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**Anwendungen und
mögliche Auswirkungen der
Blockchain-Technologie in
den Bereichen Logistik und
Lieferkette**

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Anwendungen und mögliche Auswirkungen der Blockchain-Technologie in den Bereichen Logistik und Lieferkette

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Applications and Potential Impacts of Blockchain Technology in Logistics and Supply Chain Areas

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Abstract

The motive of the present thesis is to analyze the applications and potential impacts of blockchain technology in the logistics and supply chain areas. For this purpose, the literature from different sources has been used to analyze and get an overview of the current status and role of blockchain technology within the logistics and supply chain areas. Different use cases, as well as pilot projects from organizations all over the world and also from Germany, have been included. Suggestions for further applications and implementations of blockchain technology along with their potential impacts have been made. Additionally, the cost of implementing blockchain-based solutions and applications has been estimated along with providing recommendations and suggestions for important and key points to be considered before preparing and deciding to implement blockchain-based solutions in any organization.

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Non- Disclosure Notice

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Acknowledgment

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1- Introduction

Logistics and supply chains have evolved with the passage of time. There have been developments and advancements as per the modern needs and requirements of the time. But at the same time, this evolution and advancement also resulted in increased complexity along with a growing number of intermediaries. The role of these intermediaries is considered to be important in several aspects such as performing required actions, speeding up processes as well as playing the role of enablers. But at the same time, increased complexity and a growing number of intermediaries in logistics and supply chains also have some consequences. These consequences include the slow and more expensive processes in these logistics and supply chains. But on the other hand, the changes in customer demands are also observed. Today the customer requirement is that the delivery time should be as short as possible. Not only that, the customer also demands as lower cost as possible along with improved and real-time traceability of the product. But the usual practice to be observed in complex supply chains is that more than half of the time period, the shipping goods and containers do not even move from their place (Verwijmeren, 2017).[1] That was the main reason behind the collaboration of IBM and Maersk. They started their project in 2016 to provide solutions to these problems. For that, they utilized blockchain technology to create such a platform on which every participant, as well as intermediaries, could be united and it would be possible for all of them to access the information related to their cargo, goods, and containers. The information is not only accurate but also real-time and would be available to all at the same time without any priority or preference. This way, they would be able to resolve the issue of high and unnecessary costs along with minimizing the lead time and risk (De Meijer, 2018).[2]

The underlying technology of blockchain is a distributed ledger that helps the spread and availability of information to all the involved parties in the network and that too in real-time. Another plus of blockchain is that its structure is based on a peer-to-peer network (Iansiti, et al., 2017).[3] This also eliminates the role of intermediaries because of the possibility to store and exchange the data related to transactions. That is the reason why blockchain technology has the potential to eliminate and change several roles within logistics and supply chain areas such as the role of customs officer can be ruled out by utilizing smart contracts (Copigneaux, et al., 2020).[4]

Smart contracts are the digital contracts which contain rules and regulations in the form of coding. Basically, all the terms and conditions are defined in these contracts with the help of coding. In practice it means that if a party A delivers the good, it should be paid its share of contribution. Another example of this is the goods container will be loaded only if the lock on the door is in perfect condition and has no damage on it. All of such information related to

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[1] What Is Causing Supply Chain Complexity? – 2017
[2] IBM-Maersk Blockchain Platform: Breakthrough for Supply Chain? – 2018
[3] The Truth About Blockchain – 2017 [Harvard Business Review]
[4] Blockchain for supply chains and international trade – 2020 [EPRS | European Parliamentary Research Service]

terms and conditions are first analyzed, confirmed and agreed by involved parties and then this information is recorded in smart contracts in the form of coding. Smart contracts along with blockchain technology have the potential to provide such an interface which enable security as well as immutability (Copigneaux, et al., 2020).[5]

Since the complexities are increasing in logistics and supply chains, this is also affecting companies involved in these sectors. Resolving these complexities is proving to be a challenge for such companies in the coming time because of the enormous involvement of human intermediaries in this area. These intermediaries play several important roles such as when it comes to serving as enablers in the network as well as organizing and coordinating different processes and tasks to be performed within the network of participants. There are several kinds of intermediaries. For example, the chatter of cargo ships, port managers, customs officers as well as a provider of logistic services and etc. They are all important intermediaries with important roles in current logistics and supply chain infrastructure. But at the same time, they are also the reason for high cost and sometimes cause failures as well. Since blockchain has disrupted several sectors around the globe, the same way it has great potential to transform the logistic and supply chain sectors. The technology does not only promise to minimize and in some cases eliminate the role of human intermediaries but it will also change the processes such as there would be no requirement of piles of paperwork in the process of cross-border trades and shipments. As a result, this will also eliminate the role of another intermediary which is customs officers (Bartsch, et al., 2020).[6]

The main target of our research is to find out the true potential of blockchain technology for the logistics and supply chain sector. The following research questions will guide our study.

RQ1: Does blockchain technology have the capability to disrupt, evolve and transform the logistics and supply chain sector?

RQ2: If yes, what are the possibilities, and what are the current use cases around the globe and also specifically within Germany?

For this purpose, we are going to analyze different use cases and pilot projects being implemented around the world in the logistics and supply chain sectors. We are also going to analyze how blockchain can resolve some of the major issues in logistics and supply chains such as the issue of traceability, trust, the immutability of the data, real-time information sharing, food safety, counterfeiting, child labor, labor rights, and etc.

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[5] What are smart contracts in a blockchain? [IBM]

[6] Blockchain Technology in Germany: An excerpt of real use cases in logistics industry – 2020 [Hamburg International Conference of Logistics (HICL)]

2- What is Blockchain for Supply Chain: A Brief Overview

According to John Cohn, who is the Chief Scientist for Internet of Things at IBM

"In my 35 years as a scientist at IBM, I have never seen anything come from such obscurity into such a center stage."

As we are aware of the basic definition of blockchain that it is a shared cryptographically unalterable ledger for recording the history of transactions. It causes the increase of trust, reliability, transparency, and accountability across and among business networks. But what's quite interesting to notice is that, unlike many things, blockchain is decentralized which means it is not owned by any single or individual party. This is one of the most important things which makes blockchain democratized. Why this is amongst the most important qualities of blockchain to be democratized is because this quality of blockchain helps increasing the trust between parties involved as no one is on top. Further, it also results in increasing the accountability along with most important and above all, it makes the process transparent. Transparency is given much importance because the kind of transparency provided by blockchain, it can enable lower friction.[7]

2.1   Blockchain A Reliable Data Base for Supply Chain

Let's consider a current business scenario. How a business environment looks like in today's era. It includes multiple parties such as retail, producers, transport, warehousing, finance, regulatory and etc. And all of these parties use several different types of ERP systems including different internal systems in order to maintain their own records.
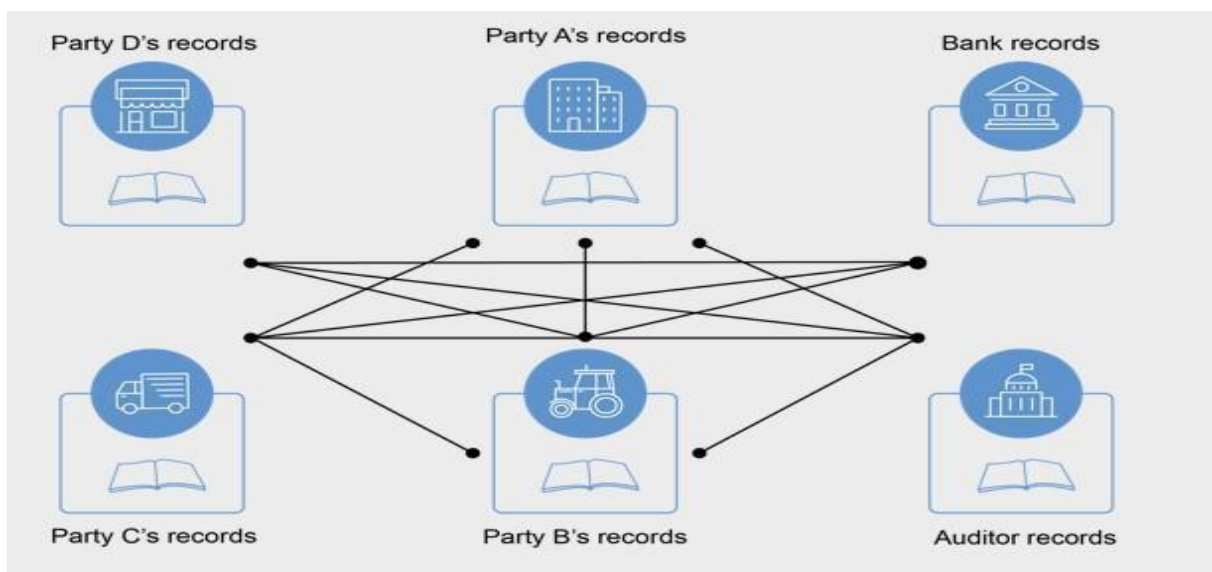
Figure 1: Business networks are Inefficient, expensive and Vulnerable

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[7] Using blockchain to drive supply chain transparency [Deloitte]

As things move across that, people have different visions. Each and every party has a different vision of what the current state is. There can be disagreements. Natural disagreements, etc. Not only that but there's a lot of friction as well. Sometimes these are text messages or emails or worse, paper documents. So, we find a whole lot of inefficiency in the current business environment as it is expensive, vulnerable, and also alterable – anyone can change a record.

What blockchain does is that it solves all of these problems of the current business environment by providing a single database with enhanced protection against changes, improved transparency, and more reliability that everyone can trust. Every involved party can have an identical copy of this single database. Here, by everyone, we are talking about enterprises (Lewis, 2017).[8]

2.2   IBM Hyperledger

IBM has invested a lot of energy in the last one and half years on Hyperledger. They designed a permissioned blockchain on enterprise-level which is efficient and provides solution and protection against inefficiency, vulnerability, and expensiveness by providing visibility to all the parties who agreed to be part of the consortium of this permission chain. They get visibility to all of the data that they have permission to access. That gives them the ability to locate their shipments as they get the visibility to see where their shipments are at that current time period along with the condition of those shipments.

As in such a scenario, each party has to agree on the current state of things and that is the reason why there is never a possibility of any argument among participants. There is only one state of truth that is distributed among all the parties at the same time without any priority or preference given to anyone. The Hyperledger also provides a permanence so that if there is any debate or regulatory oversight or anything like that, there is a permanent unalterable record of that.

IBM has been one of the founding partners of the Hyperledger movement in collaboration with the Apache organization. As a result of this movement, they now have over 110 members companies and hundreds and hundreds of projects in progress around the globe (O'Brien, 2021).[9]

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[8] Blockchain: four use cases transforming business – 2017 [IBM]
[9] How IBM is using blockchain to transform the potential of enterprise data – 2021

2.3   Blockchain in (IoT) Internet of Things

The most common concept of blockchain among people is that it is more on the financial side. It is mostly considered to be relevant with trade, retail, census, or other things similar to them. But

According to John,

> *"IBM strongly believes that blockchain has the absolute potential to transform and revolutionaries Internet of Things (IoT). And the reason I say that is because I personally have been working in this area for quite a long time."*

Let's take an example of shipping and logistics where we have one of those trade scenarios in which we have a producer, it goes to a warehouse or it goes to a transport and etc. If one wants to monitor the location, status, and condition of the shipment, it's incredibly important to be able to do it. To enable this, IBM has been involved in working with a consortium of the Baltics and Finland in a group called "Keno" out of "Kovlol", and they have been able to build a device that would help them in this test. The device provides real-time information, talking the last bit into the IBM Hyperledger region and makes it possible to track shipments all the way through.

The same goes for mechanical. When we are dealing with airplane parts that has literally millions of parts, checking the provenance and the version control mechanically so that one can read the barcode off of every little thing and allow that to participate in a Blockchain transaction and have a permanent record is very very good for version control and regulatory.

The same way, it can also be helpful in metering and control, things like electric meters or other devices that one wants to be able to transact directly with, Blockchain can be used directly in the hardware where you have an unalterable ID in the hardware and it allows you to make a secure transaction.[10]

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[10] How does the Internet of Things work with blockchain? [IBM]

3- Role of Blockchain in Food Safety

We take into consideration how food moves from farm to fork and how Blockchain could be a disruptive technology to make that a safer, more efficient, and more sustainable system. It is a fact that the world is changing at a very rapid speed, and this change is also affecting and impacting other sectors in the world which as a result compelling them to adapt to those changes as well, and that too very rapidly. The same goes for the food system as well. The food sector is also changing with time. In fact, the reality is that the food system has been changing since the beginning of time, and still continuing to change.

3.1   Food Industry after Industrial Farming Revolution

If we go back to the beginning of time, we find men and women, humans were mainly hunter-gatherers who weren't too concerned about supply chains as there obviously was no need for them to do so. Because if humans just went out there, hunt their food, and brought it back, there is the mere possibility that one could be concerned about food safety. Then we go fast forward over time and we find the common practices of men and women starting to domesticate plants and animals in and around their villages, mainly around the area where water was easily available, primarily focused on food production.

Then we fast forward to the early 1900s, which is merely a hundred years ago, we see the industrial farming revolution. Starting this era of the industrial farming revolution, farmers finally became capable to produce more food than ever before in the history of mankind. And with that, they were able to feed a growing population of the world.[11]

Retail shops from the 1900s used to be merely two hundred square feet of the area, hardly with the capacity of a couple of dozen shelf staple foods. But if we fast forward to today's environment, we find huge supercenters all around the world. Specially Wal-Mart supercenters, the company which is ranked among top in the Fortune 100 and among world's largest retailer that serves over 240 million patrons every week. These supercenters and modern grocery stores have thousands of food products including frozen, fresh fruits and vegetables from around the world.[12]

In the 1980s, the typical grocery stores used to have about 15,000 food SKUs, food products. But if we look into the typical grocery stores of today, they have more than 50,000 food products. But with with e-commerce, where one can get online, order anything, anywhere, anytime, this is considered to be an endless store. Where a million food SKUs would be a definite possibility in our near future (Malito, 2017).[13]

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[11] The Agricultural Revolution: Timeline, Causes, Inventions & Effects – 2021
[12] About Walmart [Walmart]
[13] Grocery stores carry 40,000 more items than they did in the 1990s - 2017

3.2   Global Food System

Let's take the example of blueberries in the 1900s. If a person likes blueberries and wants to eat them in the era of 1900s, it was impossible for him/her to enjoy this fruit more than once a year in his/her respective country. But now it is possible to enjoy such seasonal fruits every week because of a global food system. Locally produced is important. Fresh meat, seafood, poultry. Home meal placement solutions. The grocery store today is looking like food service.

Most of the people who have coffee in their breakfast on daily basis, they are able to do so because of the global food system. Because there are countries that are not producing coffee ingredients and have to import them from another country. Without the global food system of today's era, it wouldn't have been possible. Even if we analyze our daily routine intakes of eatables, we would come to the conclusion that It's hard to live on a strictly pro-local diet. In today's world, it is good to be pro-local or pro-global where all of the world feeds the rest of the world.

Another example is the ingredients of the tiramisu dessert. The cocoa powder comes from Switzerland. chocolate from Belgium, cream from the United States, mascarpone cheese from Italy, Kahlua from Mexico, and more products from the U.S., Colombia, and vanilla beans from Madagascar. This relatively complex but simple dessert has the equivalent of 41,000 food miles. This isn't anything strange in this era. Even if we apply the same statistics on products we consume on daily basis, it would be similar. This proves that the world and the food system are becoming more global.

The benefits of today's modern food system are profound. Fresh available products year-round from all over the world, nutritious at a fraction of own dollar. If we were to fast forward in the time from the 1400s to a grocery store today, we would be in awe having an impression of us all living like kings (CHILTON, 2020).[14]

3.3   Vulnerabilities of Modern Global Food System

Even though the modern global food system today has a lot of benefits. But at the same time, it also has some risks. When comparing the benefits of the global food system to the risks we face, risks are clearly outweighed in comparison to the benefits. But it is impossible to ignore the risks completely as they expose today's modern food system to vulnerabilities.

Even in this modern era of technology and innovation, there are big companies, big suppliers, and even big countries who are exposed to these risks and vulnerabilities and are not safe from them. These vulnerabilities are Traceability and Transparency.

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[14] How Grocery Stores Have Changed Over the Years – 2020

3.4 Case Studies

3.4.1 Spinach Outbreak in United States (September 2006)

In 2006, 26 states of the United States suffered from spinach outbreak. According to the Centers for Disease Control and Prevention, a total of 199 documented cases were reported. For every documented case, somebody had to be sick enough to go get tested and confirmed with E. coli. There were over 4,000 cases projected along with 31 cases of HUS (Hemolytic Uremic Syndrom) severe kidney failure. Three people died because of this outbreak across 26 states. In 50 percent of the cases, patients were required to be hospitalized.

It was declared in the very early stages by epidemiologists and public health professionals that everybody who got sick is because of consuming bagged baby leaves of spinach. So the root cause of this outbreak was determined to be spinach and a bacterium called E. coli 157. on September 16 of 2006, a warning by FDA was also issued all over the Unites States to avoid eating spinach, because of the ongoing outbreak.[15]
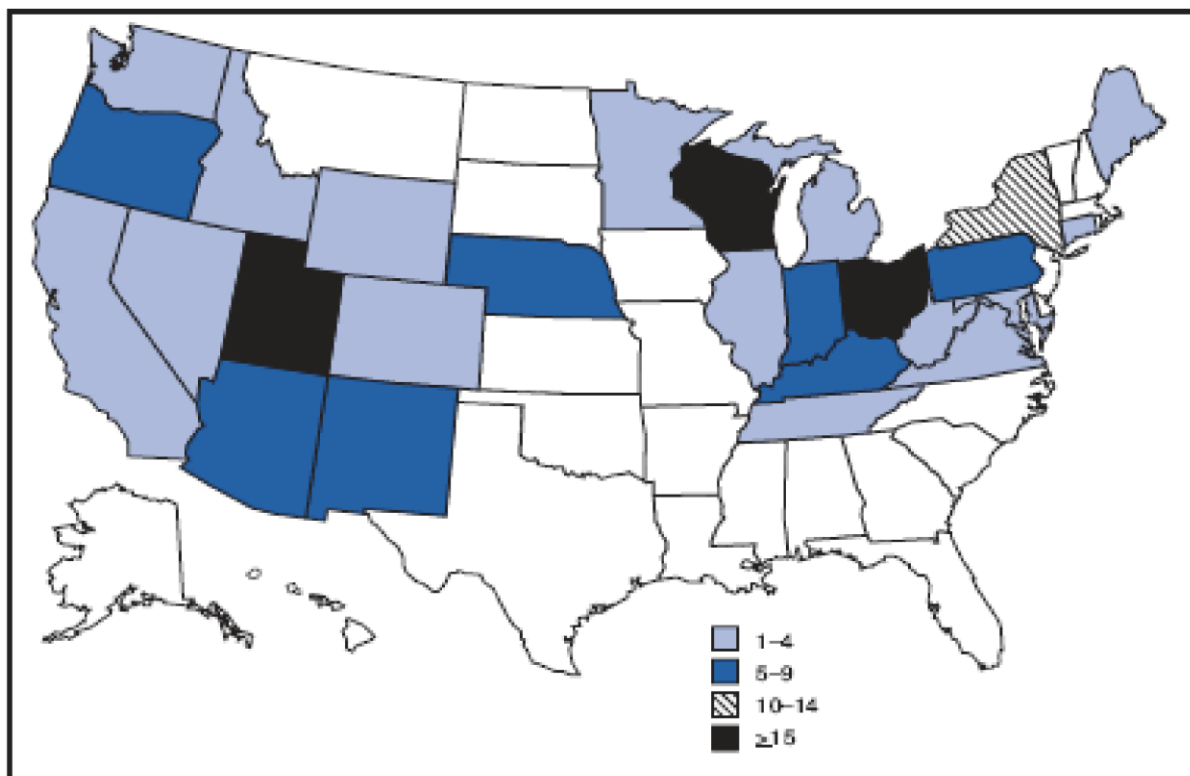
* Confirmed cases reported as of 1:00 p.m. EDT on September 26, 2006.

Figure 2: Number of confirmed cases (N = 83)* of Escherichia coli serotype O157: H7 infection by state – United States [16]

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[15] FDA To Consumers: Don't Eat ANY Fresh Spinach - 2006
[16] Ongoing Multistate Outbreak of Escherichia coli serotype O157:H7 – 2006

As a result, all the retailers and foodservice companies across the United States had to pull spinach nationwide. But it took two weeks for FDA to trace back the source of that spinach to the original farm. And for those two weeks, there was no spinach served all over the United States. But when it was all settled, it was found out that it was only one supplier, in one farm, in one lot, and only one day of production because which caused this dilemma. But because of this, the entire industry was killed along with the livelihood of all the farmers. And that was all because there was no way which makes the authorities capable to trace and track efficiently. This is a major vulnerability that blockchain has a great potential to resolve (Preston, et al., 2006).[17]

3.4.2 2008 Outbreak in United States

Another outbreak that occurred in the United States was in 2008. This time the company responsible for it was Peanut Corporation of America. This company was responsible for only 2% of the entire United States' production of the peanut paste which is a very small volume.

Peanut paste is an ingredient which is used in a lot of other products. And since the outbreak occurred because of peanut paste, it had a knockoff effect. Every product that had granulated peanut from the supplier, got recalled. Crackers that had peanut butter in it, cookies, chocolates, granola bars, ice cream treats, even pet food products had to be recalled (Goetz, 2013).[18]

By the time it all settled, there were total of 3,913 different food products that had to be recalled because of a small manufacturer that produced only 2% of the peanut paste. Stewart Parnell, the CEO of Peanut Corporation of America was sentenced to 28 years in prison for doing that.[19]

But the recall of 3,913 food products took as long as two months after the detection of the initial outbreak. And here comes the same vulnerability again which is the inefficiency to trace and track efficiently. Because of the lack of this capability, contaminated food products were sitting on shelves for the entire period of two months just because people didn't know that the ingredient was in their products. This is a major vulnerability and a threat to today's modern and global food system. And this is not only limited or unique to the United States or any single country in the world. In fact, such outbreaks also occurred in other countries i.e. the E. coli outbreak in Europe which was assumed to be caused because of Spanish cucumbers but later on it was found out that it was caused because of sprouts.

Now looking on to the solution side, blockchain is the technology which has the great potential to resolve this major vulnerability of today's modern global food system. For this, we will look into a pilot project of Walmart and IBM.[20]

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[17] Possible Source of Bad Spinach Is Named as Outbreak Widens – 2006 [The New York Times]
[18] Peanut Corporation of America from Inception to Indictment: A Timeline – 2013
[19] Multistate Outbreak of Salmonella Typhimurium – 2009
[20] Foodborne Illness Outbreak Database

3.5 Introduction to Walmart

The name of Walmart is included amongst the largest retailers in the world. They have 11,695 stores all over the world in 28 countries. The number of global suppliers utilized by Walmart exceeds to more than 100,000 which is huge and impressive. On one hand, this factor gives Walmart important and key competitive advantages over their competitors. But on the other hand, this is the same reason why their supply chain is also regarded as one of the most complex global supply chains. Being amongst the top and largest retailers in the world, Walmart also faces some risks which include reputation risks, financial risks along with health and safety risks. To take care and completely eliminate such risks, is amongst the top priorities of Walmart. In the pursuit of elimination of such risks Walmart, in collaboration with IBM, is envisioning a fully transparent 21st Century digitized food system by completely digitizing their supply chains through blockchain technology. For that, they are already working on pilot projects.

3.5.1 Why it is Important for Walmart?

Being amongst the top retailers in the world, Walmart also bears an even bigger responsibility towards their customers which is to make sure providing safe and healthy products to them as customers rely on Walmart and put their confidence and trust in them. Being very well known globally, the risk of damaged reputation for Walmart increases even more in case of any issue or condition arises concerning their products regarding health or safety. Even if the issue arises outside the control of Walmart, it still has the big potential to cause damage to their reputation all over the world.

It's been more than 20 years since Walmart is working on traceability and transparency to make their supply chains safer and more secured by creating detection along with accountability across their supply chains. This is due to blockchain technology which enables them to integrate full transparency along with complete traceability into their supply chain.

This is important because in the complex supply chains we have in today's world when an issue regarding contamination occurs, it takes days and even weeks to trace, track and identify the source of the problem. We take the example of the salmonella outbreak in Mexican papayas. It took more than two months for concerned authorities to trace and identify the actual source of the problem and recall the products. But with the help of blockchain technology, it is possible to reduce the time of this process from days and weeks to minutes and even in seconds. This will not only reduce investigation time for agencies but will also enable responsible authorities to reach the root cause and conclusion of the issue. As a result, this would also enable companies and manufacturers to easily trace the specific items or ingredients causing risk and allowing them to limit their recall to the specific item/ingredient only rather than calling the whole production.[21]

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[21] About Walmart [Walmart]

The benefits are not only limited to this. In fact, it will also result in the following advantages:

1- Contamination of illness would be quick and much faster as a result of much shorter response time
2- This will also result in decreasing food waste
3- Improved & enhanced compliance of regulation with the help of better tracking
4- Trust enhancement throughout the whole supply chain as a result of substantial information sharing

Walmart and IBM announced their blockchain partnership in August 2017. It also includes a consortium which has several food supply chain big players naming, McCormick, Dole, Tyson Foods, Unilever, Kroger, Nestlé, and more. In this partnership, they are going to collaborate with each other in order to find out innovative ways and applications of blockchain which could enhance the traceability of food in their complex supply chains (Aitken, 2017).[22]

Among all of the participants of this consortium, Walmart is leading them so far as they have already performed multiple trials in collaboration with IBM. In one of the trials, they successfully tracked pork in China whereas in another trial, they tracked mangos in Mexico. As a result of these trials, they were able to create a unique historical record for the product by digitalizing the information of the product along with the safety processes of food on the blockchain. Not only this, in fact, they were also able to significantly reduce the time period required for the process of tracking information of a product from days and weeks to literally 2.2 seconds exact.[23] In the United States alone, the industry records more than 500 food recalls every year along with 10 to 15 billion expenditures on incidents related to food safety (WHO, 2021).[24]

Table 1: World examples of some expensive food outbreaks/recalls [25]

Year	Contamination/Food Product	Estimated Economic Loss	Region/Country
2013	*Clostridium botulinum*/Whey concentrate	Unknown	New Zealand
2009	*Salmonella*/Peanut products	$70 million	USA
2008	*Salmonella*/Tomatoes	$250 million	USA
2008	Mad cow disease/Meat	$117 million	USA
2007	*Salmonella*/Peanut butter	$133 million	USA
2006	*E. coli*/Spinach	$350 million	USA
1992	*E. coli*/Hamburgers	$160 million	USA

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[22] IBM & Walmart Launching Blockchain Food Safety Alliance In China With Fortune 500's JD.com – 2017 [Forbes]
[23] IBM Forges Blockchain Collaboration With Nestlé & Walmart In Global Food Safety – 2017 [Forbes]
[24] DRAFT WHO GLOBAL STRATEGY FOR FOOD SAFETY 2022-2030 – 2021 [WHO | World Health Organization]
[25] Economic Impact of Food Safety Outbreaks on Food Businesses - 2013

Such significant results of trials offer a great deal of operational and financial implications not only to participants of the consortium but also to the whole ecosystem. In order to digitalize the food system further, IBM and Walmart along with the participants of the consortium are planning to continue running such trials for further few years. Walmart's vision is to transform their food supply chain into a system that is completely transparent (IBM, 2017).[26]

3.5.2 Walmart & IBM Envisioning a Fully Transparent 21st Century Digitized Food System

Walmart and IBM are working on two pilot projects. Among them, one is in the United States and the other one in China. In these piolets, they are envisioning a fully transparent 21st Century digitized food system. It is the requirement of the time and it would resolve the major vulnerability of the food system.

We consider the life of a mango and how it gets from a farm tree to a shelf in the supply chain cycle of Walmart. Mangos generally are grown. They might start from seedlings or graphs. But if it starts from seedling, it takes that mango tree five to eight years to fully mature and bears fruit. A lot of care, right soil conditions, weather conditions, fertilization, irrigation in this time. But about five to eight years later the mango tree produces this fruit. At a certain period of time, these mangos will be harvested by the harvest crew right before they have fully ripened. Because once a mango is picked, it can ripen within one to two weeks. These mangos are grown by very small farmers in either Central or South America. Then they get shipped to a packing house and the mangos get washed and boxed. Then these mangos get transported by air, land, or sea. In the case of Walmart, they cross the U.S. customs border and enter the United States where a Walmart processing facility in the U.S. takes those mangos, for further washing. Mangos then get peeled and sliced to be packed into containers.

From these packages, these mangos then get shipped to a Walmart distribution center where they get refrigerated. As stores place the order, Walmart distribution centers, transport them across the country with their DCs strategically located across the country, and this way, mangos enter the Walmart stores where they are refrigerated. Then these mangos are placed out on a refrigerated display case as cut foods have to be refrigerated. From there, customers buy these mangos this way the cycle completes.[27]

It's a pretty complicated journey and more complicated is if someone or a customer/ consumer wants to know where did these mangos come from. Especially if the situation of outbreak occurs or happens to be a food safety scare with mangos. Of course, there would be a need to trace and track these mangos, as soon as possible. But as shown in the above case studies, it will take at least days if not weeks to be able to trace those mangos from that grocery cart or home back to the farm in the current system.

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[26] IBM Announces Major Blockchain Collaboration - 2017
[27] IBM & Walmart Launching Blockchain Food Safety Alliance In China With Fortune 500's JD.com – 2017 [Forbes]

What IBM and Walmart are envisioning through their pilots is to provide the capability of tracing products within minutes and even in seconds instead of days and weeks. And that's the goal of their projects.

Through such implications of blockchain technology, it can move the whole food system even beyond traceability to what is called transparency. Transparency is another most important factor. If we compare transparency to traceability in the context of the global food system, the classic sense of traceability would be one step up and one step back. It defines attributes of a product that are what, where, and when. What was the product? where did it go? Where did the customer get it from? Where was it? And on which dates the product moved. Even in today's modern era of technology, disparate methods are being used in the food system along with a lot of different supply chains in the world, mainly on paper and food. using such methods means that there is never a possibility to have a long view of the food system.[28]

What Walmart & IBM envision with transparency is to have an entire interconnected view of that system for everyone. This fact is irrefutable that traceability attributes which have been defined are important. But transparency enables us to know more than just what where and when. More importantly, how the product was produced. Was it organically grown or not? Was it sustainably grown or not? Was it responsibly sourced? What are the labor sources that are being used to produce this product? Is it a GMO product? Were pesticides used in the growing of that product? And it can provide further interrelated insights that could yield to new information that would enhance how the food was produced.[29]

Figure 3: Walmart & IBM Pilot Infographic In case of food safety issue, traceability in minutes & seconds instead of weeks

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[28] IBM Forges Blockchain Collaboration With Nestlé & Walmart In Global Food Safety – 2017 [Forbes]
[29] IBM Announces Major Blockchain Collaboration - 2017

Walmart has been pursuing the holy grail of traceability and transparency for 20 years. But the availability of Blockchain and smart devices in every farmer's hand can make it absolutely possible today. In the above figure, this is an infographic of the pilot Walmart & IBM are doing with mangos in the United States. In this infographic, information is being collected at the farm with the help of Blockchain. Information captured at the packing house and transportation along that entire flow is also visible. Even sharing or communicating that information to the customer is also possible. Customer being able to scan a code on a package and know where that product came from, temperature conditions, and any other attributes that they choose. If they are interested in organic production. And that's the vision of the Blockchain pilot.

Blockchain technology has the potential of shining a light on the food system bearing transparency. And that transparency would not only result in driving appropriate self-desired behaviors. But also, some other important benefits as follows:

1- **Enhanced Food safety**
   For every one percent reduction of foodborne diseases in the United States, it saves the U.S. economy $700 million.

2- **Fresher Food**
   Everyone in the world always prefers fresher food

3- **Less Food Waste**
   A Big social issue is to reduce food waste. A third of all food that's produced on the planet goes to waste. We will have to feed nine billion people by the year 2050 and we can't produce our way out of this. That is the reason why we must reduce food waste. And if blockchain can optimize the supply chain and reduce food waste, that is a good thing for society.

4- **Deter Food Fraud**
   Food frauds like horse meat scandal in Europe in 2013 in which frozen meals which were claimed to be hundred percent beef lasagna but they contained no beef at all. It was one hundred percent horse meat. Blockchain would help deter such frauds by providing clear visibility and through which people could get tracked and caught.

5- **Promote Responsibility**
   There is a difference between accountability and responsibility and blockchain by shining the light on the food system will cause people to self-govern their behaviors.

6- **Build Trust**
   It will build consumer trust. Consumers today are less trusting as we are living in a global trust bust. The less trusting of institutions, governments, politicians and the food system. Traceability and transparency are two sides of the same coin and they can help bring back the trust of consumer (Galvin, 2017).[30]

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[30] IBM and Walmart: Blockchain for Food Safety [David Galvin]

4- Block Chain Contribution in Compliance to Supply Chain Law in Germany

German government officials are working towards introducing a law related to the supply chain which the government of Germany wants to introduce before the end of the current legislative period. According to this proposed law, it would be mandatory for all the large companies in Germany to make sure that they monitor and promote compliance with human rights in their respective supply chains from the year 2023 and onwards. Blockchain technology can play a vital role in helping these companies to meet and fulfill the mandatory requirements by law.

4.1   Overview of German Supply Chain Law

German government authorities and involved ministry officials finally reached to an agreement after several rounds of lengthy negotiations and as a result, they would be able to pass it before the end of the current legislative period which ends in September of 2021. The main purpose of this act "Act on Corporate Due Diligence in Supply Chains" is to make sure that the problems and complaints which are already existing in the global supply chains of transnational companies, could be addressed, resolved and rectified.[31]

There are several instances in which private companies are involved in violations of human rights in their international supply chains. For example, companies exploiting child labor in the textile and raw materials industries, infrastructure projects where labor is compelled to work in slave-like working conditions, production conditions which are dangerous or harmful for the health of labor, even risking the lives of workers as it was experienced in 2013, in the case of Rana Plaza in Bangladesh where the building collapsed and a large number of people lost their precious lives.

This is following 2011 when UN Guiding Principles were introduced on Business and Human Rights adoption, several countries have actively been taking actions, introducing policies and laws in order to make sure their companies comply and respect human rights in their supply chains. These countries include France which passed a law in 2017 by the name of "Loi de vigilance". Another law (UK Modern Slavery Act 2015) was passed in the United Kingdom and (Wet Zorgplicht Kinderarbeid) was passed in the Netherlands. According to these laws, companies are required to make sure that their supply chains are properly monitored so that there must be no instances of child labor exploitation or modern slavery conditions. Legal Affairs Committee of the European Parliament also helped in the introduction of Supply Chain Law in Europe by the name of "Due Diligence Act" in January 2021.

An examination in 2018-2020 was carried out by the government of Germany to check and monitor the companies regarding what importance is given to human rights by them in their

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[31] The European Due Diligence Act & Germany's Supply Chain Law [Blockchain Applications]

supply chains and how these companies are voluntarily making sure to protect human rights as a part of the National Action Plan for Business and Human Rights. Surprisingly, the research findings were not encouraging as only 17-22% of the companies which had more than 500 employees were found taking enough measures in order to protect the human rights of their laborers. That is the reason why the introduction of law for the protection of human rights is considered to be an important step towards the improvement of companies' policies in Germany and is expected to be introduced before the end of March (Ecker, 2020).[32]

4.2   Use of Blockchain technology in Implementation of Supply Chain Law in Germany

Blockchain technology is quite promising and has a great potential to help authorities in the implementation of Supply chain Law in its entirety in Germany. In fact, this supply chain law can even provide a launching pad for the application and utilization of blockchain in the supply chain area.

As blockchain technology is already being utilized by several corporate sectors in their supply chains for the purpose of monitoring and tracking. Here the factor to analyze is in which manner can blockchain technology be useful in the implementation and compliance of new supply chain law. To analyze this, we first look into the basics of blockchain technology, and then we will move to the implementation part to analyze different potential aspects and applications of blockchain which could assist in the compliance of this act and meet the requirements of this law.

4.3   Basics of Blockchain

Blockchain at its core is a technology which provides a decentralized database to its users. The transactions which are stored in its database use a chain of blocks in such a manner that they are immutable. On the other hand, it is possible for all the authorized participants to access and use its database for monitoring and also to store new data and further transactions. Method to digitally sign all transactions in the database through Encryption key which is always asymmetric, unique, secrete and secured for every transaction is used. But another key is generated which is public and can be used for the verification purpose of the decryption. As a result, this process makes it possible to authenticate the originator of a stored transaction at any time without any suspicion or confusion, hence providing trust and confidence among participants of the database.[33]

When another transaction is required to be added to the blockchain database, it is imperative for all the participants (nodes) to reconcile the sequence of already existing data among each other and validate the transaction only if it is based on so far formed blockchain. It is

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[32] Examining Germany's Potential Supply Chain Law – 2020 [MINESPIDER]
[33] What is blockchain technology? [IBM]

impossible for anyone to make any kind of amendments in the contents of previous blocks without having control over more than 50% of the participating nodes in the blockchain.

It is because of such secured properties and characteristics of blockchain that it is possible to store generated data during communication or record transactions in the database in a safe and immutable manner. Hence parties involved in the database do not require any intermediary to build their trust in the data stored in it (Darlington, 2021).[34]

4.4   Blockchain Technology in Context of Supply Chain Law

Supply chain management is not a new field for the application of blockchain technology as it has already been implemented widely in this area. The mapping of individual processing steps in a totally forgery-proof manner is possible with the help of blockchain. These steps include from the extraction of raw material to the end customer. Not only this, the information regarding processing status can be accessed and tracked at any time. There is also a possibility to use sensors in such cases where compliance with a cold chain is required to be proved. Commercial offers of such solutions are already available in the current market by providers like ReCarbonX Systems or OpenSC. Another possibility is the execution of smart contracts on the basis of such a blockchain.[35]

The second step of this corporate due diligence is that companies should regularly perform risk analysis concerning human rights on their supply chains. But it is not possible to perform risk analysis without having the information regarding the steps in the supply chain and that is the reason why turning to the data which is stored by blockchain would be feasible. Companies which have already implemented blockchain, are able to perform risk analysis as they already have the necessary amount of data required to perform this task.[36]

In addition, the implementation of blockchain technology would also assist organizations in proceeding with further crucial steps and measures towards the prevention of human rights. This can be possible by assigning unique RFID chips to all individuals by whom the tasks are being performed on the product. Every individual would be able to identify itself with the help of uniquely assigned RFID chips and this way, it would help a great deal in the elimination of child or forced labor. The same task can be performed with the help of biometric identifiers instead of RFID chips. Monitoring and verification of statutory minimum wage compliance in a production company are also possible by linking electronic accounting data to the blockchain. Not only this, but it would also make it possible to check whether the company is observing maximum working hours or not (Matičević, et al., 2011).[37]

Another requirement of the law is that companies should be taking corrective measures in case of facing risks regarding violations of human rights. In usual cases, the German company is more often responsible to perform this task. It makes sure that the production company facing such risks of human rights violations, is compelled by the German company to

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[34] Blockchain For Beginners – 2021 [Blockgeeks]
[35] ReCarbonX Blockchain Based Manufacturing Tracking Systems Explained - 2019
[36] Germany Passes Supply Chain Due Diligence Act - 2021
[37] RFID and Supply Chain Management for Manufacturing Digital Enterprise – 2011

implement corrective measures. The application of blockchain in this process can also make it much simpler and even more comprehensible to track the implementation of such measures as blockchain can store the implementation as a date in its database (e.g., payment for an outstanding wage).

The introduction of complaints mechanisms in companies is also mandated by this new law. But while introducing such a mechanism, it is necessary to structure it in such a manner that it must be able to check and confirm whether the individual by whom the complaint is being filed was actually working in the company's supply chain at the time of the alleged claim or not. Such checks and verification processes can be performed with the help of blockchain. Not only this, in fact, blockchain can also store each and every complaint along with all the steps included in the processing of each complaint which would provide the read right and be available any time for the view of complainants. This way blockchain can also contribute to the complaint mechanism itself (Hillemann, 2021).[38]

Reporting is another requirement which is mandatory by this Supply Chain Act. According to this requirement, all the companies under the umbrella of this act will be obliged to produce an annual report. And this is the process in which companies are expected to put their most significant efforts in order to meet reporting requirement of this act. But for the companies utilizing blockchain in their supply chain, this step of reporting would be much simpler and straightforward. Because with the use of an application, it is possible to turn every step that can be mapped on the blockchain into a report. On top of that, it is also possible to provide access to control authority by simply setting up reading right for them.

At the same time, the synergy effects which blockchain could bring with its implementation in the supply chains of companies as a result of this act are particularly worth considering. The introduction of the supply chain law could prove to be the driving force for many companies to integrate blockchain technology across their supply chains. And once blockchain is implemented, benefits would not only be limited to make it simpler for them to meet and comply with the requirements of this act. In fact, such companies would also be able to benefit themselves with the other utilizations of this technology in several areas such as quality management, quality assurance, tracking of location, smart contracts and etc. This would also make it possible for them to use several other data points for the purpose of introducing and demonstrating a large number of the measures which are required by the law (HERBERT SMITH FREEHILLS, 2020).[39]

4.5   Role of Blockchain in Protection against Fines & Penalties

The purpose of introducing and implementing supply chain law is to make sure that companies along with their suppliers (from Tier 1 to Tier n) are in compliance with human rights. As a result of this, companies under this act will be required to structure such a mechanism so that they would be able to prove their compliance to authorities. This is the situation where most of the companies face major challenges and if they are not resolved in

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[38] Germany's supply chain law is a gamechanger for blockchain – 2021
[39] GERMAN SUPPLY CHAINS: MANDATORY HUMAN RIGHTS COMPLIANCE MOVES CLOSER – 2020

a timely manner, there is a high potential for such companies to face fines and penalties in the near future.

The important point to be noticed here is that the companies who want to improve their supply chains by exploring transparency are found to be embracing approaches that are focused on the purpose which is to highlight and analyze compliance in line with human rights. It is often the case that efforts to have a comprehensive view of all the products and components included in the supply chains of companies do not succeed. The reason behind this is that this process requires an extensive number of resources which also include manpower. On the other hand, there is an alternative method to succeed in this process which is to review the supply chains of the company and reduce the complexities found in them. While this approach has a plus point that it does not require enormous resources to be invested in it, but on the other hand, it has a negative point as well as in this globalized world it cannot be implemented successfully in many companies and industries because of their growing specializations.

In this scenario, blockchain technology has the potential to provide solutions for companies looking to obtain a holistic view of their supply chains in regards to transparency and it will also prove cost-saving for them.
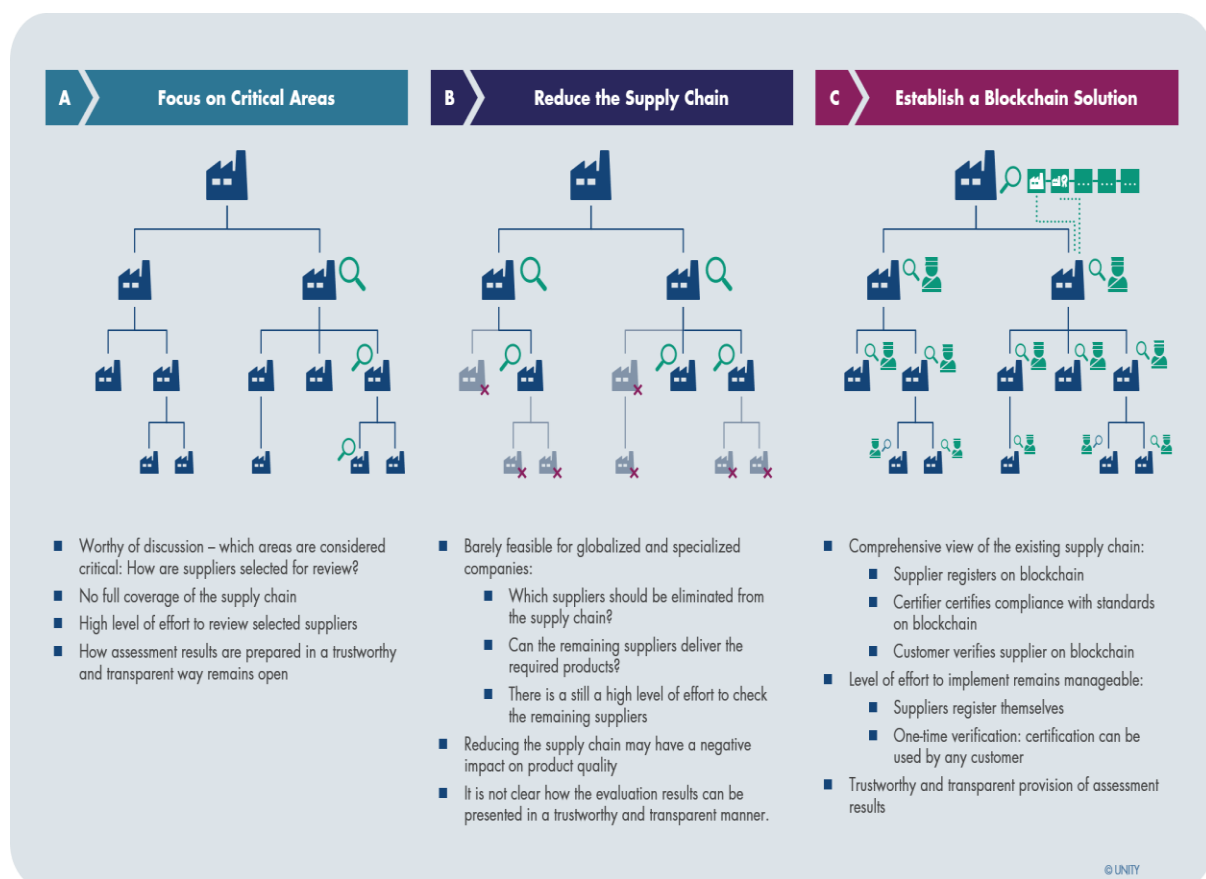
Figure 4: Blockchain Solution Providing Holistic View Of Supply Chains Transparency [40]

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[40] SUPPLY CHAIN ACT FOR HUMAN RIGHTS [UNITY CONSUTLING & INNOVATION]

4.6   Blockchain as a Supplier Database

It is plausible to use blockchain as a supplier database which would work as a global blockchain database for all the participants. This would not only allow the possibility for suppliers to register themselves on this global blockchain, but also enable them to save their relevant information (including certifications) on it. Here comes the role of certification bodies as their approval would be required for the authentication of suppliers' certifications. Blockchain also provides the feasibility through which reliable certification bodies would be able to digitally authenticate the certifications of suppliers which would be available to manufacturers for their viewing.[41]

As a result, this global blockchain database would enable companies to check and verify the relative information about companies with which they are working with and they would be able to make sure if their partner companies meet with required standards (set by authorities) or not. Gaining this information would not consume more than a time of click and would be available at a fairly low cost. Another big plus is that the information available with such less time and cost would also be verified, trustworthy and reliable. The reason behind this trustworthiness as available information on this database would be provided in by independent and authentic testing bodies and organizations instead of being fed in by suppliers themselves (Ledger Insights, 2020).[42]
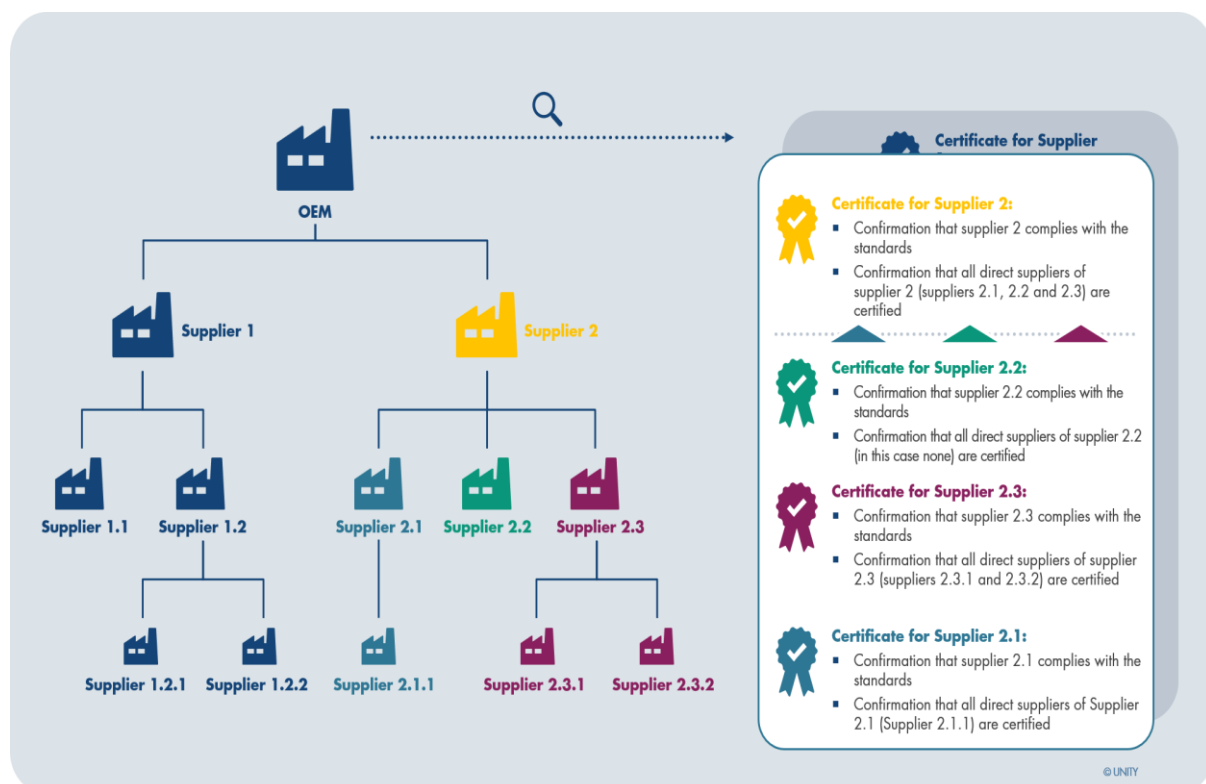
Figure 5: Blockchain Database for Suppliers' Certifications

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[41] IBM LAUNCHES NEW BLOCKCHAIN PLATFORM FOR SUPPLIER DATA MANAGEMENT – 2019
[42] Accenture uses blockchain for supplier procurement platform – 2020

Another positive which global blockchain database provides is the capability to certification authorities which enable them to revoke the license/certification of any company in the public register available on blockchain at any time in case of any irregularities or violations are found during their audit. Once any certification of any company is revoked by authorities, all the potential customers of the affected company would be notified immediately due to being in the public register on the global blockchain.

Authorities could also design a mechanism or define criteria in which awarding of certification would be subjected to the fulfillment of condition where the company should only be working with certified suppliers. By taking such steps, conformity of the entire supply chain of a company could be ensured.[43]

4.7   Blockchain Database as a Trace & Track Solution

Blockchain provides a solution to structure a database that could potentially be utilized in a "product-oriented" approach. This would provide feasibility to assign a digital ID to each and every product or component in the supply chain. The assigned digital ID would be distinctive for each product and would be listed in the blockchain database solution. As a result, this would eliminate the need to manually link transitions with digital IDs, and each and every step of the process including transitions among suppliers would be automatically linked to digital ID. At the same time, documentation would also take place on a blockchain solution. Hence the tracking of the product would be easier and simpler along the supply chain as it passes from each supplier to other (sub) suppliers (DHL & accenture, 2018).[44] Not only this, in fact, it would also provide the functionality to store additional valuable information i.e., information regarding the compliance of the cold chain. Along with storing such information, it would also make it verifiable. We find the use case of this in the current example of the COVID-19 vaccine from BioNTech/Pfizer.

Such solutions are not new in today's world. In fact, some of these solutions are already being utilized. We can take the example of a solution in which suppliers of raw materials are documented along with their compliance status with required standards. This solution does not only provide tracking functionality, but also visibility for the end customer so that customer enjoys transparency to the origin of their own product.

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[43] SUPPLY CHAIN ACT FOR HUMAN RIGHTS [UNITY CONSUTLING & INNOVATION]
[44] BLOCKCHAIN IN LOGISTICS – 2018 [DHL Trend research]
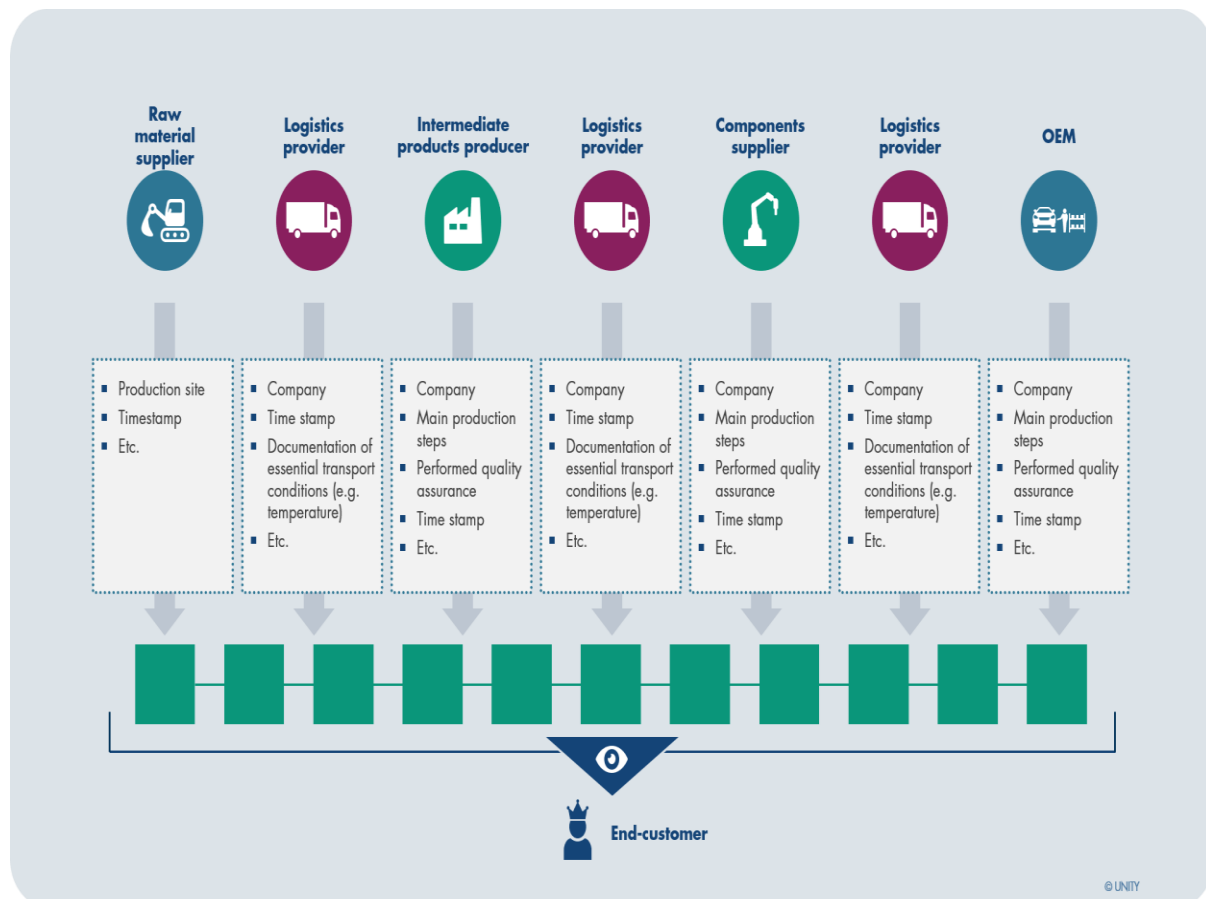
Figure 6: Blockchain as a track and trace solution [45]

4.8   Conclusion

The main requirements of the German Supply Chain Act mandate the companies to conduct their supply chain activities in such a transparent manner that there should be no room for suspicion. They must be able to convince supervisory authorities regarding the quality of their data and establish such a mechanism that helps in building and enhancing the trust of authorities in regards to the accuracy and immutability of their supply chain data.

Currently, we are seeing the focus of lawmakers in the introduction and implementation of laws regarding human rights. But very soon, we would also witness such policies focusing on the emissions of CO_2 (carbon footprint). This would be the point where blockchain advantages would be more obvious and evident. Especially the value it provides in the immutability of data even regardless of numerous participants. Along with that transparency is another factor that is of much importance not only for consumers but also for authorities introducing such laws (World Economic Forum, 2018).[46]

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[45] SUPPLY CHAIN ACT FOR HUMAN RIGHTS [UNITY CONSUTLING & INNOVATION]
[46] Building block(chain)s for a better planet – 2018 [World Economic Forum]

There is no doubt that the introduction and implementation of blockchain across the whole supply chain of a company would require significant efforts and resources, especially in the initial time period. They would need to convince their suppliers to participate in the process. With that, they would also need to make sure that they are able to face and overcome the hurdles during the implementation time period (whether they be technical or legal) without letting them affect their progress.

But this would be for the initial time period and the after-effects of this technological implementation would be much beneficial for companies, especially in the long run. So far, there is no supply chain law that has yet been implemented by authorities. This also provides an exceptional opportunity to be grabbed for organizations interested in the adoption of blockchain. They can take small and selected steps such as introducing prototypes that are easily manageable and selecting only a few specific suppliers for their integration process. By the time, the experience and the expertise increase, it would be easier to scale up the solution along with its advantages. Along these lines, companies would not only guarantee experience gain in the use of blockchain but direct value addition as well. Hence resulting in remarkable changes in the future for the economic process of the company.[47]

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[47] SUPPLY CHAIN ACT FOR HUMAN RIGHTS [UNITY CONSUTLING & INNOVATION]

5- Building Transparent Supply Chain

Basically, blockchain is the digital system for record-keeping which was developed for the record-keeping of cryptocurrency networks. But by the time, it has been well established that supply chain management is another area where this emerging technology of blockchain has amongst the most promising applications to offer along with its great potential to help and resolve several issues and challenges being faced by supply chain partners. A complete, tamperproof, and transparent record-keeping ledger can be created which would be immutable and capable to store the track record of the inventory flows along with information flows and financial flows in transactions.

There are many corporations in the United States, which are involved in exploring and adopting the blockchain at its initial phase in order to find out how this technology could help them in their supply chain area and whether it has the potential to improve their supply chain operations or not. Among them, seven large corporations were selected and studied to collect information. These companies include IBM, Emerson, Hayward, Mastercard, Corning, and two other companies which preferred to remain anonymous. These companies are not limited to any one industry. In fact, they belong to different industries including technology, retailing, financial services, and manufacturing.

When it comes to exploring or implementation of blockchain, these companies are found at different levels as compared to others. Some of these corporations have just begun their journey towards the exploration of blockchain. Whereas some of them are in the process of conducting pilot projects and others have already advanced from these stages to proceed even further in the direction of developing applications, working with their supply chain partners.

As per the progress and outcomes which have been achieved by these corporations as a result of their early initiatives in the implementation of this technology, it is obvious that blockchain has the capability to enable more cost-efficient and quicker delivery of products along with creating better traceability across the supply chain by making products more traceable. Not only this, it is also helpful in streamlining the process of financing along with enhancing coordination and collaboration among partners, buyers as well as banks.

But in order to use blockchain in the area of supply chain management, it requires some special conditions to be taken care of. These requirements include:

- Restricting Participation to known by only allowing database access to well-known and trusted partners
- Adoption of a new consensus protocol
- Precautionary steps to be taken in order to make sure the elimination of counterfeits as well as errors from the supply chain

By making sure to meet these special conditions and requirements, blockchain could have big dividends to offer for companies involved in its exploration and adoption.

As explained above the blockchain mechanism is based on a digital system that is decentralized, distributed ledger and works in a tamperproof, immutable, and verifiable manner to record transactions between multiple parties and participants. The ledger also gives the possibility to program it in such a way that it would enable the automatic triggering of transactions. Among the most important functions of blockchain, one is that it enables limitless number of participants (unknown and anonymous) to transact with each other in a decentralized and reliable manner without any risk of safety and security. But for the supply chain, blockchain has a slight change in its role as compared to its role for cryptocurrency networks. Instead of allowing transactions for limitless parties which are unknown and anonymous, it should only allow a limited number of parties (known) to transact with each other in a secured environment. The purpose of this role difference in both conditions is to make sure that the business operations of such companies remain secured and protected against any malicious act or actor. At the same time, it will also ensure support in the improvement of their performance.

New blockchains which are permissioned, need to be designed as they are required for the successful applications of blockchain in the area of the supply chain. There will also be the need to set new standards which will be used for the representation of involved parties' transactions on the block. Along with this, they also need to introduce new rules for the purpose of governing the systems which are all in different stages and processes of development (Downes, 2021).[48]

5.1   Blockchain Advantages

Since the year 1990s, the use of enterprise resource planning (ERP) has contributed to significant progress in the development of information sharing in the supply chain area. The companies leading in this include Procter & Gamble and Walmart. Regardless of this progress and development, one challenge is still being faced by large supply chains of companies that are involved in complex transactions. This challenge is how they can make their supply chains more visible.

If we look into present ERP systems being used by companies in the supply chain area along with financial-ledger entries of the current world, we find that they still have some limitations to them which could be resolved with the help of blockchain. If we take the example of a scenario where retailer, supplier, and bank are involved in a simple transaction. The retailer is dependent on a supplier to source a product from it whereas a supplier is dependent on the bank in order to get working capital from it which is required to fill the order of the retailer. So if the retailer sources a product from a supplier and the supplier gets the working capital from the bank to fill the order of the retailer, this simple transaction includes three flows which are inventory flows, financial flows and information flows. Now, this is to be noted here that given flow does not result in financial-ledger entries at all three parties

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[48] THE YEAR IN TECH 2022 – 2021 [Harvard Business Review]

involved. At the same time even current ERP systems, inspections, and manual audits are also not able to solve the challenge of connecting these three flows in a reliable and trustworthy manner. As a result, this becomes difficult for corporations to improve their decision-making, eliminate their execution errors, and resolution of conflicts related to their supply chain.

In today's world, supply chains are yet to overcome the challenge related to real-time detection of execution errors. These execution errors include missing of shipments, payment duplication, and data entry mistakes and the realization of these mistakes in real-time is still difficult to identify in most cases. Even if the problem is discovered, still the process to track the source of the problem proves to be difficult and much expensive. Another approach is that sequence and order of recorded activities in documents and entries of the available ledger are traced. But this approach also faces the same challenge as it is not easy to trace the sequence and order of recorded activities and at the same time, this process also proves to be costly. Even though current available ERP systems are fully capable to record all flows regardless of their types, but at the same time, the possibility of facing difficulty is much likely to be faced when it comes to the process of assessing journal entries in order to find out the correspondence among specific journal entries with specific inventory transaction (which journal entries correspond to which inventory transaction). This especially proves to be true when it comes to those companies which have complex supply chains and are involved in thousands of transactions each day across their large network of supply chain products and partners.[49]

The problems are not only limited to this extent. In fact, if we look into deep, it is clear that activities that are related to supply chains usually prove to be overwhelmingly complex and complicated in comparison to what they are actually shown in their exhibits. We can take the example of a complicated scenario when it might not be possible to sync up shipments, orders, and payments with each other. Now there might be two reasons behind this. One of them could be that a single order is split into multiple shipments and because of this it also has multiple invoices related to it. Another reason could be that several orders are combined into one shipment (Gaur, et al., 2020).[50]

There is a common approach of verifying transactions with the help of audit which many companies adopt for the purpose of better and improved execution of their supply chain. There is no doubt that if companies want to make sure compliance with contracts, auditing is a prerequisite requirement for their needs of compliance. But at the same time, when it comes to addressing the area of operational deficiencies, companies need to focus on improving their decision-making processes. In order to do so, this approach of verifying transactions with the help of audit has very limited assistance to offer in the improvement of decision-making to address operational deficiencies.
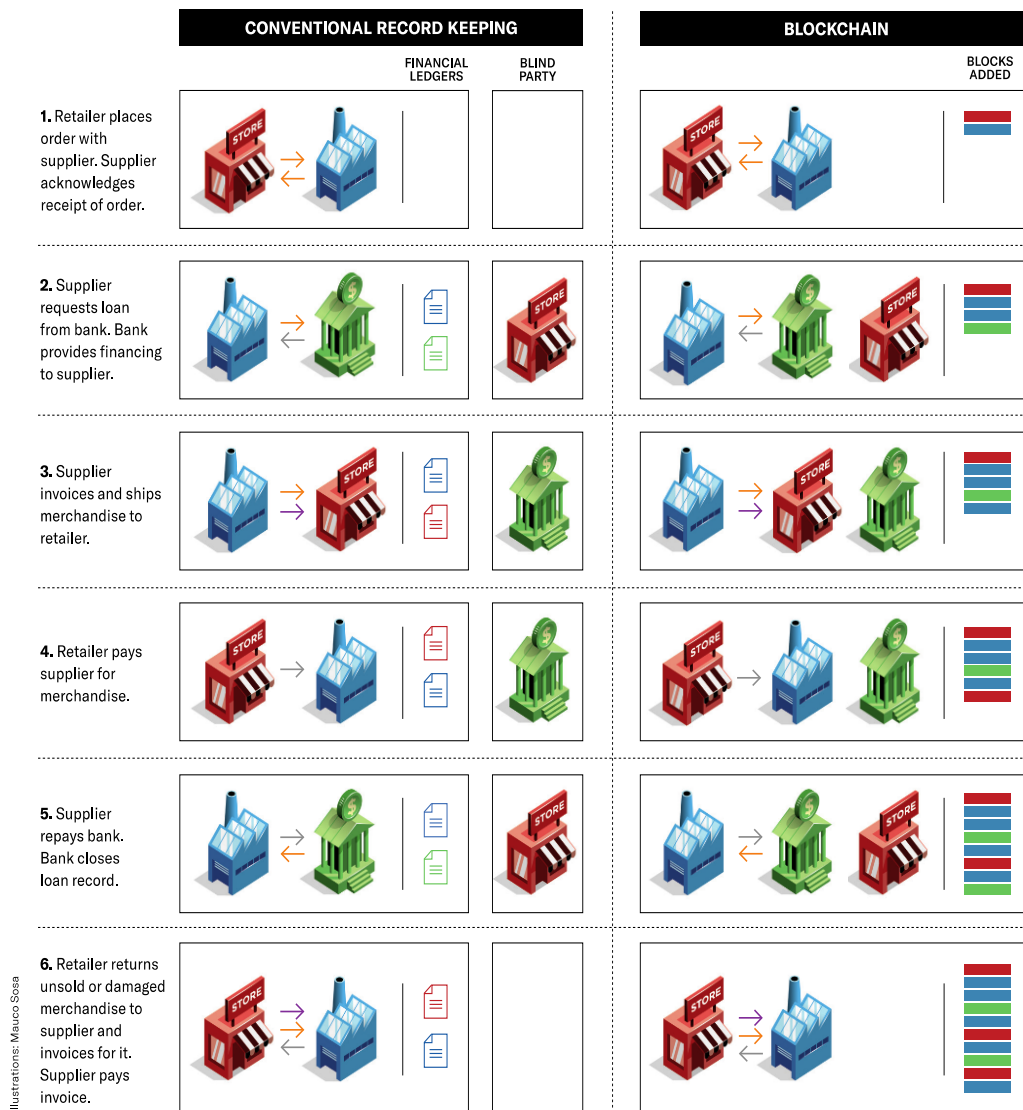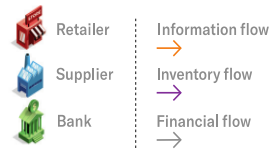
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[49] Advantages of the blockchain [IBM]
[50] Building a Transparent Supply Chain – 2020 [Harvard Business Review]

Figure 7: Capturing Details of Simple Transaction

A usual problem which is faced especially by food companies is when the shelf life of their products reaches the end in a retail store. A study which has been conducted with a major manufacturer of packaged foods shows that even though it is possible to get the information that would reveal the number of expired items in the store, with the help of inspection or audit of the inventory. But it would rather be limited and would not be sufficient to address the root causes of this issue of expiration. Whether the issue arises because of glitches in any part of the supply chain and if yes, then in which part and because of which glitch. The reason may include excessive allocation of inventory to stores, inefficiency in the management of inventory, weak or sporadic demand, inefficiency in the rotation of shelves (failure to place older products in front of new products so that older products which have less time to expire in comparison to newer ones, get consumed before newer ones). But if it is made possible to keep a record of all such activities, then it would be helpful in reducing the possibility of facing such issues of expirations.[51]

There is another approach of inventory marking that has the potential to strengthen the supply chain operations of organizations. In this approach, RFID tags (Radio Frequency Identification) or electronic product codes that comply with GSI standards (globally accepted rules for handling supply chain data) could be utilized for the marking of the inventory. After the marking process is completed, the next step would be the integration of the ERP systems of the company with the ERP systems of its suppliers. This approach would not only help in enabling the construction of complete transactions record but would also result in improved traceability along with eliminating execution errors in the supply chain.

But this approach also has some difficulties when it comes to the integration part of ERP systems. The experience of the companies included in this study shows that when it comes to the integration of ERP systems, the process proves to be quite expensive along with time-consuming. Throughout the life of large organizations, they go through multiple mergers and acquisitions along with organizational changes and as a result, they could end up having even more than 100 ERP systems to be integrated with each other. Usually, such systems are so different to each other that even the way data fields are defined in these systems may differ to each other. There is also a possibility that such systems are not even capable to communicate easily with each other. We take the example of a large company included in this study which had 17 ledgers in different ERP systems associated with a single activity— trucking—and on top of that, the distributors and suppliers of this company had their own ledgers and ERP systems.

But with the help of blockchain, the complexity of such processes could be eliminated. When blockchain is used for the process of record-keeping, unique identifiers are assigned to assets. These include units of inventory, loans, orders, and bills of lading. In this process, unique identifiers serve the role of digital tokens (similar to bitcoins). There are two possibilities for participants of blockchain in this process. They can either be assigned with unique identifiers or with their unique digital signatures which are used by them to sign blocks at the time of adding them to the blockchain. As a result, it makes it possible for each step that is included in the transaction to be recorded on a blockchain as corresponding token transfers from one participant to the other participant.

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[51] Winning the Food Fight: Best Practices for Managing Grocery Retail Supply Chains [RELEX]

When it comes to representing the transaction on a blockchain that is shared among participants, it will look like the one mentioned in the above figure (Capturing Details of Simple Transaction). At the point, when an order would be generated by the retailer to send it to the supplier, this would be the first step and at this step, no entries are recorded in a financial ledger, simply because there has been no exchange of either goods or services taken place among both participants. But at the same time, the digital token would be recorded on blockchain by the retailer for the order it placed. Then in order for the confirmation to be sent to the retailer, it would require the supplier to log in the order and confirm the receiving of the order to the retailer. Again, this step would also not result in creating any entry in the financial ledger other than only being recorded on the blockchain. The next step would include the supplier and the bank in which a request for a loan would be made by the supplier to the bank so that working capital could be arranged which would enable the supplier to finance the goods production ordered by the retailer. Before approving the loan, the bank would first log in the order, verify it on the same shared blockchain, and then will approve the loan. This step would also result in recording the digital token (on the shared blockchain) of the approved loan by the bank. And the process would continue the same way.

Blockchain does not only enable the details capturing of those transactions which are not recorded in the system of the financial ledger, but it also contains such chronological string of blocks which makes it capable to integrate all three types of flows in the transaction. This is one of the many reasons why blockchain has such importance and value in the supply chain. This does not end here, in fact, each block in the blockchain is encrypted and the distribution of these encrypted blocks to each participant allows them to preserve their own copies of the blockchain. It is because of these special characteristics of blockchain which make it capable to provide a complete, immutable, trustworthy, and reliable audit trail of all activities included in these three categories in the supply chain.

This is the reason why blockchain is considered to have great potential in terms of tackling and reducing the problems faced in the process of traceability, execution and coordination. As individual copies of a blockchain can be preserved by all participants involved in transactions, it makes the process reliable, traceable and transparent because every participant has the access to review transactions at any time without any priority or preference. This also enables them to identify errors in case of any glitches and then hold their counterparts responsible for their faults. It also restricts the overwriting of data which makes it immutable because if anyone wants to temper with past data, it would not be possible to do so without having the access to all the preserved copies of each participant in the blockchain and the ability to overwrite all the blocks of those copies. Hence, it makes it impossible for anyone to change or rewrite the past data.

Blockchain also provides the opportunity for banks to utilize its potential in order to improve their supply chain financing. Usually, when it comes to lending decisions, there is a series of procedures and processes to be performed by banks that are not only tedious but also vulnerable to errors. These processes include financial reviews as well as physical audits. But with the help of blockchain, transactions between suppliers and retailers can easily be verified by banks without having to perform such processes as they can confirm these transactions by only reviewing them on the blockchain. There is another benefit of blockchain which it provides by enabling the inclusion of data related to several types of transactions in its

database. The inclusion is not only limited to data related to payments, invoicing, and lending records, but it is also possible to preserve records related to physical movements of goods as well. This also creates feasibility and eases the auditing processes of transactions along with being more cost-effective and less risky for all participants.

Another big plus of blockchain is its capability of automating many of these functions with the help of smart contracts. Smart contracts can execute transactions automatically without any involvement of manual efforts. They are based on lines of computer code that are designed to obtain data from blockchain in which conditions and prerequisites are already defined along with functions to be performed in both scenarios of either fulfilling or failing to fulfill conditions and prerequisites. They are well capable to verify whether contractual obligations are fulfilled or not. If yes, they can automatically issue the payments. And if not, payments can be refused. Smart contracts are programmed to be capable of assessing the status of transaction and on basis of this assessment, they can take predefined actions automatically such as the reading of ledger entries, releasing of payments, and identifying irregularities needing manual intervention.

When it comes to efficient or fast storage along with retrieval of data, blockchain is not considered to be suitable for such functionalities as it comprises of encrypted linked list or chainlike data structure. That is the reason why it would not be right to expect blockchain to be able to replace broad range of transaction-processing and accounting along with management-control functions of ERP systems such as reporting, payment, and invoicing. As transactions are stored in blocks and these blocks would be generated by participating firms from their own ERP systems internally and then added to the blockchain database, the blockchain role would be to interface with these legacy systems of all participating firms. Hence, it would make the process of integration rather easier for transactions of various flows among all the participating firms (Downes, 2021).[52]

5.2   Applications

There are several needs and requirements of the current time in the supply chain area which existing technologies are unable to address. In this segment, we are going to analyze how various applications of blockchain are being utilized by companies included in our study in order to meet these requirements.

5.2.1 Enhancing Traceability

One of the requirements which current technologies are unable to tackle is traceability across supply chains. In 2013, the Drug Supply Chain Security Act was introduced in the U.S. The purpose of this act is to safeguard consumers of prescription drugs from stolen, harmful, or counterfeit products. As a result, companies are required to enhance traceability so that they are able to monitor and identify such products in their supply chains and then be able to trace

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[52] THE YEAR IN TECH 2022 – 2021 [Harvard Business Review]

them before they reach to customers (Reed, 2014).[53] As the act mandates compliance, one of the large pharmaceutical companies, which is included in our study, has already started a collaboration with its supply chain partners for the utilization and implementation of blockchain in their processes for the same purpose.

In this process, all the products of the inventory which are drugs are assigned and tagged with electronic codes. Adherence is always made sure to GSI standards. As a result, it enhances traceability in the supply chain because this process enables the company to preserve the record on the blockchain-related to each product flow of inventory by scanning the tags assigned to each product along with their movement from one firm to another. This way, it generates a complete track record and history of all products across the entire supply chain from their source to consumer. With the early success of this project in the U.S., the company was encouraged for broad implementation of such pilots and as a result, it initiated further similar projects in Europe and other locations. On the other hand, IBM is another leading organization in this field. It is working in a similar direction and progressing towards the transformation of a safer and reliable supply chain for food products. They are already in partnership with Walmart to implement and utilize blockchain in order to trace and track fresh food products which we have already discussed above in detail.

Blockchain also provides the opportunity of participation to all such firms which are cautious about their information-sharing and especially do not want to share any information related to their competitive data with any other firm on the same blockchain. Because these applications do not require detailed information sharing, companies are not required to share their data such as records related to their payments, invoices, and purchase orders. This results in enhancing their trust and reliability along with their willingness to participate on blockchain platforms.

When it comes to such implementation and utilization of blockchain technology, it has very clear and obvious advantages. One of the obvious advantages is that it makes it possible for companies to efficiently recall the faulty product in case of any complaint before it's too late. Because, in case of such a scenario, blockchain makes it extremely easy not only for the firm itself but also for its partners to trace and track the faulty product across their entire supply chains. It also enables the company to identify all suppliers along with production and shipment batches of the faulty product. Further, it enables participating firms to automatically monitor the quality of products along with keeping the complete record of temperatures in which products are stored during their flows from one place to another. It is especially useful in the case of perishable food or drug products that are required to be fresh. In order to do so, an internet of things (IoT) device is used as it is installed in a refrigerated container, containing such products. This IoT device enables the monitoring of temperature in the refrigerated container in such a way that it records any unfavorable fluctuation (whether it is an increase or decrease) in temperature and preserves it on the blockchain. Additionally, as it is impossible to maintain a verification history of faulty or counterfeit products on blockchain, that is the reason why it is helpful and being utilized by many

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[53] How to comply with the U.S. Drug Supply Chain Security Act Rule using GS1 Standards – 2014 [Johnson & Johnson]

companies to address and eliminate authenticity concerns of such products which are returned by retailers because of any complaint or issue.

It is clear that the use of blockchain technology is not limited to any specific reason or industry. In fact, it is being utilized by several companies across industries in order to meet different requirements. Either these companies are obliged to implement this technology in order to abide by the law and fulfill the requirements of the acts being implemented or because of the importance and emphasis customers and regulatory authorities are showing for visibility and transparency across supply chains (Gaur, et al., 2020).[54]

5.2.2 Reduced Disruptions along with Enhance Efficiency and Increased Speed

Emerson, included in our study, is a multinational firm and is involved in engineering as well as manufacturing activities. As a multinational firm, Emerson deals in thousands of product components with several customers, suppliers, and different locations around the globe. This includes Emerson in the list of firms having complex supply chains.

"When a firm has such a complex supply chain, it usually faces several challenges. These challenges do not only limit to lack of visibility of goods across the supply chain but also include long and unpredictable lead times of components delivery. And these problems can occur even because of a slightest disruption or delay in any part of the supply chain, resulting in excess of inventory and stock-outs in other parts".
Michael Train (President of Emerson)

Michael Train is amongst the strong believers of blockchain technology and firmly believes that it has a great potential to help resolve such issues and challenges being faced by companies having complex supply chains.

Here is an overview of a problem which is usually faced by companies having a complex supply chain and what role can blockchain play in overcoming such challenges. If we consider a product, naming it product X, constituting on two components Z1 and Z2 for its manufacturing. On the other hand, we have another product, naming it product Y and the manufacturing of this product also constitutes on two components which are Z1 and Z3. If because of any issue or problem, the company faces any kind of disruption in the production of Z3 which is one of the components along with Z1, used in the manufacturing of product Y, the company would not be able to continue manufacturing product Y. In such situations, the best practice is to allocate another component (Z1) of product Y to the manufacturing of product X, as product X and Y, both have one common component (Z1) used in their manufacturing. Such practices may continue until the disruption in the production of other component (Z3) is not resolved. But the problem with this approach arises when there are multiple companies involved in the manufacturing and production activities of such products and their components without having access to enough information or visibility to the inventory of other companies. Such a situation could easily lead to excess inventory of

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[54] Building a Transparent Supply Chain – 2020 [Harvard Business Review]

component Z1 for the company involved in the manufacturing of product Y even if the company responsible for the manufacturing of product X is facing the stock-out situation for component Z1 at the same time.

One approach which could help to tackle and overcome such situations is to form a consensus among such companies so that they agree to share their production and inventory-allocation data on a centralized platform. This way, they would have visibility to the inventory data of other companies and hence avoid excess inventory or stock-out-like situations. But this approach would require a huge amount of effort and time, especially when it comes to the process of integration for all such companies. Additionally, they would have to trust other companies with their data which most of the companies usually feel reluctant to do so. Also, such companies will have to agree on centralized decisions regardless of considering the fact the decision is made by their partners or competitors. Such obvious complications in this approach make it unrealistic to be implemented.

Considering all these complications of integration, implementation, data sharing and trust deficit, a more realistic and practical approach for participating firms will be to utilize blockchain for sharing required data related to their inventory flows. This will not only allow all companies to utilize complete and accurate information available on a common blockchain database, but they would also be free to make their own decisions. Additionally, when it comes to production management as well as order placement among participants, utilization of Kanban system would be possible for participating firms to perform such tasks. In the Kanban system, companies would be able to assign Kanban cards to all the produced items in their inventory and these cards would be represented by digital tokens which would be recorded on the blockchain. As a result, all participating firms will enjoy enhanced visibility and access to data related to inventory flows across supply chains. Hence, resolving the problem of unexpected lead times, making them more predictable.

Michael Train is not the only believer of blockchain technology who believes in it to address and resolve the current challenges of increased efficiency, transparency, and speed being faced by the supply chain of Emerson. In fact, there are many more companies who also believe in the potential of this technology. One of these companies is Hayward, which is a multinational firm and manufactures equipment for swimming pools. Don Smith who is the senior vice president of Hayward believes that work-in-process inventory along with process capacity, finished goods, and raw materials can be treated in the same manner as digital currencies are treated. By implementing this approach, it would not only enable the reliable assignment of inventory at various stages to orders made by customers but would also increase the assignment reliability of machine time for them. This would be possible with the help of blockchain as it would enable companies to tackle and avoid the challenge of double-spend-problem in which the same unit of an inventory is inaccurately assigned to multiple different customer orders.

Another entity that has already begun the implementation process of blockchain in its supply chain processes is Walmart Canada. In this phase, trucking companies that are responsible for supply chain operations including transport of its inventory are utilizing shared blockchain with Walmart. This enables the automation in payments processing along with synchronization of data related to logistics and providing them access to shipments tracking.

All of this is possible with the help of blockchain and that too without any requirements of significant integration efforts or changes in the internal systems and processes of its partner trucking firms in the supply chain.

When it comes to participating firms utilizing blockchain technology in the supply chain area for the purpose of enhanced efficiency along with increased speed, the big plus such applications present to partner firms is that they require very minimal information and limited sharing of data related to their inventory or shipment. Additionally, these applications and their benefits are not only limited to smaller firms using one and only ERP systems, in fact, they present the same opportunities and benefits to even large organizations having several ERP systems without even requiring significant efforts for integration processes.

5.2.3 Improvement in Contracting, Financing and International Transactions

Companies implementing and utilizing blockchain as a reliable database to share their data and information related to their inventory along with financial transactions and flows among participating firms, do not only gain significant benefits in the area of contracting and supply chain financing, in fact, this approach even enables them to address and resolve a lot of challenges when it comes to conducting their business activities internationally.

When it comes to financing activities, banks usually are faced with a very common problem in their procedures related to the processing of trade credit and working capital to applicant parties. The problem is caused because of the possible inaccuracy in the available or provided information to the bank related to the business of the applicant firm, quality of assets, and incorrect representation of the firm's liabilities. The possibility of a firm requesting a loan from a bank, showing one purpose but then using it for a totally different purpose cannot be neglected. Another possibility is that the firm trying to borrow capital from several banks at the same time against one same asset. Such risks need to be managed and to avoid such scenarios and situations, banks are compelled to take risk management measures in order to control their risks. But such processes often do not only result in slowing down the access to capital, but also a significant increase in the costs of transactions along with reducing the availability of capital to smaller firms. These challenges, if not addressed with suitable measures and solutions, prove to be damaging not only for banks but also for firms that are in need of cheap working capital.

Management of accounts payable is another area that still has further room for improvement which can very well be filled with the help of blockchain. Even though many detailed and complex processes of accounts payable management, such as keeping track of terms and payments, invoicing along with their reconciling against purchase orders, and conducting reviews and approvals at each step, have already been automated to a great extent with the help of current ERP system. Still, these processes cannot be completed without significant manual steps and efforts to be involved in their execution. Another weak link is the unavailability of complete information to the companies involved in transactions. Since none of them have complete and accurate information, this factor usually results in leading them to conflicts.

5.2.4 Blockchain Enabling Tracing of Counterfeit Source

Cross-border trade is another area that involves a great deal of manual interventions and efforts in its processes. Not only that, but it also includes physical documentation of goods being traded from one country to another country along with multiple checks, inspections, and verifications of these goods and their documentation at each entry and exit port of countries involved in the route of goods being traded. Additionally, the processing of transactions is not only slow and inefficient but also proves to be much costly. Low to no visibility of the shipment's current status and location is another problem faced when it comes to international trades.

Companies that are included in our study are involved in both types of services such as retailing and financial services. All of these companies have already started the implementation of blockchain technology by either rolling out pilot projects or development of blockchain platforms related to all three areas of financing, contracting, and cross-border trades. When it comes to reconciling the process of invoicing, payments and purchase orders, participating firms involved in the implementation of blockchain in this area, find it quite comfortable and easy to perform these tasks. Additionally, blockchain also provides them the capability of tracking the status of transactions in process with their counterparties. All of this is possible because of the connecting and sharing characteristic of blockchain which does not only enable participating firms to create connectivity among financial flows, inventory and information but also sharing these details with each and every participant involved in these transactions. Being a participant of transaction, banks have access to the blockchain. This enables banks to provide working capital to suppliers (without any delay or lengthy procedures of verification) as soon as the orders are received. The same applies when it comes to obtaining the payments. As soon as suppliers deliver the ordered goods to buyers, banks are able to obtain their payments immediately. Additionally, automation of reconciliation processes along with audit trail availability also provides the possibility of utilizing such smart applications which are based on blockchain data. This way, it helps a great deal to completely eliminate the possibility of conflicts between any bank and the borrowing party (Downes, 2021).[55]

5.3   Designing a Feasible Technology

When it comes to the comparison of cryptocurrency networks with supply chains, an obvious finding based on the blockchain experience of companies included in our study is that they both are different from each other in important ways. Hence, blockchain cannot be implemented in supply chain management in the same manner used for the implementation in cryptocurrency networks as supply chains demand special needs and requirements which are quite different from cryptocurrency networks. That is the reason why there is a requirement for new rules to be introduced for the implementation of blockchain in the supply chain management area.

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[55] THE YEAR IN TECH 2022 – 2021 [Harvard Business Review]

The Bitcoin network utilizes an amazing protocol of blockchain which is capable of performing multiple tasks and achieving several goals at the same time. Being decentralized, it does not depend on any centralized authority to control or operate it. With providing ownership proof of a digital coin, it also guarantees extraordinarily safe, secured, and immutable transactions' record and reduces the problem of double-spending. Additionally, all the participants in the network can keep their identities anonymous without having any restrictions on their entrance and exit in the network. But in the process of providing all these amazing features, the Bitcoin network is also prone to facing vulnerabilities such as facing some risks of hacking, costing the network to sacrifice the speed hence resulting in functioning with reduced and slow speed. Additionally, consumption of energy is another issue as the mining process of bitcoins requires immense energy consumption.

But when it comes to the utilization of blockchain in supply chains, it is totally a different case. The reason is that not only the operating procedures and processes of supply chains are different, but their attributes and traits also differ from cryptocurrency networks. That is the reason why there is no need to sacrifice speed and efficiency nor there would be any issue regarding excessive energy consumption and the possibility of hacking. Below, we are going to discuss them in detail (Casinoa, et al., 2018).[56]

5.3.1 Participants are Known

As supply chains involve transactions being processed among known parties, dealing with each other, open blockchains are not suitable for them because open blockchains are used among users who are anonymous to each other. But since in the case of supply chains, users are known to each other, private blockchains are the requirement for them. Another requirement is to make sure that all the units of inventories are clearly linked to the specific identities of their distinct owners throughout the entire process. This is necessary in order to provide the capability of determining the origin and the quality of the inventories to all the participants of the supply chain. This also results in completely eliminating the possibility of any unknown element participating in such blockchain because of the prerequisite of receiving the required permission for all the companies looking to participate in the system before their participation. This means that any company which is not provided with the required permission to join the system, would not be able to participate.

Since blockchain consists of an open and decentralized structure, this leads to data and privacy risks. It means that when participants utilize the blockchain to post their transactions on it and as the data piles in volume, any party with required permission in the blockchain can retrieve this information. Hence, there is a risk of this data being misused by any participant to either predict movements in markets, gaining competitive intelligence, or trading stocks. In order to avoid such security risks, it is therefore necessary that selected participants must be investigated thoroughly before being provided with the required permission to participate in the respective blockchain.

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[56] A systematic literature review of blockchain-based applications: Current status, classification and open Issues - 2018

A solution that will result in overcoming several challenges can be to build a group of partners including all the participants who can be trusted when it comes to sharing data with them on the blockchain. The first challenge is to structure such a governance mechanism that could enable the establishment of system rules & regulations. For example, selection of participants to be invited and granted permission to join the network, which level of access should be granted to which participants, what would be the resolution mechanism in case of arising any dispute among them, which type of data should be shared with which participants and how the shared data should be encrypted and when it comes to IoT and smart contracts, deciding the scope for their utilization. Since additional transparency in the supply chain related to quantity or age information of products could potentially cause blockchain to impact on pricing and inventory allocation decisions. The challenge would be to determine the way in which to address this impact in a proper manner because as a result of this transparency there would be some costs and benefits as well. But it would not be easy to predict which area of the supply chain will bear the cost and where the benefits of this transparency will fall.

That is because of this reason that the companies which are included in this study, their main focus is not on broader applications of blockchain. They are rather focused on applications that are not only narrow and limited but they also have such use cases which are well defined and are also supported by regulatory requirements. Such applications include accounts payable management and traceability of food products and drugs items. In order to make the system safe & secured, less prone to risks related to data & privacy, easy to integrate for the supply chain partners, and accept the system without concerns, companies are keener towards limiting the types of information to be recorded on the blockchain.

5.3.2 Requirement of Simpler Protocols of Consensus

Requirements of consensus protocols for supply chains are different from those of cryptocurrency networks in many ways. Higher speed and volume limits of transactions are the prerequisites for supply chains. Blockchain needs a mechanism that enables the maintenance of a sole version for the entire history of transactions processed among participants on the network and is acceptable to all. Such a mechanism is called consensus protocol. Cryptocurrency networks utilize consensus protocols that are based on proof of work and that is the reason behind the complexity of such protocols. The reason behind using this complex method is the peer-to-peer, decentralized structure of cryptocurrency networks. Additionally, this method also guarantees the acceptance of participants' majority for every single transaction being processed among participants on the network. But on the other hand, this also causes a reduction in the speed limit of blocks added to the network. Considering the volume and speed of transactions in supply chains are much high, it would not be possible for the same consensus protocols being utilized by cryptocurrency networks to be implemented and utilized in supply chains as they would not be suitable because of their lack of ability to meet the speed and volume requirements of transactions in supply chains.

If we consider the capability of the Bitcoin network, it can only process about 360,000 transactions in a single day. On the other hand, the statistics show that only the supply chain in the pharmaceutical industry of the United States receives 4 billion units of drugs every year. If we take the handling average of each of these salable units, it comes from three to five

times for every unit. Calculating all of these transactions to find out the average of per day transactions in the pharmaceutical supply chain, the number comes from 33 million (minimum) to 55 million transactions per single day. This shows a huge difference in the capability of the Bitcoin network and the requirements of supply chains when it comes to transactions processing.

But this volume and speed limitation in the capability of Bitcoin Network lies mainly because of the proof-of-work method as the blockchain in the network is public and this method is necessary for public blockchains to establish consensus. But when it comes to the supply chain, the requirement is to utilize blockchain which is private & permissioned. It is a big plus as such blockchains do not need a proof-of-work method for the establishment of consensus as they can do it by utilizing simpler methods. With the help of these simpler methods, it can be easy to regulate such a mechanism that decides the addition right of the next block among participants on the blockchain. One such simpler method is "round-robin protocol". In this method, every participant gets the right to add blocks on the blockchain in a fixed rotating manner. Since the blockchain is private and permissioned, all the participants would be known. This makes it easy to discover any malicious actor in the network in case of any participant using its turn to make any illegitimate or harmful changes in the blockchain. Consequently, it enables them to resolve their disputes with ease by validating their previous blocks.

5.3.3 Physical Assets: Safety & Security

Security of blockchain records does not necessarily eliminate the danger of counterfeit or contaminated products' introduction in the supply chain. In fact, tagging and the introduction of such products in the supply chain, either by a corrupt, malicious actor or as a result of an error, is still very much possible. This is not the only problem, in fact, errors in data entry along with scanning and tagging flaws also tend to cause inaccuracy in the inventory data.

These risks certainly need attention to be taken care of so that they can be eliminated by taking proper measures. So far companies have figured out three useful ways to implement precautionary measures to tackle these risks and thankfully, they have been able to reduce these risks and by overcoming them, they are able to produce favorable and desired results.

1- First of all, these companies are strictly monitoring the products entering their supply chain. For that, they match and validate shipments with the records and data of blockchain by conducting physical audits of all products at the time of shipment arrival and before the entrance of products into their supply chain. They make sure that no product enters the supply chain without a physical audit which helps them to eliminate the probability of counterfeit products presence in their supply chain.

2- Secondly, these companies are also taking appropriate measures for the prevention of disinformation. For that, they are involved in designing distributed applications which are also known as dApps. Such applications are quite useful when it comes to monitoring, checking, and verification of data along with ensuring its integrity. Additionally, they also enable timely communication with the blockchain that serves for the prevention of

deception and errors. At the same time, they also help in the tracking process of each and every product in the whole supply chain. Even if despite all these prevention measures, any error or counterfeit product is somehow able to be introduced, companies would not only be able to easily detect it, in fact, they would also be able to trace the source of such asset by utilizing a trail of transactions in the blockchain.

3- Thirdly, companies are consistently involved in efforts to improve their blockchains by introducing automation to them so that human interventions can be decreased to a minimum degree and most of the tasks are performed automatically. For this purpose, sensors and IoT devices are being involved and utilized which enable the automation of the products scanning process and adding their records to the blockchain without the requirement of any human intervention.

When it comes to the trading assets such as digital books and music, tokenization is a mechanism that is considered to be sufficient and can be utilized to ensure enhanced reliability and safety. Additionally, it also enables the complete elimination of counterfeits by tying the ownership of such assets to the blockchain platform. For example, many educational institutes including universities, explore digital reading packets for many of their courses and work in partnership with copyright owners and publishers. If such digital supply chains are knitted into a blockchain platform with smart contracts, significant improvements and efficiency gains can be attained in this area which would enable assistance for participants when it comes to accessing products, verifying ownership, and handling payments.[57]

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[57] THE YEAR IN TECH 2022 – 2021 [Harvard Business Review]

6- Testing the Potential of Blockchain (Largest Cross-Company Pilot Project in Germany)

6.1   Utilization of Blockchain in Pallet Exchange Project

GS1 founded in 1977, is a not-for-profit organizations' network which is involved globally in developing, maintaining and negotiating cross-company processes' standards. It was in the year 2018 when it decided to put blockchain technology to the test by conducting a pilot project which was focused on exchange process of pallets between logistics, retail and industry. For this pilot project, GS1 under its umbrella, united 35 companies from different industries and sectors including logistics, retail, IT and science, along with start-ups as well as associations. The purpose of conducting this pilot project was to explore the potential of blockchain technology in real circumstances and test its performance by exposing it to real supply chains, real employees and real data.

6.1.1 Objectives of the Project:
- Utilization of standardized pallet note to enable testing and exploring the potential of blockchain technology based on the pallet exchange process.
- Enabling blockchain-based digitalization of the pallet note
- Setting up an exemplary network consisting of business partners to demonstrate how the process of pallet exchange can perform
- Conducting a realistic and practical test
- Exploring and substantiating the technically essential requirements
- Enable consideration of blockchain-based solution's benefits which are qualitative
- Acquire experience and insights and enable knowledge and information sharing

Project Duration: 01/2018 till 12/2018

Design of Project: Transparent, agile, unbiased, goal-oriented and iterative

6.1.2 Phases of Project:
- Development of Use Case: Defining the exchange process of Euro-pallet exchange
- System architecture: Defining the concept of the technology design
- Governance: Defining the project and future consortium rules
- Trial run: Prototype and simulation environment development
- Field test: Blockchain-based practical application of pallet exchange process in real supply chain environment (pooling service providers, retailers, industry, logistics)
- Evaluation: Solidification of findings and discoveries along with defining required approaches for organizations.

Figure 8: Project Participants [58]

6.2   The Reason behind focusing on the pallet note

The main reason for selecting an open pallet exchange system for the implementation of blockchain technology is the non-digital and paper-based nature of this system. Almost all of the operations are performed manually even including forms that are to be filled out by hands. This non-digitalized nature and involvement of manual operations in the system does not only lead to higher costs and inefficiencies for day-to-day operations and processes to be performed but also results in a lack of transparency in the system. That is the reason why this system is considered to be the main topic of issue and concern among industrial players along with logistic companies as well as retailers. Since blockchain is well known for its transparency and is considered to have the potential to automate the system along with making it efficient, the pallet exchange system because of its nature and conditions is considered to be ideal for the implementation of blockchain technology and testing its potential (GS1 Germany, 2018).[59]

The pilot project was being conducted on such a system in which neither rules are standardized nor it has set rights or obligations towards parties involved in it. Additionally, the system works without any intermediary which means that the exchange process is not monitored. Anonymity is another factor as parties that are dealing with each other in this system are almost anonymous to one another. But the main focus of the project team was to explore the potential of blockchain and discover if it is able to stop paper pushing.

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[58] Putting blockchain to the test – 2018 [GS1 Germany]
[59] Blockchain technology and architecture in the pilot project – 2018 [GS1 Germany]
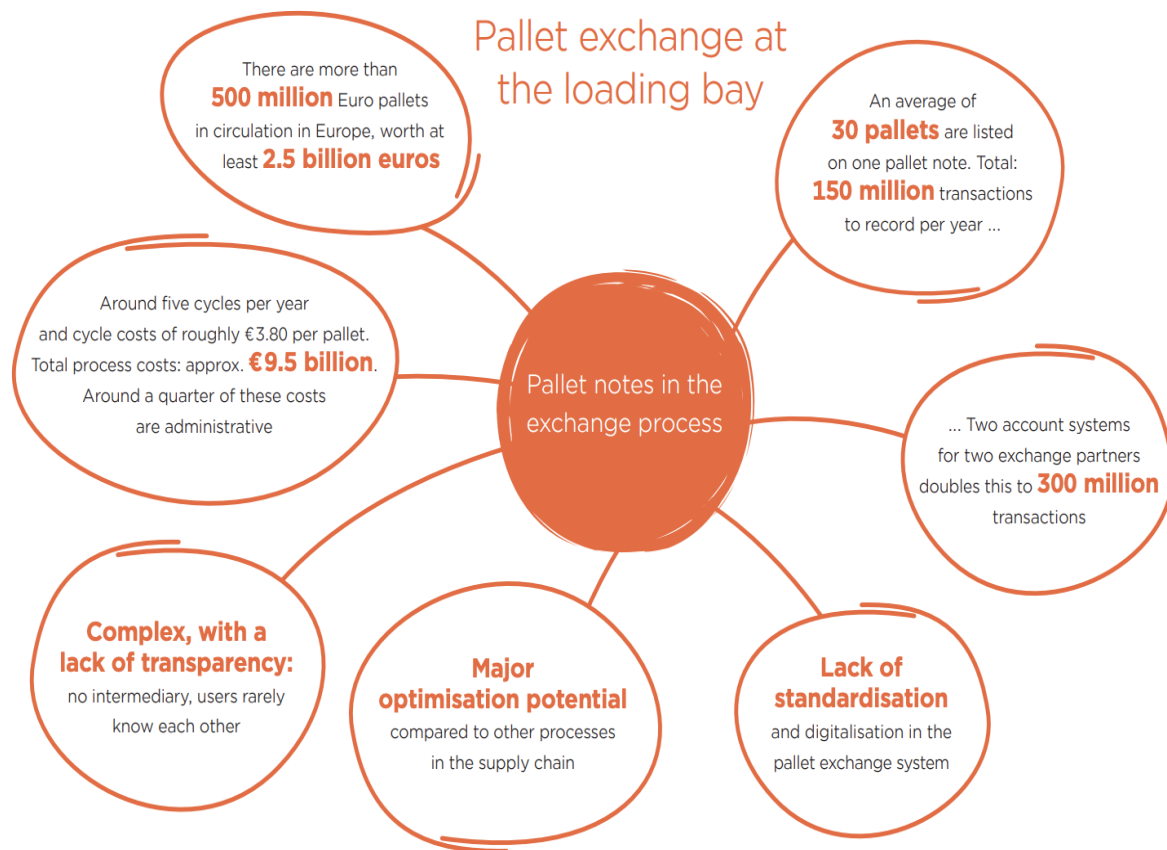
Figure 9: Pallet Notes in the Exchange Process [60]

6.3   Realistic test Conditions

The project team wanted to test the potential of blockchain technology by conducting this pilot project in such conditions which are as close to real-life as possible. This was the main challenge for the project team. The aim behind this was so that their project can be differentiated from others. Further, they also wanted to include as many business partners as possible for the same purpose. As a result, the project team succeeded in their goal, and eventually, the largest, practical, inter-company blockchain test in Germany was conducted.

To conduct this pilot project:

- A decentralized network was required to be established. The network consisted a total of 13 external nodes and each node in the network represented a different participant in the project
- Total number of participants who were involved in the field test was 17. The number of warehouses these participants had in combine were on 20 different locations

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[60] Putting blockchain to the test – 2018 [GS1 Germany]

- The main focal point of the project team was real supply-chain relationships so that they would be able to conduct this pilot in real supply chain conditions.
- As a result of their approach, all the factors included in the pilot were real. i.e., data, goods, lorries, pallets, loading bays, and employees.

Figure 10: Location of the Warehouses

6.4   Preparation for the Pilot Project

All the participants of the test, including retail and industrial partners were provided with hand-held devices along with their required accessories before the start of the pilot project. These devices were equipped with the option to function with the sim card. This function was necessary because participants were required to work with mobile blockchain-based applications on their hand-held devices. To do so, they required access to the internet. But there were some participating companies in the project which did not have connectivity to the Wi-Fi network. In this case, this option enabled them to use the internet through their sim cards installed in their devices and they were able to use blockchain-based application. Another point which was made sure that all the devices which were going to be used in the pilot project are provided to participants on their test sites. This was necessary because of security reasons. The number of provided devices to participating partners were two – one device was to be used by the assigned employee in the department of incoming and outgoing

goods and the other device was for the use of truck drivers carrying the pallets. It was not necessary for drivers to carry the device with them as the app had the option to be used either in the hand-held device or in the smartphone of the truck drivers.

Apart from the mobile app, a pallet portal, to be utilized during the pilot project was also established. This was another main focus point of the project team before the start of the test as they were aware of the importance of complete and proper training of participating employees in which they were to be provided with all the necessary information and equip them with required knowledge which would enable them to operate the required app and portal in a proper manner. For that, all the participating companies were provided with online interactive training. Along with that, they were also provided with a user information pack which was for the training of their internal employees. As drivers were to play a key role in this test, their training was also important. For that, along with login credentials, companies were also provided with a specific information pack to equip the drivers with all the required knowledge and information.

It was mandatory for all the participants to make sure that they comply and fulfil the following points before the start of this test:

- Availability of their mobile end device
- Ensuring that their device is charged and ready to use
- Checking and making sure that their device is turned on
- Provided credentials for login of the test participants are working fine
- QR code scanner has been enabled to access the camera and functioning properly
- On-site availability and access to either Wi-Fi network or network connection

6.5   Exchange Process Details and Description

The time period of the field test was around 15 days as it started on October 15, 2018, and ended on October 30th, 2018. While conducting the test, it was made sure that normal operations and processes of the participant companies are not interrupted. Normally, as companies use papers and hand-filled forms to record these transactions of pallets exchange, the similar practice continued during the trial phase and as a result, the data was not only recorded in the mobile app but also on paper. The two mobile hand-held devices which were provided to participants of the field test – one for Incoming Goods (IG) and the other for Outgoing Goods (OG) – were equipped with the functionality of scanning the QR code on the driver's mobile device. This QR code – generated for each exchange participant along with automatically storing their data as the participant logged into the exchange application – contained all the important information related to their company which was identical in the case of each different partner. This enabled the identification of the exchange partner at the time of processing the exchange transaction.

The first requirement for the participants of the test was to register their credentials in the exchange application before the start of the trial so that the QR code containing their information could be generated and available on their driver's device. This made them

recognizable by the IG/OG employee at the time of the transaction by scanning their driver's device. The IG/OG employee is then required to generate a new transaction of pallet exchange in which they would enter the total number of loaded and or unloaded pallets in that specific transaction in their pallet application. The application had another added feature that enabled users to enter a reference number in the UI along with mentioning the reason and details in case of a mismatch in the number of loaded/unloaded pallets. Once IG/OG employee had completed the process of entering all the information related to the transaction, it then required review and approval from the driver. Upon receiving this information, the driver would be able to review it on his device, under the option 'Open transactions'. If the driver does not find any mismatch and agrees to all the entries of data entered by his exchange partner, he could simply click the option 'Confirm' which as a result stores this agreed set of data related to the transaction on the blockchain. But if there was a conflict or a disagreement between the driver and partner related to data entered by the partner, the driver could simply make desirable changes in the data and then send it to the partner again. The IG/OG employee would then receive it as a new request of exchange from the driver. The same then goes for IG/OG employees. If he agrees to the changes made by the driver, he could give a confirmation for the data set to be saved on the blockchain. Unless and until both parties do not agree to data entered related to the transaction by their transaction partner, it would not be saved on the blockchain.

Before conducting this trial, the everyday practice and responsibility of the employees working in the department of load carrier management were to manually enter the data related to pallet notes. This as a result would enable them to track the pallet account in either Excel sheet or any other form of software. But as a result of the implementation of this experiment, it now provides them the access to view a pallet portal that has the record of all the data related to all the exchange transactions that took place. The employees can now keep the track of pallet account utilizing this pallet portal rather than maintaining manual entries and using excel and other software. The portal does not only provide visibility of transactions that are in open status – still in process and yet to be completed – but it also reflects such transactions that have been completed and closed.

The portal also offers the employees a complete summary related to all the requests made by exchange partners either for corrections or settlement of the balance. These are separate individual tabs in the portal for both 'New correction requests' and also for 'New balance settlements.' Another tab by the name of 'Balance' contains all the data related to balances for all load carriers and is accessible to all the employees. In order to show the balance of a specific load carrier, the employee needs to make the selection of that load carrier in the 'Balance' tab of the portal, and then it will display the balance of the selected load carrier along with all the involved exchange partners.

6.6   Findings and Insights

The motivation of participants behind conducting this trial was not only to test the potential of blockchain technology. In fact, they also wanted to find out whether this technology is capable of digitalizing and transforming the current process of pallet exchange from being

entirely paper-based to a completely paperless process. Basically, their main focus was to put an end to paper-based processes of pallet exchange. As a result, the pilot project succeeded and it was found out that blockchain can put an end to paper-pushing but only in certain conditions.

Through successful implementation of the blockchain-based process of pallet exchange, the team was able to demonstrate the digital reproduction capability of blockchain application for the pallet note. This means that current pallet exchange processes which are paper-based, inefficient, and outdated, can also be optimized by applying the same practices and procedures with the help of blockchain technology and it is possible to manage them with a single blockchain-based mobile application rather than piling up the papers for day-to-day operations and processes of pallet exchange.

The introduction of the first version of the mobile application was also a success. This prototype basically had three components in it. The first component works as a mobile application for the use of drivers along with employees and workers in warehouses and factories. These are the participants that are involved in exchange transactions of pallets. The second component of this prototype is a portal for pallets. It contains all the data related to balances of pallets and provides a current overview of the pallet balance to the employees that are involved in the processing of forms. Additionally, the portal also provides a listing of all the transactions in the company. The third component is Blockchain that bases on multichain technology. This component facilitates the managers in the IT department to gather and store all data related to transactions as well as amendments. Confirmations of positive experiences and feedbacks regarding the prototype were received from project participants. They rated graphics of the application along with its user interface easy to operate, clearly understandable, and overall user-friendly. Additionally, feedbacks for additional functionalities and features in the prototype were also received such as adding an option that enables the user to save the preferred exchange partner of his choice. Further suggestions were to allow users permission for picture attachments, enabling application to sync and operate with different web browsers, and integration of other load carriers.

The training of employees always plays a very important and crucial role in the success of any project as it is necessary that employees are provided proper and complete information regarding the processes to be implemented during any trial so that they are able to maintain a clear understanding and familiarize themselves with the new processes and procedures in time. The project team found it to be exactly true when the initial phase of the pilot project proved to be a significant challenge for them. The reason behind this was the lack of sufficient and required training of the eastern European drivers involved in the processes of the project. Such drivers lack required confidence and were reluctant in using the technology in their daily business. As a result, they were skeptical and reluctant in operating the mobile app to enter and confirm data related to their exchange transactions. If not provided sufficient training, such key weak points can prove to be very challenging to manage and tackle (GS1 Germany, 2018).[61]

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[61] The ultimate practical challenge: real life insights

6.7   Success of Practical Test

Conducting this pilot proved to be a success and testing the potential of blockchain in operations of daily routine was fruitful as it provided positive results according to expectations of the project team. Additionally, it also enabled participants to gain more insights and useful information regarding the overall capacity of this blockchain-based solution.[62]

- During the two weeks' time period of this field test, 17 partners took part in almost 600 real transactions of pallet exchange. All of these transactions were successfully mapped on blockchain
- Participants also performed the stress test of the solution. For this, a total of 3,600 transactions of exchange were executed in an hour which comes to around 87,000 transactions in a day
- The good thing was that during the practical phase of the trial, no major technical issues were faced in operations by neither participants nor the project team
- Most of the issues which were encountered during the field test, related to infrastructure such as poor connectivity of network and etc.
- There were only a few participants that encountered teething troubles with usage of the application but only at the initial stage when they were not familiar with the application and were new at using it
- Project team also defined the storage requirements in order to store all the data of transactions being performed. A total of 10 MB space is required to store 1,000 transactions of exchange. Calculating 3,600 transactions being executed in an hour, the one-year disk space requirement to store all the exchange transactions would be 200 GB which is easily manageable.

As the number of exchange transactions grows with every passing day along with increasing the number of involved participants in these transactions, this will result in the growth of data volume to be stored. This implies that storage capacity should also be expanded at the same rate.

6.8   Qualitative Benefits from the Implementation of Solution

The project team discovered that there are many users among participants of the test who are willing to further continue their usage of the mobile application. The application did not only simplify day-to-day tasks for its users, in fact, it also caused improvement in loading bay operations and made them much easier. Additionally, users also experienced improved efficiency when it comes to back-office operations such as auto-calculation of balances, reconciliation process of accounts made simpler and etc.

Since the implementation of blockchain-based solutions requires close collaboration of partners for optimal results, it resulted in strengthening and improving several partnerships

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[62] Blockchain technology and architecture in the pilot project – 2018 [GS1 Germany]

in the supply chain area. This demonstrates that the application and implementation of a blockchain-based solution are not only limited to any one sector, in fact, other sectors across the industry can also benefit from it.

Participating in this pilot project also resulted in knowledge enhancement and information gain in the employees of partner firms. Many of the employees who were not very much familiar with the internal processes of their own companies, got the opportunity to gain insights into this area. Along with that, employees got their exposure to blockchain technology which resulted in gaining valuable experience by participating in the field-test of blockchain-based solution. In addition, as it was important to continue the consistent practice of further knowledge transfer to the user community, it is made sure through special appearances at different conferences along with writing several articles and blogs on the project.[63]

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[63] Putting blockchain to the test – 2018 [GS1 Germany]

7- Blockchain Use Cases in Germany

7.1   Accenture and DHL intend to tackle Pharmaceutical Tampering with the help of Blockchain Prototype

Accenture and DHL are the two companies that are already working in collaboration with each other to unleash the true potential and power of blockchain technology in the field of logistics. They established a pharma security program that is a serialization prototype and is based on blockchain technology. The prototype provides them the capability to track and trace all pharmaceuticals in their supply chains right from the starting point of the supply chain (manufacture) to the endpoint of the supply chain that is the end customer or consumer of pharmaceuticals. Tracking is done with a ledger that can also be shared with all the important participants and stakeholders in the entire network. For example, from manufacturers to warehouses, warehouses to distributors, distributors to pharmacies, and from pharmacies to hospitals, and doctors. The blockchain of this prototype has the enormous capacity and capability to handle more than seven billion unique and different serial numbers. Additionally, it also has the potential of efficiently executing 90,000 transactions per minute that coming to a total of 1,500 transactions within a second (Air Cargo News, 2018).

"The experiments with blockchain in finance are well known, but we believe logistics is an area where the new technology will have a truly profound impact. Implementing productive solutions however, will require further technological development and, critically, collaboration between all stakeholders."

Matthias Heutger,
Senior Vice President DHL Customer Solutions & Innovation [64]

According to the data presented by Interpol, it is estimated that there are almost one million people each year who lose their precious lives and the reason behind this great loss is the counterfeit of medications. When it comes to the total number of counterfeit pharmaceutical products being sold in emerging markets, the data reveals a shocking figure of nearly 30%. Such solutions are the requirement of the time and with the help of their prototype Accenture and DHL would be able to provide a potential solution to supply chains against the great threat of counterfeits in pharmaceuticals. The successful implementation of this blockchain solution would enable a mechanism to authenticate medications and eventually result in helping authorities to save the precious lives of several patients (Hopping, 2018).

"We see especially exciting potential for blockchain in pharmaceuticals, which is why we focused our proof of concept with Accenture on the life sciences and healthcare industry. By utilizing the inherent irrefutability within blockchain technologies, we can make great strides in highlighting tampering, reducing the risk of counterfeits and actually saving lives."

Keith Turner,
CIO Chief Development Office, DHL Supply Chain [65]

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[64] Blockchain has "exciting potential", says DHL
[65] DHL trials blockchain in pharma supply chain to cut out counterfeit drugs – 2018
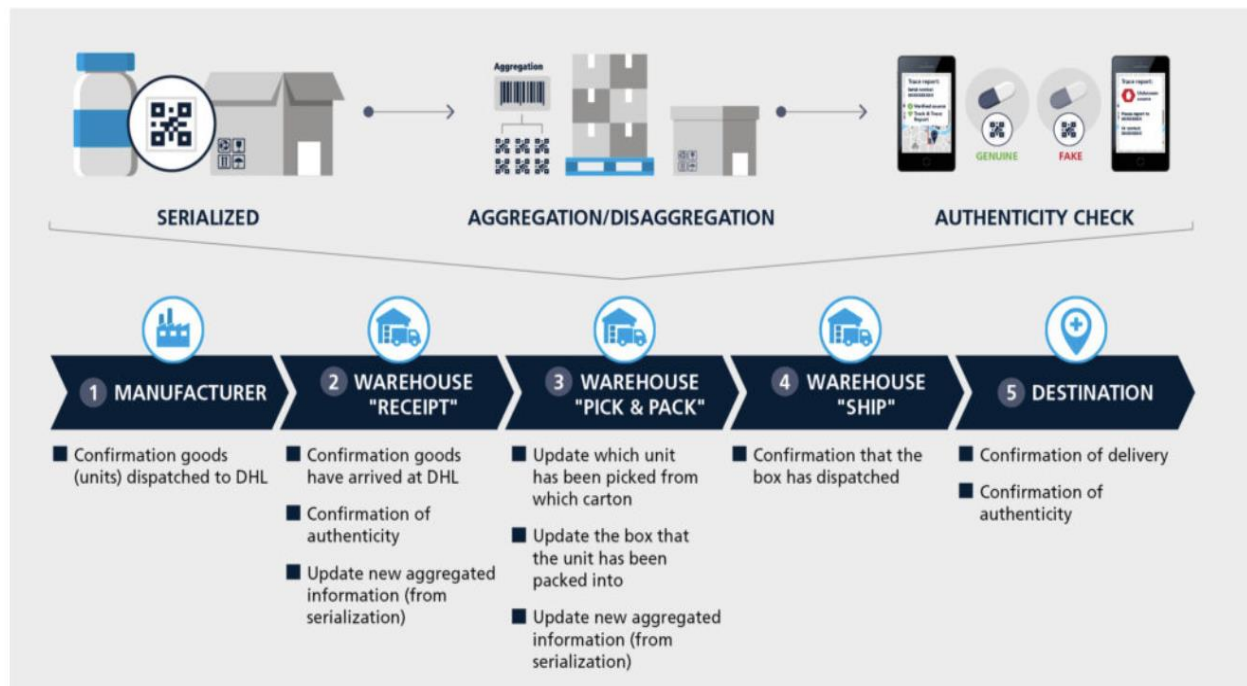
Figure 11: DHL & Accenture Blockchain Solution for Pharma Security [66]

The potential of blockchain technology does not only limit to the supply chains of the pharmaceutical sector. In fact, the application and implementation of this technology also promise great potential for the supply chains of different sectors especially when it comes to the reliability and efficiency of respective supply chains. When it comes to the development of prototypes and solutions of blockchain technology, a total of $945 million were spent globally in the year 2017 as per the figures shown by International Data Corporation (IDC). In the year 2018, a significant spike was predicted in this amount and the global spending was expected to increase more than double of the 2017 spending, reaching $2.1 billion. This amount is expected to witness a further significant increase making it to $9.7 billion per year spending by the year 2021.

"We've worked closely with DHL to understand and document the broad impact blockchain will have on supply chains of the future. Using a common, indelible and secure ledger, the industry can achieve much higher safety standards – from the factory to the patient – at much lower cost. This is one of several opportunities blockchain affords to restructure business processes while reducing cost and complexity."

Andreas Baier,
Accenture lead for the travel and transportation industry and DHL client team leader

Potential use cases of blockchain technology and its significance are not only limited to the pharmaceutical prototypes developed in collaboration with Accenture and DHL. In fact, this is only one use case where blockchain can create a revolution in the pharmaceutical industry

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[66] DHL and Accenture trial blockchain-based pharma security program – 2018

when it comes to the security and safety of pharmaceutical products and eliminating the introduction of counterfeits pharmaceutical products from the supply chains of all the companies exploring blockchain technology. In the same way, blockchain can revolutionize several sectors and industries as well. For example, when it comes to asset management, blockchain promises the great potential to provide significantly improved transparency. Not only this, but it also provides the capability to trace and track the assets. Additionally, the feasibility of smart contracts on blockchain also provides a great opportunity to management by enabling them to enhance the efficiency of commercial processes with the help of automation of such processes (Accenture, 2018).[67] These smart contracts are not only helpful in increasing the performance and efficiency of contracts, but also eliminate the need for third parties from the process. There is no doubt that blockchain promises great and significant potential in the area of supply chain and logistics. But at the same time there is no denying the fact that if companies want to move further from the trial and prototype phase towards the actual development and implementation of viable solutions based on blockchain, they must recognize that it would only be possible with further development of blockchain technology. Additionally, they would also need to consider another key and important factor that is bringing organizational transformation. Last but not the least, successful implementation of blockchain solutions also mandates a prerequisite of collaboration and sharing among business partners. That is the reason why companies and managements looking to explore blockchain technology must keep in mind that they should be agreed and willing to fulfill this important requirement of blockchain technology because when it comes to blockchain technology, success lies in working together and in collaboration with other stakeholders and business partners (HENDERSON, 2020).[68]

7.2   Smart Pallet Project based on Blockchain

BASF which is a well-known and reputable chemical manufacturer is in collaboration with two other startups Quantoz and Ahrma. Quantoz is a blockchain start-up and Ahrma is an IoT start-up. Together, they are working to make logistics and supply chains more transparent, reliable, and trackable. For that, they are exploring blockchain technology to build a platform that provides them the capability to keep track of consignments in their supply chains. This is possible by the complete transformation of traditional pallets and equipping them with sensors so that they are able to track and record the data related to movement, weight, and temperature of the pallet and make it available on the blockchain. This way they are on their mission to replace normal and traditional pallets with their newly developed smart and intelligent pallets. Additionally, this smart pallet is also able to provide in-time information to the concerned party related to the delivery status of their consignment whether it is complete or not, and if it is in perfect condition or damaged. Along with providing the data related to its load status, the pallet is also capable to record the data in case of any possible impact, fall or dropping which can cause any damage or harm to goods stored on the pallet. With this feature, customers will only have to pay depending on the usage as per the weight of the pallet. In case any part of the pallet gets missing or damaged, the pallet is able to automatically report and reorder the specific part. Along with all these features, the addition

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[67] DHL and Accenture Unlock the Power of Blockchain in Logistics – 2018 [Accenture]
[68] DHL and Accenture working on blockchain-based pharma supply chain project – 2020

of blockchain technology developed by blockchain start-up Quantoz has also increased the reliability and security of data. Additionally, such smart and intelligent pallets exploring blockchain technology also prove to be cost-efficient. They can be tracked in case of not being in use and can be used optimally. This way, costs that arise because of pallets that are lost, stolen, or are not in use, can be reduced significantly (Zhao, 2017).[69]
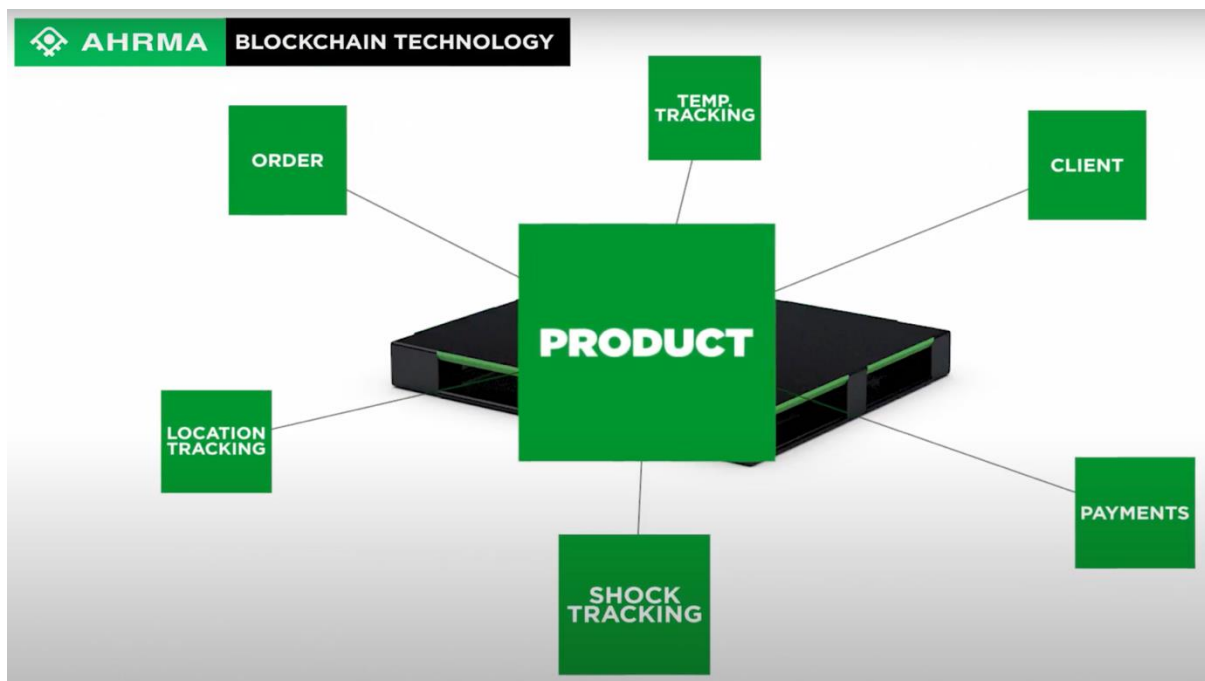
Figure 12: Ahrma Blockchain Technology

On the other hand, we all know pallets that are made of wood. The total number of such pallets in circulation is around 9 billion. The first issue with the wooden pallets is their quality. They break down a lot, have lots of rusty nails, and are unhygienic as well. These standard pallets normally live up to two to three years. The second issue with these pallets is safety, such pallets are among the main causes of damaged goods and furthermore, they can also harm the personnel working in automated production lines and through the entire value chain. A company can have tons like these pallets in its pool. Many of them are lost or damaged along the supply chain. Another unanswered question is regarding the optimized usage of these pallets. Further, they are not capable to provide any information whatsoever. But on the other hand, there's a smart choice which is the smart pallet, developed in collaboration with BSF, Ahrma, and Quantoz (Lacefield, 2017).[70] Along with being environmentally friendly, it does not have any nails in it, has high technology coating, easy to clean, and is not slippery at all. Additionally, these pallets are smart and include an active transponder that can measure their location, temperature, and tons of shock data in real-time. The transponder connects with the gateways in the factory, the trucks, warehouses, and retail outlets through the entire supply chain. The gateways collect all the information from the pallets and send it to the Ahrma cloud. The user can check all this real-time data and

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[69] German Chemical Company Pilots Supply Chain Blockchain – 2017
[70] Pilot project connects blockchain and "smart" pallets – 2017

follow goods individually via the dashboard. If connected to the loaded products, the Ahrma pallet and cloud form the base of complete blockchain technology for capacity planning, smart routing, and automated payments. This is real big data and real Internet of Things (IoT). The Ahrma Big Data system enables the first step to create economic value through the optimization of the value chain, increasing the turnover rates, and minimizing the number of pallets in the pool (Brett, 2017).[71]
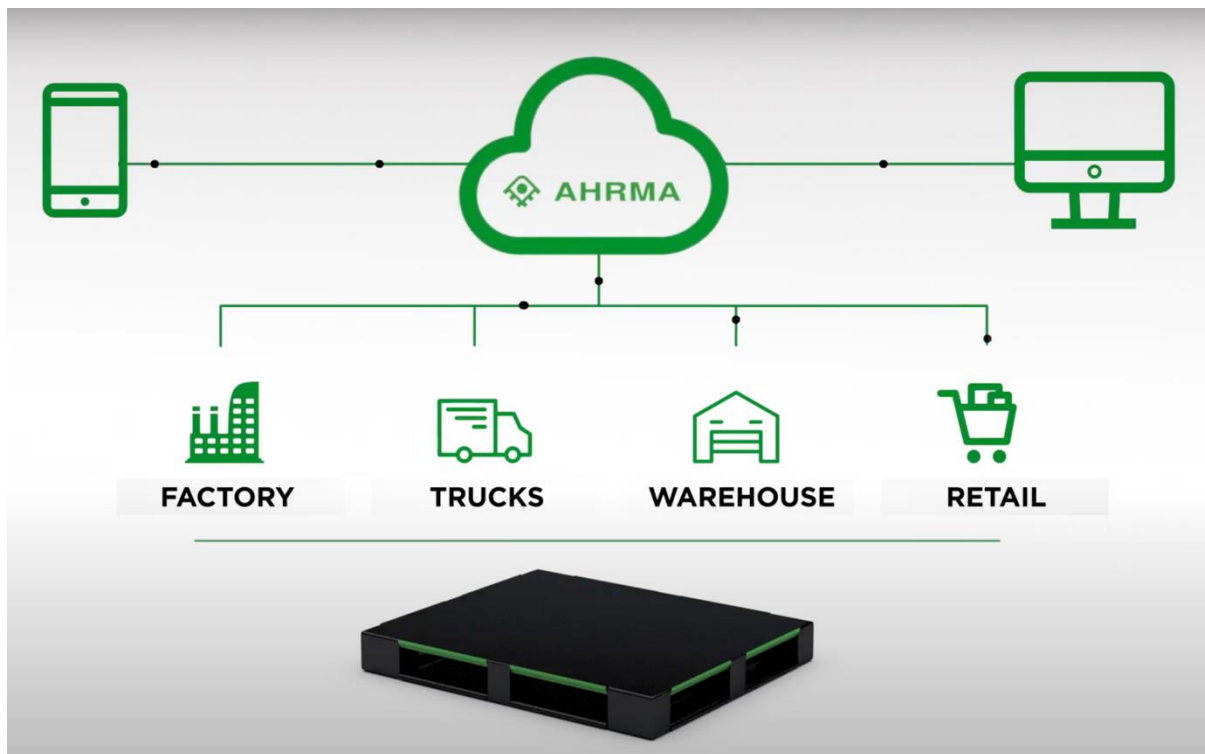
Figure 13: Ahrma Smart Pallet

7.3   Utilization of Blockchain Technology at The Port of Hamburg

Many players at the port of Hamburg have successfully implemented a solution that is based on blockchain. The purpose behind the implementation of this solution is that different tasks which are assigned to these players can be executed with the help of this blockchain solution. The role of this blockchain solution is to serve them as a common platform for the data. Additionally, this solution is also capable to enhance the efficiency of the process related to handling. This includes the unloading process of the containers from sea freight carriers as well as transportation of those containers by trucks. Participants of this solution include players such as freight forwarders, truck companies responsible for transportation as well as port terminals (HAMBURG NEWS, 2021).[72]

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[71] BASF applies blockchain to its supply chain – 2017
[72] Blockchain technology to boost release processes in ports – 2021 [Hamburg News]

DAKOSY AG based in Hamburg and dbh Logistics IT AG based in Bremen are both in collaboration with each other and working on a joint project to develop a blockchain solution that will provide them the capability to digitalize the process related to the release of import containers. Both of these players are vastly experienced as German IT suppliers as well as specialized in community systems of ports. They announced their plan that they are aiming to successfully connect the first batch of freight forwarders along with shipping companies to this platform, latest by the end of year 2021. The platform would be labeled "German Port" and will be available for the use of connected participants. Along with the port of Hamburg, this platform will also cover other ports in Germany including the Port of Wilhelmshaven, Bremen as well as Bremerhaven. When it comes to releasing operations and processes, these ports will have multiple options to explore. Additionally, users will also be able to avail multiple choices related to processes as well as technology.

This is going to be the first time when DAKOSY and dbh are working jointly to enable users and provide them access to blockchain technology. Before this, they have already been involved in the IHATEC research project ROboB and with the experience of this project, they were able to test blockchain in order to find out whether the technology is suitable or not and whether it is practical to explore blockchain for the release process at the ports or not. After the successful confirmation of the practicality and suitability of blockchain technology, they have decided to develop this blockchain solution for the release process at ports. Another important and key factor that would also work as a catalyst to efficiently enhance the implementation speed of this project is the keen interest of carriers and their willingness to participate and adopt in the digitalization of the release process (Hafen Hamburg, 2021).[73]

When participants of the project are similar to each other like terminals, transport companies, carriers, and forwarders, this usually proves easy for them when it comes to taking initial steps for the beginning of new process and taking part in its implementation.

"Our solution for the digitalized release process is based on existing platforms and processes that are already being extensively used by the stakeholders in German seaports."

Dirk Gladiator, authorized officer of DAKOSY

The application will be available for integration into the Import Message Platform (IMP) in Hamburg Port Community System. At ports of Wilhelmshaven and Bremen, the application will be integrated into the Business Integration Platform (BIP).

"Parallel to the proven IMP and BIP platforms, we are building the framework for blockchain in order to make it available as a hybrid alternative in the next step. We are already preparing the test phase assuring digitalized releases meet all requirements for security and verification of identities."

Holger Hübner, Head of Port Solutions at dbh

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[73] DAKOSY and dbh digitalize the release process for „German Ports" – 2021
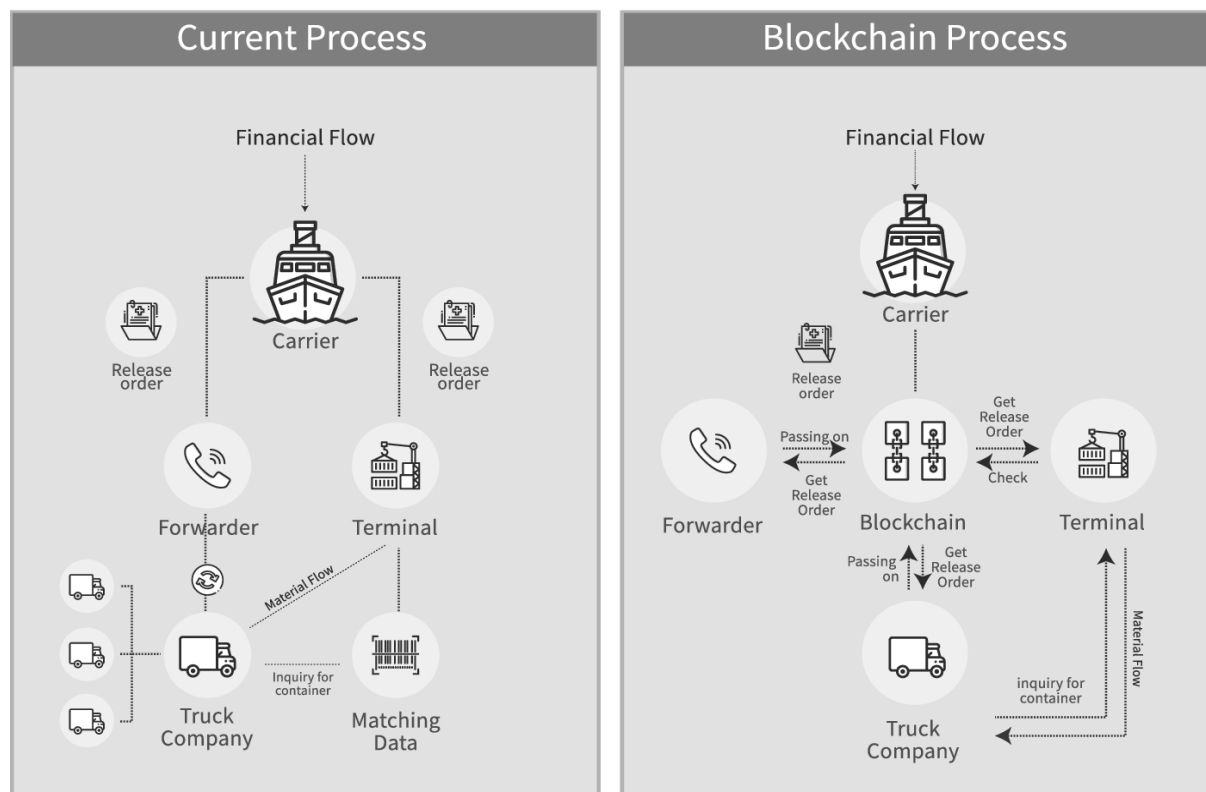
Figure 14: Blockchain Process for Flow of Information

When it comes to exchanging process of release orders among related players like truck service providers, freight forwarders shipping companies and etc. there has been no digital process in place for their communication from one participant to another. In fact, the general practice is to utilize the traditional way which is to communicate orders-related information to other parties through phone, fax, or email.

"The manual process causes a lot of extra work for everyone, as the players have to engage in bilateral dialog for each individual container to organize authorizations and empty container returns,"

Hübner and Gladiator

Once the release order is received by the holder of the container, the holder is authorized to release the goods. Since it is often the case that the goods to be released are usually of considerable value that is the reason why the release process is considered to be a sensitive process and has strict requirements in place by the authorities. But the utilization of platforms like IMP and BIP that are already existing and established as well as the availability of alternative blockchain-based solutions plays an important role when it comes to fulfilling in place requirements related to access of authorizations and secure processes of IT (MIN NEWS, 2022).[74]

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[74] The Port of Hamburg will use blockchain technology to release containers – 2022 [MINNEWS]

7.4   Utilization of Blockchain in Logistics Operations

MOSOLF is another company in the automotive industry that is utilizing the potential of blockchain technology in collaboration with Etecture GmbH and Lawa Solutions GmbH. Basically, MOSOLF is a provider of logistics services whereas Etecture GmbH is a consulting company and LAWA solutions has known expertise in corporate software in the automotive logistics sector. This is the first blockchain from MOSOLF and the developed blockchain solution enables MOSOLF to digitally create waybills and other documents such as consignment notes. When it comes to validation of these digital consignment notes and other digitally created documents in this blockchain solution, smart contracts are utilized for this purpose hence proving to be forgery-proof because of the underlying technology distributed ledger. Etecture GmbH serves as the provider of infrastructure conception and is also the developer of underlying smart contracts. LAWA solutions GmbH is responsible for providing the required programming work such as developing telematic software. This software plays an important role when it comes to enabling the application for recording and processing of the data.

"By launching our first blockchain and learning from the insights that we've gained, we can now complete further projects. We're working on other solutions with ETECTURE and LAWA Solutions in order to simplify the entire value-added process for our customers, from the end of the production line to recycling, and to develop new opportunities for application"

Antonio Marsano, Head of IT and Digitalisation at MOSOLF

Such utilization of blockchain technology in the application developed by MOSOLF, makes it forgery-proof and ensures the security for the processes of logistics operations and documents with the help of underlying smart contracts being utilized for the validation purpose. The purpose behind developing a blockchain-based solution to be utilized in logistics operations is to improve the logistics value-added chain of automobile by making the processes more efficient and at the same time improving their security. For this purpose, the utilization of digitalized consignment note is necessary. There are many stages of logistics operations and processes that are covered by this such as loading of the goods, their transportation as well as the handover process. This is the document that generates a fingerprint (hash value) and then this fingerprint is transferred to blockchain. Then it comes to the blockchain network which utilizes smart contracts for the purpose of checking and verification of the transaction by ensuring its uniqueness. Additionally, it also links freight document and vehicle with each other. Once the process is completed, blockchain records the transaction as valid along with its GPS coordinates as well as timestamp. Participants who are authorized to access the blockchain can utilize a web service in order to check and verify the authenticity of the identification number related to any vehicle (VIN) as well as the document of any freight (MOSOLF, 2019).

"This is an important milestone for MOSOLF and it underlines our company's innovative capacity. As a result, we're able to create transparency along our value chain and offer our customers genuine added value,"

Dr Jörg Mosolf, CEO of MOSOLF SE & Co. KG.[75]

7.5   Deutsche Bahn Investigating Blockchain

Blockchain technology is still in its experimental state. It is comparatively new technology and that is the reason why anyone who is willing to utilize and explore the potential of this technology, it is necessary for them to develop and test their solutions themselves. Currently, there are several potential use cases of this technology that either are yet to be developed and tested or are already being developed and tested in different projects by organizations all around the globe. For the same purpose, DB decided to step in to explore the technology of blockchain. Deutsche Bahn is the biggest mobility provider in Europe. They are involved in rural transportation, long-distance transportation, and urban transportation like metro systems. They transport either goods or people from A to B. DB Systel is the IT provider and digital partner of all DB AG companies. They have created a special department for blockchain. The aim of developing this department is to find out the true potential of this technology for rail along with exploring the ways in which this technology can benefit their operations and enhance their efficiency. The department consists of around 30 employees which include project managers, software architects as well as developers. Currently, there are around 20 use cases of blockchain which are being explored by Deutsche Bahn. Along with supply chains and logistics, these use cases also include rail operations as well as convenient ticketing across modes of transport.
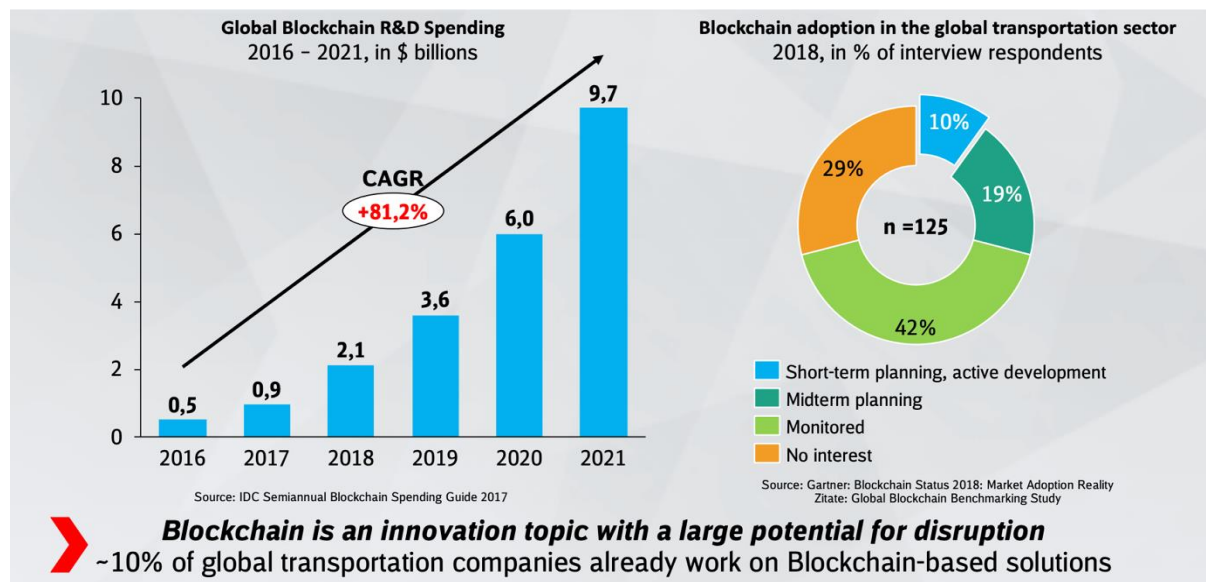

Figure 15: Blockchain as a technology of future: Active and increasing investment in R&D, transportation [76]

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[75] MOSOLF USES BLOCKCHAINS FOR CONSIGNMENT NOTES – 2019 [MOSOLF]
[76] Blockchains for Transportation and Logistics – 2019

The world we live in is changing rapidly. We are entering a digital age that offers many new opportunities. New sensors, significantly more data, and more information consumption are leading to lasting changes in customer needs. In order to be able to fulfill these demands even better, DB Systel is helping to shape the digital future right from the outset. For this, the reliance is on the use of the still very new Blockchain technology that connects all parties involved in a transaction on a uniform data basis. This simplifies administration, creates transparency, and automates individual process steps. In this way, not only processes and billing between different files can be accelerated in the future, but also throughput times can be optimized. The system operates completely autonomously and guarantees maximum security. Systel is currently developing a superior solution for a single, mobility-encompassing, trustworthy identity under the working title Trusted Identity. In the future, Systel will be able to clearly identify people or goods in transit along the entire mobility chain. At the same time, they are working on transparent and optimized billing for all service providers in a transport chain. In this way, they enable open, seamless travel from A to B across all modes of transport, with only one identity and only one ticket with fair and performance-driven billing for all parties involved. No matter whether the transport is by train, plane, ship or bus. Blockchain technology also creates the necessary conditions for flexible and digital control of operations in infrastructure management. The vision for railway operations of the future is that they will manage themselves almost autonomously. The future of modern mobility that makes optimum use of and leverages all opportunities of the digital age has begun (Kuperberg, et al.).[77]

7.5.1 Blockchain for Rail Operations

Since the first train journey between Nuremberg and Furth in 1835, the world of railway operations has developed significantly. For example, if we take signals, and track elements, they were first mechanically controlled. Later on, with the passage of time and development, they were then controlled electrically, and finally, digitalization came into play and they were then started to be controlled digitally. But if we talk about the future, the keyword is Distributed Ledger Technology (DLT) which is also known as Blockchain. The common goal is to increase quality, availability, capacity, transparency, and massively reduce costs. With the help of DLT, all participants share the same relevant infrastructure information. This actually means that Smart Contracts enable all vehicles to communicate with each other. This communication is not only limited to this level in fact track elements, such as level crossings, signals, and points can also communicate with vehicles. This results in the simplification of the infrastructure. Further, the availability of the entire system can also be improved.

Initial successful tests in Darmstadt's dispatcher training facility show that the vehicles are capable to take their own routes. Additionally, vehicles can also book and release their routes again. This is all possible without any central controlling center and also without causing any conflict. A general ledger records the state of the infrastructure elements. This general ledger is not only transparent to all parties but also secured and tamper-proof. Additionally, this ledger is continuously updated. The use of distributed ledger technology is not limited. In fact, it can be utilized for transactions such as checking driving authorization, license of the driver

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[77] Are Smart Contracts and Blockchains Suitable for Decentralized Railway Control?

as well as billing the infrastructure. Together, the partners examine how distributed ledger technology can enable more significant and efficient use of railway infrastructure for flexible, scalable, and self-organized controlling of railway operations (Emerging Tech, 2020).[78]

7.5.2 DB Systel utilizing IBM Blockchain to create a seamless transport

With the help of blockchain, DB Systel is trying to make travel and transportation for customers as easy as possible. Usually, the travel experience in Germany and Europe is that customers don't travel seamlessly through different modes like trams, buses metros, Uber, taxis, car-sharing and etc. It's all split up. So, DB Systel together with IBM is trying to create a blockchain-based solution that would play the role of a platform where customers can have a seamless experience in traveling.

Everybody who transports goods, wants to have more information, wants to digitalize their businesses. People also want to book digitally. They don't want to have the hassle of buying different tickets. Customers want a digital experience for transfer requirements, booking tickets and etc. In short, customers are going digital and that is the reason why to meet customers on the same level, DB is also adopting to digitalization needs of customers. For that, they need to reshape their processes, and to do that they found out that it's very helpful to use technology like blockchain (distributed ledger technology) to have a place where the offer of transportation and offer for the consumer meets the demand.

For the user, it is a new kind of experience to have a seamless ticket that can be used while traveling by bus, train, or so on. Customers can book this ticket just with one click and on one platform instead of signing into more and more platforms. Because of blockchain, DB Systel has a new kind of transparency between all mobility providers. They are able to split up bills by creating a fair billing structure. Most importantly, they are creating a whole new travel experience for the customers which is seamless and convenient and has never been done before anywhere else in the world (Felder, et al., 2018).[79]

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[78] New Normal, Digital Transformation, Industry 4.0 – 2020
[79] Can travel be revolutionized with blockchain technology? – 2018 [IBM]

8- Cost Estimation of Blockchain Solution

As we have discussed in detail regarding the great potential of promising blockchain technology. But when it comes to the development and implementation of blockchain solutions, the basic questions which come to mind are:

1-   How much it is going to cost for the development and implementing a blockchain solution
2-   What are the requirements
3-   What resources are required
4-   And how to acquire them

Since Blockchain is not as simple as plug and play, that is the reason why it is not easy and simple to generalize the cost estimation for blockchain solutions. Because there are several blockchains, at least in hundreds if not in thousand. So first the need is to find out whether the requirement of business is to utilize permissioned or permissionless blockchain. Then to find out which blockchain is to be utilized for the solution as per the needs and requirements of the organization. And then comes the infrastructure of IT within the organization, business processes and procedures and etc. Then it also depends on the scale of implementation of the blockchain solution. And also, whether it's the integration of blockchain solution into already existing systems of the organization or starting from scratch. The requirements and preferences of every business and organization are most likely to differ, that's why it's not easy to generalize estimation cost for a blockchain solution unless and until we don't have the information about the factors mentioned above. Below we are going to get an overview of cost estimation for developing and implementing blockchain solutions and also the factors which can impact the cost estimation and cause it to vary.

8.1   Cost Estimation of Hiring Blockchain Developers

The first thing to consider is the business of the organization intending to implement blockchain solution. If the organization is dealing in the IT sector, having business in the IT industry, then they are most likely to save the cost as they might not require to hire additional resources in terms of developers of Blockchain. But if the business of the organization is not in the IT industry, then the company will need to hire developers of blockchain and in some cases, they might even need to hire software development companies in order to develop and deploy their blockchain solution.

Basically, when it comes to Blockchain developers, there are two types:

*   **Core Blockchain Developers:**

    When it comes to blockchain solution that is to be used in the commercial sector, core blockchain developers are required as they are expert in designing the architecture and security of such solutions.

- **Blockchain Software Developers:**

    They are responsible for creating the foundation as well as the architecture of smart contracts and decentralized apps which are also known as dapps.

As per the statistics, if we consider the requirement of IT professionals in the market of the United States, blockchain developers are among the most demanded. The average annual salary of an Engineer is estimated to be $79,583. When it comes to Software Engineers, the numbers are slightly higher as their annual salary is estimated to be $107,851 (Indeed.com).

Further, if we look into the freelancing sector, a skilled blockchain developer on average charges $55 per hour. These numbers conclude that a blockchain developer while working as a freelancer charges an annual salary of $100,100 (Toptal.com).

That is the reason why when it comes to hiring a skilled blockchain developer with the required experience and knowledge, it is not considered to be an easy task. Because they are highly in demand as many companies from several industries and sectors are in search and need of blockchain developers. Additionally, this factor also contributes to raising their demand in the local market as well as their charges/salaries.

That is the reason why many companies and startups with limited budgets and a shortage of resources try to cut down the expenses. And for that purpose, they prefer to look for software companies that are offshore and cheaper so that they can outsource their blockchain projects to such companies which will save them resources and also result in minimizing the cost of the project. This practice is not only common in the United States, but also in western markets. When it comes to the most feasible, less expensive, and budget-friendly destinations for the purpose of outsourcing the development of blockchain solutions, there are multiple countries that are well-known in the markets such as India, Vietnam as well as countries in the Eastern part of the Europe such as Poland and Ukraine.[80]

But when companies decide to outsource their blockchain development, they might also need to consider hiring additional resources such as a development team that can operate remotely. This team should also include managers for managing the project as well as quality assurance personals and testers. This can help the organization when it comes to efficiently outsourcing its blockchain development project to an offshore company. This will not add much to the cost of the project as the hourly rates of these professionals are also much lower than their counterparts in the United States.

As per the statistics from Clutch.co which is a B2b market site, the hourly charges for blockchain developers in Vietnam start only from $25 per hour, and even in some cases, they charge even lower than $25.

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[80] How Much Does It Cost Building Blockchain Projects?

8.2   Cost of Developing Blockchain Application

Since blockchain technology is still considered to be new and has not reached the level where the technology can be considered to be fully matured, that is the reason why creating an efficient blockchain solution does not only require effort, time, and resources but it also mandates to consider requirements of several regulations and laws and make sure to be in compliance with them.

When it comes to developing and running a blockchain solution, there are various factors that can influence the cost of the project and as a result, it can vary significantly. These factors include:

- Hiring of Blockchain Experts
- Development of the commercial blockchain solution
- Deployment and on-boarding
- Sales and marketing
- Monitoring and Maintenance
- Other legal aspects

It is essential that a team of expert professionals is hired. If the company is looking to launch a coin, then hiring a team of marketing advisers is another prerequisite. Additionally, it also needs cybersecurity professionals who are specialists in their field as well as PR managers, developers of the software and etc.

Another important factor to consider is that whether the company is looking to start the development of a blockchain solution from the scratch or it already has the infrastructure and it is just looking for integration. If the company is starting right from the scratch, it will take significant time. Because first the solution is to be developed and then it will go through the testing phase and later on through the implementation phase. Overall, these processes and phases in combination can take several months or even years to be completed. If we talk about the overall cost of blockchain solution development, excluding the cost of administrative expenses as well as sales and marketing can be calculated by multiplying the required time period for the project with the hourly rates mentioned above.

When it comes to blockchain solution that is to be involved in dealing with data such as personal finances as well as other data of the customer, the company will need to take extra care and consider fulfilling and meeting the requirements of laws and regulations. In short, compliance is important when it comes to the data of the customer (Azati Team, 2021).[81]

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[81] How Much Does It Cost To Build A Blockchain In 2021 – 2021

8.3 Important Factors to Consider Before Implementing Blockchain Based Solution

As mentioned above, the cost of developing and implementing blockchain solutions will always vary because it does not depend on any single factor. In fact, it is dependent on various factors such as what are the required functionalities by the business and how complicated is the implementation process for them. Additionally, it also depends on the choice of blockchain as well as the platform for it. For any business which is looking to develop and implement a blockchain solution, it is essential to consider the following factors. It will not only help in identifying the needs and requirements of the business, in fact, it would also be helpful in getting the estimated overview of the cost of blockchain solution as well.

- What are the requirements of Integration? In cases where the companies already have existing infrastructures and systems in which they intend to integrate their newly developed blockchain solution, it sometimes may be the possibility that they face such integration scenarios which are much more complex than their expectations. As a result, their development cost can also increase along with the required time and effort for the project.
- Is there a requirement for an MVP or POC?
- Which blockchain is required, Private blockchain or public Blockchain
- Processes and procedures for the deployment of blockchain solution as well as the choice of platform for its hosting.
- What is the estimated number of users who are going to use this solution? This is important because number of users does not only influence the request volume, but also the size of the transaction. This eventually requires reserving additional capacity for the infrastructure of IT.
- Is this solution going to deal with financial transactions?
- Is cloud computation service required for the blockchain solution?

When it comes to the development and application of blockchain solutions, all the factors mentioned above have a direct impact and influence on them. Additionally, they also influence the development cost of the solution. That is the reason why if a company is looking to estimate the development cost of their desired blockchain solution, it should evaluate these factors and upon reaching the answers to these questions, the company would be able to get an accurate cost estimation for the development of their blockchain solution (Appinvetive Technologies, 2021).[82]

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[82] Blockchain App Development Cost – 2021

8.4   Cost of Blockchain Implementation: Process

In the following table, we have represented phase-wise cost distribution of different development phases in percentage.

Table 2: Phase-Wise Cost Distribution

Cost Distribution with respect to Milestone	In-House
Consulting	10%
Designing	15%
Development	50%
Quality Assurance	25%
Deployment and 3rd party Cost	Private Blockchain: ~$1500/month Public Blockchain: $0.01 / transaction-based for public blockchain + ~$750 for 3rd party
Maintenance Cost	~15% to 25% of the overall project cost.

Here are some of the 3rd Party Tools that Blockchain Apps might need:

- Amazon Web Services: Computing, Delivery, and Storage ($100 to $1000, depending on the number of users)
- Bug Tracking Tools like Instabug and Bugsee: Gathering and reporting live bugs ($10 to $100 per month)
- Monitoring Services like Uptime Robot and Statuspage.io: Sending notifications for downtime ($10 to $50)
- Notification Services like Twilio, Kumulos, Amazon SNS: Enabling notifications within the app ($10 to $50)
- Analytics with Flurry or Mixpanel: Analytics of data, funnel, insights and reporting ($0 to $150)[83]

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[83] HOW TO DETERMINE THE COST OF BLOCKCHAIN IMPLEMENTATION?

8.5   Conclusion

Blockchain is still a relatively new technology and has not yet reached to it maturity level. This technology has the promising potential to influence and disrupt several industries and sectors around the globe. Blockchain-based applications have already been implemented in several use cases and they are solving critical issues and problems in many areas. Hence each use case and solution will depend on different factors such as platforms, specialized technologies as well as the approach for the implementation. When it comes to cost estimation, it is not possible to provide an exact number for the cost estimation of a blockchain solution without considering and identifying above-mentioned factors as well as the needs and requirements of a business.

When we talk about starters, it can be estimated that an MVP for a blockchain solution can be developed costing around $5000. But this is only for starters. When considering moving to the full-scale solution, the cost will increase significantly and estimated to be around $100,000. But at the same time, when it comes to the overall cost for the development of blockchain solutions, the cost may vary. This is because of the reason that it does not only depend on one single factor. In fact, for the cost to be estimated, it is necessary to consider the specific requirements from the company looking to develop and implement the blockchain project. Further, it is also necessary to consider that what are the functionalities that the business requires to include in the application and thirdly, what is the complexity level of these requirements and functionalities when it comes to implementation.

If the blockchain solution is going to be commercial, it is important to consider other costs as well such as sales and marketing, cloud hosting (optional), on-boarding, and other legal expenses and costs along with maintenance (TPP Technology, 2020).[84]

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[84] Blockchain Solution Implementation – How Much Does It Cost In 2020? – 2020

9- Most Important Points to be Considered for any Blockchain Project

Blockchain has emerged as a promising technology with a great potential to resolve many critical issues and problems. That is the reason why the potential and implementation of this technology is a heavily discussed subject across the corporations and the organizations of different sectors around the globe. But since the technology is still fairly new and not much tested, many firms are usually reluctant to implement it on an inter-company level. When we talk about blockchain as a potential solution for any problem, it is not only about the implementation of this technology, in fact, there are so many important factors to be considered before even thinking about the implementation phase.

1. First the use case, then the implementation

Since blockchain is not capable of producing optimal results for every use case in all conditions. Therefore, in order to ensure the appropriateness and suitability of blockchain solution for the use case in question, it is of utmost importance and necessary that deep analysis and thorough evaluation of the use case are conducted well before the implementation of blockchain technology in any pilot project. Further, it should also be made sure well in advance that all the processes and procedures are clearly understood, well defined, and distinctly described. The team should be cleared about certain points such as Why blockchain solution for their use case? Aren't there more suitable solutions? What value addition would blockchain bring to their project?

2. Blockchain is not as simple as plug and play

There are several blockchains that are all unique and different from each other depending on their varying characteristics, features, and capabilities. Therefore, it is not possible to implement any blockchain solution to any use case without ensuring the suitability and appropriateness of the blockchain solution for the use case in question. Hence implementation of blockchain is not a simple process. The first requirement is to design such a suitable and appropriate blockchain solution that is in accordance with different needs, terminologies, processes, and procedures of the use case. Along with that, it should also be made sure that all the procedures and processes are clearly defined and described well before the implementation of a solution on a technical level. Additionally, high importance should be given to the future users and their feedbacks. This will not only enable developers to identify the needs of future users, resulting in improvements in the solution but will also help them in finding a common language between technology and use-case. All of these measures are necessary in order to ensure the success of the project.

3. The Role of IT

When it comes to the installation of a node, it does not involve lengthy, time taking and complicatedly technical steps. That is the reason why it is not considered to be a time-consuming process and can hardly take a few hours for the installation of a node. It is such a simple process that does not even necessarily require the involvement of IT specialists in it. It is possible even for the people outside the IT to handle and complete the installation process of the MultiChain node even within less than a day time. Additionally, it is also possible to host it in a cloud without costing too much, hence being cost-effective because of its availability at a very reasonable monthly price. During the Pallet-Exchange pilot project by GS1, they hired services from Amazon Web for running their node which hardly costed them around 100 euros per month. If the requirement of the project is to utilize fully managed hosting services, they can also be avail with the help of SAP Cloud Platform. The cost of utilizing fully managed hosting comes approximately 400 to 450 euros per month. Basically, the expenses and costs related to IT are not constant. They depend on multiple factors such as the selection of different blockchain technologies chosen to provide solutions for the project and also, on the in-house structure of the firm's IT facilities. Depending on such factors a firm can experience a significant increase or decrease in IT-related costs and expenses. But another fact to be considered is that regardless of the conditions and circumstances, one node is never the only requirement and cannot be sufficient on its own. There are other requirements as well such as quality of business practices and processes in the organization, interfaces should be suitable and easy to utilize to provide smooth user experience, shared standards, and proper connectivity.

The fact of the matter is the actual and real cost of blockchain technology does not lie within itself, in fact, it lies outside of this technology. More efforts and costs are required when it comes to designing the frontend and/or creating an agreed consensus among partners involved in the blockchain solution. Such companies that are involved in either developing/implementing a solution or designing such an implementation of their own for which running a node is simply not sufficient enough to fulfill the requirements and they need more than that, they should consider the allocation of resources in their budget for at least one to two developers along with UX designers and process managers.

4. Availability of Sufficient Data and its Quality

Availability of sufficient data with required quality and standards plays a significantly crucial and important role in the successful implementation of any blockchain solution. Blockchain is of no use if there is no availability of data, or even if the data is available, but not in sufficient quantity, or even if the quantity is sufficient, but not of sufficient quality – incomplete or inaccurate data that does not meet the requirements and lack the standards of quality. It is therefore impossible for blockchain to add any value without sufficient, suitable, appropriate, complete, and correct data availability.

5. Trial before the Launch

Since blockchain is still a relatively new technology and is not yet fully matured, there are many concerns and question marks related to this technology and its potential to provide solutions in different cases, conditions, and circumstances. Therefore, it is never recommended nor suitable to initiate the implementation process of blockchain solutions in any business process without testing it on a smaller level and gaining the required practical experience. The firm that intends to utilize blockchain should first explore its potential either through a pilot project or proof of concept rather than directly stepping into the implementation process on a massive scale.

6. Utilization of Existing Resources for Value Addition Purpose

In order to get the best of blockchain technology in terms of performance and value addition, it is recommended to consider it connecting with solutions and systems that are already in use, proven, and well-established. As a result, this would enable blockchain to provide value addition as well as create synergies. Additionally, this will also result in shortening the time period of the project significantly, saving a lot of valuable time, cost, and resources for the organization. The design of the system is also of much importance. It should be designed to meet the possible future requirement of expansion at any later stage or adaption to already available systems. Another important point is to decide and agree on the type of data that the company is willing to share with its blockchain partners and allow them to use it.

7. Complexity in Governance

When it comes to the blockchain solution, the first and more important step than technical programming is to form a consensus on rules and protocols of participation along with agreeing on specific participants to be granted permission to enter the network. The technical programming part should always be considered afterward. Because when it comes to blockchain, neither the technology itself nor the issues related to it are as complex as they are considered to be. Actual complexities lie when it comes to solving the external issues, outside the technology, such as issues and questions related to general governance. For example, when it comes to choosing the blockchain technology for the implementation of the solution, it is much simpler to decide and select the suitable and appropriate blockchain for the project. But when it comes to establishing, determining, and defining processes, procedures, and protocols such as determining read and write permissions for the participants, defining and agreeing on blockchain participation rules, and deciding the process for the establishment of companies' network, the processes are usually more critical and complex (Knirsch, et al., 2019).[85]

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[85] Implementing a blockchain from scratch: why, how, and what we learned – 2019

8. Forming a Network of Business Partners is a Challenge

Establishing such a consortium of blockchain that does not only involve market players that are real but also belong to dispersed geographical locations is important. But it is not a simple and smooth process as it requires a critical number of partners to be involved. The challenge is to unite every participant from a particular value-added chain, community, or sector into a network of blockchain. There are many questions that arise. For example, questions related to the identities of parties setting up the network. Who are they? Are they reliable? Are they neutral? Is there any economic interest for them? Are they capable to dominate the market? These are all the concerns that need to be addressed for the satisfaction of the participants.

9. Transparency a Positive or Negative

When it comes to sharing of data among business partners, blockchain technology is known and proven for its characteristic of reliability. This is because of the transparency and immutability blockchain provides to its users. But the matter of concern is that this level of transparency is not always desired by everyone. There are many such businesses and partners that are really sensitive about the privacy, transparency, and protection of their data and are not comfortable at all when it comes to sharing their data even with their partner companies. This is usually because of the sensitive nature of data such as the data which contains information related to competition and could possibly be exploited to gain insights of useful and sensitive information about the business which is not meant to be disclosed and could result in losing competitive advantage. Another example is the data which is politically delicate.

In the pilot project of pallet exchange, conducted under the umbrella of GS1, complete transparency of the entire pallet exchange data among business partners was mandatory. The reason behind this was that in the pilot, partners were required to keep the track record of balances of other partners, and doing so was only possible if complete transparency of data is ensured among business partners involved in exchange transactions. Even though, the data of this pilot contained transactions of pallet exchange and pallet account balances of partners which was less sensitive as well as not politically delicate and partners had no issues in sharing their data with participants of the pilot. But this is not always the case with all the other businesses and partners. There are companies that are reluctant and not willing to share their data even if it is not of sensitive nature. That is the reason why this is the area of blockchain which is still under consideration and it is yet to be established that how much transparency should be provided in accordance with the amount and level of information the company is willing to disclose and share with other business partners.

10. Change is mandatory for a paradigm shift

When it comes to processes and procedures related to collaboration among business partners, blockchain has a completely different concept and approach in comparison to the current business practices of many companies and their sectors. Therefore, in order to utilize blockchain and explore the potential of this technology, it requires companies to revisit and

restructure their B2B relationships with their partner firms. Current business operations and processes of most companies along with their organizational structures are usually not suitable as well as not in alignment with the demands and requirements of blockchain technology. Hence, it mandates such companies to rethink their strategies entirely along with redesigning their processes and principles to deal with their partners if they want to benefit from this technology. This raises a question regarding the adaptability and acceptability of the changes blockchain entails to companies. Are these changes going to be encouraged? If yes, how quickly can businesses adapt to these changes in their culture required by blockchain?

11. Openness as a principle

Openness and transparency are often termed similar to each other. But in comparison to transparency, openness has a completely different concept. Transparency is to ensure that the data is available to all the participants at the same time without any restriction. Whereas openness implies to open mind and flexible approach in regards to dealing with different types of interfaces, different formats of data as well as approaches to handle different operations and processes. The potential of blockchain cannot be exploited to its full unless and until organizations and businesses looking to benefit from it are not willing to embrace and adapt according to the mandatory requirement and principle of blockchain which is to have an open mindset and flexible approach, especially on an organizational and technological level. For example, when companies in a B2B consortium need to deal with an open data format, blockchain requires them to agree and adapt to the use of a common solution for which they need to be open and flexible in their approach. Not only this, but the implementation of blockchain also requires such interfaces that are shared and accessible to other participants. These different interfaces cannot be used if involved parties are not flexible and open in their approach in regard to interaction points. Additionally, openness also implies the decentralization of data in the form of distributed ledger which means that every participant should have copies of data and is allowed to work with their own node of blockchain.

When it comes to transparency of data, it is not necessary to implement it for all the partners involved in exchange processes, especially when dealing with sensitive data and its transactions. It is possible to choose participants and allow them with required permission whereas specific participants can be assigned with limited and restricted permission to data. But on the other hand, when it comes to data that is not sensitive i.e., information related to the requirement of pallets or to surplus pallets, such information has low to no level of sensitivity hence should not have restrictions or limitations to it and can be transparent and accessible to all the business partners of the entire network. The matter of fact is that, if companies are not open and ready to accept and implement transparency on a technological level, it is not possible for them to utilize blockchain in its true sense nor to add any real value for their businesses. But on the other hand, corporate guidelines are usually observed to act as barriers when it comes to openness even in recent times.

12. Importance of Intermediaries

When it comes to the process of creating a blockchain consortium, it is usually possible that it brings such companies and competitors together in the same network that hardly know anything about each other or their business activities and operations. Sometimes even their businesses are different from each other. To work in such a network with such companies, a great deal of trust and confidence is required which would also be helpful for the consortium to process smoothly. That is where the role of neutral authorities and intermediaries comes into play. They act as a catalyst that assure the establishment of such shared governance that is purely based on the principles and fundamental concepts of blockchain. Their role is important to balance the interest of all involved parties on the network, especially when the network is new and in the establishing process. When it comes to dealing with such negotiation matters that are of sensitive nature, a neutral authority that is independent and does not involve any of its own interest, is considered to be greatly reliable for all the involved parties and can be helpful in smoothly concluding such negotiations with much ease. Additionally, they can also prove to be helpful in managing coordination processes and activities between involved parties on the consortium.

13. Trust is Priority

It has always been observed that whenever a new technology is introduced, people usually lack confidence in it and are more likely to be reluctant when it comes to the acceptance part of the technology, especially when the technology is at its initial phase. The reason behind this common practice is the fear of the failure of new technology because of insufficient awareness and knowledge among people related to new technology. Managers have the issue of data ownership and they fear its security whereas users like to prefer utilizing papers for their day-to-day operations as for them papers are more reliable than digital apps. The same goes with blockchain technology as it is still considered to be comparatively new and at its initial phase where many companies and businesses are still skeptical to adopt, implement and explore this technology as they still lack trust and confidence in it. As trust is usually developed by human relationship and their interactions with each other. Hence same is the case with blockchain as it is not possible for this technology to automatically develop trust and confidence among people. That is the reason why employee training is considered to be of utmost importance. Before the implementation of blockchain as a solution, it is mandatory to make sure that intended users are provided with complete awareness of this new technology as well as the added value it brings for them. What are the problems that this solution is going to solve for them? That is the only way people will be motivated to start using and understanding this technology and hence develop their trust and confidence in it.

14. Importance of Network Coverage

The prerequisite of digitalization is the high-performance network coverage that is available nationwide and without these prerequisites, it is not possible to implement digitalization. In the same way, blockchain is not in any way different from digitalization when it comes to the importance of these prerequisites. But on the other hand, when it comes to mobile networks

and their coverage in Germany, the country lacks these prerequisites. One of the reasons behind this is the use of excessive concrete and steel in the construction of buildings that belong to logistics premises. As a result, such infrastructures act as a blockage and resist signals from outside to reach users inside and users have to face reception problems. That is the reason why many companies usually rely on Wi-Fi for connecting their staff with internet. But the drawback with Wi-Fi is that the same infrastructure that stops network signals from outside to reach users inside also blocks the WI-FI signals from inside to reach users outside. As a result, users who are outside of the buildings end up having very limited access to internet signals of Wi-Fi.

Before the implementation of blockchain solutions, an important prerequisite for the companies along with their business partners is that they take care of this important requirement and ensure that network coverage is provided to everyone so that everyone is able to access the internet without any problem.

15. Better Collaboration

With the help of blockchain, more and more people, as well as companies, are forming collaboration. Additionally, it is because of blockchain and the hype around this technology that companies along with their business partners are compelled to change their current approach towards collaboration. Another reason is the peer-to-peer approach of blockchain technology which cannot be fruitful unless and until the relationships among businesses are not redefined with a modern mindset.

16. Potential of Blockchain with Internet of Things (IoT)

Blockchain technology has been a revolution and it has added significant value to many current processes and procedures. But a greater potential lies in the combination of blockchain technology with the Internet of Things (IoT). These technologies together in combination with each other can add further significant value to existing processes and procedures as it proved to be the case in the practical experiment and example of pallet exchange process when smart, serialized pallets were utilized. But for this great potential to be explored, there is a compulsory need and requirement for the decisions to be made so that necessary changes can be made and implemented accordingly.[86]

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[86] Putting blockchain to the test – 2018 [GS1 Germany]

10- Conclusion

There is no denying the fact that supply chains in today's era are prone to many risks and vulnerabilities. They need significant improvements especially when it comes to areas such as coordination, end-to-end traceability of products, financing, and speed of product delivery. In our study, we analyzed numerous use cases and pilot projects of blockchain technology being implemented by companies in logistics and supply chain sectors of different countries as well as in Germany. The purpose of this research was to find out the capability and true potential of blockchain technology to transform the logistics and supply chain sector and also the current status of this technology around the globe. For this purpose, we included pilot projects and use cases from different countries in our study. As per the experience of companies and their use cases included in this study, it has been established that blockchain is the technology that can play a vital role in addressing these risks and vulnerabilities and can help companies to address and overcome the shortcomings in their logistics and supply chain areas. But as the technology is new and is still considered to be in its early stages of adoption, there is a need to assess and realize its true potential especially for those on the sidelines. As more and more businesses are going to be involved in the adoption of this technology, it would enable further exploration of the unrealized potentials of blockchain.

But at the same time, this is also to be noted that implementation of solutions based on blockchain technology requires a serious amount of time, effort, technological and human resources as well as investment. This is one of the reasons why most small companies with limited budgets and resources are usually reluctant to be involved in blockchain technology whereas big companies are usually found to be involved in the implementation of blockchain solutions and testing the pilot projects. But once the organizations successfully complete the implementation and testing phase, the advantages and benefits of this technology are huge and also for the long term.

Blockchain technology is here to stay and the adoption speed of this technology is increasing with every passing day because of the true potential of this technology not only limited to logistics and supply chain area but also in many other areas. That is the reason why even companies that are reluctant to be involved with this technology, soon going to realize the compulsion to adopt this technology, or else it will be too late for them and they might also lose their competitive advantage. Because the sooner the involvement with this technology, the better for the organization to gain benefits as well as a competitive advantage over their competitors.

There is also a need for this technology to be experimented with different technologies along with its implementation in different sectors of the industry so that new rules can be developed, different pilots can be conducted with other platforms of blockchain, and companies can build their ecosystem with other firms. Doing so will definitely require time and effort along with investment and commitment of resources from firms, but will surely result in producing beneficial and favorable outcomes in the long term.

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Declaration of Originality

I hereby declare that the present thesis contains literature and original research work by the undersigned candidate, as part of my studies in Industrial Engineering (M.Sc.).

I also declare that I have fully cited and referenced all material results that are not original to this work.

This thesis has not been submitted in the same or similar form by any other examination office.

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