Blockchain in the Food Industry:

The Ethical Risks of a Decentralized Technology

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Introduction

Blockchain is now considered the frontier technology for sustainability and economic growth by the United Nations (UN, 2018). Dealing with cryptocurrencies and mainly with bitcoin, blockchain first started as a ledger for such technologies. Nowadays, blockchain is massively expanding beyond the financial sector into various types of industries including, the food industry.

Generally, "blockchain is a trustless computing infrastructure for large-scale applications that have the potential to solve fundamental trust issues and allows financial transactions without intermediaries" (Tang et al., 2020, p.603). Blockchain startups are generating worldly and innovative solutions to unprecedented challenges. For instance, blockchain is fighting hunger in Jordan. In Jordan's Azraq Syrian refugee camp, around 10,000 refugees are purchasing food using a blockchain platform (WFP, 2017).

Managing the refugees' financial activities through blockchain is reducing the likelihood of fraud and is speeding up transactions. Refugees instead of using cash in buying groceries from local supermarkets are relying on digital scans connected to biometric registration data from the United Nations High Commissioner for Refugees (UNHCR) (WFP, 2017). Blockchain technology is used for humanitarian purposes, allowing for faster and transparent transfer of aid to more people in need. Additionally, Walmart, partnering with IBM, has adopted a decentralized food supply chain system using blockchain technology in two main links.

First, for pork supply chains from China, "certificates of authenticity" are now being uploaded to the blockchain after being under continuous fraud and mismanagement concerns.

Second, the time needed to trace the mangoes in the United States used to take around 7 days. Yet, after adopting blockchain technology this time went down to 2.2 seconds (Hyperledger, 2016). Accordingly, the current boom of blockchain in the food supply chain is expanding to many states. Academics and entrepreneurs are stressing the potential consequences that blockchain technology can have on the economy and global sustainable development.

"Openness, decentralization, transparency, pseudonymity, and immutability are the fundamental merits that distinguish blockchain from other traditional computing solutions" (Tang et al., 2020, p.605). However, the negative impacts of blockchain are not yet defined and addressed. Likewise, the minimal focus has been placed on the ethics of blockchain and what potential consequences it might have on people and communities. Accordingly, this case study focuses on the ethical implications of blockchain in the food supply chain.

What is Supply Chain Management?

The International Monetary Fund defines supply chains as "the assembly lines that deliver goods for final consumption" (Smith, 2022). The assembly lines are the journey that each product undertakes before arriving in the customer's hands. It is the journey that different raw materials of a certain product take across countries to get assembled into one final product before ending up on the shelves for a user to buy. This journey involves "product development, sourcing the raw materials, assembling the parts, testing the end product, and shipping" (Smith, 2022, para.2). Globalization made supply chains highly complex as every supply chain of a product can involve many producers across countries. For example, a laptop, as a final product, could include raw materials, such as iron and steel mined in Africa and plastic produced in Japan. Additionally, It could have been designed in North America, processed in a Chinese factory, and delivered to the customer through a British shipping company. This complexity is essential to ensure country-based benefits in the development of such a product.

Supply chain management is the act of "handling the entire production flow of a good or service" (IBM, 2019, para.1). To perform this act, companies create a complex network of chains and manage the movement of the raw materials through all suppliers till the final product reaches companies that deal with the clients. In an article on management tools, Bain and Company show that supply chain management highly relies on forging strong relationships with suppliers to together build "the value chain to deliver the right products to the right places at the right times for the right costs" (2018, para.1).

The goal of supply chain management is to satisfy customers while maximizing profitability. Four stages were identified for the supply chain management. First, companies work to build trust across various supply chains to form long commitments with various partners. The second stage involves finding ways to maximize the exchange of information. Information includes knowledge of demand forecasting, supply capacity, production timeline, and delivery dates. Third, companies' efforts would be concentrated to manage supply chains while consistently enhancing their ability to gather and analyze information. According to IBM, "as recently as 2017, a typical supply chain accessed 50 times more data than just five years earlier" (IBM, 2019, para.6). However, only less than a quarter of these data are being analyzed. As a result, current supply chain management organizations frequently concentrate on strategies to maximize the value of the data gathered. During the fourth stage, companies allow for innovative ideas and ensure flexibility for continuous transformation of the supply chain to tackle unprecedented challenges (Bain and Company, 2018). These four stages lead to cost, waste, and time minimization in the production process.

What is blockchain technology?

Stakeholders across a wide range of industries frequently gather, archive, and analyze data to get the knowledge that will guide their decisions. Big data is the term used to describe this information when it is stored in massive quantities. Big data is difficult for humans to interpret or evaluate because of its complexity (SAS, 2016). To analyze big data effectively and efficiently, algorithms are used. These algorithms are created to produce patterns that help anticipate future behaviors and events with little to no human involvement.

In financial services, blockchain is a ledger: a large collection of financial accounts. PwC defines blockchain technology as "a decentralized ledger of all transactions across a peer-to-peer network" (2013, para.2). This technology allows users to conduct transactions without a central authority clearing intervention. Private companies, governments, or sustainable development organizations can use blockchain to vote, operate, transfer, manage trades, provide healthcare services, and so on. For example, Figure 1 shows how blockchain works from the moment a product is requested to the completion of the transaction (PwC, 2013).

Blockchain technology receives and delivers information in a faster and more accurate way than traditional financial tools. Additionally, using this technology for tracking and trading any product or service leads to risks and cost reduction for all involved stakeholders (IBM, 2022). As it guarantees transparency, confidence, and opportunities for maximizing the benefits of concerned stakeholders, blockchain technology is increasingly appropriate for holding such financial transactions.

IBM identifies three key elements to be applied in blockchain technology. First, "distributed ledger technology" which is the shared aspect of the ledger. All stakeholders in the supply chains should have access to the records of information in the ledger to avoid any duplication. The second element is “immutable records". Records in the stored data cannot be modified. When an error occurs in a transaction, a new transaction must be added to cancel the error, and both transactions will be visible. Thirdly, “smart contracts” are sets of rules that “define conditions…for transfers” (IBM, 2022, para.4). For this case study, the focus is on blockchain technology as a tool for the food supply chain, highlighting the application of blockchain technology in the production and logistics of food chains.

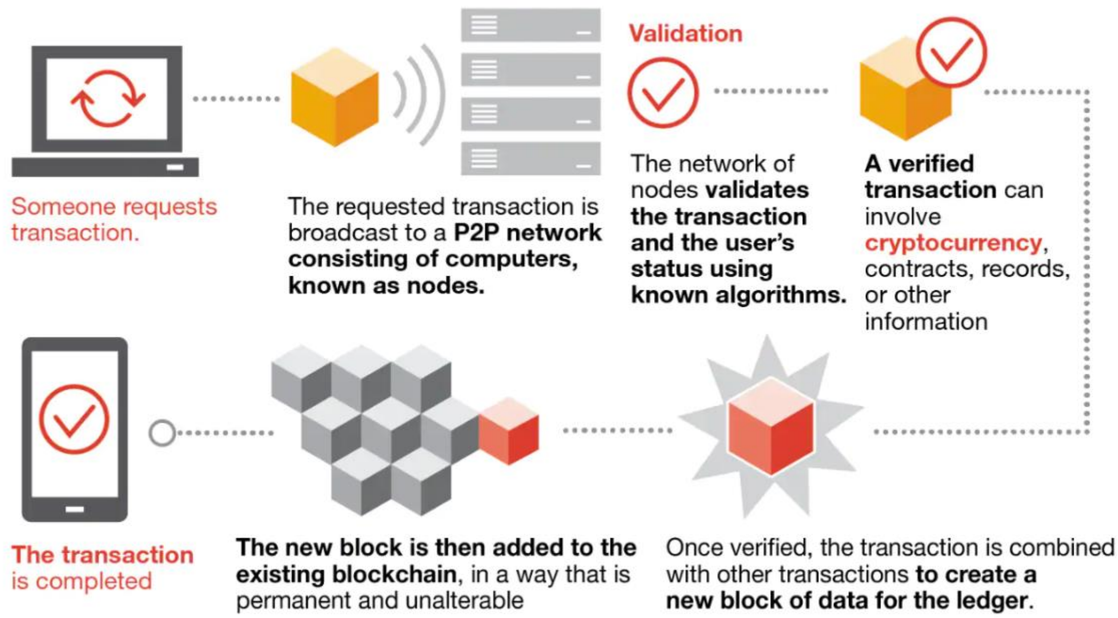

Figure 1 How Blockchain works. Source: Making sense of bitcoin, cryptocurrency and blockchain, PwC

Blockchain Technology in the Food Supply Chain

According to the WHO, there are around 600 million cases of foodborne diseases and more than 400 000 deaths caused by unsafe food consumption each year (WHO, 2022). Along with other serious and unprecedented challenges in the global sphere, such as the COVID pandemic, smart technologies are increasingly being used in the food production cycle, including production, manufacturing, packaging, conducting, and monitoring the supply chains, and waste management. Blockchain technology is one of many other smart food innovations that are being deployed in the food supply chain. The United States, China, and India are the most active countries in using blockchain technology in this area. Additionally, there are international partnerships among countries in the development and application of blockchain technology in the food sector (Mohapatra, et al., 2021).

Traceability is the primary reason to use blockchain in the food supply chain. Both public and private sectors are discussing the adoption of systems that enable traceability while implementing smart technology in the reforms of the food business. Traceability is defined as “a tool that allows a food business operator to trace food products along the entire food chain” (World Bank Group, 2019, p.6). It allows for quick identification of a certain problem related to food safety and enables stakeholders “to take steps necessary to withdraw or recall a food product from the market with minimal interference in production” (World Bank Group, 2019, p.6). The existent regulation on traceability is what makes it a high priority. For example, there is a requirement under the European national legislation to maintain traceability in the food industry (European Parliament, 2002). Additionally, major industrial countries, including the United States, Canada, Japan, and some European countries, focus on implementing traceability because it offers reliable protection for stakeholders, businesses, and customers (World Bank Group, 2019).

Blockchain technology also enhances transparency. Transparency in maintaining “timely and transparent payment mechanism, record keeping, efficient supply chain management, and warranting credit as well as insurance in the agri-food system” (Mohapatra, et al., 2021, p.22). Food safety, privacy protection, waste management, and food supply chain integrity are other key benefits of blockchain adoption (Sehgal, et al., 2022). Moreover, several private and public companies are relying on blockchain technology for developing resilience in times of crisis. Climate change is another fundamental advocator for adopting such technologies. In their study on digitalization and the future of agro-food supply chain management, Amentae and Gebresenbet place a strong emphasis on sustainability and crisis resilience as high-demand development areas for businesses adopting smart technology in food commodities (2021).

In terms of access and validation of blockchain technology in the food industry, it is crucial to highlight that blockchain technology used for the food supply chain is a “private permissioned” type of blockchain. A “private permissioned” blockchain is a closed system in which only stakeholders who have permission from the administrators are granted complete access to the ledger. This type of blockchain is different from a “public permissioned” blockchain which grants access to anyone (World Bank Group, 2020). Figure 2 shows the characteristics of each type of blockchain and their interconnections (Wegrzyn & Wang, 2021).

The use of blockchain technology in the food industry has been the subject of extensive research and literature, but there are still several obstacles that could derail this technology's potential. The costs of implementing blockchain technology, inadequate infrastructure, lack of laws and regulations, and lack of knowledge and skills pose significant obstacles to blockchain technology's potential benefits in the current food ecosystems (Amentae & Gebresenbet, 2021).

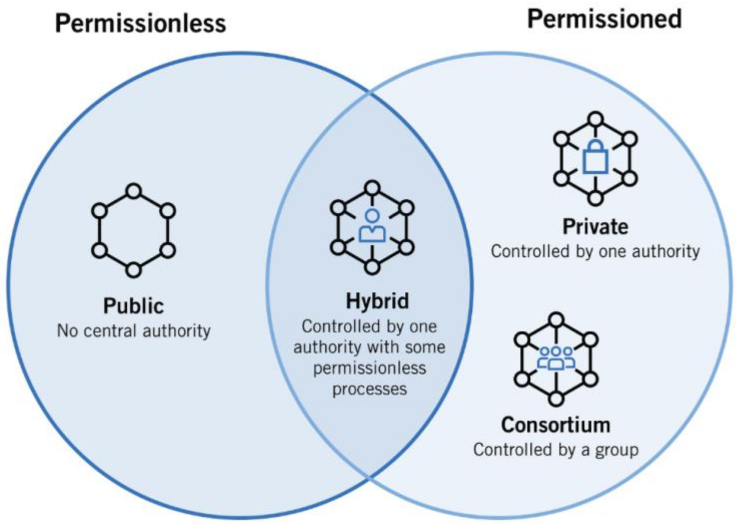

Figure 2 Types of blockchain. Source: Types of Blockchain: Public, Private, or Something in Between, Foley and Lardner, LLP

Harnessing Blockchain for Food Supply Chain in India: TraceX technologies

In 2015, Srivatsa Sreenivasarao and Anil Nadig founded an agricultural organization, Jivabhumi, in India that aims to deliver great quality food to consumers. For years after they started, the lack of data about supply and demand was their main challenge. Data was not enough to make decisions and it was also not easily available. Thus, TraceX was developed as a solution to tackle the lack of information. They started building a tech platform that is based on blockchain technology to store enough data allowing them to make decisions regarding the demand and supply of safe food. The main aim of TraceX is to create data-driven agriculture to help the organization "ensure a safer, transparent, and traceable food supply chain" (World Bank Group, 2022).

TraceX is currently successfully deployed. It has digitized the entire supply chain from pre-harvest to post-harvest, allowing for more effective connections across all stakeholders. Using TraceX, transparency, and traceability can easily be attained which convinces the consumers that buying from certain suppliers connected to the blockchain provides them with high-quality food. TraceX allows each stakeholder of the supply chain, starting from the farmer to the consumer, to access one blockchain network and transact businesses with all information needed. For example, farmers can add data on the types of seeds used or water quality, the processor can add data on cleaning procedures or packaging, and so on. Through this value chain, traceability is more credible as several independent parties are getting together into a common network to work as one entity (TraceX, 2022). Figure 3 shows the TraceX blockchain Network (World Bank Group, 2022).

Using TraceX, transparency is attained by a simple QR code. Customers can follow all the traces and information about how the food in their hands was produced by simply scanning a QR code. TraceX currently has around 30 customers who are paying to use the software. For example, Mcdonald's India has recently joined the blockchain for the use of lettuce in their burgers. Customers buying burgers from Mcdonald's can have access to the lettuce supply chain starting from the farms to the restaurants, ensuring safety and sustainability in lettuce production (World Bank Group, 2022). For a successful blockchain, accessing mobile and web applications is necessary for all stakeholders.

TraceX's blockchain is also working to empower stakeholders in the supply chain to apply sustainable practices in the food ecosystem, such as climate-resilient and carbon offsets in food production. However, this autonomous supply chain is facing several challenges. According to the founders, "lack of trust in supply chain claims, no ability to track trace, and [no ability] to comply with quality and food safety regulations" remain the key challenges for TraceX (World Bank Group, 2022).

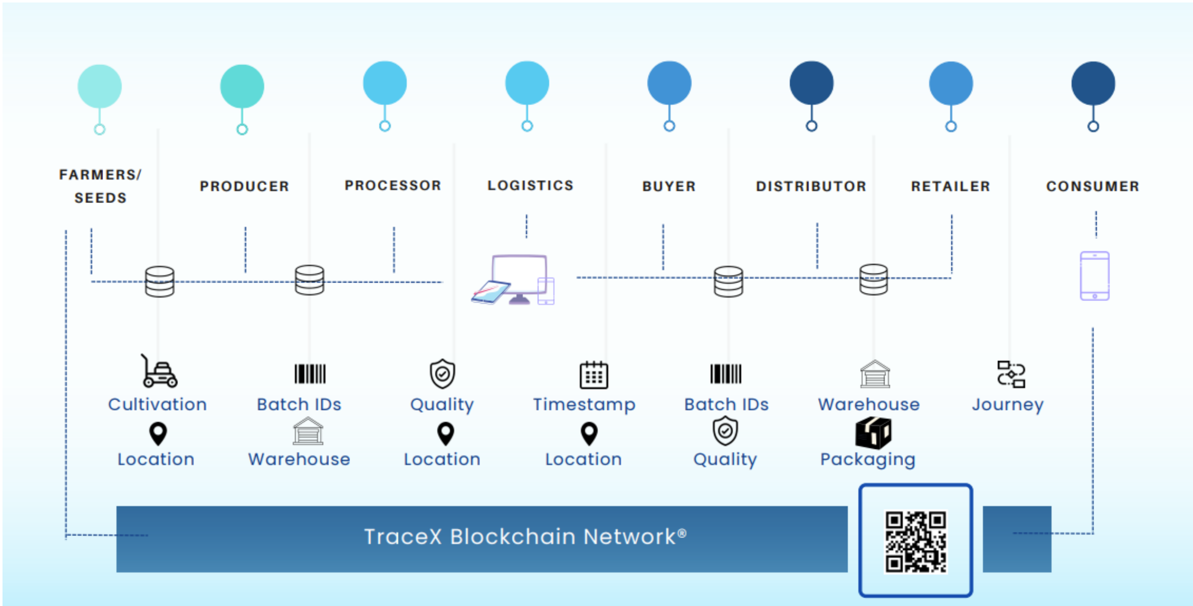

Figure 3 TraceX Blockchain Network. Source: Digital Ag Series, World Bank

Blockchain in Food Supply Chain: Ethical Implications

The exploration of the implications of blockchain in the food supply chain is key to engaging in the complexity of ethics and understanding underlying social and economic risks. Ethics is broadly defined as "a set of moral principles that inform judgments of right or wrong for a particular group or activity" (Manning et al., 2022, p.34). Among several areas or perspectives that the concept of ethics entails, Duran and Jongsma refer, in their article on black box algorithms, to the concept of ethics applied in normative values that guide human behaviors (2021). For this case study, the concept of ethics is viewed from the lens of the ethical behaviors applied in food supply chains. How do these behaviors influence the lives of people who are subject to blockchain use in food commodities?

Digital collaboration in the food industry is showing tremendous benefits for all involved stakeholders. TraceX as a small startup is a great example of this collaboration leading to sustainable and economic growth. In this section, three ethical considerations are discussed to question the ethical implications and regulations of using blockchain in food supply chains.

1. Responsibility and Accountability

There is strong academic literature, business articles, and governmental initiatives defining responsible AI and ways to put it into practical applications (Dignum, 2019). In food production, responsibility is mainly determined by food safety and trust in the final products as well as the production process (Manning et al., 2022). One of the most benefits of TraceX, as an example of blockchain in India, is not only to seek trust across all stakeholders but also to deploy a technology that adapts quickly and effectively to unpredictable events. In this context, responsibility is determined by the ability of the stakeholders to ensure trust for all entities interacting with the blockchain. However, the flexibility that blockchain offers can lead to harmful consequences. For instance, how to ensure that personal financial data is protected or financial information is not tracked for future transactions?

The self-reporting nature of the blockchain system is key for its effectiveness: humans select what information to report, mainly financial information. It becomes crucial to examine how well humans can avoid this self-report bias in blockchain going forward? Bias and discrimination might involve in the way blockchain ledgers are storing data. This could appear in the way the supplier is accessing the data and who, based on the information provided, will make decisions on supply needs, and consumer profiles. For example, by accessing data information, suppliers might infer patterns in the customers' characteristics and demands. While this information might be helpful to produce needed materials and products to meet people's needs, it can be used to discriminate a certain population over another. When bias occurs, suppliers might tend to sell and ship their products to areas with high demand, neglecting regions with lower demand which might be areas of underprivileged communities. Additionally, regardless of the density of the demand, suppliers might discriminate certain groups over others by manipulating and shaping the customers' characteristics they hope to attain for a particular product.

Marieke de Ruyter, the founder of the New Fork, emphasized, in her presentation on food supply and value at the World Bank, how blockchain neutrality makes establishing trust and taking accountability easier. She argues that blockchain is a set of rules, yet without a ruler since all stakeholders have access to the ledger (World Bank Group, 2020). This statement, while it secures trust, highlights a serious challenge to the accountability of blockchain in the food industry. In cases of cyber-attacks, who is responsible for the consequences that a supplier or a consumer might suffer. For example, if a cyber-attack occurs at TraceX, what regulations to follow or how to identify the wrongdoer as all suppliers have access to the ledger? Should developers be responsible for their created ledger?

Moreover, the responsibility for errors leading to bias made by blockchain needs to be considered. "Beyond data collection, an algorithm's design has the potential to echo any pre-existing biases its human creator may have" (Manning, 2022, p.39). These biases might not necessarily impact financial data security but might lead to bias in food distribution to a certain socioeconomic group of consumers. As one of three of Asimov's laws of robotics mentions: "A robot may not injure a human being, or, through inaction, allow a human being to come to harm" (Murphy & Woods, 2019, p.15).

Rules and regulations are still needed to ensure corporate social responsibility in blockchain technology. Is it possible to develop alert systems in blockchain technology as a food supply management tool to control the food supply chain and maintain its level of accountability? Would it also be beneficial for these alert systems to run completely by another AI agent or allow human intervention? Additionally, blockchain technology requires governance protocol for its ledger, which identifies who uses the data and what data can and cannot access. This protocol is still missing in various uses of this technology, creating risks that affect controllability and accountability. To prevent this decentralized technology from decentralizing trust, creative ethical design approaches are required.

2. Decentralization and Social Impacts

Several studies have supported the fact that “traceability supports ethical sourcing by having clear information on product history” (Park & Li, 2021, p.8). Authors of these studies argue that by ensuring traceability, blockchain technology protects “human rights and safe and healthy business environments in supply chains” (Park & Li, 2021, p.8). While blockchain startups are booming as we saw with TraceX, most of the emerging research focuses on technical skills with no discussions on the social implications (McKinsey, 2021; Dongoski, 2022). What are the ethical implications on society of such a decentralized technology? (Peterson, 2022). The major social impact of such decentralization is widening the gap between those who are privileged enough to engage in blockchains and those who are not. In TraceX, all suppliers need to have access to the blockchain networks via websites and mobile apps. This opportunity is limited to most Indian farmers who lack the digital skills required for this ledger. With more people gaining trust in TraceX, it becomes harder for fresh and organic small businesses to use traditional tools to sustain in digitized investing markets. This social structure change might negatively impact economic growth in the long run. How, using blockchain, businesses can secure social structural change while minimizing its negative effects?

The social-good applications of blockchain are great assets not just for suppliers but also for consumers. Lapointe and Fishbane identify some social good applications of this technology. These applications include “expanding access to services”, “protecting vital records”, “recording public transactions", "enabling secure mobile voting", "preventing human trafficking", and "improving medical research and healthcare" (2019, p.56-58). Lapointe and Fishbane argue that the assets of blockchain technology are also its greatest challenge (2019). Yet, there is still missing research on the tradeoffs in using blockchain and the ethical consequences of blockchain on people and communities. What will an ethical design approach look like for blockchain to ensure positive social impacts? Additionally, what are the role and laws and regulations in developing such a design? Within the massive variation in perspectives about the socio-technological issues of using blockchain, thinking about ethical codes is key to achieving human security.

Moreover, companies, startups, and governmental institutions that are adopting blockchain technology are working to tackle challenges related to infrastructure and digital knowledge and skills. However, it is still not transparent the way these public and private organizations are addressing these challenges while ensuring fair distribution of resources. With every digital innovation used, there is a risk of automation and the social problems associated with workers losing their jobs. In fact, with blockchain technology in the food supply chain, there is an additional risk of unfairness in the distribution of resources. This risk is also highly correlated with major economic disruptions that go beyond losing jobs to threatening food distribution to underprivileged people, especially in developing countries. Would designing infrastructure development projects and conducting training programs to facilitate the use of blockchain in food commodities to larger numbers of people be enough to limit the unfair distribution of food by using blockchain technology? What policies and regulations need to be adopted by actors of the food sector who are blockchain technology?

Additionally, blockchain technology might not be free from manipulation. Even if blockchain technology is a good example of utopian anarchy, it is very hard to have one entity responsible for regulation (Atzori, 2017). As Böhme et al. argues, a clear understanding of regulatory risks is still an unmet need when it comes to blockchain ecosystems (2015). With this unmet need, blockchain is still at the risk of being manipulated in a way that determines wages, fulfilling the interests of the actors who have permission to access the ledgers. Manipulation can also be conducted leading to wrong patterns that push suppliers to set unrealistic goals or force them to produce under unhealthy working conditions.

Meguerditchian, in her report on blockchain standards, argues that the best way to regulate the undesired social impact escalating from blockchain technology is to develop blockchain standards based on existing regulatory frameworks in the financial, IT governance, cybersecurity, and healthcare sectors (2017). Ensuring fairness in the process of developing blockchain standards requires avoiding any attempts to favor particular actors whether certain suppliers or consumers "at the cost of the majority" (Tang et al., 2020, p.624). Additionally, there is an ongoing question of whose responsibility it is to develop such standards. However, one remaining challenge is how to develop criteria based on which we can evaluate the ethical implications of blockchain systems. Would designing "a moral Turing test" for blockchain systems help address the ethical problems of blockchain technology as Allen et al. suggest? (Allen et al., 2000, p.254).

Conclusion

The case study defines and discusses key ethical dilemmas that still need to be addressed when adopting blockchain in the food supply chain. There are potential benefits of using blockchain in food commodities including transparency and traceability. While these benefits are leading to economic growth as well as sustainable and environmental solutions, other risks could exacerbate, threatening access to food in developing countries. Additionally, unforeseen impacts could highly impact economic growth: lack of accountability and unfair distribution of resources.

The ethical questions raised in the case study aim to further explore ways to shape a better knowledge of the social impact of blockchain in the food industry and work towards mitigating the risks associated with this technology. Potential directions should focus on designing rigid systems of rules and regulations to ensure the application of ethical principles and methods that prevent the negative consequences of blockchain. How should these rules and regulations be developed? And what sectors to engage in the process? Additionally, further research could focus on the role of the government in ensuring that blockchain serves humankind.

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