Using Blockchain for Effective Risk Management in Supply Chain: A Qualitative Study

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Abstract
This study was based on three distinct areas of study, which are Supply Chain Management (SCM), Risk Management and Blockchain Technology. This study analyses and explorers the possibility of using Blockchain for Effective Risk Management in Supply Chain of today's company by doing a qualitative study. In this exploratory study, experts were identified in the field of analysis and they were interviewed and probed further for their opinions and better understanding the field of study. Accordingly, three research questions were identified to build a skeleton for the study to hang on and then further according to the scope each expert was interviewed separately. Finally, a thematic analysis in the guise of descriptive analysis was done, in which the overlaps of different experts were reviewed. The findings revealed that blockchain could be a suitable technology for effective risk management. However, not all companies are ready to adopt blockchain and there is a need to create awareness. All the respondents generally stated that blockchain brings transparency, traceability, and immutability, which reduces risk. Companies should firstly have a willingness to adopt and accept blockchain and sort out any issues. This study contributes to both theory and practice by interlocking risk management and supply chain and the subsequent involvement of blockchain to mitigate risk effectively.

Keywords: Blockchain, Supply chain, Risk management, Effective risk, Supply chain analysis, Transparency, Traceability, Compliance, Standards, Immutability

Introduction
Supply chain management (SCM) refers to the management of the flow of goods, services, and information. It is directly linked to risk management to reduce any impending risks and achieve high performance effectively (Tan, 2001). Supply chain management also includes Supply Chain Collaboration (SCC) efforts between companies, as this improves overall supply chain performance (Soosay & Hyland, 2015). It is indeed noticeable that while SCM is taking place inside a firm or between partners or sellers and buyers by SCC, there is a lack of transparency and trust in the information shared. This leads to more issues and financial losses for the parties involved, primarily due to the high number of the parties involved (Casey & Wong, 2017). Blockchain technology has been in the news since 2009, wherein the cryptocurrency Bitcoin, the first Blockchain application was developed to be used in the financial industry. Underwood (2016) and Zhu et al. (2017) argued that this technology could be the catalyst to change throughout industries inclusive of their culture and supply chains.
Risk management and contingency planning are crucial for companies to sustain and maintain a competitive advantage. Literature regarding risk management exists in several disciplines

(Smith et al. 1990; Simons and Walker, 1999). However, supply chain disruptions creating a domino effect heightened in the last decade (Engardio, 2001), and the related risk is rarely being studied. The disruptive effect of any joint of the supply chain can affect the operations, customer support and distribution of goods. Risk management in SCM has been overlooked by firms wherein there is a significant risk due to long supply chains (Braithwaite & Hall, 1999). Engardio (2001) further stated that these risks had been masked due to flexible manufacturing and just-in-time (JIT) supply chains. Although issues plaguing JIT have been explored, vulnerabilities still exist. (Svensson, 2002). As suggested by a United States (US) distribution giant executive, finger-pointing will increase due to a lack of ownership in supply chains that were highly integrated. This will also exacerbate the risks of products going obsolete due to the lack of responsiveness to fluctuations in customer demand (Souter, 2000). To achieve a competitive advantage, SCM must evolve and improve overall performance by leveraging on SCC. However, SCC requires a more transparent approach (Simatupang & Sridharan, 2002).
Jüttner, Peck, and Christopher (2003) stated that the concepts of supply chain vulnerability and risk management are still in their infancy despite increasing awareness among practitioners. The literature is currently void on how to tackle the traditional supply chain conundrum wherein information sharing lacks transparency, nor is there trust between the different parties or even intra-organization. Casey and Wong, 2017 have highlighted the positive impact that blockchain can bring to the supply chain, furthermore, bringing traceability as well. The gap exists wherein most of the research done about blockchain is mainly revolving around cryptocurrencies, and hence the focus is the financial sector. However, the impacts and implementation of Blockchain into SCM for risk management have yet to be explored. The following research questions have been proposed for this study:

1. How can Blockchain technology be implemented in the supply chain of companies today?
2. How can blockchain technology impact SCM and bring it towards effective risk management?
3. How can blockchain influence long supply chains and information sharing throughout them?

Literature Review.

Supply Chain Management

Currently, there is no explicit definition of supply chain management. The definition of SCM literature is filled with words such as integrated logistics, supplier integration and supply chain collaboration (New, 1997). Although all of the terms address some parts of the supply chain stages, supply chain management covers all of them succinctly. SCM is basically the linking chain amidst the several elements involved in manufacturing till the end-user (New & Payne, 1995). It is also describing relationship management between suppliers and customers along the supply chain, inter-nationally within the organization and, of course, throughout the supply chain (Harland, 1996). The focus of SCM is on firm utilization of supplier processes, capability and technology to coordinate manufacturing, materials management and logistics (Lee & Bellington, 1992). SCM is focused on bringing the end- product from manufacturing to distribution to customers while updating information seamlessly in inventories (Lamming, 1996). SCM encompasses three points which are: logistics, supply and purchase and any activities that add value to the chain. Sharing the information throughout SCC also poses risks such as sole venture and vertical integration of the suppliers or leaks of trade secrets. Integration with itself also brings in punctuality internally and externally, and it limits vertical take-overs as well (Lee & Billington, 1992). Hence, SCM has become a process to reduce redundant waste and increase overall efficiency. SCM has to be more flexible to be responsive to immediate changes immediately to increase performance (Ellinger et al., 2012). Although integration of supply chain activities through SCC is advantageous, however, the implementation is near impossible, mainly due to technological over-reliance, when and whom to collaborate with, lack of trust and transparency (Sabath & Fontanella, 2002) and different work cultures and structures (Fawcett et al., 2010). Long-term SCC requires sharing both benefits and risks based on trust, without which potential negative impact may be borne (Ramon et al., 2017), such as resistance to information sharing (Fawcett et al., 2010).

Risk Management

Risk Management is defined as a variation in supply chain distribution, which disrupts the flow of information, materials, or products throughout the chain (LaLonde, 1997). Any risk management in an integrated chain is a valuable part of SCM wherein decision making is involved (March & Shapira, 1987). In addition, risk management is poorly understood in the context of SCM and needs more research (Braithwaite & Hall, 1999). Supply chain globalization and outsourcing have also increased the chances of disruption in the SCM (Engardio, 2001). Therefore, risk mitigation is required to reduce cost and maintain quality through strategic moves by the organization. Risk management also reduces the vulnerabilities in the supply chain for effective risk management. Risk Management in SCM includes assessing the sources of risk, identifying the consequences involves, tracing the drivers of risk, and mitigating the risks in the chain. Risk includes environment risk, organizational risk, and network risk. Both organisational and environmental risks are due to the supply chain links, whereas the network risk sources are emanating innately from the links (Das & Teng, 1998). Lack of ownership is due to outsourcing, and complex networks arise from a high number of logistical partners wherein relationships are blurred, and responsibility is misplaced. This causes informational disruption in inventory, which is congregational on each link of the supply chain. Chaos is a direct result due to a lack of intra-organizational and inter-partner trust throughout the supply chain (Lee et al., 1997). Therefore, it is understood that network risk sources can either amplify or cushion the effects of environmental or organisational risk. Due to the complexity of supply chains, the risk assessment of such factors is improbable (Gilbert & Gips, 2000) and infeasible, which is the main driver to decision making (Sitkin & Weingart, 1995). Therefore, network risk assessment requires more than traditional tools such as supply chain mapping (Scott & Westbrook, 1991).

Blockchain Technology

Blockchain, most famously known due to Bitcoin, is currently one of the hottest topics in the industry (Swanson, 2014). Casey and Wong (2017) defined Blockchain technology as the exoskeleton behind cryptocurrencies, wherein distinct computers follow a cryptographic protocol for validation through a common ledger. They help in lodging every single transaction in a digital ledger to ideally form a block, which is further added to the general ledger, making up a Blockchain (White, 2017). The block is made up of transactions, which in turn are made up of hashes and data. Data stored in the block has the transaction details and hashes are generated from block data and used for validation (White, 2017), with each containing its own digital fingerprint. New hashes are based on hashes from the previous block. However, that is not the case of the Genesis block, which is the first block wherein the hash has been generated arithmetically (Tapscott and Tapscott, 2017). In the blockchain, each transaction is continuously replicated throughout many computers in a network, maintaining visibility and accessibility (McConaghy et al., 2017). They are rechecked, cleared and saved in the ledger (Tapscott and Tapscott, 2017). Users in the network may remain anonymous. This does not affect Blockchain transactions, which are taking place between Blockchain IP addresses (Casey

Wong, 2017). This renders the block very difficult to manipulate or hack, as such a feat would require total Blockchain mutation (White, 2017). This will maintain the level of security high throughout the Blockchain (Nakamoto, 2008). According to Wu et al. (2017), blockchain can be either on a public ledger over a distributed architecture or a private one on a centralized architecture. The blockchain maintains the level of trust due to no one miner being responsible for the upkeep of the ledger (White, 2017). Blockchain technology is based on a decentralized network with continuous verification from many different individuals or institutions (White, 2017).

Blockchain can create value for the firm and the supply chain as it can be used in various situations (Tapscott and Tapscott, 2017). Bocek et al. (2017) touch upon the usage of smart contracts through blockchain, wherein an independent contract is created without any middleman such as banks or lawyers (Fairfield, 2014). Enterprise Resource Planning (ERP) systems are currently used for information sharing, which requires intermediaries to store the data (Nakasumi, 2017). In contrast, the dependency and vulnerability can be eliminated using blockchain, a decentralised network (Bocek et al., 2017). Casey and Wong (2017) argued that the blockchain could find time delays through the supply chain. This is due to the tracing and tracking nature of Blockchain (Glover & Hermans, 2017) wherein the supply chain can be monitored (Casey & Wong, 2017). However, some limitations exist in Blockchain adaptability into the supply chain due to the complexity of bringing all the partners together to integrate their supply chain (Clancy, 2017). Zheng et al. (2017) argued about Blockchain scalability due to limited transaction handling to ensure high security in the blockchain. Kshetri (2018) argued that due to the global supply chain, blockchain might be difficult throughout developing countries due to a lack of ability.

Furthermore, laws and regulations also prove to be barriers to the implementation of Blockchain (Casey & Wong, 2017). Although the interest of Blockchain adoption is high, however little research exists about Blockchain implementation in the supply chain. This is what is going to be studied with its implementation and possible effects on efficiency.

Research Methodology

Research Design

This research was based on Interpretivism philosophy. Interpretivism advocates that the researcher must understand the differences between humans in our role as social actors. This emphasizes the difference between conducting research among people rather than objects such as Blockchain (Saunders et al., 2016). This research is based on an inductive approach that is used as this research falls under a qualitative exploratory study. This is the way to find different perspectives on the research topic wherein the current experiences in the society can be used to maintain the truth. The study is using a qualitative where a cross-sectional time horizon is maintained. Data collection is done through expert interviews. The qualitative data was collected from experts is subjected to subjective interpretation to understand and study the imminent implementation of technology like blockchain for risk management in the supply chain (Saunders et al., 2016). The reason behind using qualitative methods was to seek in-depth and condensed information about Blockchain technology (Saunders et al., 2016). This method allowed the researcher to have a deeper understanding of the research area by considering the study population's perspective and the context in which they live (Hennink, Hutter & Bailey, 2011). In addition, a qualitative research method is the most suitable to answer the questions of ’why’ and ’how’ (Hennink et al., 2011).

Sampling and Data Collection

Judgmental sampling was used to attain expert views in the field. Snowball sampling was used wherein one expert can refer to other experts in the field. The researcher was involved in identifying and selecting individuals that are exceptionally knowledgeable about or experienced with Blockchain technology (Cresswell & Plano Clark, 2011). Scholars have argued that for qualitative studies, the determination of sample size is problematic. As stated by Saunders et al. (2016), the recommended sample size for semi-structured interviews is between 5-25 respondents. As stated by Saunders et al., (2016), the sample size is often adaptive and emergent, and as suggested by Saunders et al., (2016), the principle of saturation was adopted. In this study, the data was collected until the saturation point was reached where additional data collected provide little, if any, new information (Saunders et al., 2016). In this research, five respondents were selected, and a semi-structured interview method was used to collect data. The appropriateness of an interview in our study stems from the fact that there is little empirical data on Blockchain implementation in the supply chain and its effect on risk management. Therefore, expert views must be considered from the industry. This type of data collection helps solve complex questions, and while in such an interview, the interviewer can probe further to attain more information regarding some new factor that has been uncovered which may affect the study's outcome (Gubrium and Holstein, 2001). In this study, the semi-structured route was used wherein the only reference point was to have the three research questions answered by asking questions and further probing the interviewer towards the requirement (Gubrium and Holstein, 2001). The interviewer used Skype and telephonic interviews, which were then recorded. Although the interview's planned length was around 30 minutes, some respondents exceeded the one-hour extra limit. In total, five interviews were done, ranging from industry experts to Blockchain developers. The interview recording was done with the permission of the respondents. All the respondents wanted to stay anonymous. All the respondents were, therefore, given a pseudonym in order to protect their privacy.

Table 1: List of Respondents

Interviewee (Not actual Name)	**Job Type**	**Interview date**	**Length of Interview**
Surya	Blockchain consultant	16 Feb 2019	1 Hour
Stefan	Blockchain developer	22 Feb 2019	1 Hour 13 Min
Sarfar	Blockchain developer	25 Feb 2019	1 Hour 24 min
Alo	Functional Analyst	26 Feb 2019	31 Min
John	Blockchain Consultant	4 March 2019	32 Min

Data Analysis

To collect data, the researcher participated in a Blockchain event. This was followed by networking and follow with the experts in the field to collect more information. The interviews' objective was to find out the impact of Blockchain technology on the supply chain and its consequent effect on effective risk management. In the analytical process, we followed the five analytical phases: Compiling, disassembling, reassembling, interpreting, and concluding (Yin, 2011). These steps could be done due to the nature of the interviews being recorded with prior permission granted by the subjects. The data recorded in the interviews was uploaded onto YouTube for ease of access while transcribing, after which the SubRip Subtitle file (SRT) file was downloaded and re-edited to check for any inconsistencies. After all the data was downloaded, it was then put into a Word file. This was followed by disassembling the data into different themes and being placed under the previously created three research questions. This was done to make some sense around the thematic analysis, wherein common themes were identified alongside keywords and sentences. In the next phase, which consisted of reassembling, every single theme was readjusted, and new themes where needed were introduced wherein other data could be placed as in new factors were realized. The fourth phase, which was the interpretation, was done after going through all the data several times. The findings were then onwards realized through our own understanding of the data analysis and by connecting the literature review and cross-examination and validation of previously held notions about the involvement of Blockchain in SCM. Finally, a conclusion was made upon the very stable foundation formed throughout the analysis process. It should be noted that not all the steps were followed to a specific point or in the same order (Yin, 2011).

Findings and Analysis

This section presents the Qualitative data analysis on the gathered data from the interviews conducted wherein each interview is presented case by case due to the difference in their views about Blockchain solutions. The main objective here is to answer each research question by explaining how blockchain can be implemented into the supply chain of current companies and how it will help us reach effective risk management.

Interviewee 1 (Surya)

RQ1: How can Blockchain technology be implemented in the supply chain of companies today?

According to Surya, the implementation of blockchain in any supply chain in companies has an inherent problem. Generally, blockchain has become a hype. This means that a lot of people believe they need blockchain. However, that is not the case scenario. This is because a smaller company does not require it because blockchain is like any other software in the market whereby a smaller company does not require to create codes to do certain work because existing software are enough to do the tracing or whatever is required. The interviewee stated that a blockchain is a software that does traceability. The records may be changed, but the Blockchain benefits from immutability wherein the records cannot be changed. Blockchain logs everything as it is without any change being made once the recording is done. Surya added that blockchain must be a standalone software, and it cannot be put on top of pre-existing software in the supply chain. Companies want to implement blockchain, but they go for private blockchain to enable them to retain data inside their own company. Company A can have a private Blockchain whereby suppliers will be given a specific access code for certain areas to the private blockchain to enter and put in information.

RQ2. How can Blockchain technology impact SCM and bring it towards effective risk management?

As mentioned in the previous research question, Surya, reiterated that blockchain brings in Traceability and Immutability, therefore, reducing the risk in the supply chain. Surya gave an example of a gaming company A which creates a gaming CD, where after the employee takes the CD and records it in the blockchain that he is taking it. The employee takes it and travels to delivery point B, wherein the second company scans it, saying that the CD is received. The moment the CD is received, the money will be transferred immediately to the gaming company A. Everything is automatically recorded with timestamps and whoever took the shipment and it is immutable; therefore, the records can never be changed. In this way, the person who took it, the risk goes down because the employee is tracked and traced from destination A to B, wherein there is a lag in delivery. Therefore, there is no worry about employees being late and lagging on the delivery. The CD itself can be tracked and traced in its casing until it reaches its destination. This reduces the risk of stealing and hijacking the item. The same can be applied to the supply chain.

RQ3. How can blockchain influence long supply chains and information sharing throughout them?
Surya gave an example of an airline company from a different country. The airline and Post Aviation have a contract wherein some food supplier company sends food containers to through Post Aviation to be received by the airlines. In our case scenario, perhaps 100 food containers for inflight meals were ordered. However, once landing back in Kuala Lumpur Airport (KLIA), the airways reported that only 80 containers were sent. The discrepancy can be solved through IoT and Blockchain implementation into the logistics, whereby at every point, scanning is being done. Surya also went on to explain about the different Blockchains. For instance, if two companies have Blockchains but set up by different companies, they can be tweaked to communicate with each other.

Interviewee 2 (Stefan)
RQ1: How can Blockchain technology be implemented in the supply chain of companies today?
Stefan mentioned that in his opinion, the supply chain in companies these days is divided into five different categories. The first one being financing and the other four related to operations. The four different categories are production, warehousing, logistics and distribution/trading activities. Financing needs to be backing these four categories to ensure easy running. Supply chain companies' main pinpoint is that they require Transparency and Operational Efficiencies in the supply chain, which would be brought in by blockchain.
Furthermore, Data Collection is required to do analytics and improve operational efficiencies, which would be coming from IoT (Internet of Things) devices. According to Stefan, transparency needs to be improved in a supply chain due to much fraud that can happen in the supply chain. Stefan explained that blockchain brings in Immutability and Transparency. Immutability means that once something is recorded inside the blockchain, it cannot be modified nor erased. In that way, traceability can be maintained since everything is recorded. Stefan added that the correct record must be added, and once recorded, it cannot be changed. A company that wants to implement blockchain needs to adopt the" Spirit of Blockchain," which refers to Immutability and Transparency. Transparency means that once the data is input in the blockchain, every single participant in the blockchain can see whoever recorded it in the blockchain. However, at the same time, the blockchain is giving the user some privacy to the user by knowing that some information was put in, and the information was updated or not. However, without the private key, a person cannot see the content of the information. Stefan further added that there is no restriction on the company's size that wants to implement blockchain. However, the willingness to adopt should be there and an understanding of their own demands by using blockchain. Before implementation, the requirements should be clarified and the Blockchain consultant should sit down with the company and discuss the company's needs. Stefan further stated that companies should use blockchain if they have big concerns and a deep understanding of transparency of the operations. The effectiveness of blockchain is dependent on the correct information was put into the blockchain. In addition, blockchain is thought by people to be able to handle a very big volume of data, but that is not true. The blockchain needs to be customized and optimized to minimize delays and lags. Blockchain technology is very young, and it needs time to stabilize.

RQ2. How can Blockchain technology impact SCM and bring it towards effective risk management?
Stefan explained that typical risks in the supply chain system are fraud and operational risks. Transparency is there in order to avoid the risk of fraud. That is the reason why blockchain is called a decentralized ledger (Bocek et al., 2017). If one part is destroyed, the data can be

recovered from another place in a snap. Every node in the Blockchain stores the same data. So, to remove the data, every single node would be required to be destroyed. Therefore, fraud prevention can be done through blockchain and it brings in Traceability and Operational Efficiency. Operational efficiency can refer to paper-less, meaning to say digitalizing data reduces paper usage." A unique id can be given to each product, so when call-back is done, then the manufacturer must confirm that the call-back product has been received back by the manufacturer. If the confirmation is not sent, a smart contract can be used to self-destruct mode on the tag, wherein it would notify the system that this product is spoilt, and therefore fraud can be prevented. In order to adapt to the complex operation in the supply chain, IoT devices need to be used. Therefore, the implementation of blockchain mainly would require IoT devices in production and logistics but not much in distribution. Risk can be reduced through the Immutability, Traceability and Transparency.

RQ3. How can blockchain influence long supply chains and information sharing throughout them?
Information can be shared seamlessly due to decentralization. This is supported by other scholars (White, 2017; Bocek et al., 2017). The data copies exist on every node. Stefan also explained that the more concern of privacy is there amongst distributors, retailers, producers, or consumers. For example, a different distributor would like to know the source of the product. However, that might be a trade secret against a competitor. Even though all the data is on the blockchain, this does not mean that trade secrets would be leaked. This is because of the private key, which allows us to see the contents of information and public key, which allows us to see the existence of information. A person can see the data existing but not the contents without the private key. The outcome is that once blockchain is implemented in the long supply chain, the trustfulness of the blockchain can be increased. Other than compliance with standards, blockchain helps increase operational efficiencies. Fraud cannot be prevented from the beginning, however, who created and when can be traced back on the blockchain. Paperwork is reduced without any copying nor back writing, as the data on the blockchain is correct. Stefan really advocated for self-checking for companies to refer to for them to know if they really require a Blockchain.

Interviewee 3 (Sarfar)
RQ1: How can Blockchain technology be implemented in the supply chain of companies today?
Sarfar iterated here, that first thing that needs to be decided is the company wants to create their own blockchain or if some existing Blockchain is to be used for their supply chain management or risk management. Sarfar explained that blockchain is a buzzword these days and everyone wants in. Therefore, when a company intends to implement blockchain, then the Blockchain consultant would have to ask questions to determine whether a Blockchain is required. Therefore, the first question to a company would be to assess the existing system's issues and the volume of data that needs to be shifted to a distributed database. According to Sarfar, the existing system does not need to interact with the blockchain, and therefore blockchain must be a standalone system. The only link between them would be at the time migration only. Blockchain should be a database with Immutability, Traceability, and Verifiable. Sarfar explained the reason behind a standalone software is that only one-time migration is required. However, if the software liaised with an already existing software for every data transaction, data would have to be pulled, which would cause time delay.

RQ2. How can Blockchain technology impact SCM and bring it towards effective risk management?

Sarfar reiterated that blockchain brings in Traceability and Immutability, which further reduces the risk in Supply Chain. If someone did something they were not supposed to do, they could be tracked through blockchain. All data is migrated, and people are assigned to specific tasks, which is also stored in the blockchain. This further supports traceability. The network is trustable due to the immutability of the data. When banking was mentioned, Sarfar exclaimed that even though banking does send salary credit at the end of every month to the accounts of employees, but it can only do that much. He added that Ethereum has the possibility of doing complex operations through the usage of smart contracts. In terms of chaos being a risk, the smart contracts functionality can be leveraged, therefore decreasing risk.

RQ3. How can blockchain influence long supply chains and information sharing throughout them?

Sarfar stated that information could not be changed due to the Immutability nature of the blockchain. According to Sarfar, Blockchain provides the same benefits for short or large supply chains as it can contain huge amounts of data. It is easy to track the complete history of products and blockchain has an inherent property of keeping reliable and verifiable data. This is advantageous for long supply chains. Sarfar also added that blockchain is un-hackable and it cannot leak from the blockchain itself, as long as privacy protocol is secure. However, information can still be read by others whenever the usage of insecure communication channels. To overcome this, most nodes of the network implement high-security measures for the communication channels. Any new nodes joining the Blockchain network would have to follow enforced rules of the blockchain, and if the node does not comply, then the nodes joining request may be denied. Sarfar also argued that viruses could not come into the blockchain because each node can easily verify the data being sent to it by following through with the hashing algorithm of the blockchain. Sarfar also mentioned that having a Blockchain network in the supply chain would ensure that the network is at the highest level of protection and no data can be taken out or edited in without being found out. Blockchain makes sure to keep the sanctity of the information being shared and the information sharing is seamless. Only one node needs to be connected to, for information sharing. Therefore, as long as the node is connected, information sharing is instantaneous. There may be some network latency issues.

Interviewee 4 (Alo)

RQ1: How can Blockchain technology be implemented in the supply chain of companies today?

Alo explained that most established companies feel that they do not have any significant purpose in implementing blockchain. However, concerns of Traceability and Transparency should encourage them to explore into blockchain and self-assess. He talked about primarily needing a feasibility study to make sure which parts of the supply chain would like to explore in terms of adopting the Blockchain technology. For this, he iterated that a Proof of Concept (POC) would be made and then assessed whether this POC could help achieve the objective defined by the company. Alo emphasized that there is no commercialized solution for a company to implement blockchain because this technology is still very immature.

Furthermore, knowledge about Blockchain technology is lacking. Therefore, one way to implement blockchain would be by making a POC. The other solution was to implement blockchain on top of a company's current Enterprise solution, which is used to trace and track orders. As such, blockchain would come in to complement and improve the company's supply chain collaboration (SCC) with different entities. This will help achieve a high Traceability of any products or any documentation or even medical records. Alo explained that blockchain is more suitable for a longer supply chain. However, it is a grand challenge because not everyone is well aware of blockchain, and there is no one product that can be commercialized and used on a large scale for different companies. Therefore, when POC is done and pilot projects are done, this shows companies and other interested people the usability of blockchain and raise awareness to allow to create an ecosystem wherein blockchain is readily accepted.

RQ2. How can Blockchain technology impact SCM and bring it towards effective risk management?
According to Alo, Blockchain brings in another dimension of traceability in the entire supply chain wherein many partners are operation, but more as silos, that do their own checking for their own stuff. Blockchain would bring in true transparency and traceability to the supply chain and it would enable each party involved to view the whole processes and steps from start till end. Alo said that each party in the supply chain would have different risks and give an example of a retail store that risks customers buying defective products and then blaming the store for not having good quality and asking for reimbursement. However, the defect was never due to the store's negligence, but at the manufacturing level at a particular production line. Alo explained that at the current system application level, a trace cannot be kept on the production line or which machine or pipe conducted this defect. Therefore, such a risk brings huge losses in money when they are recalled from the customers' hands. Blockchain can prevent that by bringing in full traceability from end to end so that a full recall or cut of the entire batch is required if anything happens. Blockchain will help drill down to a specific root cause. In turn, this would reduce risks in the supply chain as in today's market, a lot of recalling and discarding of goods occurs, especially in the pharma industry where the manufacturer alone all the parties do not bear the cost in millions.

RQ3. How can blockchain influence long supply chains and information sharing throughout them?
Alo explained that information sharing is about the traceability of information. That brings trust into the system. He talked about the immutable nature of blockchain. He explained that once any data is entered into the blockchain, it is then cryptographically secured from any change, deletion, amendment, or hacking. If any amendment is required, a new record has to be made to explain that the previous record is wrong and the new one is right and, in this way, transparency is maintained for all partners of the Supply Chain. Three distinct points were touched by Alo, which were Traceability, Transparency, and Immutability. The current supply chain does not have full traceability. It lacks transparency due to many different partners and supply chain collaboration (SCC). Moreover, there is a lack of immutability, as data can be changed. Another point Alo introduced to our discussion is that blockchain is technically a database, so it stores information, and as such a weak point of blockchain is if data entry is wrongly recorded, then it is going to be tracked the whole way and the authenticity of the data entered will not be there. Therefore, blockchain can create a variable scenery if it is used alongside with IOT (Internet of Things) devices whereby human intervention is reduced as keyed in information is digitalized. This complementation with IOT would bring another level of trust, reliability, transparency and data integrity.

Interviewee 5 (John)
RQ1: How can Blockchain technology be implemented in the supply chain of companies today?
John explained that a blockchain is genuinely only a new form of data structure. What makes blockchain different and extraordinary is because Bitcoin led it. It has proven that the transfer of value between parties can be kept a transparent and trust-less manner without needing any

middleman. He iterated that the key issue plaguing today's supply chain is trust. He explained that trust-less means that transactions can be performed without any party needing to trust each other. Therefore, the trust-less manner itself brings in the high trust in blockchain as in technology. For instance, the key concern of an organization arises due to trust and the authenticity claims of how a product is made and its processes. In his opinion, the first step for a supply chain company to implement blockchain is to earn the trust of the parties involved in the supply chain, such as the customers, producers, or manufacturers. The better way for a supply chain company is to focus on what they do well and what really attracts others to do a transaction with them. This will form the foundation of trust. He explained that blockchain is not the only solution needed for the supply chain. It should be coupled with IoT (Internet of Things) devices to capture and digitize data immediately into the blockchain automatically with little human intervention. The supply chain requires the transference of real-world data on to a Blockchain and in this process, trust should be earned, processed should be shown to all the parties, in turn getting everyone's trust. Blockchain should also be coupled with" AI (Artificial Intelligence) to detect bad actors in the network and employ the best cybersecurity engineers to safeguard the integrity of the data."

RQ2. How can Blockchain technology impact SCM and bring it towards effective risk management?
Disintermediation is a huge cost reduction and if the trust is maintained, then the risk is lower. When trust is lower, then the risk is higher. Only when a supply chain company can demonstrate trust, then you get a platform that may be machine automated. John explained that in the past, authorities' verification was done, which can be removed, and it reduces costs. This means that before introducing the blockchain, the risk would have already been lowered. The only additional factor Blockchain brings to bring any manual intermediary, which would be the human factor that raises the risk level. He explained that apart from that, blockchain might give other benefits for risk management. Blockchain can provide a data structure, where data can be authenticated and verified in a decentralized manner. This does not require any party to trust any other party but only to trust the blockchain itself. Human factors bring distrust, and this can be taken away by blockchain, which lowers risk, and the data can be verified through AI, and whatever entry is done in the blockchain is through IoT.

RQ3: How can blockchain influence long supply chains and information sharing throughout them?
He stressed that blockchain's influence lies in its ability to capture trust. The beauty of a Blockchain is that if a person can capture trust for a short supply chain, the same is true for a long time; it is just more complex. Thus, the process of earning this trust is ironically a very labor-intensive human process. It is both a technical and psychological one." John also continued to explain that blockchain may bring disadvantages mainly due to blockchain not being for everyone. Everyone wants to create a faster transaction. On the front end, a much more enhanced experience is brought to the customer, however, on the back end the work is more tedious. Verification of a transaction is easier to get approval from one person, not from every single person in the company. That is why this must be taken into context as well. Decentralization is not always good for everything. He explained when one can know if one needs to use blockchain or not. When two parties want to transact and can trust one another, there is no need for a Blockchain. When two parties want to transact and one party cannot trust another, maybe there is a use case for a Blockchain. When two parties want to transact and both cannot trust each other, blockchain can help."

Conclusion and Discussion

This study aimed to get an insight into how blockchain may be implemented in the current supply chain to bring in effective risk management. Three research questions were made to answer the main objective of this study. This was followed by conducting interviews with experts in the field and going through existing literature to form an understanding of what risk management is, what blockchain is, and what does supply chain include. Furthermore, a link was created between these three to understand how risk affects the supply chain and what is required to mitigate it and can blockchain be the latest solution for effective risk management in the supply chain. For this purpose, the potential applications of blockchain were studied, and then it was reviewed on how blockchain can be implemented in the current companies' supply chains.

In all the interviews, a convergence was seen at the main themes of Immutability, Compliance of Standards, Traceability and Transparency. All the interviewees agreed on all the main themes existing in the blockchain, and how that brings advantages to the Supply chain. The findings showed that blockchain is an emergent technology that should be given a chance to help change and bring forward the supply chain. This study found that there is still little awareness of blockchain, which limits the willingness to adopt it. Generally, the data analysis showed that the blockchain brings in the amazing benefits of immutability whereby data becomes tamper-proof.

Furthermore, through analysis, it was understood that smart contracts are, in reality, just macros that are implemented in today's traditional system; however, these ones can input data into the blockchain. It was also heavily implied by Interviewee 5 that disintermediation is the reason for reduced costs; however, the others believed tracking and traceability to be the points contributing to reduced costs. Furthermore, Interviewee 3 argued that the implementation of blockchain as a standalone software might reduce costs from traditional software that are costlier to upkeep. However, most of the interviewees agreed on one more point that the implementation of blockchain would require IoT devices, and that is a definite steep cost. However, it is cheaper to operate on IoT because it brings transparency and credibility due to digitalization and reduces human error at the input point.

All the interviewers agreed on blockchain being confused for Bitcoin, and that it is a hype and a buzzword these days. Therefore, companies before coming to implement blockchain should go through a self-assessment checklist. The high level of transparency and traceability with information security due to the blockchain's unhackability were mentioned as key advantages when sharing information alongside long supply chains. It was also hinted that the longer the supply chain, the easier it is to verify the transaction made, as the number of good actors would be higher than the bad actors. Financial Blockchain can be compromised. However, this would require more research as blockchain is still a very young and immature technology, and the sky is the limit when evolution occurs in technology. It is noted that blockchain offers a way to keep data secure and give ownership to the data, which may not be changed once entered. However, that brings another question: where the data will be stored, there must be some limit to storage capacity, and that should translate to the physical world.

RQ1: How can Blockchain technology be implemented in the supply chain of companies today?

The conclusion for this research question was that before anything, a self-assessment check should be done by any company looking into blockchain. First, awareness has to be made for blockchain, and that will bring in the understanding of Blockchain adoption. It is understood that not all companies require blockchain. Furthermore, the implementation of blockchain may be partial on the supply chain, and full implementation needs more research to be done. It also has to be understood that blockchain is not the answer to all problems, and as John put it beautifully, it all boils down to trust and how to secure data has to be kept.

RQ2: How can blockchain technology impact SCM and bring it towards effective risk management?

It was mentioned that blockchain brings Traceability and Immutability, which reduces risk. It was also mentioned that everything, even environmental risks, can be recorded into the blockchain. In addition, AI and IoT combined with blockchain will bring about a change in the current supply chain, and this will increase the effective risk mitigation in the industry. Blockchain was still at an early stage; there might be other ways to reduce risk through its usage in the supply chain. The typical risks were fraud and operational risks and transparency in blockchain will help overcome such risks as data can always be recovered from different nodes that have the same true copy.

Traceability and digitalization will increase operational efficiency by going paperless. In addition, IoT implementation will help provide the correct on-time information that can help prevent fraud as risk can be reduced through the immutability nature of Blockchain, Traceability and Transparency.

The exact same view was held by Interviewee 3, who talked about tracking anything that was done, as it would be recorded in the system. Sarfar agreed with Surya about the environmental risk and he gave another view of using smart contracts in a blockchain that can operate as a macro. Stefan actually agreed with smart contracts being truly a macro. Sarfar went on to talk about chaos being a risk, and that a smart contract can be leveraged to reduce any chaos. He also talked about implementation time and cost due to extra infrastructure, as he was supportive of IoT usage as well. Sarfar agreed with Surya that Blockchain can be a standalone project. However, Stefan argued differently, stating it is between the front-end and the back end. Alo held the same view of transparency being brought in the supply chain through the use of blockchain and he talked about mitigating risk through traceability, agreeing with others. John, however, explained that even though immutability exists, it is different for centralised and decentralised networks, and true immutability may never exist, other that networks like Bitcoin. Everyone commenting on immutability also commented on the issue of human error and then sup-ported the use of IoT devices.

RQ3: How can blockchain influence long supply chains and information sharing throughout them?

Surya explained that companies should firstly have a willingness to adopt and accept, wherein two companies can sort out issues through Blockchain usage in the supply chain. For example, in the case of missing luggage from the airport, who would be held responsible that is the ground authorities or the airline. Like the others, Surya held the view that although different blockchain can communicate and can be tweaked to do so, research is still being done on that front. Surya gave his view that sooner or later adoption of one Blockchain platform might take place. This would make it better for different companies to liaise in their supply chain while keeping the benefits of Blockchain implementation for effective Risk Management.

Stefan gave the view of a private key and a public key wherein the private key gives access to the information required, how-ever the public gives access to knowing if the content exists or not. He was of the view that the longer the supply chain was, the more trustworthy it can be, and this would bring about compliance of standards. Furthermore, Stefan reiterated that fraud could not be prevented due to human intervention; however, it can be traced due to blockchain. Stefan also added another view that although companies like IBM are providing general solutions, it is better for companies to seek customised solutions to ensure their operations are not affected, which would also be easier to adopt. Although, Stefan agreed that currently, two

different Blockchains could not communicate, however, research was being done. If requirements arise, then distinct Blockchains can be merged with each other seeing the situation. However, there is no general solution available now. Stefan added that although blockchain is less expensive than the traditional software, the implementation of blockchain might require IoT devices, which might be expensive right now; however, the cost will diminish as days go by is a better solution in the long run. Stefan also concluded that blockchain brings the same benefits regardless of the supply chain's size and that the cryptographic nature of blockchain safeguards the supply chain.
Alo said that information sharing depends on information traceability, which can be provided through blockchain due to its inherent immutability and cryptographic nature. Alo also mentioned that information sharing also requires transparency and traceability wherein the current supply chain does not have these both, and therefore trust is low in supply chain collaboration (SCC). In this regard, blockchain can bring in true supply chain collaboration without the need to trust the partners, but trusting the system is enough. This was reiterated by John as well. All respondents agreed that human error in the input is one of the disadvantages of blockchain, primarily due to its immutable nature. They mentioned that Blockchain implementation might be costly as it involves transaction fees, and the more the transactions, the more fees would have to be paid. Alo was strictly against a private Blockchain, and he advocated a public one stating that it brings innovation. Although, the private blockchain, according to Alo, was cheaper to implement. However, it increases the risk of data loss and issues in supply chain collaboration wherein partners want sole ownership. This can be resolved by using a public Blockchain.
John gave the real disadvantages of blockchain, especially hit home with everyone about Blockchain hype getting people to come in without the need for its implementation. Like others, he said that a self-check list must be sent round-robin to every company that is not as much aware of blockchain. He also explained that decentralisation was not always good and should be seen case by case. John further argued about immutability being dependent on the extent of centralisation, hence completely trying to disprove a critical notion of blockchain being immutable. John suggested different consensus models such as Proof of Stake, mainly because the Proof of Work consensus model used for Bitcoin is very energy consuming. He explained that the longer the supply chain, the less the risk and the more the data is authentic. Finally, he concluded that blockchain is still new, and research is still being done on how to make it less risky and more advantageous.

Implications

This study contributes to both theory and practice by interlocking risk management and supply chain and the subsequent involvement of blockchain to mitigate risk effectively. As a performance-enhancing strategy, Blockchain may be coupled with AI and IoT devices to bring in an era where information is kept secure and untampered. This also reduces trust issues faced by many players in the supply chain. Contributing theoretically, research about supply chain, risk management, and blockchain was introduced and then delved into. Next, all three topics were interconnected, and the convergence points were examined regarding the framework. The interviews were done to strengthen the already limited literature found on the topic, and newer findings were made through expert knowledge, which gave back to literature bring in an added layer of explanation to already young Blockchain technology and its implementation into the supply chain. These findings give a more holistic view to the supply chain industry coupled with the technological advances and newer technologies and their adaption in the industry, such as AI and IoT. The analysis of Blockchain usage in the supply chain for effective risk management is done in-depth and supported by both literature and expert interviews. Due to this way of an exploratory study, it helps the common man to understand and be made more aware of new technologies like blockchain and also understand its limitations and causes of concerns in business especially in their supply chain, and how risk can be managed effectively in those companies by the help of blockchain. People can refer to our findings and understand and analyses the different aspects presented here to be able to find their own solutions for risk management in the supply chain and the usage of blockchain in business strategy and development alongside the usage of AI and IoT.

Limitations and Further Research

This study is an exploratory study that delves into a new topic in the industry that is still young and a proper hype in the industry. Risk management has always been one of the main aims of a business, however effective risk management through the usage of technology such as blockchain coupled with AI and IoT is still new. Therefore, it is understandable that there are many limitations and further research is required in this field of study. The main reasons for this are the limited literature on this topic and the technology of blockchain being relatively new. All the companies that are proclaimed experts in the field are also discovering new places and ways of Blockchain implementation. The evolution of blockchain is as per Murphy's Law for Transistors. In the few years, blockchain has traversed an era, and in a few more, it will take us through a millennium of innovation. All of this means that more research must be done in this area, and the expert views might also change with time. As seen in the discussion, there are some places wherein experts do not agree as well. Moreover, it should be noticed that due to non-availability and time concerns, we were only able to get five expert interviews. The inconsistencies need further research to find more concrete answers. In-depth views of the experts in this field require more research to get more in-depth and consistent answers for all the questions raised. A longer time horizon would have been used with a time change study over a year; we believe it would have given a better and more in-depth view of blockchain and how it is evolving over time and impacting the supply chain, consequently effective risk management.

Furthermore, another dimension that may be studied is through governmental initiatives that provide ample research opportunities and funding to conduct the research with greater access to our time's leading minds. A study done in this way can give a better view and a more abundant explanation of how the industry is changing by the introduction of blockchain as a technology coupled with IoT and AI in addition to its impact on supply chain and risk mitigation.

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