the use of blockchain for notary services raises issue of national data protection legislation and international rights to identity.

REFERENCE:	Sundararajan, A. (2016) *The sharing economy: the end of employment and the rise of crowd-based capitalism*. Cambridge: MIT Press.
DATE ACCESSED:	August 3, 2017
ACCESS SOURCE:	Strathclyde library
KEYWORDS/STRATEGY:	Sharing economy
OTHER:	

Not a blockchain specific text, but provides wider grounding in principles of the sharing economy (i.e. – what is it? what is it not?); references to OpenBazaar and other social media platforms.

REFERENCE:	Swan, M. (2015) *Blockchain: Blueprint for a new economy*. Sebastopol, Calif.: O'Reilly Media.
DATE ACCESSED:	May 3, 2017
ACCESS SOURCE:	Strathclyde Library
KEYWORDS/STRATEGY:	Blockchain
OTHER:	

One of the seminal texts on blockchain; widely cited, covers the majority of blockchain technical basics including potential domains for development (with a focus on smart contracts, dubbed by the author as Blockchain 2.0).

REFERENCE:	Swarm City (2017) The *first truly decentralized peer to peer sharing economy*. Available at: https://swarm.city/ (Accessed: 14 August 2017).
DATE ACCESSED:	August 14, 2017

ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Swarm City
OTHER:	Suggested addition by supervisor

Homepage of Swarm City (split from Arcade City); see additional sources on ride sharing applications backed by blockchain.

REFERENCE:	Synereo (2017) *Announcing Qrator: the first liberated attention economy app*. 3 April 2017. Available at: https://blog.synereo.com/2017/04/03/synereo-announces-qrator-the-first-liberated-attention-economy-application/ (Accessed: 1 August 2017).
DATE ACCESSED:	August 1, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Synereo
OTHER:	

Further information on Synereo's Qrator application, including informational video.

REFERENCE:	Szmigielski, A. (2015) 'Distributed vs. decentralized networks', *CryptoIQ*, 2 March 2015. Available at: http://blog.cryptoiq.ca/?p=26 (Accessed: 14 August 2017).
DATE ACCESSED:	August 14, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Distributed versus decentralized networks
OTHER:	

Excellent illustrations showing the differences between centralized, decentralized, and distributed networks.

REFERENCE:	Taylor, P (2016) 'Applying blockchain technology to medicine traceability', *Securing Industry*, April 27. Available at: https://www.securingindustry.com/pharmaceuticals/applying-blockchain-technology-to-medicine-traceability/s40/a2766/#.WTx8t2X1_wy (Accessed: 6 June 2017).
DATE ACCESSED:	June 6, 2017
ACCESS SOURCE:	Google Scholar
KEYWORDS/STRATEGY:	Blockchain and medicine
OTHER:	

Supports Swan's (2015) writings on the cost saving mechanisms of blockchain in the healthcare industry; "the amount of media disruptions involved during the treatment of a patient (e.g., change of communication media, various medical health records, incompatible IT interfaces, etc.) can lead to time-consuming and resource-intensive authentication and information processes for all medical stakeholders involved".

REFERENCE:	Thomson, A. (2015) 'Using the blockchain to fight crime and save lives', *TechCrunch*, 27 September. Available at: https://techcrunch.com/2015/09/27/using-the-blockchain-to-the-fight-crime-and-save-lives/ (Accessed: 1 June 2017).
DATE ACCESSED:	June 1, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Blockchain and crime
OTHER:	

Interesting note on the use of blockchain for pharmacies (predominantly in the United States): "A number of leading sites such as Snapdeal Medidart, Buydrug and Meramedicare have installed safety features, requiring users to upload prescriptions for prescribed drugs while placing orders,

and extra checks on vendors. However, the World Health Organization estimates that more than 50 percent of medications purchased from online vendors in which the doctor's name is concealed are counterfeit".

REFERENCE:	Torpey, K. (2016) 'Chicago's Cook County to test Bitcoin blockchain-based property title transfer', *BitCoin Magazine*, 6 October 2016. Available at: https://bitcoinmagazine.com/articles/chicago-s-cook-county-to-test-bitcoin-blockchain-based-public-records-1475768860/ (Accessed: 18 July 2017).
DATE ACCESSED:	July 18, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Land registry and blockchain
OTHER:	

Reference to land registry use of blockchain in the United States; first to be implemented in Chicago, "the Cook County Recorder's Office is the second largest such office in the United States, and it will be the first in the country to experiment with blockchain technology".

REFERENCE:	UK Government Office for Science (2016) *Distributed ledger technology: beyond bitcoin*. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/492972/gs-16-1-distributed-ledger-technology.pdf (Accessed: 14 August 2017).
DATE ACCESSED:	August 14, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Distributed ledger taxonomy
OTHER:	

Excellent image of distributed ledger taxonomy based on Birch (2016)

REFERENCE:	Underwood, S. (2016) 'Blockchain beyond bitcoin', *Communications of the ACM*, 59(11), pp. 15-17.
DATE ACCESSED:	May 23, 2017
ACCESS SOURCE:	Science Direct
KEYWORDS/STRATEGY:	Blockchain
OTHER:	

Underwood discusses a wide variety of blockchain applications with focus on land registries.

REFERENCE:	Valenzuela, J. (2017) 'Arcade city aka 'uber killer' hard forks, founder claims fraud', *Coin Telegraph*, 9 January 2017. Available at: https://cointelegraph.com/news/arcade-city-aka-uber-killer-hard-forks-founder-claims-fraud (Accessed: 31 July 2017).
DATE ACCESSED:	July 31, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Arcade City, blockchain and uber
OTHER:	

Valenzuela discusses the 'hard' fork between Arcade City and Swarm City; issues of cryptocurrency fraud are also discussed.

REFERENCE:	Walport, M. *et al.* (2016) *Distributed ledger technology: beyond block chain*. UK Government Office for Science. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/492972/gs-16-1-distributed-ledger-technology.pdf (Accessed: 12 June 2017).
DATE ACCESSED:	June 12, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	
OTHER:	

Walport et al. discuss the importance of distributed ledger technology to the future: "ensuring the security of distributed ledgers is an important task and part of the general challenge of ensuring the security of the digital infrastructure on which modern societies now depend" (p. 6).

REFERENCE:	Walt, V. (2017) 'Is this tiny European nation a preview of our tech future?', *Fortune*, 27 April 2017. Available at: http://fortune.com/2017/04/27/estonia-digital-life-tech-startups/ (Accessed: 17 July 2017).
DATE ACCESSED:	July 17, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Estonia blockchain
OTHER:	

Highly accessible article on the history of Estonia and its relationship to the blockchain; Walt (2017) posits on how Estonia's systems can be applied to other nation states, and the challenges and promises this may hold.

REFERENCE:	Watson, M. (2010) *Building your portfolio: the CILIP guide*. London: Facet.
DATE ACCESSED:	May 1, 2017
ACCESS SOURCE:	Strathclyde Library
KEYWORDS/STRATEGY:	Librarian professional development, continuing professional development for information professionals
OTHER:	

Watson (2010) offers practical suggestions for continuing development for information professionals, including the application of new forms of knowledge: "It is not sufficient to just have an experience; you need to reflect on that experience and evaluate it, and then apply that knowledge to another experience or activity".

REFERENCE:	Webster, F. (2005) 'The end of the public library?', *Science as Culture*, 14(3), pp. 283-288.
DATE ACCESSED:	May 11, 2017
ACCESS SOURCE:	EBSCOHost
KEYWORDS/STRATEGY:	Future of libraries, public library development
OTHER:	

Older reference in comparison to other sources; Webster (2005) addresses the stereotypes of libraries and librarians, including a misguided focus on physical resources such as books.

REFERENCE:	Webster, J. and Watson, R. (2002) 'Analyzing the past to prepare for the future: writing a literature review', *MIS Quarterly*, 26(2), pp. 13-23.
DATE ACCESSED:	May 4, 2017
ACCESS SOURCE:	ScienceDirect
KEYWORDS/STRATEGY:	Literature review

OTHER:	

Webster and Watson (2002) reiterate the merits of a literature review, which aim to create new facets and research avenues within both established and emerging domains.

REFERENCE:	Wong, J. (2017) 'Sweden's blockchain-powered land registry is inching towards reality', *Quartz Media LLC*, 3 April 2017. Available at: https://qz.com/947064/sweden-is-turning-a-blockchain-powered-land-registry-into-a-reality/ (Accessed: 20 July 2017).
DATE ACCESSED:	July 20, 2017
ACCESS SOURCE:	Google
KEYWORDS/STRATEGY:	Sweden and blockchain
OTHER:	I have never heard of Quartz Media, but it is cited by other scholars as a reliable media outlet

Wong discusses the use of blockchain in an established land registry system as Sweden currently exhibits a highly developed, corruption-free land registry system. However, the Swedish government has recognized the cost saving implications of blockchain which "could save the Swedish taxpayer over €100 million ($106 million) a year by eliminating paperwork, reducing fraud, and speeding up transactions".

REFERENCE:	World Health Organization (2010) 'Growing threat from counterfeit medicines', *Bulletin of the World Health Organization*, 88(4), pp. 241-320.
DATE ACCESSED:	May 12, 2017
ACCESS SOURCE:	ScienceDirect
KEYWORDS/STRATEGY:	WHO counterfeit medicine statistics
OTHER:	

Bulletin on global distribution of counterfeit medicines; statistics are provided that may be useful to support arguments for further blockchain development in this area.

REFERENCE:	Yeoh, P. (2017) 'Regulatory issues in blockchain technology', *Journal of Financial Regulation and Compliance*, 25(2), [no pagination]. doi: http://dx.doi.org/10.1108/JFRC-08-2016-0068
DATE ACCESSED:	May 10, 2017
ACCESS SOURCE:	ScienceDirect
KEYWORDS/STRATEGY:	Blockchain regulation
OTHER:	

Yeoh (2017) posits on global implications of blockchain technology, including the eventual need for collaboration among varying international jurisdictions of law and commerce (arguing that the regulation of cryptocurrencies such as Bitcoin, currently determined at varying national levels, must be developed with consideration for the wider implications of the underlying blockchain technology in all domains of social application). Case precedent from the financial sector may serve as a model for further cross-disciplinary regulation.

REFERENCE:	Yii-Huumo, J. *et al.* (2016) 'Where is current research on blockchain technology? A systematic review', *PLoS ONE*, 11(10), [no pagination]. doi:10.1371/journal.pone.0163477
DATE ACCESSED:	May 4, 2017
ACCESS SOURCE:	ScienceDirect
KEYWORDS/STRATEGY:	Blockchain literature review
OTHER:	

Yii-Huumo *et al.* provide a systematic review of technical blockchain literature, concluding that while systematic literature reviews offer a comprehensive overview of technical findings for a given period, they may prove inadequate in addressing the continually evolving global nature of

blockchain technologies and agreements.

REFERENCE:	Yue, X. *et al.* (2016) 'Healthcare data gateways: found healthcare intelligence on blockchain with novel privacy risk control', *Journal of Medical Systems*, 40, [no pagination]. doi:10.1007/s10916-016-0574-6
DATE ACCESSED:	May 6, 2017
ACCESS SOURCE:	ProQuest
KEYWORDS/STRATEGY:	Blockchain healthcare
OTHER:	

Yue *et al.* (2016) discuss the use of mobile technology for healthcare blockchain applications; the authors propose a smartphone application titled Healthcare Data Gateway (HGD) with "architecture based on blockchain to enable patient to own, control and share their own data easily and securely without violating privacy" (Yue *et al.,* 2016). Smartphones offer a low barrier to adoption given their prevalence, computing power, and current availability of mobile wireless networks.