The Blockchain High of Cannabis Supply Chains

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Abstract: The worlds of technology and industry are changing and developing rapidly. Each day innovative technologies are dreamt of and developed. These two fields are merging and changing one another with each passing day. This paper aims to provide an overview and explanation of the innovate technologies of blockchain, distributed ledger, and cryptocurrency. Furthermore, it will demonstrate how these technologies can be applied to existing strategic business frameworks, such as the four pillars of productivity (4POP) model. The application of such will spur further innovation and increase productivity. This information will then be applied to demonstrate how a distributed ledger can be applied to the growing Canadian industry of cannabis; specifically, within the cannabis industry's distribution and supply chain management. Altogether, this paper will provide readers with a basic understanding of the technology, how it can be applied to existing strategic business models, and its practical application in growing global industries, such as the Canadian cannabis industry. There is a discussion as to why blockchain is so relevant to solving many of the issues associated with introducing legalized cannabis, and how government, academia, and industry can leverage the emerging technology and recent legalization to the greatest effect.

Keywords- Canada, productivity, blockchain technology, distributed ledger, digital currency, supply chain management, cannabis.

Introduction

Bitcoin, blockchain, distributed ledger, cryptocurrency, and the internet of things are just a few of the catchphrases and lingo being flung around by mainstream media. It is easy to understand why. The landscape of technology is changing at an ever-increasing rate; new developments and innovations are made with each passing moment, each day a new story is told. It is happening so swiftly, it is hard to keep up. This rapid change and adoption of technology mirrors the rapid change of the globe and its economy of transactions. But, what are these new technologies and what do they mean for the everyday operations of individuals' lives and businesses. How will they impact previously constructed business models? How will they fit into the world of global transactions? How can they be applied for the better management and distribution of supply chains? The questions go on and on; it is difficult and daunting to attempt to answer them. But, this new language of advancement must be learned.

So, when and how did it all begin? On the 31st of October 2008, nearly a decade ago, a white paper was published by the pseudonymous programmer, Satoshi Nakamoto. It was titled: Bitcoin: A Peer-to-Peer Electronic Cash System. The story begins here. It outlined the concept of a purely peer-to-peer version of electronic cash, which would allow online payments to be sent directly from one party to another without the need of going through a financial institution (Nakamoto, 2008). This technology allows for the completion of a secure transaction without any of the traditional institutions that humanity relies on to establish trust (Johnson, 2018).

Nakamoto recognized the numerous inefficiencies and accounting issues prevalent with prevailing fiat-currencies. In short, drawn-out and tedious transaction times, combined with intense intermediary pressure, resulted in a no value-added situation. His intention was to use digital signatures to eliminate the need for intermediary organizations. Digital signatures are a type of electronic signature that encrypts documents with digital codes that are particularly difficult to duplicate. Vinay Gupta captures the relevance of the event, "Many of the technologies we now take for granted were quiet revolutions in their time," (Gupta, 2017). All the media hype today is built upon the technology outlined in the aforementioned white paper. Very few understood then how significant the global applications of the technology would be, and how it would lead to much more than just cryptocurrencies.

A couple of months after the initial publication of Nakamoto's white paper, the first transaction was completed. The infamous Bitcoin was born. On January 3rd, 2009 the 'Genesis Block' was mined, (Grant Thornton, 2017). A genesis block is the first block of a blockchain (see fig. 1); modern versions of Bitcoin number it as block 0, though very early versions counted it as block 1. The genesis block is almost always hardcoded into the software of the applications that utilize its blockchain (BitcoinWiki, 2017). Nine days later the first bitcoin transaction took place; an exchange between Hal Finney and Satoshi Nakamoto (Grant Thornton, 2017). Approximately a year later, the first ever cryptocurrency purchase occurred. A purchase for two pizzas was completed for the exchange of 10,000 Bitcoin on May 22nd, 2010; as of today, approximately $CA140 million (Grant Thornton, 2017). Bitcoin's exchange value reached parity with the US dollar in February 2011; two years later, in March 2013, the market capitalisation for Bitcoin reached $US1 billion (Grant Thornton, 2017).

Over the next five years Bitcoin increased in popularity, and value; it became a house-hold name. Across the globe, Bitcoin's notoriety spiked curiosity; what was the underlying technology of Bitcoin and how did it work? The answer was: blockchain, also known as distributed ledger technology. The assimilation of the two phrases may cause some confusion.

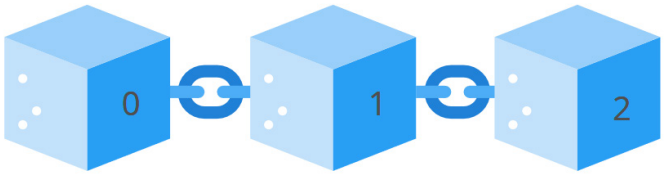

Figure 1. The genesis and first blocks in the blockchain

Technology

Think of blockchain and distributed ledger technology in the same way you might think of Q-tips and cotton swabs (Meola, 2017). The former is a type of the latter, but due to its increased popularity and notoriety it has become engrained in people's minds as the actual product (Meola, 2017). Each phrase describes certain elements of the technology. A block in the blockchain represents a transaction, or a group of transactions, depending on the implementation. In most cases, once the block has been produced and accepted throughout the network it is considered to be verified as part of the blockchain. There are some additional scenarios beyond the scope of this paper.

The term distributed ledger describes the decentralized nature of the database; unlike a traditional database with a central administrator, a distributed ledger has a network of replicated databases, synchronized via the internet and visible to anyone within the network, (Thompson, 2016). Thus, the terms database, blockchain, and distributed ledger will be used interchangeably henceforth. Understanding the architecture and basic theory of the crypto economy will help demonstrate the possibilities for real world applications in supply chain management (Thompson, 2016).

The database is supported and managed by a network of nodes, which are spread around the world. These nodes are responsible for the verification, and secure storage of data. Simply speaking, a node is a computer, or a server connected to the network. The first time a node is connected to the network it immediately downloads a copy of the distributed ledger database. There is no official copy of the database, and no individual node or computer is seen as being more valid than any other (Saye, 2016). The revolutionary aspect of this technology is held in its decentralization (Saye, 2016). The security element is drawn from the ledger being shared across multiple computers, thus, to change the record each node would need to be changed.

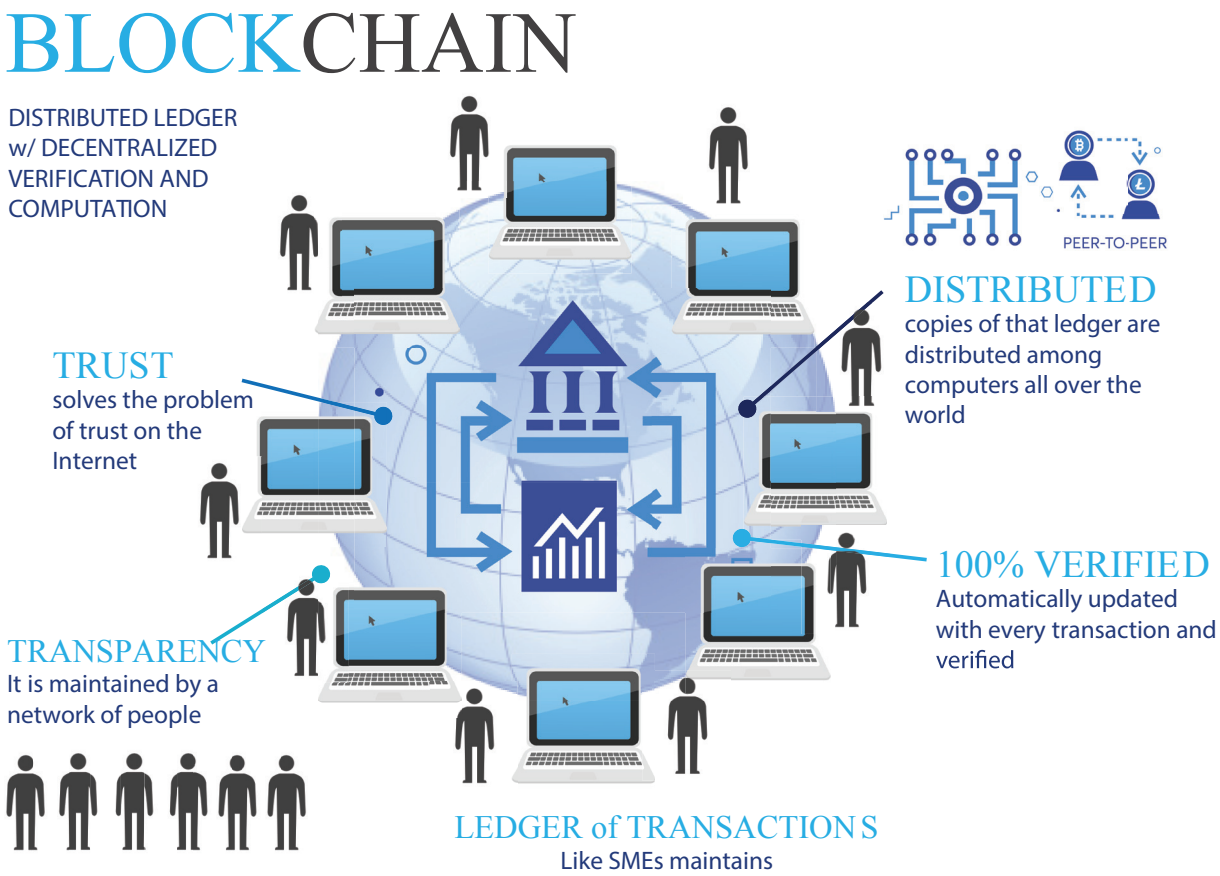

Figure 2. Distributed ledger with decentralized verification and computation.

Nodes are responsible for pulling pending transactions from a pool, which have been submitted to the database. They analyze the database transactions using a set of rules and algorithms, which the database has agreed upon, to determine whether the submitted transactions are valid. Validation occurs with the agreement of at least 51% of all the computers on the network (Rijmenam, 2017). Validation is done through advanced cryptography, essentially a difficult mathematical equation (Rijmenam, 2017). Solving these equations requires powerful computing power, however, once solved it becomes very clear what the answer is (Rijmenam, 2017). It can be compared to a game of sudoku; difficult to solve, but once allegedly solved it is easy to verify if the offered solution is correct.

Verified transactions are then grouped together and added to the database in a block. The verification process is completed with the assignment of a time-stamp and a hash for each block. The technology gains its name from how the blocks are added; they are stacked one after the other forming a chain. Blocks can be added to the chain but cannot be removed or corrupted (Saye, 2016). Each block in the chain is given a hash function. The hash function identifies each block in the chain of data and links it to each predecessor and successor. This function creates the security, accountability, and transparency of blockchain technology. Any changes within a block would require the changing of the hash, which is linked to all predecessors and successors. Thus, it would require the changing of all members of the chain, making the database nearly impossible for corruption or hacking. Furthermore, any changes that any individual would try to make must be approved and verified by at least 51% of the participating nodes of the network (Rijmenam, 2017).

The unique value of the hash function is calculated through a mathematical equation known as a trapdoor function (Pan, Wang, & Xu, 2016). In essence, a trapdoor function is an equation that is easy to solve one way but, nearly impossible to solve inversely without special information. Trapdoor functions are part of the reoccurring element of cryptography. Cryptography, in its modern form, is the study of mathematical techniques related to aspects of information security such as confidentiality, data integrity, authentication, and non-repudiation (Maze, 2003). By using these advanced trapdoor functions each block is given a unique value, it is connected to all previous and all succeeding data blocks.

To summarize, blockchain and distributed ledger technology has five basic principles underlying their technology (Casey & Wong, 2013). These principles are: distributed database, peer-to-peer transmission, transparency with pseudonymity, irreversibility of records, and computational logic. First, the fact that they are distributed databases means each party on the blockchain has access to the entire database and its complete history (Casey & Wong, 2013). Furthermore, since no single party controls the data or the information every party can verify the records of its transaction partners directly, without an intermediary such as a bank or financial institution (Casey & Wong, 2013). Secondly, peer-to-peer transmission. Peer-to-peer transmission outlines how communication occurs directly between peers or nodes rather than a central administrator or node; each node or computer is responsible for storing and forwarding information to all other nodes or computers (Casey & Wong, 2013) .

Third, transparency with pseudonymity explains how every transaction and its associated value are visible to anyone with access to the network. Each node, or user, on a blockchain has a unique 30-plus-character alphanumerical address that identifies it from the other nodes on the system (Casey & Wong, 2013). Users can choose to remain anonymous or provide proof of their identity to others, but regardless of what they choose, transactions occur between blockchain addresses (Casey & Wong, 2013). Fourth, the irreversibility of records. Distributed ledgers possess irreversible records; once a transaction is entered into the database and accounts are updated, the records cannot be altered, because they are linked to every transaction record that preceded them. Each node on the database has a copy of the transaction (Casey & Wong, 2013). Fifth, computational logic. Due to the digital nature of distributed ledger technology transactions can be tied to computational logic and thus, be programmed (Casey & Wong, 2013). Hence, users can set up rules and algorithms that will trigger transactions automatically between users and nodes (Casey & Wong, 2013).

The Four Pillars of Productivity Framework:

To maximize the benefits of distributed ledger technology, enterprises must apply it to pre-existing business strategies. This technology cannot be applied to any business section, especially distribution and supply chain management, without the concise practice of strategic planning. By aligning it with relative business frameworks enterprises will be able to apply this technology to increase their competitiveness while planning for the future. As Michael Porter says, "Every organization needs a strategy to deliver superior value to its customers," (Porter, 2008). Furthermore, the framework needs to be aligned with the growing needs of productivity and innovation. Thus, the business framework of the four pillars of productivity (4PoP) is a good fit for distributed ledger technology.

The 4POP framework was outlined in the article titled, 'Four Pillars of Productivity: a systematic solution for Canadian small and medium sized businesses.' The four pillars of productivity are strategy, operations, technology and innovation, they stand upon a base comprised of a solid organizational culture (Chowdhury, 2016). This framework was designed to spur the growth and sustainable continuation of productivity. Thus, its application is a strong match for distributed ledger technology in the sectors of distribution and supply chain management for increased competitiveness.

Culture is the foundation of this productivity model. Without a solid cultural base, the four pillars cannot be supported. When one considers how complex the Blockchain and smart contracts truly are in the beginning, having a corporate culture that encourages continuous learning and fosters innovation is clearly a prerequisite for successfully adopting the aforementioned technologies. Workers must be willing to invest the time to understand and apply the technology to first understand and make use of it, and possibly eventually build upon it

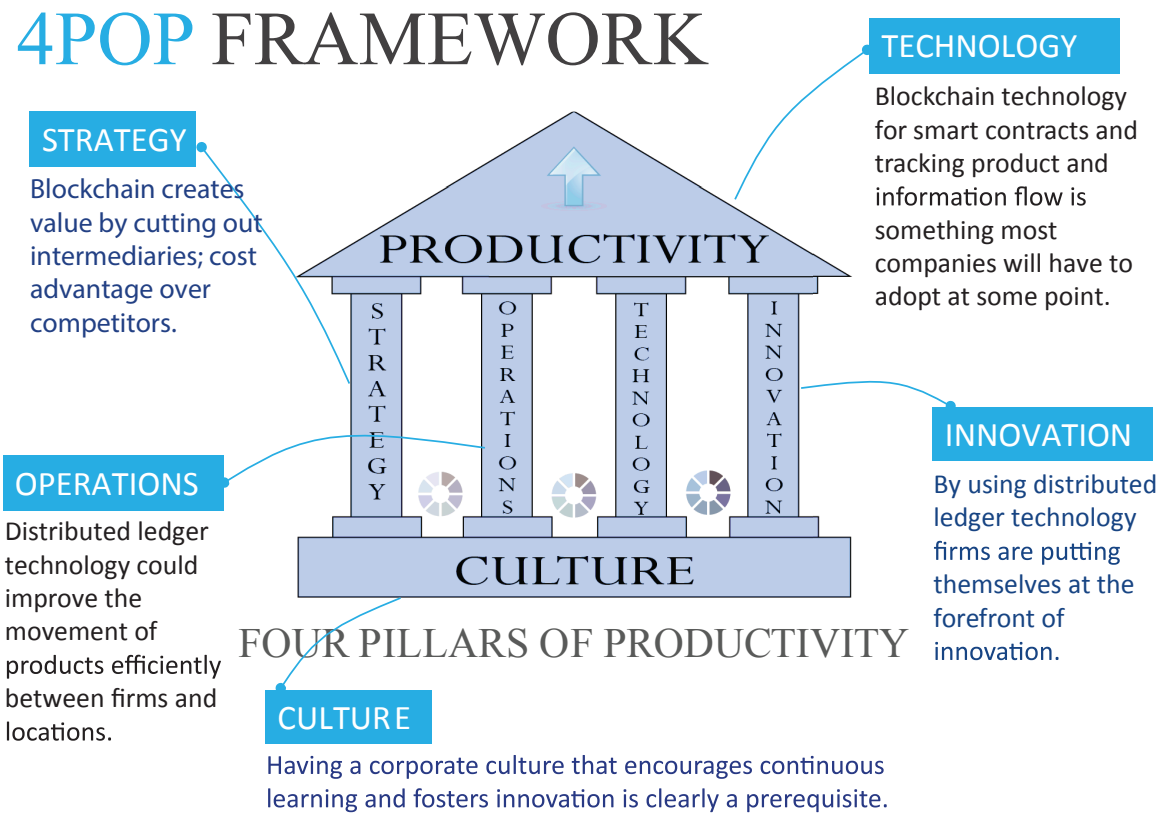

Figure 3. The Four Pillars of Productivity Framework

with new innovations. Without a culture that encourages this, the adoption of blockchain technology in the firm will most likely be unsuccessful.

Strategy is the first pillar of productivity because without strategy underlying the guidance of all the firm's decisions, such as how and where to compete, the firm will find it very hard to make decisions. When decisions are made, without strategy, they often conflict with one another (Chowdhury, 2016). Strategy is essentially about value: creating value, capturing value, and delivering value. Blockchain creates value by cutting out one or more intermediaries. Benefits will be felt by all downstream and upstream partners (other members of the company's supply chain). If implemented correctly, the Blockchain will provide near real-time information about supply chain activity while avoiding the use of some intermediaries. Another strategy framework advocates looking at where a company falls on the degree of differentiation and a degree of cost leadership scale. While arguably most firms could benefit from adopting blockchain based distribution, it is likely those competing on the basis of price will benefit the most, as the technology will give them a cost advantage over competitors. However, even those competing by focusing on differentiation will still benefit from cost savings, and if their customers make use of the blockchain that is an additional novelty that sets them apart from the competition (at least until blockchain technology becomes more commonplace).

The second pillar of productivity is operations. Operations can be described as the tactics and short-term implementation of strategy. Essentially, operations are the physical application of the strategy with increased placement detail. For example, the strategy for distribution and supply chain management would be to implement distributed ledger technology for the differentiation of services and cost reduction, the operations pillar would be how that strategy impacts the day-to-day operations of the firm. In that manner, operations are the decisions that materialize progression (Chowdhury, 2016). The application of distributed ledger technology for operations would be how the shared database could improve the movement of products efficiently between firms and locations. By using this technology firms would be able to see where items are within the supply chain and plan for their continued flow from firm to firm to consumer. It would allow firms to plan each day's operations to an incredible amount of detail and increase efficiency. The real-time data provided would also let the firm know where to most efficiently allocate resources. For example, if a shipment is stuck at customs for some reason, someone can immediately be dispatched to fix the issue (either by phone or by going there in person to get the goods through customs). Better allocation of parts of the workforce is just the tip of the iceberg when it comes to how the real-time information provided will assist operations.

The third pillar of productivity is technology. Technology can be thought of as a tool available to the firm, and as with all the tools the right one must be selected for each job (Chowdhury, 2016). Blockchain technology for smart contracts and tracking product and information flow is something most companies will have to adopt at some point. It does have the disadvantage of being reasonably hard to understand, even on a basic level, and as such only a firm with a culture that encourages learning and change will be able to make use of it, at least for now. The adoption of the technology could take a while for most firms, but those that do it sooner will have some market advantages.

The fourth pillar of productivity is innovation. The 4PoP framework was designed to put companies at a globally competitive level, which makes it a good match for distribution and supply chain management; the fourth pillar of systematic innovation is needed if a company is to become a world leader in productivity (Chowdhury, 2016) . Thus, the innovative technology of distributed ledger aligns perfectly with it. By using distributed ledger technology firms are putting themselves at the forefront of innovation. By establishing this technology within the firm, the firm is creating an environment and culture that encourages and fosters innovation (Chowdhury, 2016). Furthermore, the blockchain technology is such a new phenomenon that new uses for the Blockchain are being discovered at a very high frequency. By adopting blockchain related technologies, it is far more likely one or more employees will begin to try to use it for new applications, so it is a springboard for additional innovation.

In summary, the application of distributed ledger will help shape a firm's strategy for differentiation and

cost leadership and increase operations efficiencies. Furthermore, it will be an effective tool for the creation of sustainable innovation. All in all, applying distributed ledger technology with the framework of 4PoP will lead to increased productivity. Using this framework for the application of distributed ledger technology will increase efficiencies of distribution and supply chain management and increase competitiveness.

Issues in Distribution and Supply Chain Management:

Combined with business strategy frameworks distributed ledger technology has the potential to fundamentally change how businesses and their transactions are conducted. It has been shown that if distributed ledger technology is combined with the 4PoP model it can enhance and increase productivity and efficiencies throughout distribution and supply chain management. To further understand how the application of this technology can benefit these processes, the problems facing global distribution and supply chain management must be identified.

Twenty years ago, the largest problem facing distribution and supply chain management was primarily the physical protection of theft, but today this threat has been surpassed (Pan, Wang, & Xu, 2016). On a global level, supply chain management is facing an increasing number of challenges. In brief, the industry is facing challenges surging from an increasing number of participants, toughening international regulations, and expanding geographical coverage (Pan, Wang, & Xu, 2016). Consequently, the industry faces additional obstacles such as: the inability to track and monitor transactions and supplies in real time, and a lack of transparency and accountability (Casey & Wong, 2013). Furthermore, supply chain integrity and information security are becoming utterly important. To summarize, the existing framework of supply chains faces three crucial issues: integrity of goods, trust, and tracking (Pan, Wang, & Xu, 2016). These challenges and obstacles decrease productivity and efficiency on a large scale, but distributed ledger technology can minimize, correct and prevent them.

The increasing number of participants in supply chain management has many implications and restrictions. In truth, it summarizes all the issues facing supply chain management; the increasing number of participants impacts all obstacles. The main issue of having numerous participants in supply chains is the complexity that comes with each additional member. However, the complexity is a requirement of the increasing demands of global consumerism. Distributed ledger helps to reduce this complexity by integrating all members of the supply chain in one concise and reliable manner. By establishing a distributed or shared ledger between all or selected participants in the supply chain each component would have access to a record of digital transactions. Since the digital shared ledger is updated and validated with each transaction it results in a secure and permanently recorded exchange (Watson Customer Engagement, 2017). Furthermore, a key benefit of distributed ledger technology for supply chain networks is that it establishes a shared, secure record of information flows; it is a shared version of events across networks for supply chain transactions, processes and partners (Watson Customer Engagement, 2017). In short, it helps to mitigate the risks of each issue.

The first obstacle within every supply chain is the tracking and monitoring of transactions. Although there are pre-existing integration technologies such as EDI, XML and API, they do not have the same capabilities as distributed ledgers. A healthy supply chain relies on the efficient exchange of information between a buyer and their suppliers, but more often than not this exchange does not occur in real time, thus causing inefficiencies and delays (Mulholland, 2015). Even the most fundamental types of business communication, such as; orders, shipment advice, status notifications and invoices, are hindered by outmoded, error-prone methods (Mulholland, 2015). Therefore, it is clear that the applications of distributed ledger technology would help. By having a company's network on a distributed ledger database efficiency would be increased while inconsistencies would be eliminated (Pan, Wang, & Xu, 2016). Considering all transactions would be agreed upon by all participants of the network the shared records would enable information to be consistent across all points in the supply chain; this would reduce the processing time between intermediaries from days to minutes by eliminating the timely process of exchanging information between individual members up and down the supply chain (Pan, Wang, & Xu, 2016). By having a shared ledger between all members of the supply chain real time tracking and monitoring could be easily attained. The second

obstacle of distribution and supply chain management is transparency and accountability. Once upon a time the origins of a company's products were murky, and beyond the supply chain function, virtually no one cared (New, 2010). However, that has completely changed; consumers, governments, and companies are demanding details about the systems and sources that deliver their goods (New, 2010).

For example, the United Kingdom and the United States have both passed acts that require increased transparency and accountability. The Modern Slavery Act, United Kingdom 2015, requires organizations netting over $37.6 million a year to publish the steps they will take to root out slavery from their supply chains (Lopez & McKevitt, 2016). The Trade Facilitation and Trade Enforcement Act, United States 2016, restricts the imports of goods produced with forced labour (Lopez & McKevitt, 2016). The recent demand for increased transparency and accountability is due to the ever-increasing number of reports indicating poor practice by numerous companies. Recent investigations into retailers' supply chains have found rampant human rights violations and abuses within the supply chains of fashion merchants ASOS, Marks & Spencer and Uniqlo (Lopez & McKevitt, 2016). Recent reports of poor working conditions at a Nike contractor in Vietnam has stirred further outcries (Lopez & McKevitt, 2016). The accounts have caused individuals to become more concerned about quality, safety, ethics and environmental impacts within supply chain management (New, 2010). Thus, these new requirements increase the complexity of supply chain management.

Distributed databases unlike any other type of technology have the potential to address the need for increased transparency and accountability. A simple application of distributed ledger technology would register the transfer of goods on the ledger as transactions that would identify the parties involved, as well as the price, date, location, quality and state of the product and any other information that would be relevant to managing the supply chain (Dickson, 2016). Hypothetically, the public availability of the ledger would make it possible to trace back every product to the very origin of the raw material used (Dickson, 2016). Furthermore, the decentralized structure of distributed ledgers would make it impossible for the manipulation of data. Therefore, the accountability of the supply chain would be withheld and uplifted to new levels. Essentially, the ability to document a product's journey along the supply chain in this manner is one of the key innovations behind blockchain (Pan, Wang, & Xu, 2016).

Establishing distributed ledger technology for distribution and supply chain management for the purpose of tracking and monitoring transactions would have the additional beneficial effect of increasing transparency and accountability. Consumers' choices could heavily be impacted by this technology as it would allow them to know where the raw ingredients came from, where the product was made, and who made the product. It could revolutionize the way companies decided to market their products while simultaneously increasing their transparency and accountability. However, one issue in distribution and supply chain management remains: integrity and security.

The third and final obstacle of distribution and supply chain management lies within its integrity and security. The exchange of information between numerous members of a supply chain opens holes for potential harm. A supply chain attack, also called a value-chain or third-party attack, occurs when an individual infiltrates a company's system through an outside partner or provider who has access to the company's system and data (Korolov, 2018). The increasing effects of globalization can be felt deeply in these fields; sensitive data is more exposed than ever before.

A survey conducted by Ponemon Institute revealed that 56 percent of organizations had experienced a breach that was caused by one of their vendors in their supply chain (Korolov, 2018). These attacks are on the rise, as this is an increase of 7 percent since the previous year (Korolov, 2018). Furthermore, they showed that only 35 percent of companies had a list of all the third parties they were sharing sensitive information with; meaning that a large portion of supply chains are sharing sensitive information with organizations they may not be familiar with (Korolov, 2018). Ponemon identified six trends as of 2017 that will affect organizations (OPUS, 2017)

1. Data breaches caused by third parties are on the rise.
2. Companies lack visibility into the security practices of third parties but continue to share data.
3. The effectiveness of third party governance programs is decreasing.
4. Companies are beginning to take third party data risk seriously.
5. Third party risk is now a board level concern.
6. Proper governance of third party data security decreases the likelihood of a data breach.

Canadian Marijuana Index

624.64

Constituents	24
Open Price	638.53
Total Market cap	$24.32b

INDEX CONSTITUENTS

Name	Symbol	Last	Volume	Market Cap
WeedMD Inc.	WMD:CA	1.940	192.24k	208.13m
Canopy Growth Corporation	WEED:CA	35.000	5.86m	6.99b
CannTrust Holdings Inc.	TRST:CA	8.570	480.40k	786.25m
The Hydropothecary Corporation	THCX:CA	5.170	2.11m	969.06m
THC Biomed Intl Ltd	THC:CNX	1.140	232.71k	134.83m
OrganiGram Holdings Inc	OGI:CA	4.880	570.46k	608.14m
Namaste Technologies Inc.	N:CA	1.470	1.10m	404.61m
MYM Nutraceuticals Inc	MYM:CNX	1.300	197.13k	143.31m
Maricann Group Inc.	MARI:CNX	1.630	594.54k	217.43m
MedReleaf Corp.	LEAF:CA	24.510	374.87k	2.48b
Isodiol International Inc.	ISOL:CNX	0.680	707.89k	195.52m
InMed Pharmaceuticals Inc.	IN:CA	0.990	237.79k	151.27m
Newstrike Resources Ltd.	HIP:CA	0.670	3.62m	323.97m
Hiku Brands Company Ltd.	HIKU:CNX	1.500	324.72k	211.43m
Invictus MD Strategies Corp	GENE:CA	1.810	482.05k	168.91m
The Supreme Cannabis Company Inc.	FIRE:CA	1.770	473.80k	449.25m
Emerald Health Therapeutics Inc.	EMH:CA	4.210	420.58k	553.18m
Emblem Corp	EMC:CA	1.500	260.16k	166.25m
Cronos Group Inc.	CRON	6.010	1.90m	1.06b
Cannabis Wheaton Income Corp.	CBW:CA	1.390	1.63m	650.18m
Cannabix Technologies Inc	BLO:CNX	1.730	96.99k	167.84m
Aphria Inc.	APH:CA	11.900	3.44m	2.50b
Aurora Cannabis Inc.	ACB:CA	8.020	5.65m	4.50b
Abcann Global Corporation	ABCN:CA	1.440	546.05k	279.80m

Figure 4. Canadian Marijuana Index. Retrieved on May 27, 2018 from http://marijuanaindex.com/stock-quotes/canadian-marijuana-index/

The trends as identified by the Ponemon Institute demonstrate the necessity of distributed ledger technology. Distributed ledger technology has the potential to answer these trends; it would decrease cyber security risks compared to previous company databases (Pan, Wang, & Xu, 2016). The indelible nature of the ledger, with traceability for every transaction, and the prohibitively excessive cost to alter transactions would deter individuals who possess malicious intent from attacking the network (Pan, Wang, & Xu, 2016). In addition, the codified rules increase the supply chain's network's integrity. These rules could even be enhanced with specific conditions to be met before transactions were permitted to process (Pan, Wang, & Xu, 2016). The simple fact of having distributed ledger technology, with automatic ruling, throughout the supply chain would protect against suspicious, unwanted, or fraudulent goods from entering (Pan, Wang, & Xu, 2016).

On paper, it is easy to see how distributed ledgers can drastically impact supply chains and how they operate. It is easy to see how it will help overcome the obstacles of tracking and monitoring transactions, transparency and accountability, and security and integrity. The obstacles in the world of data are becoming more important with each passing day. These obstacles have been highlighted in the growing industry of cannabis in Ontario, Canada. Distributed ledger can be leveraged to defeat these obstacles and resolve public concerns of safety.

High-Tech in High-Industries:

It is no secret, legalization is around the corner. The industry is booming, investment is growing, and a distributed ledger will be involved. Canada's current cannabis industry consists of just medical patients, but in a few short months the whole industry will explode and change with legalization. The potential for distributed ledger technology is endless, and the cannabis supply chain is no different. For the first year of legalization demand has been estimated anywhere between 600 and 900 metric tons in 2018 (Zhang, 2017). Deloitte projects a total market size of $22.6 billion (Castaldo, 2017). The issues that will arise from growing, shipping, and selling cannabis will spur the same distribution and supply chain obstacles previously identified.

The three main obstacles of supply chain management and distribution are the same obstacles that will be present in the distribution and supply chains of the legal cannabis industry. Once more, the three obstacles are tracking and monitoring, transparency and accountability, and security and integrity. Furthermore, distributed ledger technology will help distributors, and provincial governments to minimize fraud and potential criminal activity (Coop, 2018). In addition, it will benefit the medical community of the industry as well.

The first issue of tracking and monitoring is not much different than it is in any supply chain. When data is shared between multiple members with outdated technology, processes take longer to occur. Better tracking and monitoring technology creates better efficiency and productivity through innovation. By being able to track and monitor supplies as they flow through the chain, opportunities for synergies will present themselves. Furthermore, the technology would allow operators to monitor successful products for the purpose of future growing and business planning. Businesses would be able to identify and pinpoint where inefficiencies are occurring and correct them; it would happen immeasurably faster than using paper-trails (Williams & Fool, 2018). The creation of a real-time trail that businesses can follow will benefit them by reducing costs.

The second obstacle as mentioned before is traceability and accountability. Applying distributed ledger technology has many benefits in this regard. The traceability aspect of the technology would grant consumers the ability to trace seed-to-sale and sale-to-seed. Distributed ledger technology provides a far greater degree of reliable accuracy on the metadata associated with products (Mass Roots, 2018). Attached with products could be: times, dates, locations, quantities, crops, strain, chemical make-up and more (Mass Roots, 2018). It would benefit end consumers by allowing them to trace the life cycle of their product. Consumers and retailers will have immutable proof they are getting the product they expect (Williams & Fool, 2018). For medical clients it would give them the assurance that the product they need, did indeed come from where it was said to be from. Additionally, it would eliminate friction

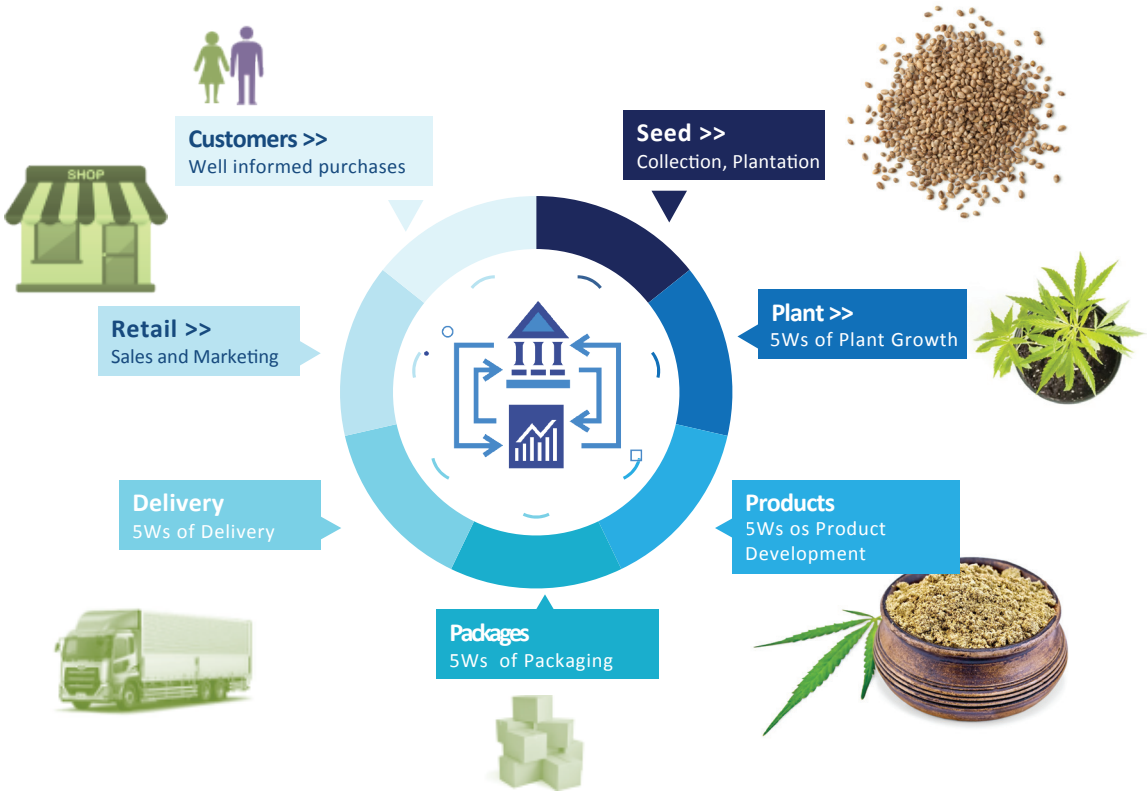

Figure 5. The Supply Chain of Marijuana

in the cannabis market-place, save businesses valuable resources, and provide greater transparency to government regulators (Mass Roots, 2018). As for accountability, distributed ledger records are immutable, and unchanging. Therefore, their transparency would be ideal for financial institutions for the purposes of auditing cannabis companies (Williams & Fool, 2018). Thus, insuring that the companies must be operating in an ethical manner. Government institutions would also be able to use the technology to properly tax the companies, regulate the industry, and know with confidence that the products on store-shelves across the country were grown legally and sold legally.

The third obstacle is security and integrity; similar to the pre-existing problems within the supply chain management industry. As before the main issue in the cannabis industry with security and integrity is with the information being shared throughout the supply chain. Unlike the cases of other industry players, cannabis companies operating in Canada will have the additional security and integrity benefit of working with the government. By being regulated by the government the entire supply chain becomes a more valuable target for cyber-attacks. In addition, integrity needs to be protected for the medical participating members. This is a critical part of having distributed ledger technology connected to the cannabis industry. Furthermore, the industry is pushing towards having online operations requiring individuals to have sensitive data online, by having this system arranged on a distributed ledger consumers, producers, and the government could be assured that all party data would be secure.

Just like any other industry requiring the use of a distribution and supply chain network, the industry of cannabis would benefit from the addition of distributed ledger or blockchain technology. The use of distributed ledger technology would help to increase the ability to track and monitor the fluctuation and flow of product from seed-to-sale. This would give producers the ability to forecast sales with more accuracy while also being able to

pinpoint areas of inefficiency. Distributed ledger would create better traceability benefiting the medical community immensely by providing them the ability to be able to trace from seed-to-sale. The same capabilities would also give the government a way to mandate greater accountability in the industry. The traceability of each plant would prove that all products were grown and sold in a legal fashion. The security and integrity of the industry would benefit as well from having the network on a distributed ledger, which would protect sensitive data.

It is important to note that the blockchain has benefits for all stakeholders of the supply chain, even the sometimes "invisible" stakeholders (such as the government with regard to its role in regulation and taxation). Particularly with Cannabis, there is a great need for transparency and accountability, since an expectation of the people will be that legalized cannabis will be devoid of the problems most commonly associated with illegal marijuana distribution from a consumer perspective: poor quality product, product mixed with harsher drugs to create dependency, and artificially high prices. The blockchain will allow the product's "path" to market to be deduced extremely quickly. In the event that something nefarious occurs, or simply an unintentional error, the point of failure can be quickly established in most cases. This does not only need to apply to interested law enforcement parties, as even consumers could be included and allowed to track their purchases. Several companies have emerged already attempting to integrate blockchain technologies into various cannabis services and enterprises. However, the government will surely want to get involved as soon as possible to handle regulation and taxation. Fortunately, this can easily be achieved by setting up the blockchains to accommodate this. Similarly, academia will be greatly impacted. Courses related to cannabis industries and blockchain are going to see a lot of demand in the years to come. From a botanical, medicinal, and technology perspective, the cannabis industry (as well as blockchain companies) and government entities will want to work with academia to implement innovations as rapidly as possible.

The early stages of a legalized industry or innovative product represent the time at which the most opportunities have yet to be pursued, and the greatest gains are there for the taking. This happens to be the time at which both the industry is new and an innovation that complements it is becoming mainstream. It is the perfect environment for pursuing new ventures with relatively low risk, with possible first mover advantages also present to entice entrepreneurs. Colorado has been finding that despite legalizing cannabis, the illegal cannabis trade has increased. One reason for this appears to be that tax need not be applied on the black market, so the illegal dealers still have a cost advantage. The blockchain is really helpful in this regard, as if someone's cannabis cannot be traced to a legal source through the well-documented blockchain, it means immediately that they obtained it illegally. The blockchain can therefore serve as a huge deterrent, as consumers will not be able to hide behind the excuse that they thought they purchased cannabis from a legitimate source.

Conclusion

The world is changing quickly. The global village is expanding and bringing more businesses and more people together. The networks that criss-cross and connect trade are becoming more complex with more vulnerability. Businesses are struggling to remain productive in the ever-changing atmosphere of global competition. However, this report has shown that the expansion of technology will not just be a challenge of the global village, but a source for better connection. This report has shown how blockchain developed and took the world by storm. It has shown that the true power of blockchain lies within its underlying technology of distributed ledgers. It has shown how this technology works in principle. It has shown how this technology can be applied to pre-existing business strategies for the improvement of productivity and innovation within the realms of strategic business planning. It has shown how the obstacles of distribution and supply chain management can be corrected and reduced through the application of distributed ledger technology. Lastly, it has shown how even in new developing industries, such as the cannabis industry, distributed ledger technology will have a place to make operations more efficient while providing enormous benefits for consumers, producers, regulators and society at large.

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