# The impact of blockchain technology on consumer behavior: A multimethod study

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**The impact of blockchain technology on consumer behaviour: A multi-method study**


## Abstract

Blockchain is a ground-breaking technology that is transforming supply chain management. This study aims to empirically investigate the impacts of blockchain technology on consumer behaviour. We conduct this research in collaboration with a Chinese e-commerce company who has introduced a blockchain platform for tracing. We use a multi-method design by combining natural experiment and case study methods. First, we collected data from four industries (i.e., milk powder, seafood, alcohol and nutrient) to conduct the experiment and the findings reveal that firms that adopted the blockchain tracing system have an increase in product sales and a decrease in product returns compared to those who did not. Second, we conducted a multiple case study with four cases from the four industries. The findings reveal that the adoption of the blockchain tracing system improves supply chain transparency and process management which then enhance consumer service and trust. This study contributes to the literature by providing empirical evidence that adopting blockchain technology can improve firms' marketing performance. The findings also reveal that how the adoption of blockchain technology affects consumer behaviour.



**Keywords:** blockchain, tracing, consumer behaviour, multi-method


## 1. Introduction

Blockchain is a distributed ledger using a peer-to-peer network to keep records of transactions (Yli-Huumo et al., 2016). It has been viewed as the most important invention since the internet (Iansiti and Lakhani, 2017). As a record-keeping technology, it enables any network of users to track and trace virtually anything of value (Ferguson, 2018). Blockchain technology can create mutually assured trust and validation to ensure security and accuracy of data because a user does not need to trust the other party in the transaction or a central intermediary (Iansiti and Lakhani, 2017, Gandhi et al., 2018). Blockchain has received heightened attention from the business community due to its profound effects on how an organization manages supply chains and creates value (Min, 2019, Tan et al., 2018, Swan,

2015, Gandhi et al., 2018). An IBM study reports that one-third of organizations are considering or actively engaged with blockchain technology (Treiblmaier, 2018). In another survey conducted by Deloitte, 53% of respondents agree that blockchain technology has become a critical priority for their organizations and 82% respondents believe that their customers, suppliers and competitors are working on blockchain technology to solve current challenges in the supply chain (Deloitte Insights, 2019).

Blockchain technology has been applied in the supply chains of several industries (Pournader et al., 2019, Wang et al., 2019a). The adoption of blockchain presents a shift away from how firms have stored and shared data (Partida, 2018) and the technology can transform how businesses and supply chains are organized and managed (Tapscott and Tapscott, 2017). For example, blockchain technology allows pharmaceutical companies to share information within and track every stage of their supply chains, enabling them to eliminate counterfeiting and to ensure the security in clinical trials (Hussain, 2018). Blockchain technology also transforms agriculture supply chains by enabling direct links between farmers, retailers, consumers and producers which improve food quality, foster food transparency and reduce food fraud and food-borne diseases (Shah and Thadamalla, 2018). Some world-leading retailers have adopted blockchain technology in their food supply chains. For example, Walmart and Carrefour have joined IBM's Food Trust blockchain network (Javalgi, 2018, Sharma, 2019). The companies find that blockchain technology enables them to achieve real-time and end-to-end visibility with low costs, which significantly improve supply chain traceability, efficiency and responsiveness, supplier relationship and quality management. As a result, Carrefour believes that blockchain allows it to create a global food traceability standard (Javalgi, 2018) and Walmart finds blockchain enables it to provide consumers with safe, quality foods (Sharma, 2019).

Researchers argue that blockchain technology helps firms coordinate business transactions in supply chains through a shared ledger and blockchain-based platform can reduce the time, cost, and risk associated with information processing while improving supply chain security and visibility (Queiroz et al., 2019, Pournader et al., 2019, van Hoek, 2019a). However, its application in supply chain management is still in a piecemeal fashion (Michelman, 2017, Felin and Lakhani, 2018) and experimental (Kshetri, 2018). Although anecdotal evidence exists that the application of blockchain technology can improve the food safety, reduce food waste and enhance customer wellbeing and

confidence (Sharma, 2019, Javalgi, 2018), blockchain is still a largely unproven innovation for retailers (Min, 2019). Additionally, Deloitte's survey reveals that 28% of the respondents believe uncertain ROI is the main barrier for investment in blockchain technology (Deloitte Insights, 2019). There is a lack of academic investigation on how blockchain technology creates value for consumers and influence consumers' behaviour (Chang et al., 2019, Queiroz et al., 2019). The objective of this study is to empirical investigate the impact of blockchain technology affects consumer behaviour. This study aims to answer two research questions: First, does the application of blockchain technology affect consumer behaviour? Second, how does blockchain technology affect consumer behaviour?

The next section reviews the literature on the application of blockchain in the supply chain. Section 3 discusses the research methods and presents the findings. We adopt a multi-method approach by combining nature experiment and case study. We highlight the theoretical and practical implications and point out the limitations and future research directions in section 4.

## 2. Literature review

As a ground-breaking innovative technology, researchers have investigated how to successfully adopt blockchain in supply chain management and how the adoption influences supply chain performance (Pournader et al., 2019, Wang et al., 2019a, Swan, 2015, Hastig and Sodhi, 2020). The first stream of studies focuses on the impacts of blockchain on supply chain management from a technological perspective. Blockchain is a stack of technologies that uses the internet as an infrastructure and various applications such as digital identity and smart contracts can be operated on the application layer (Yli-Huumo et al., 2016, Androulaki et al., 2018). The core of a blockchain-based platform is a distributed ledger that records all the transactions that take place in the supply chain (Wang et al., 2019a). Blockchain can be used to cryptographically capture and store an immutable record of the interactions among supply chain members (Felin and Lakhani, 2018, Dutra et al., 2018) and every transaction that has ever occurred in supply chains, and define rules and processes that govern the supply chain operations and the roles of supply chain members (Queiroz et al., 2019). The consistency and visibility of the information flow in supply chains can be improved as authorized users in the supply chain have an identical copy of the record and changes are easier to track (Gandhi et al., 2018). The use of digital

keys and digital signatures can provide supply chain members different levels of authorization to protect supply chain members' private and sensitive knowledge. Smart contracts can be created to quickly and automatically conduct supply chain transactions and update the ledger. As a result, the ledger reflects any changes in near real-time (Androulaki et al., 2018). Every users' copy within the network also reflects these changes in the same time frame and records of transactions can be maintained and updated securely by the supply chain members themselves. Thus, blockchain enables firms to maintain accurate and secure data among partners (Partida, 2018) and avoid the need for daily checking and rechecking of supply chain transactions and processes. Also, the ledger is permanent and tamper-resistant as it does not require a centralized point of control and the details of all recorded transactions cannot be altered reactively without the full agreement of the supply chain (Androulaki et al., 2018). Therefore, blockchain enforces transparency and guarantees eventual, system-wide consensus on the validity of an entire history of transactions (Queiroz et al., 2019). The technology allows firms to trace upstream and downstream of the supply chain network, and track the origins and the source of raw materials as well as goods along with multi-level distribution networks through end consumers (Deloitte, 2017, Swan, 2015).

The second stream of studies investigates the factors that influence the adoption of blockchain technology in supply chains. First, empirical evidence exists that the adoption of blockchain is influenced by external and supply chain environment. For example, van Hoek (2019b) and Zhao et al. (2019) highlight that regulatory environment significantly affects the implementation of blockchain. The structure of the supply chain (van Hoek, 2019b, Saberi et al., 2018) and trust among supply chain members (Wang et al., 2019a, Kumar et al., 2020) have been identified as influential factors driving blockchain implementation in supply chains. For example, Cole et al. (2019) argue that blockchain is more powerful at managing complex supply chain networks with multiple echelons, complex product flows and many different suppliers. Collaboration (Hastig and Sodhi, 2020) and the inter-organizational processes (Saberi et al., 2018) between supply chain members have also been identified as critical in blockchain adoption. Second, studies show that a firm's capability and practices affect the implementation of blockchain. For example, Du et al. (2019) argue the implementation of blockchain is more likely to be successful when a firm focuses on incremental changes and avoids

large amounts of data and transactions. Researchers also argue that the successful adoption of blockchain depends on a firm's systems and technological capabilities, such as storage capacity and scalability, and throughput and latency issue (Saberi et al., 2018, Wang et al., 2019a, Hastig and Sodhi, 2020, Zhao et al., 2019), complementary assets such as the digital network (Ehrenberg and King, 2019) and platform development (Yang, 2019), and the intra-organizational and operational processes (Wang et al., 2019a, Saberi et al., 2018). The lack of understandings about blockchain, including its technical limitations, costs and ROI of implementing the technology and how to integrate blockchain into existing processes, hinders the adoption of blockchain (van Hoek, 2019b, Zhao et al., 2019). Third, product features, such as the need for traceability (Kumar et al., 2020) and the importance of product safety, quality failure and counterfeiting to consumer wellbeing (Cole et al., 2019) also affect the decisions on blockchain adoption.

The third stream of studies focuses on how the adoption of blockchain affects performance outcomes of a supply chain. Researchers argue that the implementation of blockchain benefits supply chains by improving transparency and traceability. Blockchain can provide indisputable, verifiable and immutable evidence in each touchpoint of the supply chain network for customers, governments and enterprises, prove the origin and authenticity of products, and hence firms can manage and respond to risk in a responsive and documented way (Chang et al., 2019, Deloitte, 2017). Blockchain can also improve the visibility of supply chain processes and advance the information and product security and safety, which enhance product quality management and facilitate anti-counterfeiting in supply chains (van Hoek, 2019b, Kumar et al., 2020, Zhao et al., 2019) and hence it increases consumers' confidence (Cole et al., 2019). As a result, the implementation of blockchain allows supply chain members to secure information sharing and build trust (Wang et al., 2019b), improving customer order management (Martinez et al., 2019), supply chain coordination, operational efficiency and sustainability performance (Hastig and Sodhi, 2020, Saberi et al., 2018, Zhao et al., 2019).

## 3. Research methods

This study adopts a multi-method approach (Boyer and Swink, 2008, Choi et al., 2016). There are four reasons for combining natural experiment and case study methods (Saunders et al., 2016). The first

reason is initiation. The initial use of natural experiment is used to define the nature and scope of the sequential case study and it helps in the formulation of interview questions and the selection of cases and participants. The second reason is interpretation. The results of the case study allow the meanings and findings of the natural experiment to be elaborated and explained. The third reason is focus. The natural experiment is used to answer the question of does the application of blockchain affects consumer behaviour, while the case study is used to answer the question of how the application of blockchain affects consumer behaviour. The fourth reason is triangulation. Using two methods allows researchers to combine two sources of data to corroborate and validate research findings which lead to greater confidence in the conclusions (Choi et al., 2016).

We conduct the research in collaboration with JD.COM (JD). JD is a leading innovation-driven and the second-largest e-commerce company in China. JD is transforming to a retail infrastructure service provider in China and has expanded into the segments of warehousing, distribution, after-sale services and marketing to provide high quality and personalized products to consumers. As an essential building block of JD's intelligent supply chain management, JD started its blockchain project in 2016 and launched the Blockchain platform designed with one-click deployment for tracing in 2017. The platform helps companies build their blockchain applications and host them on consortium blockchain. In collaboration with IBM and Walmart, JD introduced the Blockchain Food Safety Alliance in December 2017. The alliance aims to use blockchain technology to guarantee food safety, remove counterfeiting, improve product quality and build consumer trust and confidence. Therefore, this study focuses on food products. After discussing with JD's procurement managers and the blockchain platform team, we decide to focus on four product categories: milk powder, alcohol, seafood, and nutrient. In the Chinese market, these products seriously suffer from fake and counterfeit products and the issues related to product safety and quality can damage the reputation of the brand and the health of consumers. The supply chains of these products carry a sense of urgency for reliable traceability and product provenance. Consumers, governments and companies are increasingly demanding greater transparency of the origin and the footprints of how these products have travelled throughout the supply chains. The adoption of blockchain allows companies to capture information at different stages of the supply chain, to ensure the data immutability once it is stored, and to provide certain supply

chain participants with the truthful information at any time. As a result, JD's blockchain platform enables consumers to read relevant information including origin, production process, lot number, packaging date, shipment identifier, auditing, warehousing date and order delivery logs which are linked to the individual item by scanning a QR code.

*3.1 Experiment*

*3.1.1 Experiment design*

We conducted a natural experiment on the stock-keeping units (SKUs) to study the differential effect of a treatment (i.e., blockchain implementation) on a treatment group (i.e., treated SKU) versus a control group (i.e., control SKU) (Gallino and Moreno, 2014). The experiment employs the difference in differences method which calculates the effect of blockchain implementation on outcome variables (i.e., sales volume and return rate) by comparing the average change over time in the outcome variables for the treated SKUs, compared to the average change over time for the control SKUs. This approach permits each treated SKU to have its counterfactual performance by matching control SKUs based on similar characteristics (Heckman et al., 1998). Data of 415 SKUs (78 treated SKUs and 337 control SKUs) in the product categories of milk powder, alcohol, seafood, and nutrient are collected in a time range of 52 weeks (26 weeks before implementing blockchain and 26 weeks after implementing blockchain) from JD (Table 1). We collected data on sales volume, order quantity, return quantity and average transaction price for each SKU.

The fact that companies adopted blockchain at a different time naturally generates a convenient empirical setting of this experiment. The variation in the implementation of blockchain allows us to eliminate the effects of cyclical volatilities and other shocks endogenous in the market. Thus, there is no need to capture the endogenous factors to estimate the effects of blockchain implementation. We examined outcome variables beginning 26 weeks before and ending 26 weeks after the week during which a company adopts blockchain. By focusing on a long pre-implementation period, we were able to tease out the potential intervention of promotion activities which are often used as the warm-up before new features come up.

Table 1. Sample description

| | | **Milk powder** | **Alcohol** | **Seafood** | **Nutrient** | **Total** |
|---|---|---|---|---|---|---|
| | Aug-2017 | 2 | | | | 2 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Date when companies adopted blockchain** | Nov-2017 | 2 | 5 | 1 | | 8 |
| | Apr-2018 | 12 | 10 | 5 | 7 | 34 |
| | Jun-2018 | | | 6 | 4 | 10 |
| | Jul-2018 | | | | 4 | 4 |
| | Aug-2018 | 7 | | | | 7 |
| | Sep-2018 | | | | 2 | 2 |
| | Oct-2018 | 7 | 1 | 3 | | 11 |
| **Total treated SKUs** | | 30 | 16 | 15 | 17 | 78 |
| **Total control SKUs** | | 106 | 35 | 110 | 86 | 337 |

A treated SKU and its matched control SKU should have similarly targeted consumers. To construct appropriate control SKUs, we focused on the observable attributes and the unit price of products which are widely believed as the main determinants of market position. First, we mapped the observable attributes of each treated SKU with the SKUs in the same product-subcategory that did not adopt blockchain at the time of the research. According to the advice from JD's procurement managers, we chose three attributes (i.e., brand, product origin, and supplement and taste) and one subcategory (i.e., age grades (level 1 to 5)) for milk powder, one attribute (i.e., product origin) and three subcategories (i.e., red wine, liquor and Chinese liquor) for alcohol, two attributes (i.e., organic food and preservation method) and three subcategories (i.e., fish, shrimp, and sea cucumber) for seafood, and two attributes (i.e., product origin, and suitable population) and twelve subcategories (i.e., immunity, movement, baby, liver, three-hypers, beauty, lose-weight, skeleton, sleep, anaemia, stomach and kidney) for nutrient. For each SKU, we generated a series of keywords for the particular attributes and constructed a one-hot vector to indicate whether the words appear in the name and description of the product. We then used the attribute vectors to identify the set of control SKUs to each treated SKU. Therefore, an SKU is selected for a treated SKU if it does not adopt blockchain, belongs to the same subcategory, and has the same attribute vector (angle distance equals to 0).

Second, the control SKUs must have the unit price similar to that of the treated SKU. This is because two products with similar attributes have similarly targeted consumers only when they are priced at a similar level. We used the reference price instead of the time-variant market price to reflect the product's natural market positioning. In particular, for each SKU that has been selected in the first step, we computed the difference between its reference price and the treated SKU's reference price. If

the price difference is less than 50% of the treated SKU's reference price, it is included in the control set.

Construction of the control set for the difference in differences method is followed by two modification processes. First, to pool control SKUs and treated SKUs across time, we transformed calendar weeks to implementation weeks. For example, the week when the blockchain is implemented is denoted as week 0. The week before the implementation is week -1 and after the implementation is week 1. Second, we excluded control SKUs that have missing data for longer than seven consecutive weeks in the observation period. The control units matching process successfully identified at least one matched-pair SKU to each treated SKU.

*3.1.2 Model Specification*

The model $Sales_{it}\ or\ Return_{it} = \beta_0 + \beta_1 Implementation_{it} + \beta_2 Implementation_{it} * Treated_i + \beta_3 Treated_i + \beta_4 Price_{it} + \gamma_i + \epsilon_{it}$ is used to examine the causal effects of blockchain implementation on return rate and sales volume. It is noteworthy that we used the natural log of sales volume, instead of sales value, to measure ($Sales$) because it does not incorporate price differences (Qian, 2014). The weekly return rate ($Return$) is measured by the return quantity scaled by the total order quantity occurred in the week. The two variables are considered as dependent variables in the model. The sample period is split into pre-implementation and post-implementation periods. The dummy variable $Implementation$ is coded as 1 if a week falls in the post-implementation period, and coded as 0 if otherwise. Additionally, all SKUs are divided into treated and control groups by a dummy variable $Treated$ which equals 1 when a SKU has implemented blockchain, and 0 if otherwise. The interaction term ($Implementation * Treated$) allows an assessment of the independent association of the blockchain implementation with the dependent variables. Therefore, the use of the control SKUs enables control for unobservable temporal trends, such as capacity improvement of JD that might impact outcomes. For control variables, we included the natural log of SKU-week average market price ($Price$), which is believed can impact consumer's willingness to purchase and return products. Our model also included fixed effects ($\gamma_i$) to control for the effect of any unobservable time-invariant factors that affect dependent variables. The descriptive statistics of the variables are presented in Table 2.

Table 2. Descriptive statistics

| Variable | N | Mean | SD | Min | Max |
|---|---|---|---|---|---|
| *Sales* | 20975 | 5.43 | 2.26 | 1.1 | 12.09 |
| *Return* | 21042 | 0.05 | 0.16 | 0 | 1 |
| *Implementation* | 21042 | 0.51 | 0.50 | 0 | 1 |
| *Treated* | 21042 | 0.18 | 0.38 | 0 | 1 |
| *Price* | 20602 | 4.97 | 0.83 | 2.18 | 7.64 |

Different temporal trends between the SKUs may cause misleading empirical patterns after blockchain implementation. One critical assumption central to the difference-in-differences method is that trends in the dependent variables for the treated and control SKUs are similar in the pre-implementation period (Xu, 2017). To test the assumption, we used a regression model for SKU-week observations during the pre-implementation period. Similar to Gallino and Moreno (2014)'s method, we included the number of weeks before blockchain implementation, the treated SKU indicator, and controlled product level fixed effects. The coefficient of the interaction of the number of weeks and treated SKU indicator are insignificant in the testing models predicting sales volume and return rate. Therefore, we concluded that our treatment group and control group are in similar trends regarding the two performance indicators.

*3.1.3 Statistical results*

Table 3 presents the results of the regression analyses. We included the fixed effect dummies to control for unobservable factors of the products, therefore, the variable $Treated$ is suppressed by the fixed-effect model. The regression results suggest that both the sales volume has changed during blockchain implementation. In particular, comparing to pre-implementation period, the sales volume has increased by 8.84% ($p<0.01$) in the post-implementation period for all products, however, there are no significant changes in product return rate (see first columns of Panels A and B respectively). The results indicate that JD has experienced expansion during this period. The findings also reveal that the products adopted blockchain have an increase in sales volume (15.9%, $p<0.01$) and a decrease in return rate (3.79%, $p<0.01$) compared to those did not adopt blockchain in the post-implementation period.

The results in Panel A show that the milk powder, alcohol and nutrient products in the treatment groups have larger increases in sales volume compared to those in the corresponding control groups by 29.9% ($p<0.01$), 30.6% ($p<0.1$) and 25.6% ($p<0.05$) respectively in the post-implementation period. However, the difference between the treatment and control groups for the seafood product is not significant. The findings in Panel B show that the milk powder, alcohol, seafood and products in the treatment groups have larger decreases in return rate compared to those in the corresponding control groups by 2.81% ($p<0.05$), 14.7% ($p<0.05$), 2.32% ($p<0.01$) and 1.45% ($p<0.05$) respectively in the post-implementation period. Therefore, the results suggest that the implementation of blockchain can boost product sales and reduce product return.

Table 3. Statistical results

Panel A: DV: $Sales$

| | **Overall** | **Milkpowder** | **Alcohol** | **Seafood** | **Nutrient** |
|---|---|---|---|---|---|
| *Implementation* | 0.0884*** | 0.00831 | -0.106 | 0.116** | 0.0883** |
| | [0.0260] | [0.0344] | [0.0716] | [0.0563] | [0.0379] |
| *Implementation*Treated* | **0.159*** ** | **0.299*** ** | **0.306*** | 0.0612 | **0.256**** |
| | [0.0547] | [0.0915] | [0.172] | [0.134] | [0.102] |
| *Price* | -2.804*** | -7.205*** | -2.825*** | -2.200*** | -1.944*** |
| | [0.120] | [0.506] | [0.321] | [0.154] | [0.108] |
| *Constant* | 19.34*** | 45.72*** | 19.63*** | 14.84*** | 13.56*** |
| | [0.594] | [2.694] | [1.834] | [0.711] | [0.493] |
| Fixed effects | Included | Included | Included | Included | Included |
| Observations | 20542 | 6829 | 2190 | 6292 | 5231 |
| Log likelihood | -21347.6 | -6057.8 | -2432.4 | -7424.6 | -4226.4 |

Panel B: DV:$Return$

| | **Overall** | **Milkpowder** | **Alcohol** | **Seafood** | **Nutrient** |
|---|---|---|---|---|---|
| *Implementation* | 0.00751 | -0.0249*** | 0.0475*** | 0.0285*** | 0.0129 |
| | [0.00555] | [0.00866] | [0.0172] | [0.00844] | [0.0114] |
| *Implementation*Treated* | **-0.0379*** ** | **-0.0281**** | **-0.147**** | **-0.0232*** ** | **-0.0145**** |
| | [0.0144] | [0.0273] | [0.0705] | [0.0155] | [0.0140] |
| *Price* | 0.106*** | 0.316*** | 0.165*** | 0.0773*** | 0.0188 |
| | [0.0219] | [0.0936] | [0.0463] | [0.0180] | [0.0401] |
| *Constant* | -0.480*** | -1.622*** | -0.873*** | -0.337*** | -0.0323 |
| | [0.108] | [0.497] | [0.271] | [0.0851] | [0.179] |
| Fixed effects | Included | Included | Included | Included | Included |
| Observations | 20602 | 6863 | 2201 | 6299 | 5239 |

| | | | | | |
|---|---|---|---|---|---|
| Log likelihood | 17123.0 | 5111.0 | 1254.0 | 6405.3 | 5169.5 |

*Notes: Standard errors in brackets. *,**,*** denote significance levels at 10%, 5% and 1%, respectively*

### *3.2 Case study*

#### *3.2.1 Data collection*

We then conducted a multiple case study. In collaboration with JD's blockchain platform team, we theoretically selected four manufacturing firms from the milk powder, alcohol, seafood and nutrient industries. The four cases (i.e., MP, AL, SF and NU) were chosen based on literal replication as similar results are predicted to be produced from each case (Yin, 2009). They all had joined JD's blockchain platform for more than a year and found increases in sales and decreases in product return after the adoption of blockchain technology for tracing in supply chains. The unit of analysis is at the firm level and a description of the four cases is provided in Appendix I.

The data sources for this study included semi-structured interviews, a questionnaire survey and secondary data (e.g., information from the internet and company documents), allowing triangulation on important issues (Yin, 2009). The interviews were guided by a research protocol (Appendix II), which was initially developed based on the research questions and the findings from the experiment. The research team, which included two operations management professors and two PhD students, interviewed the firms. Each interview lasted approximately 2 hours and was conducted in Chinese. The informants included general managers and managers in the supply chain, marketing and information technology departments (Appendix II). The interviews were all tape-recorded. The case database included transcripts, notes, questionnaire survey, documents gained from each manufacturer and information from the internet. The reliability was addressed using the research protocol and the development of the case study database (Saunders et al., 2016). Using multiple data sources and maintaining a chain of evidence help this study establish validity (Saunders et al., 2016).

### *3.2 Findings*

#### *3.2.1 Supply chain transparency*

The case evidence reveals that the blockchain tracing system can significantly improve supply chain transparency. The managers all agreed that they all face growing demand from consumers and regulators for comprehensive transparency of the supply chain network. They also highlighted that the

more visibility of the supply chains, the better they can serve end consumers. NU's supply chain manager mentioned that "*consumers now are expected to know the origin, shelf life, and source of the products' ingredients. A tighter and more transparent supply chain is not just a nice-to-have option anymore; it's quickly becoming a must-have.*" NU can rapidly track hazardous products back to their starting place and check at what other places they have been disseminated. This significantly reduces and time and expenditure of product recall. MP explained that the blockchain tracing system allows the firm to have tracing information from the factory to JD (e.g., sourcing, production and logistics) and tracking information (e.g., inventory and delivery) from JD to consumers. MP used to only have access to the tracing information of the upstream of the supply chain. SF had a tracing system that was developed by the bureau of fisheries. The blockchain tracing system significantly extended the scope and functionality of that system. The adoption of blockchain tracing systems allows SF to track sea cucumbers until they reach consumers and acquire comments and feedback from consumers. SF's general manager commented that "*the information of supply chain has been synchronized to the blockchain platform, therefore, the whole process of sea cucumber from provenance to customers can be tracked and traced.*" AL also agreed blockchain tracing system provides visibility and transparency to the supply chain which strengthens the management of complex supply chain networks. AL's supply chain manager commented that "*blockchain helps bridge the information gaps presented in the supply chain."*

*3.2.2 Process management*

The case evidence reveals that adoption of blockchain tracing system strengthens the intra-and inter-organizational processes and improves their channel management and the ability to coordinate with upstream and downstream of the supply chains. All case firms agreed that the blockchain tracing system prompts them to continuously improve their safety standards and optimize their process management. SF's general manager highlighted that joining blockchain platform requires SF to provide detailed supply chain information of the seedling, production, processing and delivery to consumers and allow consumers to see its factory and farm, which drive the firm to invest on process reengineering to improve the quality and standards of its processes and operations. MP's supply chain manager commented that the adoption of the blockchain tracing system enables it to develop a process

to respond to quality problems and to prevent the problems from expanding. AL pointed out that using the blockchain tracing system helps it strengthen channel management by preventing products from unauthorized channels to enter markets, providing an opportunity for AL to standardize the supply chain processes. NU also agreed that the use of the platform has forced it to improve their internal process and operations, so to improve the quality and safety of products continuously.

*3.2.3 Consumer trust*

The findings reveal that the application of the blockchain tracing system strengthens the firms' brand image and the consumers' confidence and trust in their products. All managers emphasized that product quality, safety and authenticity are critical factors for building trust. Seventy percentage of MP's products are manufactured in Europe. Each can of MP's milk powder is marked with a QR code which is an "identity card" that records all information of the product including origins, production, storage, transportation, sales etc. Consumers could scan the QR to check the information. MP's marketing manager commented that "*customers could track the provenance of the products which enhances the confidence that they are produced in Europe, improving trust of consumers for the brand."* SF's general managers also commented that "*consumers can see the entire production process of the product, which eliminate the consumers' doubts and build their trust about the origin and breeding of sea cucumbers, so they are more willing and confident to purchase the products.*" Consumers have a high level of confidence in JD. Products of the firms who adopted the blockchain tracing system sold on JD are marked with the label of "quality traceability". According to marketing managers in AL, the label has greatly increased consumers' trust in their products, therefore, attracted more consumers. AL's supply chain manager also commented that "*the verification capabilities of blockchain assures the authenticity and further builds the consumer trust of our premium products*". NU's marketing manager mentioned that the blockchain tracing system enables consumers to answer questions such as "*Whether the products are organic? Which part of the world their curcumin extract came from and which farmer grew it? Whether the firm was paying farmers fairly and following fair trade practices, and therefore committed to sustainability?"* Blockchain tracing system thus provides evidence and proof to validate the marketing campaigns and advertisement, improving consumers' trust in the brand.

*3.2.4 Consumer service*

The evidence also reveals that the application of the blockchain tracing system improves the service level. All the case companies agreed that the blockchain tracing system enables them to provide more attractive services to consumers, which increase their satisfaction and reduce product return. The managers all mentioned that the blockchain tracing system significantly strengthens the interaction and communication with consumers, and hence it shortens the distance between them and markets. Moreover, as the case companies can obtain additional resources and support from JD because they joined the blockchain platform. MP's marketing manager commented that *"(JD) will provide personalized advertising services as well, which would attract more consumers.*" JD also helps MP to answer consumers' enquires when they scan the QR code and this significantly improves after-sale service and significantly reduces consumers' worries about the product authenticity, decreasing product returns. SF's general manager commented that many consumers are concerned about the authenticity and quality of sea cucumber. Many consumers log onto JD's online purchasing page and leave messages about the blockchain tracing system which will be quickly responded by JD's after-sales team. SF's general manager also mentioned that "*blockchain technology allows consumers to easily access the quality information such as the origin and breeding that consumers generally care about*, *which helps customer made informed purchasing decisions*". Blockchain tracing system helps AL directly advertise their products by showing information encoded in a QR-code (i.e., whisky recipes, ingredients, production method) when consumer browsing products. AL's marketing manager commented that "*this allows consumers to follow the entire story of the whisky just by scanning a QR code label on the bottle. A microsite that is developed by JD shows the videos and photos of the product at various stages of production and displays important information such as vessel identification, volume, test results at each stage, and timestamps*." The unique encoded QR-code used for each bottle allows AL to protect their products from counterfeits. AL also highlighted that JD provides additional support in channel management and loyalty programs which improves pre- and after-sale services as a result of joining the blockchain platform. AL's marketing managers highlighted that they have received much fewer complaints from consumers.

*3.2.5 Propositions*

During the interviews, the managers all agreed that more and more consumers are demanding detailed food supply chain information including where the food is grown, produced, processed, packaged, examined and who is included. The questionnaire survey further reveals that their past tracing systems offer limited visibility into the status of goods as they moved through the supply chains. The information is available at the origin but not at the destination, and the processes become particularly less transparent as goods move to consumers. Jointing JD's blockchain platform allows the case companies to not only trace the upstream of the supply chain networks and track the origins and the source of raw materials but also trace the downstream of the supply chain networks and track goods along with multi-level distribution networks through end consumers. Therefore, the adoption of the blockchain tracing system enhances supply chain transparency and visibility. The managers also commented the adoption of blockchain tracing system is a collaborative process and all stakeholders in the food supply chains must be involved and engaged, which provide an opportunity to re-engineer and optimize inter- and intra-organizational processes in the food supply chains. Moreover, the blockchain tracing system allows stakeholders in the food supply chain to obtain information about inventory, logistics and demand forecasting which improves cooperation and enables them to respond more quickly to external and disruptive events. The information helps firms ensure supply chain members met the standards corresponding to quality and sustainability, and standardize supply chain processes. The information also enables firms to identify problems which drive process improvement. The questionnaire survey also reveals that the adoption of the blockchain tracing system can improve supply chain management and quality management and the inter-organizational processes between the firms with JD. Therefore, we propose that:

*P1. The adoption of the blockchain tracing system significantly improves supply chain transparency and process management.*

During the interviews, the managers all highlighted that supply chain transparency allows consumers to identify faked products and counterfeit and business stakeholders to manage and respond to quality failures and. They also reported that the enhanced supply chain transparency allows them to understand consumers better and improve pre- and after-sale services, brand image and consumer satisfaction. The food supply chain involves various stakeholders, including farmers, producers,

warehousing and distributors. JD's blockchain platform allows all participants to share information rapidly and with confidence across global supply chains. Joining JD's blockchain platform is a crucial step for the firms to digitalize their supply chains. End-to-end transparency thus provides consumers with guaranteed safety in such complex supply chains and creates mutually assured trust in the accuracy of information provided by the supply chains. Therefore, the consistency and visibility of the information flow in supply chains enable firms to build trust with consumers. The improved process management can significantly enhance the quality control of food products and reduce food waste and lead-time. The questionnaire survey also reveals that JD's blockchain platform has advanced technological features with good support and hence it provides a user-friendly and easy to use method to meet consumers' information requirements. Process management enables a supply chain to securely and seamlessly manage information, physical and financial flows across organizational boundaries. Therefore, firms can quickly and effectively solve problems and respond to consumer requirements. Consumers can also reduce the uncertainty and risk involved in purchasing decision-making, improving consumer trust and service level. As a result, the consumer's wellbeing and confidence of the brand are improved which leads to more product sales and fewer product returns. Therefore, we propose that:

*P2. Supply chain transparency and process management can improve consumer service and consumer trust, increasing sales volume and decreasing product return.*

## 4. Discussion and conclusions

This study contributes to the literature in two ways. First, we provide empirical evidence that the adoption of the blockchain tracing system can improve product sales and reduce product return. Researchers have called for more empirical studies on blockchain implementation in supply chains (van Hoek, 2019a, Queiroz et al., 2019, Ehrenberg and King, 2019). This study provides insights into the application of blockchain tracing systems in the food supply chains of an emerging economy (Wang et al., 2019a, Zhao et al., 2019). The findings of the experiment reveal blockchain implementation can influence consumer behaviour and bring benefits to firms, enhancing current understandings of the performance outcomes of blockchain technology (Cole et al., 2019, Zhao et al.,

2019). The results thus suggest that when assessing the impacts of blockchain technology, researchers should take both a firm's and consumer's perspectives and consider the improvement on both operational performance and consumer wellbeing (van Hoek, 2019b, Pournader et al., 2019). Therefore, this study enhances existing knowledge on the drivers of adoption of blockchain technology in supply chain management and helps practitioners make the decisions on blockchain implementation (van Hoek, 2019b, Queiroz et al., 2019).

Second, we clarify the mechanisms through which the adoption of blockchain technology affects consumer behaviour. This study provides empirical evidence that the application of the blockchain tracing system enhances supply chain transparency and process management, which improve customer service and trust. Improved consumer service and trust lead to an increase in product sales and a decrease in product return. Currently, researchers and practitioners are not fully aware of the potential impacts of blockchain technology on food supply chains and consumer behaviours (Queiroz et al., 2019). There is a need to investigate the best practices associated with blockchain implementation in supply chains and to identify the strategies used by firms to fully reap the benefits of blockchain technology (Ehrenberg and King, 2019, Chang et al., 2019). The findings thus provide insights into how the implementation of blockchain technology influences supply chain practices and the capabilities required by the supply chains to deliver the benefits of blockchain technology to consumers (Cole et al., 2019). Moreover, this study also reveals that blockchain technology helps a firm to build trust with consumers through improving transparency and process management (Pournader et al., 2019, Wang et al., 2019a).

This study provides managerial guidelines for food supply chains to improve marketing performance. First, we suggest food supply chains adopt blockchain tracing systems to improve product sales and reduce product return. The impact on consumers' confidence and wellbeing should become a key consideration when making decisions on blockchain adoption. We suggest food supply chains adopt blockchain tracing systems as they provide an efficient method to improve upstream and downstream visibility to guarantee product authenticity to and minimize disputes with consumers. We also recommend food supply chains to invest on smart IoT devices and other information technologies to obtain relevant information from farms until delivery companies in real-time and enable consumers

to get access to all relevant information in food supply chains. Second, we suggest food producers collaborate with retailers to implement blockchain tracing systems to ensure food quality and safety. Additionally, practitioners should focus on standardizing and re-engineering their processes to integrate blockchain technology into supply chain management to fully reap the benefits of blockchain tracing systems. Firms should also rely on blockchain technology to effectively interact and communicate with consumers to improve pre- and after-sale services. We recommend firms to collaborate with supply chain partners to keep high-level and consistent quality standards.

This study has three main limitations which open avenues for future research. First, we investigate the application of blockchain tracing systems in food supply chains. Empirical evidence shows that blockchain technology can be implemented in other industries for different purposes (e.g., pharmaceutical, diamond, logistics and trading). Future studies could explore the application of blockchain technology in other industries to validate and generalize the findings of this study and provide insights into the impacts of product and industrial characters on blockchain implementation. Second, this study focuses on the benefits of applying blockchain tracing systems in supply chain management. However, we do not examine the barriers that hinder firms' adoption of blockchain tracing systems, such as regulatory environment, firms' capability and practices and supply chain relationship. Future studies could investigate the success factors that facilitate firms' adoption of blockchain technology. The findings could shed light on the firms' readiness on blockchain implementation. Third, we do not investigate the impacts of blockchain platform service quality (e.g., technical features and service support) on the benefits of adoption. Future studies could explore how the collaboration between firms and the blockchain platform affects the performance outcomes of blockchain adoption.

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**Appendix I** Case description

| Case | Background |
|---|---|
| MP | MP's revenue in 2019 is more than 400 million RMB. It is a foreign-owned firm and has around 1500 employees. It has collaborated with JD for more than 11 years and around 10%-20% of its products are sold through JD. MP's main product line is baby milk powder. As counterfeit or low-quality products are harmful to the baby's health and growth, consumers are very concerned about the authenticity of the products. Due to the safety risks of milk powder, higher product standards and more transparency are necessary. MP's supply chain of milk powder includes milk sourcing, production, transportation, storage and sales. Milk sourcing plays an important role in the quality of milk powder. The feed of cows determines the quality of fresh milk and has an impact on the quality of milk powder. In the production process, it is necessary to carry out a series of complex processing of fresh milk, which also has an important impact on quality. The management of storage, transportation and sales influences the occurrence of contamination of the product. MP has a bar-code based tracing system before adopted blockchain tracing system. |
| SF | SF's revenue in 2019 is around 200 million RMB. It is a privately-owned firm and has around 700 employees. It has collaborated with JD for more than 2 years and around 5%-10% of its products are sold through JD. SF mainly sells sea cucumber which is a popular product in China. Sea cucumber seedlings are mostly individual breeding, which might lead to the contamination of the feeds and negatively affect the quality of final products. Additionally, sea cucumbers need to be refrigerated during transportation, the temperature and humidity would affect the quality as well. Accordingly, the factors such as origin, production process, transportation and storage have great influences on the product quality. As the poor quality of sea cucumber is harmful to consumers, consumers' demand for a transparent supply chain of sea cucumber is very urgent. SF used a product tracing system developed by the local bureau of fisheries before adopted blockchain tracing system. |
| AL | AL's revenue in 2019 is around 200 million RMB. It is a foreign-owned firm and has around 7000 employees. It has collaborated with JD for more than 5 years and around 5%-10% of its products are sold through JD. AL's main product is whisky and operates in a highly profitable market. It is highly susceptible to counterfeit. To boost transparency and security of AL's supply chain, AL decided to adopt the blockchain tracing system to ensure that products are not altered or replaced in supply chains by creating a unique digital identity for each bottle which is recorded on an unmodifiable blockchain. AL has a bar-code based system for product authentication before adopted the blockchain tracing system. |
| NU | NU's revenue in 2019 is more than 400 million RMB. It is a privately-owned firm and has around 3000 employees. It has collaborated with JD for more than 3 years and around 21%-30% of its products are sold through JD. NU's main products are nutritional supplements and it has been threatened by contamination and poor quality because of the complexity of its global supply chains. The number of |

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|---|---|
| | transactions that take place, from the seed of a natural ingredient (often sourced from a foreign supplier) to the finished product sitting on the shelf, is staggering. NU has been adhering to execute the 'Three-Step' differentiation global quality strategy, from sourcing of the raw materials globally, to establishing its global exclusive raw material supply bases, and ultimately, building its organic farms worldwide. So far, its raw materials have been imported from 23 countries, and five exclusive raw material supply bases have been established in countries such as Brazil and Australia. |

**Appendix II.** Data collection

| **Case** | **Interviewee** |
|---|---|
| MP | Marketing and supply chain managers |
| SF | Marketing, information technology, and general managers |
| AL | Marketing, general, and supply chain managers |
| NU | Marketing and supply chain managers |
| **Research protocol** | |
| Semi-structured interview questions | 1. Please describe your company's products and supply chains.<br>2. Please describe how JD's tracing system works.<br>3. What are the factors that drive your company to use JD blockchain platform? What are your expectations for adopting the platform?<br>4. To what extent does your supply chains can be tracked and traced using the blockchain system?<br>5. What are the difficulties and challenges when using JD blockchain platform and how did you deal with them?<br>6. How does the adoption of JD's blockchain platform influence your collaboration with JD?<br>7. What are the advantages of JD's blockchain platform? What are the benefits to your company? Could you give us some examples?<br>8. How does the adoption of JD's blockchain platform affect your interactions with consumers? Does the adoption of blockchain tracing system influence consumer behaviour? Could you give us some examples?<br>9. Will your company continue to use JD's blockchain platform? What are the impacts of the blockchain platform on your supply chain processes and supply chain management? |
| Questionnaire | 1. Questions related to the cooperation history with JD, including years of cooperation, and percentage of sales through JD, and the experience of using a tracing system, when the company adopted JD's blockchain platform, the scope of blockchain tracing system and the technical features and perceived ease-of-use and usefulness of the system.<br>2. The impacts of adopting the JD's blockchain platform on firms' operations, including questions related to improving brand image, |

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| | supply chain management and cooperation, customer relationship management, standardization and optimization of processes, quality management, channel management, and strategic cooperation with JD.<br>3. The impacts adopting the JD's blockchain platform on firms' marketing, including questions related to improving product promotion and consumer recognition, attracting more consumers, establishing two-way interaction channels with consumers, learning consumer knowledge and preferences, improving customer satisfaction, improving sales and consumer retention, and reducing product returns and consumer complaints. |