

Blockchain for Supply Chain and Manufacturing Industries and Future It Holds!

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Abstract— Blockchain- A Blessing in disguise? Or, another ill-fated technology experiment. Moving into new technology space has always been a dilemma for conservative Supply Chain Spaces, these organizations first want to see the blockchain technologies to succeed in its spread, before embarking their journey on to this path. But, there are few questions, which must be asked to self before judging to quickly about Blockchain. Are we well informed about Blockchain? Where all we can see the uses of blockchain, is it limited to Bitcoins? What is the future of Supply Chain and what it holds for the next generations to come? Can we trust Blockchain to succeed? This paper discusses about How blockchain works with few use cases of Blockchain in Supply Chain Spaces. This paper also talks about the challenges around Supply Chain visibility across streams and Data Security of the product blueprints against counterfeit Malpractices. This paper will help to provide an insight into the role of blockchain in breaking the boundaries set by traditional organizations and will explain how blockchain could play an important role in improving business relationships between partners. Some of these questions, touch you to the core, when you are a technology enthusiast and you want to know, the TRUTH.

Keywords— Security, Blockchain, Supply Chain, Manufacturing

I. INTRODUCTION

Blockchain, is a trusted network between various business entities who do not trust each other and share information in that network. Let's start in simple words; Very similar to crochet chain stitch, think about information as the thread. When you make a loop and a knot, you are connecting the loops to create an extended garment / artwork. Each loop is the foundation for the next loop and is dependent on each other, the loops cannot exist by themselves. Also, your knowledge of crochet is stored in your brain and you can make an exact copy of the garment / artwork whenever needed. Coming back to blockchain, each block of information is similar to a loop in crochet. This block of information could be a cash withdrawal transaction from your bank or an electricity bill payment transaction or any other agreement between two parties. Each of these transactions if connected, forms a chain and each part of the chain is carved in stone - meaning secured, so that it cannot be erased or changed. This makes the chain trust-worthy and secure. Also, your identity is secured by locking it down so that no one else can see your identity but can see the transaction. An exact copy of the chain of information is stored in multiple locations (like the crochet technique stored in your brain) to ensure that if one thread gets torn or deleted, another copy of the entire chain exists somewhere else. This ensures that the chain of information is kept safe. Blockchain needs to be understood first before its implementation and use for Supply Chain Spaces.

A. Use Cases for Blockchain

Few of the Industries have already started using Blockchain as a Service to remove the obstacles related to security and visibility which is very common in Supply Chain transactional world [7]. To Name a few, These industries have started the blockchain adaptation; Real Estate, Health Care, Finance and Insurance, Retail, Transport, Pharma and Chemical, Aerospace and Defense, Utilities & Energy, Education, Agriculture. The application of blockchain for supply chain management and auditing is investigated by several start-ups and large companies. In addition, the role of blockchain for Industry 4.0 and the Internet of Things (IoT) is discussed and some companies are combining blockchain solutions with 3D printing to enable new manufacturing processes [8]. An overview of the use cases that are introduced in this section is given in Table 1 below.

Use case	Examples	Description
Supply Chain Management and Digital Product Memory	– IBM and Maersk	– Tracking of containers during the shipping process
	– Provenance	– Recording of all important product information throughout the entire supply chain
	– Everledger	– Registers certifications and transaction history of diamonds on blockchain
Internet of Things and Industry 4.0 applications	– Factom Iris	– IoT device identification over blockchain
	– Super Computing Systems	– Sensors that timestamp data on the blockchain to save them from manipulation
	– Tile Data Processing – tilepay	– Marketplace to allow customers to sell their data from IoT devices
	– IOTA	– Cryptocurrency and blockchain protocol especially developed to meet the demands for IoT applications
	– IBM Watson IoT	– Platform to save selected IoT data on a private blockchain and share it with all involved business partners
3D printing	– Genesis of Things	– Platform to enable 3D printing via smart contracts
	– Moog Aircraft Group	– Ensuring safe 3D-printing of aircraft parts via blockchain

Table 1: Overview of blockchain use cases in the manufacturing industry

B. Evaluation of Potential Use Cases

Several use cases of blockchain technology are identified in the literature and through interviews with experts from science and industry. Since the existing use cases from literature were also covered by the interviews, the concentration was on insights from the latter and evaluated the potential for the manufacturing industry. For this reason, the applications were clustered according to the time horizon for market entry and their potential for the manufacturing industry [8].

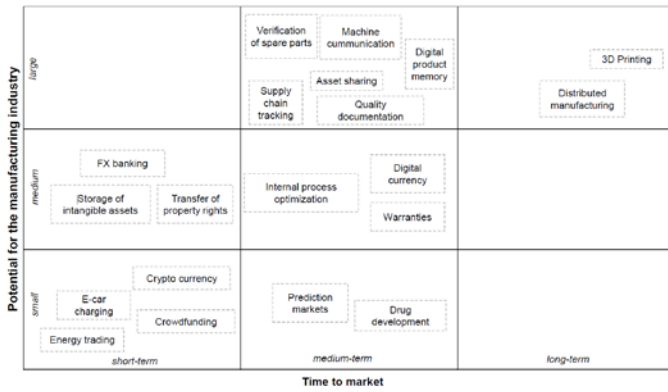


Table 2: Blockchain use cases and potential application for manufacturing

These two dimensions were carefully chosen to structure the applications of blockchain. The first one is “time to market” because currently most use cases are only proofs of concept and still have to master the market entry stage. Sometimes, use cases are more driven by hype without real chances for implementation, but blockchain as a disruptive technology will develop its impact predominantly in the long-term. Most experts expect the market breakthrough in about five years [8].

II. FUTURE OUTLOOK OF BLOCKCHAIN IN SUPPLY CHAIN

This section gives an outlook into the near future of blockchain technology for Supply Chain Space, by discussing the information and partly differing opinions received from several leading researchers and industry experts.

It is rumored that the first successful use cases will be implemented and publicly announced within the next three to five years. As already shown above, the time to market differs significantly among the potential areas, caused by different technical requirements of the specific solution. Whereas many see the first more extensive implementations in the financial sector, other industries are catching up rapidly with their development. A good example is the energy sector, where promising PoCs, namely the cooperation project of Siemens with LO3 or the energy platform project StromDAO, have already been realized. Consensus prevails insofar that the commercialized usage of blockchain in the manufacturing industry will not be reached in this three to five-year period, mostly due to technical barriers [8].

Although technical challenges are the most obvious hurdles, the vast majority of blockchain experts considers them as solvable in the future. Even the limited scalability, one of the main problems and especially crucial in IoT or the manufacturing industry, seems to be effaceable with currently evolving concepts like IOTA. Besides these technical issues, there are several additional obstacles that interestingly differ related to their respective field of activity. Specifically, the energy sector seems to face regulatory challenges concerning the establishment of a blockchain-based energy platform, whereas legal issues of liability appear when it comes to 3D printing. Surprisingly, all participants agreed independently from each other that the main problem is the general openness towards this innovative technology. A lot of people seem to connect blockchain with the darknet and therefore have a negative association with it. Others never heard of the technology, or do not want to invest in a technology that could not live up to the expectations. In most cases, alternative and

well-known solutions are preferred and prolongate the transition to blockchain solutions [8].

As mentioned above, experts predict a manageable time period to solve most of the hurdles that still prevent the industrial use of blockchain. Some interview partners see start-ups as the driving forces of this progress, rather than big and established industry companies. Nevertheless, big firms react to this development and start to increasingly invest in research, as they fear to become outdated by their competitors. Even though the impact of blockchain will firstly change internal business processes and not immediately challenge whole industry concepts, the role of established firms could change within their market [8].

Blockchain is not a Rocket Science, it is a framework to support several business entities to connect the dots and establish trust among the Non-Trusting Parties in an open/close environment. How this is established in an Industrial Manufacturing is a question, worth asking. Manufacturing Companies build the innovative products using their patented and in class technology, now these products are marketed on Internet, retailers circle, OEM's and Organizations/ Group known to these industrial Organizations. They want to feel secured and protected, Blockchain provides a proving ground in doing so.

Some of the Industries, who have established Blockchain or who have potential to establish blockchain usages are mentioned below.

A. Real Estate

- Blockchain based smart contracts can streamline property transactions by removing 3rd parties and enabling self-executing actions when conditions are met.
- MLS Property Data: At its core, blockchain is the ability to share databases and processes. This opens promising opportunities to make real estate data, which is principal to the process of buying and selling homes, more centralized and accessible. Every real estate transaction goes through the multiple listing service (MLS), which tracks what agents represent which clients, contracts, listing agreements, appraisals and more. However, the MLS is notoriously fragmented. The information is decentralized and restricted, making access difficult for people who are not real estate professionals. It's often out-of-date as well, which hampers an agent's ability to make comparisons and spot trends [2].
- Title records are another decentralized, challenging-to-access aspect of the real estate buying/selling process. Even in 2017, title information remains stored at the local level and is offline. With the blockchain, this is starting to change. The blockchain could provide a central title database for the entire country to securely store and instantly access historical title records, allowing for the streamlining of title transfer in a property sale. Inman called the Cook County experiment “one of real estate's most important experiments with blockchain so far. [2]”
- The third area of real estate that the blockchain will transform is the efficiency and the security of transactions. The blockchain does not require there to be trust between two parties to conduct business. Each user has a unique

identity on the blockchain via cryptography, which means consumer financial information can be shared securely with other parties during transactions. One person can send funds to another person that won't release until the transaction is formally completed [2].

B. Health Care

- Universal health records could be established by aggregating and placing the persons health history onto a blockchain ledger for any health care provider to access and update.
- Medical Data Management: MedRec, one prototype using blockchains, is intended to improve electronic medical records and allow patients' records to be accessed securely by any provider who needs it solving the waste of time, money and duplication in procedures, confusion and sometimes even life-threatening issue of records being distributed across many different facilities and providers. The goal with MedRec is to give patients and their providers one-stop access to their entire medical history across all providers they have ever seen. Additionally, if patients wish to grant access to their personal medical records to researchers, their data would be provided anonymously to be used in research which could make medical breakthroughs possible faster than they are now. This pioneer in the field shows the potential for how dramatically things could change in healthcare by deploying blockchains [3].
- Drug Development and Supply Chain Integrity: Not only could blockchains facilitate new drug development by making patient results more widely accessible (if the patients give their permission), it could help reduce the counterfeit drug implications that currently cost pharmaceutical companies an estimated \$200 billion in losses annually [3].
- Claims and Billing Management: Medicare fraud caused more than \$30 million in losses in the United States in 2016, and blockchain-based systems could help minimize it. In addition, it could reduce admin costs for billing by eliminating the need for intermediaries with automated activities and more efficient processing [3].
- Medical Research: Centralizing the results of clinical trials and patient outcomes for new treatment protocols can improve care and patient outcomes. Currently, with all the diverse and disconnected systems in play, there is no way for a human to process all the data that is generated and recorded in disparate systems for future treatment possibilities. Blockchains could provide the access to make medical innovation quicker [3].
- Data Security: Between 2015-2016, 140 million patient records were breached according to Protenus Breach Barometer report. With the growth of connected devices and the Internet of Medical Things (IoMT), existing health IT architecture is struggling to keep systems secure. Blockchain solutions have the potential to be the infrastructure that is needed to keep health data private and secure while reaping the benefits of connected medical devices [3]. According to Cybersecurity Ventures, the annual cost of cybercrime globally will rise from \$3trillion in 2015 to \$6 trillion by 2021 [7].

C. Finance and Insurance

- Initial coin offering used to crowdfund early stage projects in cryptocurrency/ blockchain industries by releasing their own tokens in exchange of bitcoin.
- Client onboarding: To satisfy compliance requirements such as KYC (know your customer), insurance providers must collect, validate and verify key documents to prove characteristics such as name, address, birth, health and economic status. Time delays are common as various third parties and internal departments must review the data to complete their due diligence processes. Then, companies spend vast resources fixing any errors that occurred while records were being reconciled. A blockchain network is distributed, so the necessary documentation can be made available to whoever has permissioned access. The records are secured with cryptography and linked together, which prevents them from being altered retroactively. These characteristics facilitate the secure sharing of information across an organization and to appropriate third parties. Plus, if customer identities are already secured with blockchain, insurers can efficiently verify their eligibility without needing to go to multiple sources [4].
- Underwriting: Through the underwriting process, insurers evaluate the risk of furnishing a client with a policy, how much coverage the client should receive and how much they should pay for it. Insurance might be a gamble, but no insurance company will play the game without thoroughly looking at the data and making sure the odds are favorable. Sometimes, it can take months to a year to evaluate the risk versus reward for larger corporate policies. On blockchain, external data can be included to decrease risk liability and provide semi-automatic pricing. This can help to automate and shorten the underwriting process, reducing the cost of operations. Blockchains also bring transparency and improve trust in the underwriting process by enabling shared visibility in complex multinational programs. Last year, AIG, Standard Chartered and IBM successfully piloted the first multinational insurance policy to use blockchain and smart contracts to allow visibility into underwriting coverage and premiums at the local and master level [4].
- Claims processing: For a policy holder, making a claim can be a long and confusing process. And then you have to wait as hundreds of insurers and reinsurers figure out where contracts are, which are correct, who already paid what, and which ledger has the right accounting. It's a process that can take quite a while, even if you don't factor in the extra time needed to adhere to tighter regulations for combating fraudulent claims. You already know how a distributed blockchain network makes it easier for all those insurers to access the same information, reducing administrative duties associated with claims. What if you could also use blockchain to get information about insured goods and events? Everledger is making that possible by putting diamonds on a blockchain network. Each diamond's characteristics are registered onto the blockchain and there's a record of every time it is transferred, going back to its origin. Provenance, or knowing where something came from, can be very helpful in discerning counterfeit items. With less risk of fraud, claims can be handled in a timelier manner [4].

D. Retail

- Blockchain will legitimize transparency of retail supply chains, as raw material and manufacturing sourcing can be recorded to its immutable ledger.
- Product Pedigree: This one has lots of nuances. Blockchain, because it is a distributed ledger, makes counterfeiting very hard. That's part of the value of the technology that makes it attractive as a currency. Blockchain makes it possible for every legitimate touch in a supply chain – from a supplier to a manufacturer to a shipper – to add a verifiable record to an item's pedigree [1].
- B2B payments: One of the biggest challenges for crypto-currencies is acceptance as a real currency. To get there, banks would have to be willing to hold crypto-currencies as deposits, and participate in exchanging crypto-currencies for cold, hard cash. Right now, banks are experimenting with blockchain technology, not just to take deposits or trade currencies. Twenty-eight banks from around the world are currently participating in a SWIFT-driven blockchain proof of concept to determine if they can use it to settle cross border transactions [1].
- Digital Advertising: In digital advertising, a lack of transparency is hurting the industry. Some of it comes from blind market bidding, where ad marketplaces are getting accused of taking advantage of the blind bidding, at both sellers' and buyers' expense. The big digital agencies as well as the Interactive Advertising Bureau are experimenting with blockchain to see if it will solve some of digital advertising's problems [1].
- Consumer Payments: When your in-laws start talking about buying Bitcoins, it's fair to say it has hit a level of general consumer awareness. Crypto-currencies have the potential to solve some real problems in the consumer financial world. In a McKinsey interview, Liana Douillet Guzman, the senior vice president for growth at Blockchain, said 2.5 billion people are currently outside of a financial system, including 1 in 12 Americans. The transaction costs of being outside that system can be very high, especially when you're talking about immigrants sending money back home. Douillet Guzman cited an example of someone sending \$200 to the Philippines, where the transaction fee might be as high as \$12 for a traditional transaction vs. "pennies" via Bitcoin (more on those pennies in a moment) [1].

E. Transport

- A universally accepted blockchain authenticated ID paired with biometric devices may create faster and more satisfying experience for travelers.
- Blockchain Means Better Freight Tracking, as demand for same day and on-demand delivery increases, and expectations of consumers become higher and higher, commercial transportation companies are faced with an ever-increasing need to innovate. Many trucking companies already invest in great tracking technology but scaling this technology to more difficult user demands is proving difficult—particularly when it comes to authentication. According to a research paper by TMW,

transportation companies need authenticated secure data to consistently improve their operations. The current systems for providing and recording this data—reliant on EDIs and APIs—are subject to misinterpretation or manipulation, which can have dire consequences on the global supply chain. By using the blockchain for data authentication, the entire network can contribute and validate data, and it is no longer subject to tampering. Increased reliability of tracking information can also have an impact in the conservation of goods being shipped. For example, refrigerated and temperature-controlled transportation relies on on-time delivery. This efficiency is only improved with the blockchain [10].

- Using the Internet of Things (IoT) And AI to Increase Efficiency, Blockchain, with the help of innovations in IoT, can be particularly useful for capacity monitoring. Cargo Volume often defines the cost of shipping freight. By using IoT sensors in trucks and other shipping vehicles, shippers and transportation companies can detect the amount of space taken up in a shipment and determine cost accordingly, transmitting all this information to the blockchain [10].
- Effective Tracking of Fleet or Vehicle Performance History, the importance of tracking isn't limited to delivery performance. It's also applicable to the performance of individual vehicles within a fleet. When a large company or a small business wants to purchase a second-hand delivery vehicle, the blockchain can help to authenticate information on the past performance of the vehicle and its maintenance history. While companies like CarFax already exist for this purpose, they are intermediaries. The blockchain can store and validate all this information for buyers and sellers without the need for a middleman [10].
- Easier Carrier Onboarding, just as blockchain can help validate the records of a second-hand vehicle, it can also help to validate the driver records of a new carrier [10].
- Using the Internet of Things for Vehicle to Vehicle Communication (IOT), Here's yet another way that blockchain technology and the Internet of Things can combine to improve efficiency in the trucking industry: Some companies are already implementing Vehicle to Vehicle (V2V) Communications, which essentially allow for multiple freight vehicles to form a platoon and communicate, improving fuel efficiency and safety. Storing and validating the data created using V2V Communications on the blockchain can help transportation companies across the world streamline their operations [10].
- Making Load Boards More Reliable, many transportation companies are wary of load boards because data can often get muddled or duplicated, providing an unreliable representation of demand. With the blockchain, shippers can post timestamped loads that are recorded and verified by the decentralized network. Because of this, a particular load cannot be duplicated, and the data will maintain its integrity. This also eliminates the need for a middleman in the form of a broker, because the blockchain can authenticate load data, prevent duplication, and make it visible to load boards [10].

- Smart Contracts Cut Costs and Eliminate Middlemen, Smart Contracts may be the single most impactful blockchain enabled feature to the freight industry. Smart Contracts are essentially self-executing tasks that are coded through the blockchain and executed when a certain condition is met. To use a basic example, if a company wants to release payment to a shipper when an item reaches its destination, that company can program a smart contract to automatically pay the shipper when the item has reached a specific location [10].

F. Pharma and Chemical

- Keeping drugs cold: Many medications—especially biologics—being shipped from manufacturer to warehouse to another warehouse need to stay within a certain temperature range. With blockchain technology, this can be programmed in, triggering an alert when the temperature gets too high — or falls too low. “If the trigger is set within a delivery truck, you could set the air conditioning unit in the back to immediately turn on, or you could at least alert the driver to stop and fix the situation. [5]”
- Eliminating fraud: Blockchain’s immutability provides a basis for traceability of drugs from manufacturer to end consumer, identifying where the supply chain breaks down. In addition to cutting losses, there’s the potential to improve consumer safety and prevent some of the estimated 1 million deaths annually from counterfeit medicine, the global counterfeit drug market size is around \$75-200 billion [5].

Determining provenance all along the way can help reduce the appearance of counterfeit parts within the supply chain. Deploying blockchain technology for supply chain logistics addresses a nagging problem for original equipment manufacturers — counterfeit parts. By being able to trace a part through every step of the supply chain, they can ensure the part that shipped is the part that arrived [5].

G. Aerospace and Defense

- Network of sensors such as Lockheed Martin’s ALIS, are being embedded on aircraft to detect performance and communicate maintenance needs to ground repair staff; Systems like ALIS can use blockchain technology to create a single united ledger that will form a digital copy from every part to mechanic that touches the plane.
- Aerospace and defense giant Boeing is teaming with SparkCognition Inc. in Austin, Texas, to use blockchain technologies along with artificial intelligence (AI) to track unmanned aerial vehicles (UAVs) in flight. Boeing and SparkCognition would deliver UAV air traffic management with a focus on safe integration of autonomous air vehicles using artificial intelligence and blockchain technologies to allocate traffic corridors and routes to ensure safe, secure transportation. Boeing also is pursuing electric propulsion [11].

H. Utilities and Energy

- Crypto-currencies could reduce disputed energy transactions by quickly processing payments on a transparent ledger with no 3rd party validations.
- What is more likely to happen is that blockchain will become part of the answer to updating and improving centralized, legacy systems with a distributed hybrid system made up of a patchwork of both large power plants and microgrids powered by distributed energy resources such as solar power. Such a decentralized energy system would can deliver efficient, reliable, and, in many cases, renewable energy. It’s possible that blockchain may one day enable the development of an integrated trading system that would permit businesses to trade their option to use electricity during a given time frame. For example, a factory could sell five minutes of unused power during a down time to a different factory that needs the additional power. Trading grid flexibility in this way could provide large efficiency benefits for grid operators. Another area where blockchain could take hold is in enabling customers to switch power suppliers more quickly. Companies are conducting pilots to explore blockchain’s potential to make existing processes, such as meter registration, more efficient and less costly. British startup Electron is developing a blockchain platform that could allow British customers to switch power suppliers reliably within a day, and are working with the Data Communications Company, the UK’s new centralized meter data agency. Previously, a switchover could take much longer [12].

I. Education

- Blockchain has power to create a centralized ledger of coursework and open the availability of accredited higher education to developing nations by validating the completion MOOC certifications.

Interestingly, there’s a MOOC on Bitcoin and blockchain by Princeton University on Coursera. Despite the carping, people keep on making and taking MOOCs. They are genuinely changing the way education is delivered and acting as a real catalyst for change, forcing universities into a rethink. The certification issue, though, remains a little vague. Each separate MOOC provider issues certificates. With some imagination, the real demand for MOOCs could be boosted by secure certification in the form of agreement among the major MOOC providers. It could even open MOOC certification for actual degrees. MOOCs are about decentralization and widening access, so there’s every reason to suppose that organizers will want to decentralize and increase access to their certification [13].

- Single institution, One school, Holburton School in San Francisco, a software school that offers project-based education as an alternative to college courses, has already used blockchain to store and deliver its issued certificates. It’s seen as a measure to stop fake certification. Encryption and two-factor authentication are used to create, sign-off on and place the certificate into the blockchain database. The school still gives students paper copies, but a system-created decentralized clearing number (DCN) is generated that allows authentication by employers [13].

- Groups of institutions, as educational institutions cluster and co-operate, the need for shared repositories of certification and achievement become real. An example is the group of universities, Delft, EPFL, Boston, ANU and UBC, that recently formed a codeshare-like agreement on certification. It could also be used by affiliated organizations that form a global alliance or a global group of schools. Whatever the constellation of institutions or bodies, blockchain gives them a cheap, shared resource [13].
- National blockchain database, Education is curiously nationalistic. Even in the EU, it is a devolved issue. Within a country, however, there is a great need for a shared approach to the range of credentials that are being produced at all levels in the system: schools, colleges, universities, institutes, examination boards, trade associations, employers, and so on. There is a real need for something that sits above them all. That solution could be blockchain technology [13].
- Global assessment, the current system of certification is not really fit for its purpose. A paper system is subject to loss, even fraud. With an increasingly mobile population of students and workers, a centralized database of credentials and achievements makes sense, whether you're moving to another educational institution, a new job, a new country – and for refugees who have no copy of their degrees. Some sort of secure, online repository would be helpful [13].
- Blockchain and badges, so let's up the stakes with a wider initiative around Open Badges. Open Badges gather evidence for credentials. What could be better than a tamper-proof system for their storage? If a blockchain system can offer a massive way to deal with authentic accreditation, then the problems of openness, scale and cost for badges disappears [13].
- CPD, always a problem, continuing professional development (CPD) is difficult to deliver, often fragmented, and poorly tracked. Imagine a blockchain system that really did this within a profession, taking issued CPD data from conference attendance, courses, and other forms of learning. Teachers and other professionals could get inputs from trusted providers and thus be incentivized to do more CPD, if those experiences and learning opportunities were securely stored in a reputable system [13].
- Corporate learning, Companies deliver huge amounts of training to their employees, but storing achievement is not easy. Current learning and talent management system technologies, SCORM, et al, are a bit old and tired. What's needed is a more open but secure system for use not only internally, but also by employees when they leave an organization [13].
- Apprenticeships, Vocational education is now big business, as governments around the world recognize the folly of relying too heavily on purely academic institutions to deliver post-school education. In the UK, a system of three million apprenticeships is to be funded through a levy on payroll. It's a complex business, as employers will play a stronger role in their management and delivery. How are they going to manage the process and

certification? Blockchain is a real possibility, as it could offer a centralized but neatly distributed national database for the authentication of both process and certification.

- Bodies of Knowledge, Blockchain could be used for a myriad of learning experiences from various sources. It requires a small transaction model, and this could be where 'eXperience API' (xAPI), which can be used to gather evidence from micro-learning experiences, comes in handy. It is open source, the natural successor to SCORM, and stores data in Learning Record Stores. This seems like a natural route to the use of blockchain, another is providing education with an easy method of micropayments. Traditional financial transactions use expensive third parties who charge fees. Blockchain allows free transactions between parties. This could open micropayments for the use of educational resources, courses, etc. [13].

J. Agriculture

- An immutable ledger how, when, where food was grown, packed, inspected, etc. would allow strategic removals in case of foodborne diseases.
- Food Safety, this seems to be the area where the most work has already been done because their clear vested interest from both producer and consumer. IBM along with companies like Walmart have started leading the charge in this capacity. Bringing transparency to the supply chain will allow us to identify and remove bad actors and poor processes. This ensures ideal conditions from farm to market, and we can pinpoint source quickly in the event of a food safety outbreak. This could save time, money, and lives [14].
- Traceability, the benefit to buying local food is always described as "you know exactly where your food comes from and who grew it. You know it's fresh". What if we could make this happen at scale? Meaning, no matter where you bought your food, you knew not only where it came from, but when it was harvested and processed, and even who produced it. Companies like Ripe.io are working to solve this very problem. This could also go far to prevent food fraud, false labeling, and redundant middlemen [14].
- Transaction Costs, that it is both fragmented and dependent on personally knowing a counter-party before you could trust them to do business. Companies like AgriDigital are making headway in creating more transparent and efficient supply chains using blockchain technology. They are applying the technology directly to the grain trade and plan to expand into other agricultural commodities, such as cotton [14].
- Opening New Markets, the premise here is that if we can create trust and accountability among market players, there is reduced need to evaluate each person individually on their trustworthiness and ability to execute. This means that market players that couldn't establish trust before for any reason (they didn't live close to each other, they didn't have a protocol for if things fell apart, the time to develop a new relationship didn't justify the value, etc.) now could do business without someone needing to broker trust (and take a margin) in the middle. This also means that

disadvantaged market participants can have a sort of “seat at the table” through this technology [14].

- Logistics, anyone who has worked in the agricultural supply chain knows the challenges that come with logistics. Dealing with products that often have a very short shelf life in uncertain conditions in high quantities with a lot of dollars on the line. Also, often the supply can be uncertain (it's not like a factory producing widgets). Companies such as UPS are joining the Blockchain in Transport Alliance to play a central role in the smart logistics network of the future, built on blockchain technology. As we see this materialize in other industries, agriculture will no doubt be next.

III. INDUSTRY EXPERT TALKS

This section provides feedback from leading research organizations for Blockchain and how they will be represented in the near future.

“IDC forecasts that by 2021, 20 percent of the largest (G2000) manufacturers will depend on a secure backbone of embedded intelligence to automate large-scale processes and speed execution times by up to 25%. This backbone will use IoT, blockchain and cognitive (artificial intelligence and machine learning)” [6].

Among 293 CIOs of organizations that are in short-term planning or have already invested in blockchain initiatives, 23 percent of CIOs said that blockchain requires the newest skills to implement of any technology area, while 18 percent said that blockchain skills are the most difficult to find. A further 14 percent indicated that blockchain requires the greatest change in the culture of the IT department, and 13 percent believed that the structure of the IT department had to change, in order to implement blockchain [15].

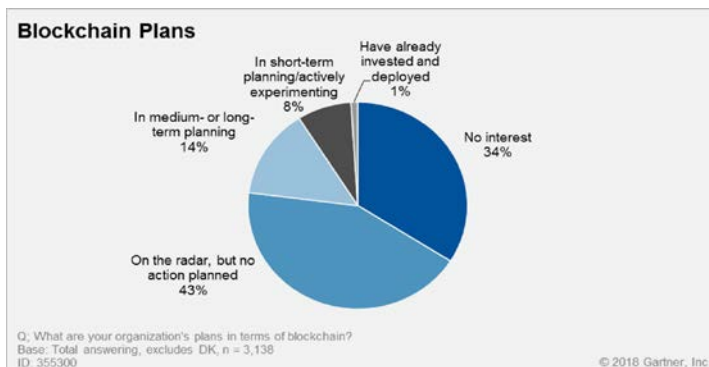


Figure 1: Blockchain Adoption, Worldwide, Source: Gartner (May 2018).

Digitalized ecosystems, Emerging technologies in general will require support from new technical foundations and more dynamic ecosystems. These ecosystems will need new business strategies and a move to platform-based business models. “The shift from compartmentalized technical infrastructure to ecosystem-enabling platforms is laying the foundation for entirely new business models that are forming the bridge between humans and technology.”. For example, blockchain could be a game changer for data security leaders, as it has the potential to increase resilience, reliability, transparency, and trust in centralized systems. Also, under this trend are digital twins, a virtual representation of a real object. This is beginning to gain adoption in maintenance, and Gartner

estimates hundreds of millions of things will have digital twins within 5 years [16].

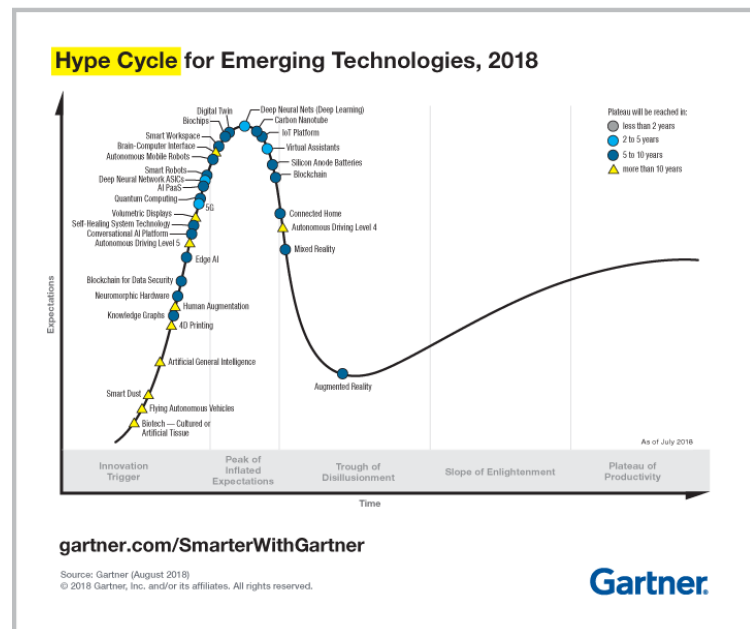


Figure 2: Hype Cycle for emerging technologies, Source: Gartner (August 2018).

IV. CONCLUSIONS

This work shows the high potential of blockchain for the manufacturing and machine tool industry. These use cases were analyzed using a cluster analysis and evaluated based on criteria for a beneficial application of blockchain. The cluster analysis assessed the potential of the use cases and the time until market entry. In addition, the cluster was used to identify cross-potentials, meaning use cases in other industries that are also relevant for the manufacturing industry. All experts agree that the first market-ready solutions that include blockchain will emerge in the next 3–5 years. According to the assessment of the interview partners and the Gartner Hype Cycle, the hype around blockchain is either already at the peak or short before [16]. Therefore, one should expect a slope in excitement for the technology in the next couple of years. The major reason for this development might be the technical and cultural challenges, but for the future, all experts agree that then those problems are solvable and that blockchain will become a key technology to transform many industries [8].

This paper focused on blockchain applications in the manufacturing industry and discloses potentials and challenges. Future research opportunities lie in a deeper analysis of the business processes in the manufacturing industry to further exploit the advantages of the blockchain technology [8].

“The blockchain has the potential to transform the supply chain and disrupt the way we produce, market, purchase and consume our goods. The added transparency, traceability and security to the supply chain can go a long way toward making our economies safer and much more reliable by promoting trust and honesty and preventing the implementation of questionable practices [5].”

CITATIONS

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