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Blockchain's role in promoting quality, safety and sustainability in the food and beverage industry

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Blockchain's role in promoting quality, safety and sustainability in the food and beverage industry

Abstract

The purpose of this paper is to examine the potential roles of blockchain in ensuring quality, and safety and promoting sustainability in the production and distribution of food and beverage products. A multiple case study approach has been chosen as the principal methodology. The article highlights how blockchain deployment in inter-organizational transactions reduces uncertainty in the actions of supply chains participants and makes dependence among value chain partners more symmetric, which can help improve quality and safety and promote sustainability in the food and beverage industry. It describes how blockchain's impact on interfirm governance structures in the food and beverage industry can be improved by increasing the number and types of participants. Also discussed is how blockchain's impact on reducing interfirm governance structures in the food and beverage industry can be improved by combining this technology with other emerging technologies. Finally, it considers how blockchain-based solutions can increase the degree of distributive fairness in the food and beverage industry and improve small-holder farmers' chance of being integrated in the global economy. The article gives special consideration to blockchain's potential in improving interfirm governance in the food and beverage industry. It explains how blockchain may reduce uncertainty in the actions of supply chain participants. The article shows how blockchain can make dependence among supply chain partners more symmetric. It suggests that by stimulating entrepreneurial opportunities for marginalized groups and promoting distributive fairness, blockchain can help take actions that are socially responsible.

Keywords: blockchain; food and beverage industry; interfirm relationships; smart contracts; sustainability; uncertainty

Introduction

Research that furthers our understanding of how we can deal with grand challenges is of profound interest to scholars (Ferraro, Etzion, & Gehman, 2015). A grand challenge that we face today is of adulterated, deceptively packaged and counterfeit food products. About 600 million people in the world become ill due to contaminated food every year. Of those about 420,000 die, which include 125,000 children under the age of 5 (World Health Organization, 2015). Among many challenges facing the food industry, improving food products' sustainability and safety are of particular importance (European Commission, 2015). A study conducted at the household level in the U.S. found that inadequate quality of food products is one of the key sources of food insecurity (Webb et al., 2006). Food fraud and adulteration cost more than \$40 billion to the

global economy annually. Estimates suggest that 30 – 40% of the food consumers eat is either “adulterated or mislabeled” (<http://www.connect.catalyst-inc.org/techwatch/arcnet>). In a survey, 39% of food manufacturers thought that their products can be easily counterfeited and 40% viewed that food fraud is difficult to detect using the currently available methods. There are also issues of slavery and forced labors in this industry.

A related grand challenge is the need to improve sustainability of the environment and social systems from issues that arise from the actions of various participants in the food and beverage industry (FBI). Serious ethical questions have been raised regarding whether small holder farmers are being paid fairly (Kshetri, 2021).

The issues of safety and sustainability are also related to organizational bottom line for firms in the FBI. Food safety and environmental concerns are being emphasized by firms in the supply chain (SC) of this industry. Acosta et al., (2019) reported that a medium-sized company in the sugar industry in Colombia has faced demands from multinational corporations (MNCs) to develop explicit corporate social responsibility (CSR) -related activities since the 2010s.

Many of the above issues can be potentially addressed with the advancement in blockchain technology, which according to the World Economic Forum (WEF) is among six computing “mega-trends” (WEF, 2017). Smart contracts, which execute automatically when certain conditions are met, have been emerging as a key application of blockchain that might provide value to various stakeholders in this industry. Research conducted in other settings indicates that smart contracts can dramatically reduce costs associated with verification and enforcement (Yermack, 2017). Other key advantages of smart contracts include higher speed, a high level of precision, higher efficiency, and more transparency (Reyna et al., 2018). There is

virtually no academic research that explicitly examines how these mechanisms might be exploited improve quality and safety and facilitate sustainability in the FBI.

This study aims to fill some of the mentioned research gaps by exploring the effect of blockchain on organizational and interorganizational processes in the FBI. Specifically, we seek to address the following research questions: RQ1) What is the nature of changes that blockchain is likely to bring in interfirm governance structures in the FBI?; RQ2) What are the potential roles of blockchain in promoting the sustainability of social systems in the FBI?

We chose the FBI for the setting of our study. The significance of the multi-trillion dollar industry stems from the fact that food is the most essential component of human life and is a key part of the national economy in many countries (Maloni & Brown, 2006). Moreover, in light of the poor performance of most blockchain projects on result demonstrability, a McKinsey.com article asserted that blockchain's value creation potential lies mainly in three areas (Higginson et al., 2019). First, in some niche applications such as SCs, blockchain can address problems related to inefficiency, opacity, and fraud. Second, in some sectors, blockchain can help modernize value by helping the digitization process, simplifying value creation process and facilitating collaboration. Some specific areas include smart contracts in the global shipping industry, trade finance, and payments applications. Third, blockchain is being used by some firms to enhance reputational value by demonstrating their ability to innovate. These strategies fit squarely into the FBI and are being pursued by firms in this industry. Indeed some of the most promising blockchain applications outside finance are expected to include those in SCs, power and food/agriculture. These use cases are believed to deliver real ROI at the early stage of blockchain development (Bunger, 2017). Among high profile applications of blockchain in this industry, IBM Food Trust is being used by many large food companies such as Nestle, Unilever, Walmart. As of mid-2018, the system

stored data related to 1 million items in about 50 food categories including Nestlé canned pumpkin, Driscoll's strawberries and Tyson chicken thighs (Nash, 2018) and facilitated more than 350,000 data transactions (Wolfson, 2018). In November 2018, IBM commercially launched its Food Trust. Companies of all sizes can join the network for a subscription fee, which ranges from \$100 to \$10,000 a month (Biscotti, 2018). Carrefour signed an agreement with IBM to use the solution. The retailer announced a plan to track its own branded products in France, Spain and Brazil and expand to other countries by 2022 (Biscotti, 2018). The company reported that blockchain's deployment to track meat, milk and fruit from farms to stores led to increase in sales of these products (Thomasson, 2019). As of 2021, the retailer was tracking more than 30 product lines using blockchain such as farm-raised eggs, Norwegian salmon and Rocamadour cheese. The company's goal is to expand the efforts to 100 product lines by the end 2022 (Forbes 2021). Research in this area is thus likely to offer insights on the role and limitations of blockchain in addressing key social and economic challenges in the FBI.

The paper is structured as follows. We proceed by first explaining blockchain and related concepts. It is followed by a literature review. Next, we. Next, we discuss the methods employed. Then, we develop a framework and some propositions related to blockchain's roles in ensuring quality, safety and sustainability in production and distribution of food and beverage products. It is followed by a section on discussion and implications. The final section provides concluding comments.

Blockchain: Some background, concepts and facts

Blockchain can be viewed as a decentralized ledger that maintains digital records of a transaction simultaneously on multiple computers. In some cases, thousands or even millions of computers around the internet are involved. After a block of records is entered into the ledger, the information in the block is mathematically connected to other blocks. In this way, a chain of

immutable records is formed (Yaga et al., 2018). Due to this mathematical relationship, the information in a block cannot be changed without changing all blocks. Any alteration in a block would create a discrepancy which is likely to be noticed immediately by others in the network (Kshetri, 2018a). To make sure only authorized users have access to the information blockchains verify identities using cryptography-based digital signatures. Users sign transactions with a “private key,” typically a long and random alphanumeric code. This code is next to impossible for hackers to guess and is known only to the person controlling the account. Complicated algorithms are used to create “public keys” from private keys in order to make it possible to share information. Public keys are known to the public. To take an example, a bitcoin wallet address is a public key. Any bitcoin user can send payments to that address. However, only the person with the private key can spend money in the account.

In blockchain-based ledgers, there is no requirement for record-keepers to trust each other. In this way, the dangers associated with data being stored in a centralized location by a single owner do not apply to blockchain. Blockchain’s key features—decentralization, immutability and cryptography-based authentication—are likely to make a powerful tool to enhance quality and safety and promote fairness in the FBI. These are presented in Table 1.

<i>Table 1 about here</i>

Smart contract

The degree to which contracts can be enforced is positively related to the size of entrepreneurial activities in the formal sector (Quintin, 2008). Better contract enforcement through smart contracts can facilitate entrepreneurial activities. Indeed, one of the most high-profile future uses of blockchain is likely to be smart contracts.

Smart contracts combine “protocols, user interfaces, and promises expressed via those interfaces, to formalize and secure relationships over public networks” (Szabo, 1997). A smart

contract assures a party with certainty that the counterparty will fulfill the promises. For instance, when a shipment of food is received from a shipper, it automatically would trigger a payment to the shipper. In this way, smart contracts can overcome moral hazard problems.

Most smart-contract solutions are blockchain-powered. In such cases, a unique address identifies each contract. Users send a transaction to the address. The correct execution of the contract is enforced by the blockchain consensus protocol.

Literature review

Information and communications technologies' (ICTs) effects on agency and boundaries

Two key attributes-- *agency* and *boundaries*-- provide a helpful theoretical perspective for understanding ICTs' roles in changing the organizational and inter-organizational processes and outcomes (Nambisan, 2017). Agency refers to the "capacity for action" (Giddens, 1984). In an agency relationship, an "agent" is designated to represent the "principal". The agent takes actions or makes decisions on behalf of the principal (Ross, 1973). It is argued that ICTs function as material agency since they can be assigned to perform actions without direct or complete control of human beings (Faulkner & Runde, 2009; Orlikowski & Scott, 2008). To take an example, digital platforms such as crowdsourcing and crowdfunding systems enable a group of actors to jointly create value (Nambisan, 2017).

When ICTs function as a material agency, they may change the boundary of actions that human agents can take. ICTs have also made entrepreneurial processes and outcomes less bounded. For instance, entrepreneurial activities are less restricted in terms of temporal and spatial dimensions.

von Briel et al. (2018) examined ICTs' two key characteristics--specificity and relationality- that affect agency and boundaries. A high degree of specificity and control over actions would increase the predictability of inputs, which can reduce the variance in outputs

produced (von Briel et al., 2018). The specificity feature of ICTs can be described in terms of restrictiveness (set of actions that can be possibly performed), comprehensiveness (number of features offered by a technology) (DeSanctis & Poole (1994) and adaptivity (set of actions and interactions enabled by the technology) (von Briel et al., 2018).

The relationality property involves ICTs' relationships with other actors that enhance their functionality (Kallinikos et al., 2013). Relationality influences the nature and number of actors that can participate in the venture creation processes (von Briel et al., 2018).

ICTs vary widely in terms of the capacity for relationality. For example, a 3D printer is characterized by a low degree of relationality as it mostly connects with a single actor at a time. On the other hand, social media have a high degree of relationality since they can connect diverse participants (von Briel et al., 2018).

In addition to the number of actors, it is important to look at the nature and quality of relations that exist between them. While some ICT applications such as social media are characterized by a high degree of relationality (von Briel et al., 2018), such relationships are often shallow. A key feature of shallow relationships such as those observed in most social media applications is that there is a high level of uncertainty. Without the perceptions of integrity, trust required for coordination and cooperation may not exist (Pirson & Malhotra, 2011). One way would be to rely on transactional trust (Zucker, 1988).

By connecting more and diverse actors with complementary capabilities, ICTs increase their potential to create new combinations of resource. These actors can also engage in modification of resources to engage in value creation activities (von Briel et al., 2018).

Institutions in food SCs, power dynamics and dependence

A dependence condition that is balanced and symmetric provides safeguards to both parties and there is a collective incentive to maintain such relationship (Williamson 1983, 1985; Oliver

1990). In a relationship characterized by unilateral dependence, little efforts are directed at developing interactions that are reciprocal, equitable and bilateral (Buckley & Casson 1988; Oliver 1990). There is the possibility of an expropriation hazard if only one party in a relationship is required to make a commitment (Williamson 1983). That is, the other party can extract the first party's profits (Porter & Fuller 1986).

Prior researchers have argued that there are three attributes of stakeholders that are important in identifying and responding to pressures from various stakeholder groups: power, legitimacy and urgency (Mitchell et al., 1997). Organizations are likely to be more attentive, responsive, and accommodating to the needs of stakeholder if they are viewed to be powerful and their claims are seen as legitimate by the society (Mitchell et al., 1997).

The issues of food safety and CSR in this industry are important for a number of powerful stakeholder groups (Maloni & Brown, 2006). These issues are thus urgent, important, and perhaps the most challenging problems in the food industry. An additional point that deserves emphasis is that due primarily to heavy price discounting and increasing input costs, the food industry has been characterized by low profitability. Food companies thus are not in a position to devote additional resources to deal with less direct issues such as safety and CSR.

The temptation to depreciate quality, commonly known as the “lemons problem,” (Akerlof, 1970) is more prevalent in electronic channels which increase the possibility of adverse selection, moral hazard, and fraud (Kshetri, 2010). Note that adverse selection (anti-selection or negative selection) arises from information asymmetry. In such a case, one party is unable to determine if the other party is lying. Likewise, moral hazard is the problem of not being able to determine if the other party is cheating or acting dishonestly. A market for lemons problem may arise in the food industry if relevant parties lack sufficient incentives to perform due diligence.

Consumers often rely on intermediaries such as third-party certification (TPC) agencies in order to overcome the adverse effects of information asymmetry.

Regarding the power dynamics, stockholders are among the most powerful actors in organizations. Porter and Kramer (2002) noted that due primarily to increased pressures to meet stockholder expectations, philanthropy has been declining. As a corollary, it can be argued that due to such pressures, powerful players in the FBI are likely to devote fewer resources to deal with unethical issues such as forced and child labor.

Uncertainty in SCs

The concept of uncertainty constitutes a cornerstone for a large body of research dealing with organizational inter-organizational behaviors (McMullen & Shepherd, 2006). Due to the complexity of global supply networks, SC uncertainty is a central issue that companies today are concerned with (Simangunsong, Hendry & Stevenson, 2012; van der Vorst and Beulens, 2002). Companies constantly need to cope with issues such as the lack of information about and understanding of the SC and its environment, inability to accurately predict the behaviors of other SC participants and the absence of controllability over the actions of these participants (van der Vorst and Beulens, 2002). A main concern facing organizations is lengthy and slow-moving SCs, which has forced organizations to restructure and find alternative ways to manage their SCs (Christopher, 2000). Consequently pressures to restructure and find alternative ways to manage organizations' SCs have been building for some time (Christopher, 2000).

Inter-organizational institutions are routines, norms, values and conventions that govern relationships among organizations (Asheim, 2008). These are related to interfirm governance arrangements (Helde, 1994), which are chosen by firms based on the level of uncertainty that exists in the relationship, and their degree of dependence (Pfeffer & Salancik, 1978). Firms establish (semi)formal links in order to reduce uncertainty and manage dependence (Ulrich &

Barney, 1984). Some mechanisms include increasing the degree of coordination with value delivery network (VDN) partners or creating "negotiated" environments (Cyert & March, 1963).

Blockchain's organizational and inter-organizational effects

Insights from research on blockchain deployment in related areas can also provide some guidance for understanding blockchain's potential roles in improving quality and safety and facilitating sustainability in the FBI.

Prior research has shown that blockchain can help achieve key SC management objectives such as those related to cost, quality, speed, dependability, risk reduction, sustainability and flexibility (Kshetri, 2018a, 2021). Many of these benefits can be realized due to blockchain-led increase transparency and accountability (Kshetri, 2018a). Some researchers have looked at blockchain's potential to achieve these SC and other objectives in the specific context of smart contracts. For instance, smart contracts can dramatically reduce costs associated with verification and enforcement (Yermack, 2017). Other key advantages of smart contracts include higher speed, a high level of precision, higher efficiency, and more transparency.

Another relevant research stream is the study of blockchain in developing countries. Kshetri and Voas (2018) noted that blockchain will have powerful impact in developing countries by reducing fraud and corruption, which can stimulate entrepreneurial activities among the world's poorest. Kshetri (2017) provided many examples of blockchain applications in developing countries that have led to increase in efficiency and reduction in transaction costs. Yermack (2017) suggested that convergence of three factors is crucial in explaining developing countries' possible early adoption of blockchain. First, the existing record-keeping systems in these countries are inadequate and outdated. Blockchain could be an appropriate tool to fill this void. Second, there has been a public mistrust of regulators. Third, modern ICTs such as smartphones are diffusing rapidly in these countries.

Methods

We build theory from multiple case studies (Eisenhardt & Graebner, 2007). Compared to a single-case study, multiple-case studies provide a stronger base for theory building (Rowley, 2002). As suggested by Eisenhardt & Graebner (2007) we have made connections with related literatures, and established theoretical gap that exists in the literature. We have provided an explicit statement of research questions. We have also made a strong case for the importance of the research questions as suggested by prior researchers (e.g., Bansal & Corley 2012). In this regard, theoretical and practical importance of research on blockchain's use in ensuring quality, safety and sustainability has been clearly established.

Selection of cases

One view is that the selection of cases in a multiple case study design has broadly the same objectives as in random sampling. According to this approach, the cases selected need to represent the population and there must be a variation on the dimensions of theoretical interest (Seawright & Gerring, 2008). A main way a multiple case study design differs from random sampling is that the choice of cases in the former needs to be made more on a substantive rather than statistical basis in order to adequately represent a target population (Greene & David, 1984).

The case selection process is also guided by logistical and financial reasons as well as consideration related to ease with which data can be gathered (Stvilia et al., 2007). We selected only cases for which sufficient information could be obtained from secondary resources. Note that archival data is among a variety of recognized data sources for case studies (Eisenhardt & Graebner, 2007). Ansari et al. (2015), for instance, relied primarily on archival data.

Following Eisenhardt's (1989) suggestion, we selected ten cases. In order to select the cases, we have combined two approaches: extreme method and diverse method (Seawright &

Gerring, 2008). More specifically, our process started with extreme case method. It evolved over time in order to implement different requirements and recommendations.

In the extreme case method, cases with extreme values on the independent (X = firm characteristics) or dependent variable (Y = deployment of blockchain) of interest are selected (Seawright & Gerring, 2008). The cases selected in this paper are extreme in the sense that they are among the earliest blockchain developers and adopters in the FBI. In particular, prior researchers have suggested that best practices models are good candidates for a case research methodology (Eisenhardt, 1989).

If researchers have some idea about other factors that might affect Y (the outcome of interest), other case selection methods can be pursued (Seawright & Gerring, 2008). Following this recommendation, we utilized a diverse case method as a strategy to select specific cases of firms deploying blockchain in the FBI. A key goal is to achieve a maximum possible variance along relevant dimensions (Seawright & Gerring, 2008).

The theoretical reasons for choosing multiple cases include (contrary) replication, a theory's extension and elimination of alternative explanations (Yin, 1994). We have tried to use these criteria. As an illustration of contrary as a reason, Brown and Eisenhardt (1998) added successful and unsuccessful turnaround cases, which enabled them to add longitudinal elements to their theory. We applied this criterion to include cases with different methods used to assess the quality of crops. For instance, farmers in Eastern Uganda transport their crops to a buying center. At the center, Nile Breweries officials check for quality and other details, which are recorded in the system (Equator News, 2019). On the other hand, Bext360's Bextmachine is a coinstar-like device, which employs smart image recognition technology machine vision, artificial intelligence, IoT and blockchain to grade and track coffee beans. It takes a three-

dimensional scan of each bean's outer fruit (Cadwalader, 2018). Bextmachines analyze farmers' coffee cherries and coffee parchment deposited at collection stations and sort them to assess the quality. Farmers that supply bigger and riper cherries are paid more.

A key idea in diverse case method is to select cases to represent full ranges of values that characterize X, Y, or some relationships between them (Seawright & Gerring, 2008). As to the deployment of blockchain, two main areas of the focus of measurement emerged: a) quality and safety, and b) sustainability. In order to achieve diversity, we selected cases with different combinations of major and minor/no focus related to these attributes. It is also worth noting that the variables related to these factors are continuous. As suggested by Seawright and Gerring (2008) for such variables, we chose cases that represent the three different combinations of major and minor/no focus areas in terms of these attributes. These are shown in Table 2. The use of extreme case method meant that we did not choose cases that did not have at least one major focus areas. For this reason, cell 3 in Table 1 is empty.

<i>Table 2 about here</i>

Sources and characteristics of data

Gottschalk (1969) suggested that the sources of evidence as well as the evidence need to be evaluated. Table 3 presents how some of the main criteria suggested by Gottschalk (1969) have been applied.

<i>Table 3 about here</i>

We made attempts to assess the coherence and internal consistency of the data. As suggested by prior researchers (e.g., Kshetri, 2018d), we evaluated coherence by comparing different data items for the same point in time and the same data items for different points in time. To illustrate this, we consider the following examples:

Bext360. The company started its pilot program in November 2017. In the same month, it teamed up with Moyee and the FairChain Foundation to produce blockchain-traced coffee

called Token. In April 2018, the world's first blockchain-traced coffee was sold. By June 2018, 60,000 kilograms of coffee from Ethiopia was exported to Amsterdam.

Walmart: We compared various steps and processes associated with deploying blockchain to verify and enforce sustainability. Key events in chronological order are as follows: October 2016: food safety and traceability protocols tests started in China and the U.S., February 2017: completion of the pilots, May 2017: release of the results of the tests, June 2019: commercial launch of its blockchain traceability platform, and November 2020: expanding the platform to more product categories.

The lack of bias, reputation and trustworthiness of the source as well as content of data are important. In order to achieve these goals, we corroborated are triangulated data and information from multiple sources. We relied on information from reputable third parties instead of taking directly from the websites of organizations chosen in the analysis.

Timeliness and currency of the data are of equal importance. In order to ensure the appropriateness of the age of the data, we followed the latest news items related to the cases chosen. In addition, we visited the websites of the relevant companies for up-to-date information.

Patternmatching theory and data

In well-conducted case study research, theory and data are “patternmatched” and propositions are consistent with the selected cases (Eisenhardt & Graebner, 2007). In this regard, Table 4 and Figure 1 provide a visual theory summary, matching with the cases, to explain how the framework developed can be applied in ensuring quality, safety and sustainability in the production and distribution of food and beverage products.

Table 4 and Figure 1 about here

**Blockchain's roles in enhancing quality and safety and promoting fairness in the FBI: A framework and some propositions
Improvements in interfirm governance structures**

In Table 5, we look at how blockchain performs in terms of two key features-- specificity and relationality—in terms of its roles in improving interfirm governance. We specifically examine how blockchain-based solutions may reduce uncertainty and change the dynamics of inter-organizational dependence.

As mentioned, food supply networks have a low degree of integration and a low degree of responsiveness, which lead to poor interfirm governance. Blockchain greatly improves this situation. For instance, if a retailer claims that its coffee beans have been ethically sourced from a developing country, this can be confirmed using blockchains such as those used by Swiss Coffee Alliance (SCA) with a higher degree of confidence than any other available methods. The journey can be traced from coffee farm to coffee cup, which can address the concern about misrepresentation (Finextra, 2016).

<i>Table 5 about here</i>

Likewise, Breaux Veritas, which provides testing, inspection and certification services, has developed a blockchain-based consumer facing food traceability system (<http://www.origin.bureauveritas.com/>). Relevant participants share records and validate transactions. It has emphasized on continual verification to provide highly reliable information about a product's history. It is proposed:

P₁: Blockchain deployment in inter-organizational transactions leads to reduction of uncertainty in the actions of SC participants, which can help improve quality and safety and facilitate sustainability in the FBI.

Symmetric dependence

As noted, opportunistic behaviors are less likely to be detected in an exchange relationship if there is significant uncertainty about the outcome (Hill, 1990). A participant engaged in exploiting a less powerful member is less likely to suffer a reputational harm in such situation.

The upshot is that opportunistic behaviors may repeat in the future without being punished (Hill,

1990). If behaviors are observable and opportunistic behaviors are detected, the incentives to engage in opportunistic behaviors are low. In this regard, the first observation is that while blockchain systems make most opportunistic behaviors easily detectable. A key benefit of blockchain is that if any information in a block is changed, that leads to changes in all blocks, creating a discrepancy which is likely to be noticed immediately by others in the network (Kshetri, 2018a).

There is a fluctuation in the quality of food products (Splitter, 2018). Currently middlemen make decisions regarding the quality of commodities such as coffee. They have an incentive to downgrade the quality. They often set the prices of these products and make decision as to how much and when farmers growing the crops are paid (Schiller, 2018). In the current SCs, there is a challenge in accurately measuring the quality of commodities such as coffee. Put differently farmers face a condition of ambiguity (Carson et al., 2006) regarding the quality of their commodities. An approach to reducing ambiguity would be to develop ways to accurately measure quality. Yet, absent such conditions, there is significant uncertainty about the outcome regarding how the quality of commodities such as coffee are assessed (Hill, 1990). This means that unfair behaviors are less likely to be detected and such behaviors are likely to repeat in the future.

The challenges with exploitation of farmers and workers in food SCs are well recognized. Some SC partners have so much power that they do not need to trust and be trusted. Less powerful actors such as small-holder farmers cannot document their value and thus are forced to depend on more powerful actors.

The fluctuation in quality of food products is mainly due to the lack of sharing of relevant information among farmers, consumers and other SC members. Blockchain makes information

sharing more meaningful. Ripe.io uses blockchain to compile data from the farm and other sources and use them to improve qualities of tomatoes. Relevant data collected from farmers and sensors include temperature, humidity, ripeness, color, and flavor of a tomato (Splitter, 2018).

Ripe partnered with restaurant chain Sweetgreen to show the use of blockchain to track crops. It provides information to farmers, food distributors and restaurants, which can be used to improve the quality of produce (Massa, 2017). Examples such as this indicate that blockchain helps develop unique, mutually beneficial and effective business relationships among value chain partners.

A main challenge most SCs face concerns an asymmetric dependence (Pfeffer & Salancik 1978). Blockchain has a potential to fundamentally change this dynamic since small food manufacturers contributions to the value co-creation activities can be tracked. For instance, as noted above, bext360's solutions provide a unique ID to each coffee bean, which can be used to track it throughout the life cycle and provide insights into attributes that may produce certain tastes. Blockchain can help establish a collaborative relation that is mutually beneficial.

Blockchain deployment can reduce the costs associated with the testing of product quality. This technology thus performs well in terms of specificity property (von Briel et al., 2018).

In the coffee industry, for instance, costs related to paperwork and physical inspection are estimated to be as high as US\$0.91 per pound of coffee (<https://moyeecoffee.ie/blogs/moyee/world-s-first-blockchain-coffee-project>). Blockchain could make the roles of actors such as certification agencies less relevant. Overall, blockchain changes the dynamics of dependence. Based on above discussion, the following proposition is presented:

P₂: Blockchain deployment in inter-organizational transactions leads to more symmetric dependence among value chain partners, which can help improve quality and safety and facilitate sustainability in the FBI.

Number of participants in a blockchain network

Most blockchain systems in the FBI use private or permissioned blockchains. As noted above, such chains are restrictive and access need to be granted by some authority. These systems thus vary in terms of the number of participants that are granted access. For instance, a blockchain system developed by the Chinese e-commerce firm JD.com and inner Mongolia-based food supplier Kerchin connects only these two firms. Kerchin collects and stores data in its SCs by scanning barcodes of its products. The information is then entered onto blockchain. After that any changes in data require a digital signature. Both parties are informed if there is any change and modification in the data (Huang, 2017).

Other blockchain systems connect larger numbers of participants. For instance, SCA uses Ambrosus' sensor-to-blockchain technology to fight unethical distribution of profits in the global coffee SCs. The participants include SCA's network of farmers, roasters, product developers, manufacturers and retailers (Ambrosus, 2018). It utilizes blockchain, high-tech sensors, and smart contracts to create immutable records of transactions in the food industry (Cag, 2017).

Eliminating uncertainty requires timely information flows from many different sources. Even if only a few participants use blockchain-based solutions, this will have a powerful effect. The power of blockchain-based solution is likely to increase with network effects. Various mechanisms can stimulate network effects with increase in SC participants. First, under some conditions the participants have a high incentive to collude and enter false information into the blockchain. An increase in the number of participants may decrease the probability of collusion among the participants.

Second, a company in the food SC can be held accountable for problems at its suppliers or even the suppliers of suppliers. By connecting them to a blockchain system, it is possible to promote transparency and hence accountability among all SC participants. Responsiveness and accountability thus can be ensured by incorporating a larger number of participants in the blockchain.

Third, a key point from our perspective is that it is important to make sure that the information entered into a blockchain is actually true. In a network with fewer participants, additional processes may be needed to ensure the accuracy of information. For instance, JD periodically implements random spot checks at Kerchin's factories to examine the accuracy and validity of information (Huang, 2017). Blockchain's potential to act as a "truth machine" can increase with the increase in the number of participants.

While relationships are often shallow in contexts such as social media despite a high degree of relationality (von Briel et al., 2018), in a blockchain model, the participants develop a meaningful relationship that can be mutually rewarding. While a key challenge that relationships social media face concerns the lack of trust required for coordination and cooperation may not exist (Pirson & Malhotra, 2011), trust is established by consensus algorithms and transparency in blockchain's trustless system. It is thus proposed that:

P_{3a}: Blockchain's impact on interfirm governance structures in the FBI can be improved by increasing the number of participants.

Variety of the roles of the participants in a blockchain network

When a wide variety of actors participate in a blockchain network, diverse categories of data and information are likely to be created and entered in the blockchain system, which is likely to reduce uncertainty. To illustrate this argument, we will first discuss the example of the Danish shipping company Maersk, which tracked a shipment of avocados and roses from East Africa to Europe in 2014. The goal was to understand the physical processes and paperwork in cross-

border trades (Baipai, 2017). In most cases, the containers can be loaded on a ship in a few minutes. However, it can be held up in port for many days due to missing paper works (Groenfeldt, 2017).

A key source of volatility (Carson, Madhok, and Wu, 2006; Williamson, 1975, 1985) is also whether various SC chain participants satisfy regulatory requirements. By including regulators in a blockchain system such volatility can be reduced.

In a Maersk pilot project completed in February 2017, which involved transporting goods from Europe to the U.S. a number of government agencies were involved. They included Customs Administration of the Netherlands, the U.S. Department of Homeland Security Science and Technology Directorate, and U.S. Customs and Border Protection (Groenfeldt, 2017). When government agencies are part of a blockchain network, relevant paperwork is likely to be uploaded in the system. In China, for example, regulators are part of a pilot project run by IBM and Walmart to make the retailer's supply network more transparent, for instance by tracing the provenance of pork and organic food (economist.com, 2017).

To take another example, Coca-Cola announced a plan to fight the use of forced labor worldwide by using blockchain's validation and digital notary capabilities to create a secure registry for workers and their contracts. The U.S. Department of State has also collaborated in the pilot (reuters.com, 2018).

Relationality also involves the nature of actors that participate in the venture creation processes (von Briel et al., 2018). In order to provide further insights along these lines, we provide a brief description of how blockchain-based systems would work. As noted above, Bext360 combines blockchain-based solutions with other technologies to assign each coffee bean a unique ID and track it. In this regard, Mainelli (2017) has identified three parties in a typical

identity document exchange: (1) subject of the identity (an individual or an asset such as a coffee bean), (2) certifier (e.g., a government agency, an accounting firm, or an independent third-party certification (TPC) agencies for organic and Fair Trade products), and (3) inquisitor (makes an inquiry on the subject in order to investigate requirements for various compliances).

Typically, a blockchain transaction has two distinct ledgers (Mainelli, 2017). A content ledger has the individually encrypted documents. A transaction ledger holds encryption key access to the document folders related to identity, health, and other individual attributes on a series of what is referred to as “key rings”. Digitally certified documents related to various attributes are put on the subject’s key rings by the certifier. The certifier often needs the subject’s permission to do so. A TPC agency, for example, may provide organic certification for coffee beans. After putting on the blockchain certifiers do not have access to the data. Inquisitors often rely on the data that a trusted third party has stamped (Mainelli, 2017).

Inquisitors can inspect the documents when the subject gives controlled key usage based on smart contracts. The network may restrict the number or timing of inquisitions. All the inquisitions are recorded for the subject (Mainelli, 2017). With the participation of these parties with diverse roles, documents stored in and distributed via a blockchain networks are likely to achieve a high degree of authenticity. By bringing different partners, various sources of volatility can be addressed. Thus, we propose:

P_{3b}: Blockchain’s impact on interfirm governance structures in the FBI can be improved by increasing the variety of the roles of the participants.

Combination with other technologies

Prior researchers have found a positive relationship between volatility and supplier opportunism in formal contracts and between ambiguity and opportunism in relational contracts (Carson et al., 2006). Looking from the agency theory angle (Ross, 1973), ICTs such as blockchain function as material agency and perform actions without the control of human agents (Faulkner & Runde,

2009; Orlikowski & Scott, 2008; Nambisan, 2017; von Briel et al., 2018). The effectiveness of such roles of blockchain can be further enhanced by combining it with other technologies.

Regarding the specificity property (DeSanctis & Poole 1994; von Briel et al., 2018), ICTs play a key role in determining the kind of resources various actors can provide as inputs and the way these resources are transformed into outputs. The potential benefits of the specificity property of blockchain can be more pronounced if it is combined with other technologies such as advanced QR Codes, artificial intelligence (AI) and machine vision. Specifically these technologies can help improve blockchain's performance in terms of adaptivity by increasing the possible sets of actions and interactions (von Briel et al., 2018).

We illustrate with three examples how blockchain can be combined with other technologies to have an amplified impact on the quality, safety and sustainability in the production and distribution of food and beverage products.

Alibaba

Alibaba implements blockchain also in its domestic SCs. In August 2018, Alibaba's online payment affiliate Ant Financial signed a strategic cooperation with the Wuchang municipality in China's Heilongjiang province to track the rice SC (Sunny, 2018). Tmall and Rookie Logistics are other partners in the project (Baipai, 2018). A major goal is to stop counterfeit versions of the Wuchang rice, which is known for high quality with limited production. The pervasiveness of counterfeit Wuchang rice has increased (Li et al., 2016). Each bag of Wuchang rice sold on Tmall platform displays a QR code with a unique identification number. Consumers can scan this code using a smartphone app before paying for the rice. The details provided include the specific field the rice came from, seeds and fertilizers used to grow the rice, as well as information related to shipments (Chavez-Dreyfuss, 2018)

QR codes have advanced which makes counterfeiting impossible or extremely expensive. Even before introducing blockchain, Alibaba launched its “Blue Stars” campaign in 2015 for high-end food and other products. The campaign used the next generation “dotless” QR-codes. Participating merchants selling on Alibaba’s online marketplace Taobao can attach a label containing a QR-code with colorful image with each package to verify the authenticity (Russell, 2014). A secure scanner developed by software company Visualead is used to scan the QR-codes. Each QR-code is unique, cannot be duplicated and brands can customize the code using different combinations of visually appealing images, logo and different colors (Williams, 2015).

Theoretically it is possible for counterfeiters to sell fake goods with legitimate Blue Stars QR-codes. To do so they can buy legitimate products, get enough genuine QR codes and put them on the packages of fakes. However, each item has a unique QR-code identifier. When a customer receives the product ordered online and scans the code, it will “burn”, which means that each code can be used only one time (Alba, 2015). This means that counterfeiters will have to buy large quantities of legitimate goods to get enough genuine codes. This makes fraudsters’ business model less attractive (Erickson, 2015).

Solution of Maureen Downey and Everledger to address physical tampering of wine bottles
Solutions have also been developed that combine blockchain with other advanced technological solutions to deal with unauthorized modification and physical tampering, especially of expensive food products. For instance, fraudsters can empty expensive wine bottles and refill with cheaper ones. Counterfeiters have also reverse-engineered the Coravin system so that they can refill a bottle. Wine expert Maureen Downey and Everledger have developed a solution to address this. A small chip is implanted underneath a plastic capsule that goes over a wine bottle's existing capsule. If a counterfeiter pierces the chip, it will be unreadable (Procter, 2018).

A key concept that forms part of this perspective is that of bounded rationality. The idea here is that while actors engaged in a transaction may intend to be rational, they can do so only to a limited extent. This is because human beings have limited access to knowledge. They also have a limited ability to process the knowledge that they have (Simon, 1991; Williamson, 1981).

In many relationship-related contexts, the lack of the perceptions of integrity hinders the development of trust required for coordination and cooperation (Pirson & Malhotra, 2011). If machines make the decisions rather than humans, there is no necessity of trusting other SC partners. Put differently, blockchain creates a trust-irrelevant context in SCs.

Overall, actions can be taken by combining blockchain with other technologies faster, and with fewer resources. Blockchain-based systems may reduce the amount of time needed to perform an action. It thus performs better than the available alternatives in terms of compression mechanisms. Another related mechanism is conservation, which is related to the reduction of resources to perform an action (von Briel et al., 2018). The above leads to the following:

P₄: Blockchain's impact on reducing interfirm governance structures in the FBI can be improved by combining it with other emerging technologies such as AI, IoT and machine vision.

Marginalized groups' engagement in entrepreneurial activity

Integration of small farmers to the global value chain

As noted above, when ICTs such as blockchain function as a material agency, they may change the boundary of actions that human agents can take (Nambisan, 2017). ICTs also create value by enabling actions and changing the nature of the work to be performed (von Briel et al., 2018).

Blockchain can change the boundary of entrepreneurial activities for small-scale entrepreneurs in developing countries. A large proportion of population in the developing world lacks necessary prerequisites such as identification documents and bank accounts to participate in the global trade. The World Bank Group's estimate indicated one billion people lack any form

of identification to prove who they are (Desai et al., 2018). According to the World Bank's Global Findex database, 1.4 billion adults were unbanked in 2022 (Demirguc-Kunt et al., 2022).

Blockchain-based solutions have been launched to address these challenges. For instance, blockchain startup Humaniq's Ethereum blockchain-based app creates user profiles based on biometric data such as facial and voice recognition algorithms. Humaniq users can complete the bio-identification process in about 20 seconds. The company's initial target audience is people in emerging economies with low level of literacy. Potential users are not required to have a passport or an email account. A person can use a smartphone to take their and record a video making facial gestures. The user is also required to pronounce a randomly selected text shown on the screen to record voice. Humaniq offers an initial deposit of Humaniq tokens (HMQ) once a consumer completes the bio-identification process. The HMQ tokens can be used as store of value and a means of payment and a medium of exchange on the platform. They can be exchanged with the third-party services such as insurance, data security, small business loans and pensions (Campbell, 2017). The Humaniq app considers the cheapest Android smartphones in mind, so that it becomes affordable to the poor people (Steemit, 2017).

As of September 2018, Humaniq operated in about 50 countries (Hurst, 2018). The company also plans to have a network of local cashiers to exchange HMQ and other cryptocurrencies into local currencies (econotimes, 2017). Humaniq's initial offerings will focus on creating an account and core banking services such as remittance payments. Humaniq will release its app code on Github. Third party developers can adapt their services to plug into Humaniq's app (Sproull, 2017). New services such as P2P lending and insurance services will be added later (Bruntinx, 2017).

As an example, Humaniq has provided a case-study of a Nigerian farmer to explain its app's benefits. The farmer lives ninety miles away from the closest bank. He does not have a vehicle. Since he does not have any ID verification, he cannot access or open a bank account. Using Humaniq app, the farmer is able to sell his produce and buy new seeds at a global level if he has a smartphone and Internet access. The costs to the farmer to do all these is a small fraction of the fee that traditional banks or money-transfer companies charge (PRNewswire, 2017).

The software technology company BanQu's "economic passport" aggregates information from a number of sources such as financial history, land records, trust networks, and business registrations. Potential borrowers can more easily receive loans by showing such information to potential lenders (Stanley, 2017). In June 2018, BanQu teamed up with Anheuser-Busch InBev to promote SC transparency and traceability in Zambia. The BanQu system is also referred to as Chembe cassava online buying project in Zambia. The partnership started with the cassava crop value chain with an aim to provide economic empowerment to small-scale farmers. Using BanQu solutions, the multinational drink and brewing holdings company Anheuser-Busch InBev's local business, Zambian Breweries can track its products throughout the SC: from the farmer to local businesses to aggregated buyers and retailers. BanQu uses GPS to locate farmers. The located farmers are identified by agents to facilitate and verify transactions. Geo-location tags and farmers' identity profiles and other pieces of information are put on blockchain (<https://www.craftbrewingbusiness.com/news/blockchain-breakthrough-poor-zambian-farmers-are-now-empowered-within-ab-inbevs-supply-chain/>). The unbanked and underbanked farmers can benefit from the immutable records of economic activities that are linked with their digital profiles. For instance, with this record, farmers can connect with NGOs, local cooperatives, microfinance institutions and banks to receive loans, grants and trainings. Thus:

P5: Blockchain-based solutions can improve small-holder farmers' chance of being integrated in the global economy.

Improving the welfare of marginalized groups

As noted, current global value chains are characterized by unfair sharing of benefits. For instance, the global coffee industry is estimated at US\$200 billion. Coffee producers are estimated to receive only 2% of the price of a cup of coffee (Moyee, 2018). Only 10% of this value is estimated to stay in producing countries (Townley et al., 2018). Moyee's FairChain coffee aims to increase it to 50% (bext, 2018). When customers have access to information regarding the way farmers are paid, social sustainability may be viewed as urgent and important.

Due to blockchain's transparency and detailed information about how value addition is distributed in the food SC, consumers are likely to feel the urgency of issues related to exploitation of farmers and farm workers. As noted by Mitchell et al. (1997), consumers are likely to be more attentive and responsive to the needs of farmers.

A technology's performance can be measured in terms of its ability to facilitate a transaction (McGuinness, 1994; von Briel et al., 2018). When the goal of a transaction is distributive fairness, it is important to look at their roles in rewarding fair and punishing unfair behaviors. Prior research has noted that under some conditions, unfair behaviors may be punished (Fehr et al., 1997). In experiments conducted to test behaviors in the ultimatum game, researchers (Camerer & Thaler 1995; Roth, 1995) have found that individuals are willing to forego some monetary benefits in order to punish unfair behaviors. A challenge, however, is that there is often no data to assess fairness of some participants' behaviors.

Blockchain deployment in food SCs is likely to make behaviors more observable and thus ensure a higher degree of fairness among different value chain participants. An actor is less likely to pursue strategies for maximizing income (Konigstein et al., 2003).

Blockchain-based solutions ensure that fair wages are paid throughout the food value chain. Denver's coffee roaster Coda Coffee uses blockchain to track coffee from African farms to U.S. coffee shops (Cadwalader, 2018). It uses solutions developed by Bext360 that consist of Stellar blockchain, cloud-based software and smart contracts to bring transparency to the SCs of coffee and other commodities such as cocoa (Kolodny, 2016). First-hand data related to product evaluation and payment to coffee growers are provided by different participants including farmers' co-ops and Uganda-based coffee exporter Great Lakes Coffee. In April 2018, Coda Coffee sold what it claimed to be the world's first blockchain-traced coffee (Food Logistics, 2018a).

Dutch startup Moyee Coffee is also using the solution. It teamed up with the blockchain firm FairChain Foundation and Bext360 to launch a blockchain-traced coffee product called Token. By June 2018, blockchain was used to track 60,000 kilograms of coffee exported from Ethiopia to the Netherlands (Globenewswire, 2018). Blockchain was used to track the coffee exported. It provides a proof that living-wage payments were made to the farmers (bext360, 2018). Moyee's plan is to launch Token in Kenya, Colombia and Rwanda in 2019 (Bryman, 2018). While a sense of urgency has accompanied blockchain companies' efforts in meeting the needs of stockholder, they have not devoted sufficient attention to issues concerning the empowerment of less powerful SC partners. In light of the concerns regarding the declining philanthropy and increasing stockholder pressures (Porter and Kramer 2002), blockchain deployment is likely to force companies to engage in more philanthropic activities. Thus:

P₆: Blockchain deployment increases the degree of distributive fairness in the FBI.

Discussion and implications

The challenges of food products with low quality and counterfeit ingredients are well recognized. Another concern is that smallholder farmers are not fairly rewarded (Kshetri, 2021). Despite the importance of the problem, the inherent difficulty of directly measuring the quality of farm

products makes farmers vulnerable to exploitation by middlemen and other SC partners. The second challenge is the lack of feedback process to help farmers improve the quality of their products. Blockchain has the potential to address these issues and to reduce exploitation of smallholder farmers. The FBI thus provides a strong fit for blockchain. The theory presented in this paper provides an approach to answering our two research questions posed earlier. They were: RQ1) What is the nature of changes that blockchain is likely to bring in interfirm governance structures in the FBI?; RQ2) What are the potential roles of blockchain in promoting the sustainability of business models and social systems in FBI?

As to RQ1, factors such as auditability, the possibility of continual verification and decentralized information flow of blockchain and smart contracts help reduce various sources of uncertainty associated with entrepreneurial actions in the FBI. Blockchain is also likely to make interfirm dependence more symmetric. Among key changes, small food growers can play a bigger role in the value chain, which can lead to a symmetric dependence. Knowing detailed information about the attributes that produce coffee with good flavor is helpful for coffee growers who can adjust the inputs. All these lead to improvements in interfirm governance structures. Blockchain needs to be combined with other advanced technologies such as AI, machine learning, machine vision and the IoT to allow for more effective use of this technology in facilitating entrepreneurial actions. This allows to improve blockchain's performance in terms of the specificity property. Blockchain's performance in terms of the relationality property can be improved by increasing the number and variety of participants. In order to overcome some limitations and disadvantages of blockchain, advanced technologies can be combined with traditional methods based on human observations. As mentioned, JD has implemented random spot checks at Kerchin's factories.

Regarding RQ2, blockchain applications such as cryptocurrencies and its micrometering capabilities help stimulate entrepreneurial opportunities for marginalized groups such as small holder farmers. Blockchain-led transparency and accountability are also likely to address the current problem of distributive fairness in terms of equity in SCs. In this way, blockchain-based solutions are likely to promote the sustainability of social systems. Prior research has noted that in their roles as a material agency, ICTs can perform actions without direct or complete control of human beings (Faulkner & Runde, 2009; Orlikowski & Scott, 2008).

In the FBI, for instance, with further developments in blockchain and other enabling technologies and processes, forced and child labor from could be eliminated. Equally important is that consumers will have information to determine if smallholder farmers that have grown the food products have been paid fair wages.

This research has a number of implications:

Implication 1: Sustainability of business models

From the above discussion it is clear that blockchain, especially in combination with other technologies, can be deployed to perform various functions objectively, fairly, and efficiently. Blockchain can also promote sustainability of business models of organizations in the FBI.

For firms in the FBI, it is important to be able to handle crisis situations in order to be profitable. Blockchain-based solutions can help deal with risk situations involving crisis and emergency (Figure 2). For instance, if contaminated food products are found retailers such as Walmart can easily identify the source and engage in strategic removals of affected products. They do not need to recall the entire product line.

To illustrate this argument, consider the 2015 E.coli outbreak at Chipotle Mexican Grill outlets, which left 55 customers ill. There had been negative news stories, restaurant shutdowns, and investigations, which led to a significant reputation loss for the company. There was a

dramatic reduction in sales revenues and its share price dropped by 42%. The roots of the problem lie partly in Chipotle's reliance on multiple suppliers. Food SCs lack transparency and accountability. Companies such as Chipotle cannot monitor their suppliers in real time. It is thus impossible to prevent the contamination or contain it in a targeted way after it is discovered (Casey and Wong, 2017). Chipotle's value proposition is centered on fresh and locally sourced ingredients. The SC systems based on non-blockchain methods are expensive and cumbersome. The process involves manual verification and massive record keeping. Blockchain can reduce the workload and ensure traceability. Huge benefits can be reaped in terms of reduced labor costs and food wastes (O'Marah, 2017).

Figure 2 about here

There have been some encouraging developments to address the above challenges. In Walmart's trial of a blockchain-based solution to monitor pork products in China mentioned above, blockchain enabled to digitally track individual pork products in a few minutes compared to many days taken in the past. Details about the farm, factory, batch number, storage temperature and shipping can be viewed on blockchain. These details help assess the authenticity of products, and the expiry date. In the case of food contamination, it is possible to pinpoint the products to recall (Yiannas, 2017).

While the test was limited to these two items, it involved multiple stores. If an item is found to be spoiled or the source of a product is shown to be compromised, the system acts proactively. The goal thus is to improve food safety. The information tracked includes the farm where the vegetable or pig originated and their operating practices. RFID tags, sensors and barcodes provide the relevant data (Kharif, 2016).

Blockchain has important cost-saving implications for retailers. In a crisis involving contaminated food products, for instance, retailers such as Walmart can easily identify the source

and engage in strategic removals of affected products. They do not need to recall the entire product line. Blockchain also enables more effective response if tainted products are discovered. In this way, the company can keep buyers' confidence in other products and avoid the danger of consumers getting ill (De Jesus, 2016).

Walmart has outlined plans to incorporate blockchain in authenticating a customer and a courier, measuring the temperatures of containers and products and comparing them with acceptable thresholds and other purposes. Overall blockchain-based solutions increase the effectiveness in dealing with risk situations such as crisis and emergency response in the FBI.

Implication 2: The rank effect:

Like other technologies, blockchain deployment tends to diffuse from larger to smaller organizations. This is commonly known as the rank effect (Gotz 1999). Current blockchain projects involve mainly larger companies and/or high value food products. For instance, JD's SC partner Kerchin that has adopted blockchain had \$300 million in revenue in 2017 (Huang, 2017). Likewise, the French retailer Carrefour's traceability project focused on its premium farm products (Barley, 2018).

Due to cost and complexity, blockchain systems are expensive to implement and manage. For this reason, blockchain is out of reach for many organizations. For instance, most of China's food supply comes from a large number of small farms. This is a main reason why food safety has been difficult to achieve in the country (Mcmillan, 2018). Most of these small farms do not possess the capability to adopt a blockchain-based system and provide relevant information.

Even among big organizations such as Nestle and Gerber challenges in incorporating blockchain are well recognized. These companies found that moving data from the enterprise software such as SAP onto a digital ledger is not an easy task. These companies also needed to

deal with paper and electronic data in diverse formats produced by farmers, processors and other SC partners (Food Logistics, 2018b).

Unsurprisingly, some firms have limited blockchain deployment to high-value food products only. In March 2018, Chinese e-commerce company JD.com announced a plan to implement blockchain to allow customers to track meat products. Initial focus was on high-end beef from Australia (Wood, 2018).

Implication 3: The promotion of transparency and accountability

Consumers are increasingly becoming concerned about the source of food and beverages (Scott, 2017). Consumers value information transparency and ethical behavior. Blockchain can give them a high level of confidence about the origination of food products they eat and the way they were produced. For instance, by flashing a QR code before buying products in a store, shoppers can see a product's history in order to make informed purchase decisions.

Blockchain can thus provide a complete transparency and accountability regime in the food SCs. Relationships created by blockchain are likely to be more impactful, and more meaningful. Because of the lack of check and balance of power and the lack of transparency in much of the activities in SCs, it is difficult for powerful SC partners to set examples, particularly when they are benefiting from the status quo. Blockchain's transparency may force retailers and middlemen to improve their practices to the potential benefit of small farmers. For instance, in SCA's blockchain system, data generated by sensors related to the activities of farmers, roasters, product developers, manufacturers and retailers are put into blockchain. The SCA aims to fight exploitation of farmers by powerful SC partners such as retailers with the help of immutable records of transactions in the food industry. These examples are excellent demonstrations that blockchain could address various sustainability-related challenges in inter-organizational

relationships. Moreover, regulators have been involved in the some blockchain systems such as those of Walmart and Coca-Cola.

An equitable solution to distribute natural capital can help take actions that are socially responsible. For instance, it has been frustratingly difficult for consumers to find whether farmers and farm workers are paid fairly by food retailers and other powerful SC partners. Blockchain-led promotion of transparency and accountability are among the various mechanisms by which this goal can be achieved. This technology is likely to force powerful SC partners to engage in fair sharing of benefits.

Blockchain facilitates entrepreneurial activities by mechanisms that are unique to this technology. For instance, blockchain and smart contracts are transforming interfirm governance structure. Key features of the changes include more symmetric dependence. The changes are the results of increased transparency and accountability of blockchain and smart contracts.

Blockchain-based solutions can help prospective entrepreneur to engage in entrepreneurial activity. In addition to blockchain's roles in stimulating entrepreneurial activities, this technology also improves distributive fairness in terms of equity.

Blockchain and smart contracts have different impacts across firms of different natures and types. Especially most small farms from developing countries lack the capability to adopt a full-fledged blockchain-based system. We noted above the roles of blockchain-based ID and cryptocurrencies in facilitating marginalized groups' access to global markets. While all these developments are encouraging, blockchain technology is only a small part of the solution for these firms. These solutions do not involve a true distributed ledger.

Figure 1: Blockchain deployment in the food and beverage industry

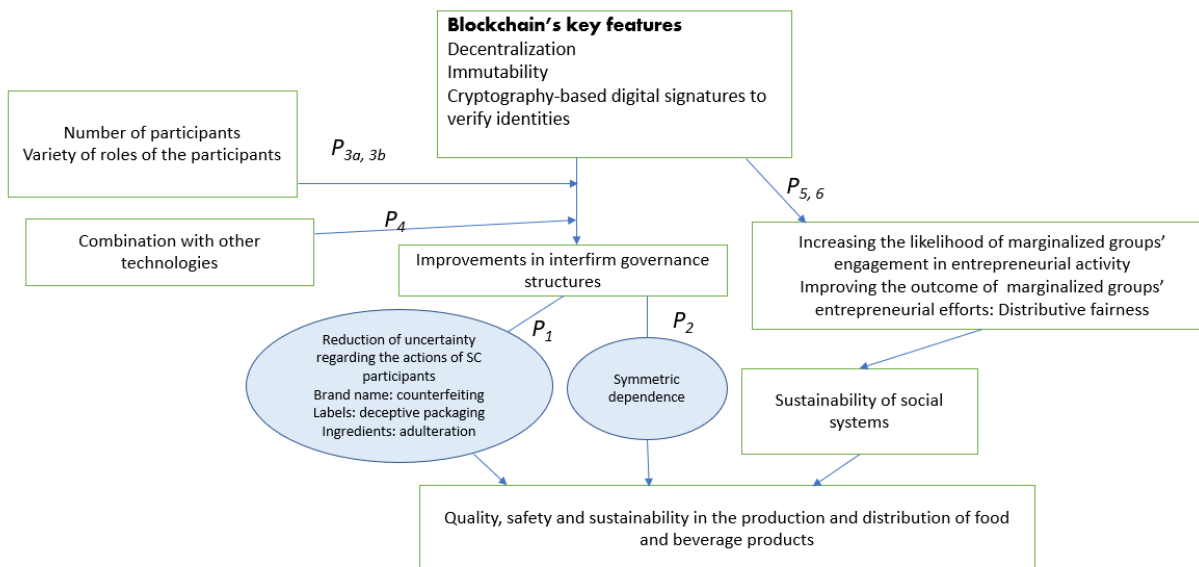


Figure 2: Dealing with risk situations: Crisis and emergency response

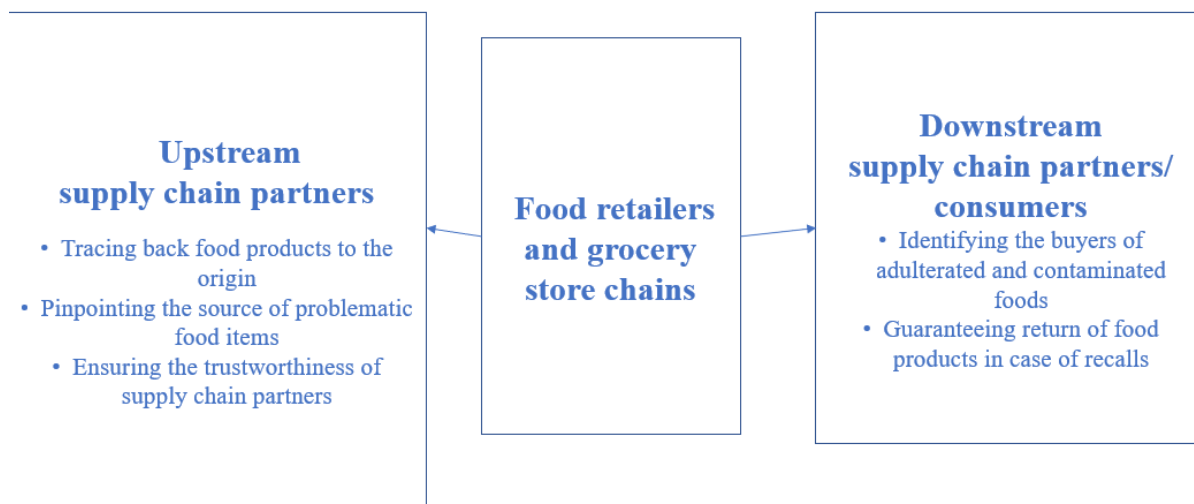


Table 1: Blockchain’s key features

Feature	Explanation	Some uses
Decentralization	Decentralized network of online registries synchronized to track transactions.	Malicious actions can be detected and prevented. Participants verify information themselves.
Immutability	Complete documentation of creation, modification and deletion of records.	Transactions are auditable

		Improves transparency (e.g., access to data about food). No susceptible to theft, damage, corruption, or fraud.
Cryptography-based digital signatures to verify identities	Users sign transactions with a “private key”: Known only to the person who controls the account.	Enables a required level of authentication, which increases confidence

Table 2: The cases selected and their classification

Quality and safety → Sustainability ↓	Major focus	Minor focus/No focus
	Major focus	(1) Bext360 [1]
Minor focus/No focus	(2) Walmart [4] Ripe.io [3] Alibaba [2] Jd.com [8] Maersk [10]	(3)

Table 3: Applying Gottschalk’s criteria for the archival data used in this research

Criterion	Explanation	Example
Time elapsed between events and reporting	Most newspaper articles were published the same day or the next day of the key event	In April 2018, the world’s first blockchain-traced coffee was released by Bext360. The news was released on April 16, 2018 (bext360, 2018).
Openness to corrections	Corrections are incorporated in many of the outlets used in this article.	If an article in fastcompany.com, from which an article has been cited (Schiller2018), is corrected the correction is stated after “ <i>Correction:</i> “(e.g., https://www.fastcompany.com/90308095/why-you-should-stop-trying-to-achieve-work-life-balance).
Range of knowledge and expertise of the person reporting the events	We used articles written by knowledgeable reporters and journalists.	An article we cited was written by Frank Yiannas (Yiannas, 2017), the current Deputy Commissioner for Food Policy and Response at the Food and Drug Administration and the ex-vice president of food safety for Walmart.
Corroboration from multiple sources	Data and information were triangulated from multiple sources. We also visited the original source as suggested by Joselyn (1977).	Data and information about Bext360’s solutions were compiled from secondary sources (O’Marah, 2017; Cadwalader, 2018) as well as news released by the company (bext360, 2018)

Table 4: Patternmatching theory and data

Proposition	Examples [Case No.]
Blockchain → Reduction of uncertainty regarding the actions of SC participants (P ₁)	Breau Veritas [9] Walmart [4] Swiss Coffee Alliance [7]
Blockchain → Symmetric dependence (P ₂)	Bext360 [1]

	Ripe.io [3]
Number of participants → Improvements in interfirm governance structures (P _{3a})	Jd.com [8] Swiss Coffee Alliance [7]
Variety of roles of the participants → Improvements in interfirm governance structures (P _{3b})	Walmart [4] Swiss Coffee Alliance [7] Maersk [10]
Combination with other technologies → Improvements in interfirm governance structures (P ₄)	Alibaba [2] Bext360 [1]
Blockchain → Increasing the likelihood of disadvantaged groups' engagement in entrepreneurial activity (P ₅)	Humaniq [6] Banqu [5]
Blockchain → Improving the outcome of disadvantaged groups' entrepreneurial efforts (P ₆)	Bext360 [1] Swiss Coffee Alliance [7]

Table 5: Key properties of ICTs and interfirm governance: The case of blockchain systems in the food and beverage industry

	Specificity (Value and effectiveness in facilitating transactions)	Relationality (facilitation of deep and meaningful relationship)
Uncertainty	Continual verification is possible Sources of contamination can be pinpointed and remedial actions can be taken without delay Smart contract: certainty that the counterparty will fulfill the promises	Decentralized information flow and chains of immutable records: any alteration of information is likely to be noticed immediately by others in the network
Dependence	Farmers are provided with the information to improve certainty about the quality of products (Ripe.io provides information to farmers to improve the quality of produce). Objective measurement: fairer decisions regarding quality	Powerful supply chain members are likely to face pressures from stakeholders such as regulators and consumers who can also be participants: more symmetric dependence

References (Selection)

- Acosta, Pilar, Aurélien Acquier, Jean-Pascal Gond. 2019. Revisiting Politics in Political CSR: How coercive and deliberative dynamics operate through institutional work in a Colombian company, *Organization Studies*, <https://doi.org/10.1177/0170840619867725>
- Akerlof, Geogre. A. 1970 'The Market for 'Lemons': Qualitative uncertainty and the market mechanism.' *Quarterly Journal of Economics*, 84, 488–500.
- Akkerman, Renzo, Poorya Farahani, and Martin Grunow 2010 'Quality, safety and sustainability in food distribution: a review of quantitative operations management approaches and challenges.' *OR Spectrum*, 32, 863–904.
- Allain, Jean, Andrew Crane, Genevieve LeBaron, and Laya Behbahani 2013 'Forced Labour's business models and supply chains.' *York: Joseph Rowntree Foundation*
- Ansari, Shaz, Raghu Garud, and Arun Kumaraswam 2015 'The disruptor's dilemma: TiVo and the U.S. television ecosystem.' *Strategic Management Journal*, 37(9), 1829–1853.
- Asheim, Bjorn 2008 'Differentiated Knowledge Bases and Varieties of Regional Innovation Systems.' *Taylor & Francis Online*; <https://www.tandfonline.com/doi/abs/10.1080/13511610701722846>
- Bajpai, Prableen 2018 'Alibaba (BABA) Thinks Blockchain Will Change The World.' *Nasdaq*; <https://www.nasdaq.com/article/alibaba-baba-thinks-blockchain-will-change-the-world->
- Bansal, Pratima, and Kevin Corley 2012 'Part 7: What's Different about Qualitative Research?' *Academy of Management Journal*, 55(3), 509–513.

- Barley, Mark 2018 'Oxfam uses blockchain to empower Cambodian rice farmers,' *Ledger Insights*; <https://www.ledgerinsights.com/oxfam-blockchain-cambodian-rice-farmers/>
- Bogetoft, Peter and Henrik Olesen 2002 'Ten rules of thumb in contract design: lessons from Danish agriculture.' *European Review of Agricultural Economics*, vol. 29, no.2, 185-204
- Brown, Shona and Kathleen Eisenhardt 1998 'Competing on the Edge: Strategy as Structured Chaos.' *Boston: Harvard Business School Press*.
- Bryman, Howard 2018 'Fully Blockchain Coffee Brand Token Invites Consumers Into the Matrix.' *Daily Coffee News*; <https://dailycoffeenews.com/2018/07/11/fully-blockchained-coffee-brand-token-invites-consumers-into-the-matrix/>
- Buckley, Peter and Mark Casson 1988 'A Theory of Cooperation in International Business, in Cooperative Strategies in International Business,' *F. J. Contractor and P. Lorange*, eds. Lexington, MA: *Lexington Books*, 31-53
- Camerer, Colin and Richard Thaler 1995 'Ultimatum Games.' *Journal of Economic Perspectives*, 9, 209-220.
- Carson, Stephen, Anoop Madhok, and Tao Wu 2006 "Uncertainty, opportunism, and governance: The effects of volatility and ambiguity on formal and relational contracting," *Academy of Management Journal* 49 (5): 1058– 77.
- Casey, Michael and Pindar Wong 2017 'Global Supply Chains Are About to Get Better, Thanks to Blockchain.' *Harvard Business Review*; <https://hbr.org/2017/03/global-supply-chains-are-about-to-get-better-thanks-to-blockchain>.
- Christopher, Martin (2000) *The Agile Supply Chain: Competing in Volatile Markets*, Industrial Marketing Management, Volume 29, Issue 1, January 2000, Pages 37-44.
- Cyert, Richard and James March 1963 'A Behavioral Theory of the Firm. Englewood Cliffs.' NJ: *Prentice-Hall, Inc.*
- Davidsson, Per 2015 'Entrepreneurial opportunities and the entrepreneurship nexus: A reconceptualization.' *Journal of Business Venturing* 30(5): 674–695
- DeSanctis, Gerardine and Marshall Poole 1994 'Capturing the complexity in advanced technology use: Adaptive structuration theory.' *Organization Science* 5(2): 121–147
- Eisenhardt, K. M. 1989. Building theories from case study research. *Academy of Management Review* 14. 532–550.
- Eisenhardt, Kathleen and Melissa Graebner 2007 'Theory building from cases: opportunities and challenges.' *Academy of Management Journal*, 50(1), 25-32
- Ferraro, Fabrizio, Dror Etzion, and Joel Gehman 2015 'Tackling grand challenges pragmatically: Robust action revisited.' *Organization Studies*, 36(3), 363-390.
- Goth, Werner and Reinhard Tietz 1990 'Ultimatum Bargaining Behavior-A Survey and Comparison of Experimental Results.' *Journal of Economic Psychology*, 11, 417-449.
- Helde, Jan 1994 'Interorganizational Governance in Marketing Channels.' *Journal of Marketing*, Vol. 58, No. 1, pp. 71-85
- Hill, Charles W.L. 1990 'Cooperation, opportunism and the invisible hand: implications for transaction cost theory.' *Academy of Management Review*, 15 (3), 500-513 .
- Kshetri, Nir 2021, "Blockchain and sustainable supply chain management in developing countries", Volume 60, October, 102376, *International Journal of Information Management*, <https://www.sciencedirect.com/science/article/abs/pii/S0268401221000694>
- Leonardi, Paul M. 2011 'When flexible routines meet flexible technologies: Affordance, constraint, and the imbrication of human and material agencies.' *MIS Quarterly* 35, 147–168.

- Mainelli, Michael 2017 'Blockchain Will Help Us Prove Our Identities in a Digital World.' *Harvard Business Review*; <https://hbr.org/2017/03/blockchain-will-help-us-prove-our-identities-in-a-digital-world>
- Maloni, Michael J., & Michael E. Brown 2006 'Corporate Social Responsibility in the Supply Chain: An Application in the Food Industry.' *Journal of Business Ethics*, 68, 35-52
- Massa, Annie 2017 'Someone Figured Out How to Put Tomatoes on a Blockchain.' *Bloomberg*; <https://www.bloomberg.com/news/articles/2017-11-09/the-internet-of-tomatoes-is-coming-starting-with-boston-salads>
- McGuinness, T. 1994 Markets and Managerial Hierarchies." In G. Thompson, et al. (Eds.), *Markets, Hierarchies and Networks*, Sage, London, England, pp. 66–81.
- McMullen, Jeffrey S. & Dean A. Shepherd, 2006 'Entrepreneurial action and the role of uncertainty in the theory of the entrepreneur.' *Academy of Management Review*, 31, 132–152.
- Mitchell, Ronald K., Bradley R. Agle and Donna J. Wood 1997 'Toward a Theory of Stakeholder Identification and Salience: Defining the Principle of Who and What Really Counts.' *The Academy of Management Review* 22(4), 853–886.
- Nambisan, Satish 2017 'Digital Entrepreneurship: Toward a Digital Technology Perspective of Entrepreneurship.' *Entrepreneurship Theory and Practice*, 41(6), 1029-1055.
- Oliver, Christine 1990 'Determinants of Interorganizational Relationships: Integration and Future Directions.' *Academy of Management Review*, 15 (April), 241
- Ouchi, William G. 1980 "Markets, Bureaucracies, and Clans," *Administrative Science Quarterly*, 25: 120-42.
- Pfeffer, Jeffrey & Gerald R. Salancik 1978 'The External Control of Organizations: A Resource Dependence Perspective.' *New York: Harper & Ro*
- Phillips, Erica 2018 'Coffee Brewers Turn to Blockchain.' *Food Logistics*; <https://www.foodlogistics.com/technology/news/21000940/coffee-brewers-turn-to-blockchain>
- Pirson, Michael A. and Deepak Malhotra, 2011 'Foundations of organizational trust: What matters to different stakeholders?' *Organization Science*, 22(4), **1087–1104**.
- Porter, M. E. and Mark R. Kramer 2002 'The Competitive Advantage of Corporate Philanthropy,' *Harvard Business Review* 80(12), 56–68.
- Porter, Michael E. and Mark B. Fuller 1986 "Coalitions and Global Strategy" in *Competition in Global Industries* *Harvard Business School Press*.
- Purdy, Chase 2017 'Supermarkets are now using blockchain to keep food fresh.' *Quartz*; <https://qz.com/1060607/supermarkets-are-now-using-blockchain-to-keep-food-fresh/>
- Quintin, Erwan 2008 'Contract enforcement and the size of the informal economy.' *Economic Theory*, 37(3), 395–416.
- Reyna, Ana, Christian Martín, Jaime Chen, Enrique Soler, and Manuel Díaz, M. 2018 'On blockchain and its integration with IoT. Challenges and opportunities.' *Future Generation Computer Systems*, 88, 173-190
- Ross, Stephen A., 1973 'The Economic Theory of Agency: The Principal's Problem.' *American Economic Review*, vol. 63(2) .134-139.
- Roth, Alvin E. 1995 'Bargaining Experiments, in *Handbook of Experimental Economics*.' *Princeton University Press*.
- Russell, J. 2014 'The Humble QR Code Is Being Disrupted... And Going Dotless.' *TechCrunch*; <https://techcrunch.com/2015/05/18/dotless-qr-codes/>

- Seawright, Jason, and John Gerring 2008 'Case-selection Techniques in Case Study Research a menu of Qualitative and Quantitative Options.' *Political Research Quarterly*, 61:2, 294-308.
- Simangunsong, E., L.C. Hendry & M. Stevenson (2012) Supply-chain uncertainty: a review and theoretical foundation for future research, *International Journal of Production Research*, 50:16, 4493-4523, DOI: 10.1080/00207543.2011.613864
- Simon, Herbert 1991 'Bounded Rationality and Organizational Learning.' *Organization Science*. 2 (1): 125–134
- Spigel, Ben 2017 'The Relational Organization of Entrepreneurial Ecosystems.' *Entrepreneurship Theory and Practice*, 41(1), 49–72
- Ulrich, David and Jay B. Barney 1984 'Perspectives in Organizations: Resource Dependence, Efficiency and Population.' *Academy of Management Review*, 9 (3), 471-81
- van der Vorst, JGAJ and Beulens, AJM. 2002. Identifying sources of uncertainty to generate supply chain redesign strategies. *International Journal of Physical Distribution and Logistics Management*, 32(6): 409–430
- von Briel, Frederik., Per Davidsson, and Jan C. Recker 2018 'Digital Technologies as External Enablers of New Venture Creation in the IT Hardware Sector.' *Entrepreneurship Theory and Practice*, 42(1), 47-69
- Webb P., Coates J., Frongillo E., Rogers B., Swindale A., and Bilinsky P. 2006 'Measuring Household Food Insecurity: Why It's So Important and Yet So Difficult to Do.' *National Center for Biotechnology*; <https://academic.oup.com/jn/article/136/5/1404S/4670058>
- Whetten, David A. 1989 'What constitutes a theoretical contribution?' *Academy of Management Review*, 14(4), 490–495.
- Williams, Owen 2015 'Alibaba is using attractive QR codes so you can check if products are authentic.' *The Next Web*; <https://thenextweb.com/apps/2015/05/18/alibaba-is-using-attractive-qr-codes-so-you-can-check-if-products-are-authentic/>
- Williamson, Oliver E. 1981 'The economics of organization: the transaction cost approach.' *American Journal of Sociology*. 87 (3): 548–577
- Williamson, Oliver E. 1975 'Markets and Hierarchies: Analysis and Antitrust Implications.' *Free Press*, New York, NY,
- Williamson, Oliver E. 1983 'Credible Commitments: Using Hostages to Support Exchange.' *American Economic Review*, 73, 519-40.
- Williamson, Oliver E. 1985 'The Economic Institutions of Capitalism.' New York: *The Free Press*.
- Williamson, Oliver E. 2002 'The theory of the Firm as Governance Structure: From Choice to Contract.' *Journal of Economic Perspectives* 16 (3): 171–95.
- Yaga, Dylan J., Peter M. Mell, Nik Roby, and Karen Scarfone. 2018 'Blockchain Technology Overview.' National Institute of Standards and Technology Internal Report (NISTIR) 8202
- Yermack, David 2017 'Corporate governance and blockchains.' *Review of Finance*, 21(1), 7–31, <https://doi.org/10.1093/rof/rfw074>
- Yin, Robert K. 1994. *Case Study Research: Design And Methods* (2nd ed.). Newbury Park, CA: Sage.