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Does blockchain introduce new tensions in supply chain networks? A view from the food supply chain industry

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Does blockchain introduce new tensions in supply chain networks? A view from the food supply chain industry

Research-in-progress

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Abstract

Traceability and Authenticity (TA) are crucial concerns for supply chain networks, as illegal and unauthorised practices spread due to a lack of TA. Innovative technology blockchain has been argued to improve TA and address different issues in the food supply chain. While existing literature has mostly taken a techno-optimistic view of blockchain's potential to solve current supply chain issues, tensions that blockchain can introduce in supply chain activities remain neglected. Therefore, this study empirically investigated blockchain implementation to uncover the new tensions in supply chain activities while solving existing tensions. Activity theory was adopted as a theoretical lens. In-depth qualitative interviews were undertaken with organisations deploying blockchain to enable TA in the network. The study proposes new theoretical insights on how tensions emerge and build on each other to achieve TA in the supply chain network. This will guide organisations to improve TA by adopting blockchain.

Keywords: Activity Theory, Authentication, Blockchain, Supply Chain, Traceability

1 Introduction

The global economy has been transformed by diminishing national boundaries, consolidating existing markets and creating emerging avenues for business through globalisation (Lustenberger et al., 2021). This emergent global supply network has become more complex, which imposes challenges in making efficient transactions, fair distribution of information, and ensuring traceability (Ivanov et al., 2019).

The supply chain network involves different actors such as producers, processors, suppliers, wholesalers, and retailers (Rana et al., 2021). These actors mostly don't have an integrated view of the supply chain and heavily rely on centralised systems or intermediaries (Helo & Hao, 2019). Thus they neither process similar information about the product nor do they necessarily communicate and know each other while working on a common standard product (Rana et al., 2021). This fragmented and asymmetric information paves the way for many unauthorised and illegal practices in the supply chain.

Many scandals related to contamination and illegal practices are identified worldwide (Bedo, 2018). Manual intervention, discoordination, fraud, counterfeit, fake or contaminated products are the typical picture of the global supply chain (Vadgama & Tasca, 2021). Brutal and unregulated working conditions are also not uncommon in the supply chain (Chia, 2018). The recent Covid-19 crisis further exposed the fragility of the supply chain and global operation, particularly in the food supply chain, in terms of supply shock, demand shock, labour shortage, transportation delay, low quality etc. (Lin & Lanng, 2020).

The food supply chain is not only global and complex but also delicate (Duan et al., 2020). By nature, the foods' quality is correlated with time, which puts additional challenges in processing and maintaining quality on time (ibid). The perishable nature of food makes it more vulnerable to bacterial infection and contamination, requiring precise handling to meet the quality standard (Friedman & Ormiston, 2022). To maintain quality standards, product information must be captured at every touchpoint in the supply chain network (Bai & Sarkis 2020).

For certain products (i.e., halal, kosher, organic, vegan), the challenge is to ensure the authenticity consumers care for is even higher (Duan et al., 2020). Lack of information about the product increases the customer's concern about the product they are consuming. This impact the trust of the consumer in the food and the organisations (ibid).

Traceability and Authentication (TA) is considered an effective strategy to gain customer trust (Yang et al., 2021) and address different issues in the supply chain network (Costa et al., 2013). To enable TA, there is a need for an effective traceability system (Rana et al., 2021) that can ensure provenance, authenticity and quality (Vivaldini, 2021).

Blockchain is a decentralised, immutable, distributed ledger which viewed as a potential tool to improve TA (Ronaghi, 2021). Based on its integrability and design principle, it can monitor real-time product information, ensuring provenance and quality (Zheng et al., 2018).

In the IS literature, studies primarily focus on blockchain applications in the supply chain and its potential to address different supply chain issues (Sternberg & Baruffaldi, 2018). While current studies provide helpful insight into blockchain's potential to solve existing tensions in the supply chain, how blockchain implementation brings new tensions in the supply chain network is overlooked. Mainly, empirical research to provide insights into blockchain implementations remained nascent (Hoek, 2019; Rossi et al., 2019). The immaturity of blockchain and limited use cases on blockchain could be the key reasons behind the situation (Clohessy & Acton, 2019).

Most of the current implementations of blockchain solutions are argued as a political move in the organisation or a consequence of hype around the industry (Furlonger & Valdes, 2017) without understanding the associated tensions with blockchain implementation and its impact. With an urge to understand blockchain impact, a call for empirical research (Cole et al., 2019; Frizzo-Barker et al., 2020), specifically case study research (Ferdows, 2018), is noticed in academia.

In response to these research calls and considering the importance of TA in the supply chain (especially the food supply chain), this study aims to empirically investigate blockchain implementations in the food supply chain. Unlike existing research which is primarily techno-optimistic about blockchain in solving existing tensions in the supply chain (Rossi et al., 2019), this research effort unveils the tensions that blockchain introduces by uncovering the frictions. As implementing blockchain within complex organisational, social, and economic systems can raise practical tensions (Treiblmaier, 2019). Hence following research question guide the study-

RQ- How do blockchain implementations introduce tensions in supply chain activities for enabling TA?

This study empirically investigates blockchain implementation in the food supply chain network through the lens of activity theory (Engestrom, 1987). Interviews are conducted with two supply chains' organisations and secondary data to unveil the emerging tensions with blockchain implementations.

In the following section, the theoretical framing of this study is illustrated. Afterwards, the methodological approach to address the research question is discussed. Later discussion was made on the preliminary findings. Following the discussion, implications and future plans are mentioned.

2 Theoretical framing

The theoretical framing of this study is informed by Activity theory (Engestrom, 1987). As a theoretical lens, it allows studying mediated activities that encompass socially constructed elements (like- community, rules, division of labour) and technology (Karanasios, 2018). It is a practice theory used to understand the change and development in human/organisational practice by studying the complexity of activities through tool or technology mediation (Miettinen et al., 2012). With this theory, this study could better understand (i) blockchain technological intervention and uses in supply chain activities (ii) inter-connectivity of the organisations in the supply chain network, and (iii) tensions from a socio-technical perspective without prioritising social over technology or neglecting technology in action.

Through the activity theory lens, organisations in the supply chain network are considered an activity system and interacting activity system makes the 'network of activity system' (Karanasios, 2018) or could say 'activity network'. Activity theory helps to resemble and analyse the supply chain network situation and the organisations' connection in the supply chain network. In the supply chain network, organisations work towards their object and connect with other organisations in the network with a potentially shared object (Karanasios, 2018). The connection of the organisations as activity systems demonstrates interacting or contradictory activities, which is useful, particularly in IS research, to understand how technology shapes the activities (ibid). Figure 1 illustrates object-oriented activity by activity system (organisation) and how activities of different actors in the supply chain network link up towards the shared object.

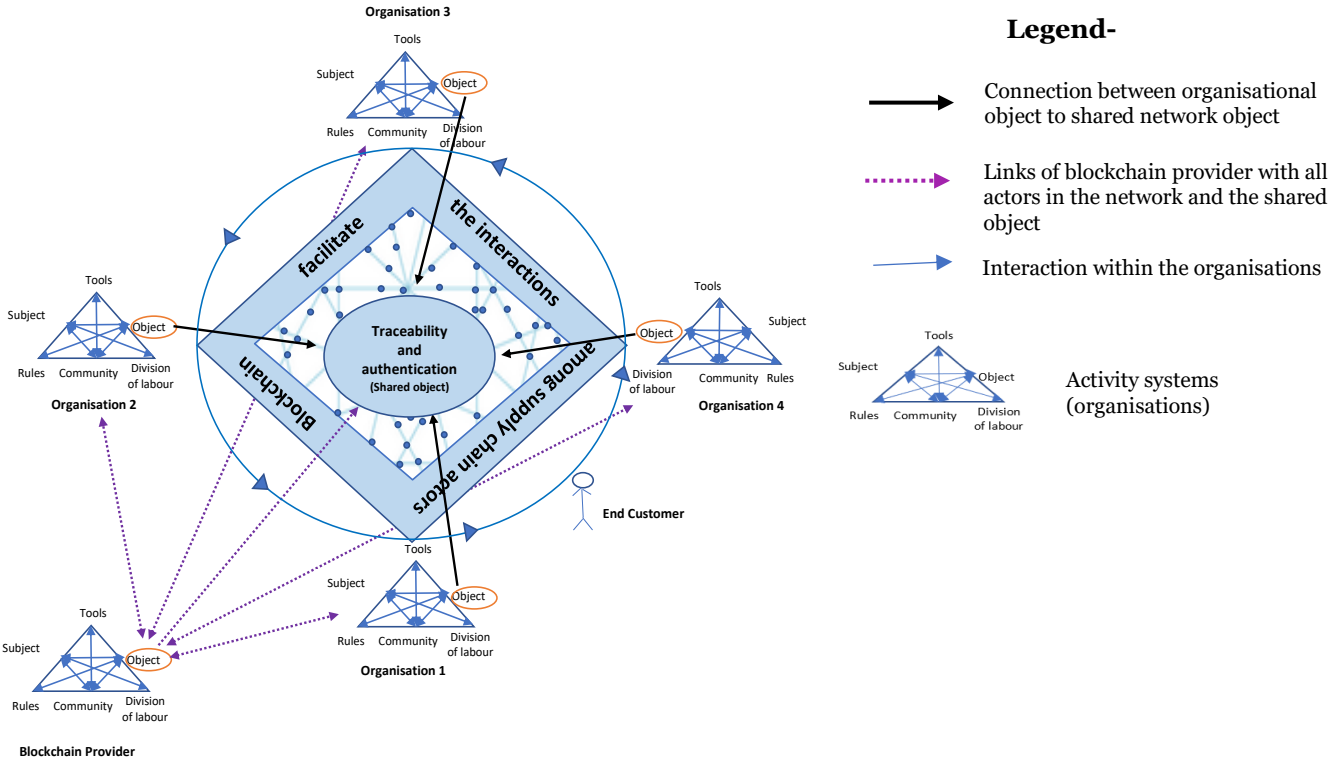

Figure 1: Supply chain activity network with shared object

This study focuses on analysing organisational activities toward shared objects (traceability and authentication). All the activities are mediated by constituent components of the activity system, i.e., tools, rules, community, and division of labour (Karanasios, 2018). Analysing these activities around shared objects helps to understand the contradictions and tensions. Activity theory focuses on contradictions as

an analytical tool to understand the problem, challenges, tensions, and clashes (ibid). This study looks at the tensions as a manifestation of underlying contradictions. Contradictions can only be identified through their manifestations (Engeström & Sannino, 2011) such as through tensions, misfits, clashes, disputes or opposition towards the shared object (Engeström & Sannino, 2011). Understanding contradictions and tensions in the supply chain activities within and among activity systems provide opportunities for understanding changes. Thus, the activity theoretical lens offers an in-depth view of contradictions and tensions in the supply chain activities after blockchain implementation.

3 Research approach

Following the theoretical framing, this study adopted a multiple case study to answer the research question. The multiple case study approach is argued to provide more analytically firm conclusions and direct replication compared to single cases, even if there are two cases (Yin, 2009). It also provides a greater chance for a broader exploration of the phenomenon (Eisenhardt & Graebner, 2007).

Cases are selected based on two main criteria. First, the organisation implemented blockchain technology in the supply chain. Second, the organisation belongs to the food industry. Two cases were selected for investigation, i.e., Orange Juice Supply Chain (OJSC), and Leafy Green Supply Chain (LGSC).

The first OJSC case study is a global supply chain comprising organisations from Europe and USA. Mainly four types of organisations are involved in this supply chain- juice processors, bottlers, retailers, and blockchain technology providers. The second case study is the LGSC supply chain, which is a USA-based supply chain involving four types of organisations: vendors, distribution companies, retailers, and technology providers. The produce of LGSC includes mainly romaine and green leaf lettuce.

Cases are diverse regarding location, blockchain implementation and experience with blockchain. These two cases provide sufficient diversity to provide insights into the tensions that emerged from blockchain implementation by capturing the core experiences and shared objects. Variation in cases is also recognised as potential to report emerging common patterns and strengthen the findings (Patton, 1990).

Additionally, the selected cases process enough similarities to stay focused on the research aim (Shakir, 2002) and perform the required research tactics (Yin, 2009). For instance, (i) one organisation is involved in both OJSC and LGSC (ii) all the involved organisations in OJSC and LGSC are large organisations and have a global reach (iii) Both supply chain comprises ready-to-eat products. This allows us to study them under the same theoretical design and cross-compare them to draw findings.

Unlike traditional case study research (Vivaldini, 2021), this study focuses on the entire supply chain network as a case rather than considering single organisations as a case. Blockchain-mediated supply chain activities in the supply chain network are considered a unit of analysis. The structured-pragmatic-situational research (SPS) approach (Pan & Tan, 2011) was followed to conduct the case study. The interactive and practical SPS steps were helpful from access negotiation to writing case-report through the framing and augmenting cycles.

An open interview question was developed based on the elements of the theoretical model to guide the interview sessions. So far, 23 interviews have been conducted including follow-ups. All the interviews are conducted online, mainly with Microsoft Teams, unless participating organisations prefer other applications (i.e., Zoom). With Microsoft Teams meetings, only audio was recorded, and transcriptions were downloaded after each interview. For other applications, manual transcription was made. The interviews aimed to identify the realised tensions with blockchain implementation in the supply chain network from the cases. Interviews were also conducted with blockchain experts to capture expert opinions on the identified tensions to provide recommendations on resolving tensions.

Additionally, this study also used various documents as a source of evidence. For instance, interviews on these supply chains published previously on websites, email correspondences, LinkedIn communications, pre-interview discussion summaries, organisation's blockchain implementation documents, and organisational annual reports. All these documents are helpful (i) for enriching insight on different aspects of the case study and support arguments (ii) for verifying specific details and making an inference (iii) for covering a wide range of events related to interviews (Yin, 2009).

After each interview, data were initially analysed with open coding. From the list of open codes, axial coding will be performed. Later, based on the theoretical framework, selective coding and interpretation of data are made.

4 Preliminary findings and discussions

This study aims to gain insight into the new contradictions and tensions from blockchain implementation. In this research in progress, the analysis only focuses on the case data. From the initial analysis of the case data, different tensions are identified with blockchain implementation. Based on the identified tensions further, we classified tensions into four contradiction categories by Engestrom (1987), i.e. (i) Primary (ii) Secondary (iii) Tertiary (iv) Quaternary (see table 1) to understand the emergence of tensions in different levels and how tensions are building on each other. Understanding the connection among these tensions helps to resolve tensions and improve the supply chain transformation activities.

Primary contradictions underlay in the elements of organisations. These are considered foundational as identifying tensions at the primary level helps to trace the root of other tensions (Foot & Groleau, 2011). This study identifies the manifestation of tensions at the primary level with the technological tool (blockchain) component. Examples of such tensions are mentioned in table 1.

Secondary contradictions help to understand the intra-organisational manifestation of tensions. Within the selected cases, such tensions are evident between components of the activity systems. For instance, in LGSC, one organisation stopped feeding data due to conflicts with its strategic priority. Hence triggering tensions between the subject and object. Additionally, due to the pressure of scanning data and the manual processes, sometimes the distributor misses feeding data in the blockchain, which impacts TA, demonstrating tension within the division of labour and object.

Tertiary level contradictions arise to remediate the secondary level contradictions and usually do not exist before implementing new technology (Foot & Groleau, 2011). These contradictions are overlooked in many studies. In this study, a manifestation of tensions is evident in the cases at the tertiary level. For instance- in LGSC, one organisation faces an issue with workload due to additional manual scanning, which is related to secondary contradiction. To solve this issue, a mobile app was developed to scan the product. However, further tension arises in using the app and the network that relates to tertiary-level contradiction.

Contradictions are also evident at the quaternary level between the activity systems, they are mainly inter-organisational tensions. Such as, in OJSC, organisations want to achieve TA but don't want to share information due to organisational privacy policy. This displays tensions between organisations. As one interviewee mentioned: *"a local IT department (of a partner organisation) was unwilling to share data to the blockchain. Once the global board pushed, we received all data required"*. The identified tensions from cases support the existing literature (mentioned in table 1).

Table 1: Different tensions with relevant literature

	Descriptions	**Examples of their manifestations as tensions**
Primary	Primary contradictions are located within the constituent components of the activity system. i.e. within tools (blockchain), within the object (TA) (Karanasios, 2018). These contradictions are foundational for other contradictions (Foot & Groleau, 2011)	Inconsistent data standards (Treiblmaier, 2019), lack of common nomenclature, difficulty in supply chain practice integration, lack of understanding of blockchain
Secondary	Secondary contradictions are located between constituent components of the activity systems, i.e. between the community and the division of labour, between rules and objects (Karanasios, 2018).	Difficulty in technical set-up, increase workload, organisational and technical ability for new technology, resistance to change (Seebacher & Schüritz, 2019), other strategic priorities, lack of internal collaboration (Saberi et al., 2019)
Tertiary	Tertiary contradictions arise to remediate secondary contradictions (Foot & Groleau, 2011)	Use complementary technology (i.e., mobile app), issues with the mobile network within organisation.
Quaternary	Quaternary contradictions occur between activity systems (Karanasios, 2018).	Information disclosure (Saberi et al., 2019), cultural issues (Saberi et al., 2019), cost and financial related constraints (Saberi et al., 2019), lack of collaboration from partner organisations (Saberi et al., 2019), data ownership issue, low awareness (Seebacher & Schüritz, 2019), communicating business value (Seebacher & Schüritz, 2019), lack of inter-organisational trust (Seebacher & Schüritz, 2019).

5 Implication and future plan

This study's major contribution is to unveil tensions concerning higher-level contradictions with blockchain implementation empirically. While most studies look at how blockchain remedies existing tensions (Rossi et al., 2019), this study provides insights into the emergence of new tensions. By contradiction categorising at different layers, this study illustrates how tensions emerge in supply chain activities. The key findings help to synthesise current conceptual debates with empirical evidence and advance IS literature on the blockchain, focusing on the supply chain. This study also contributes to the literature on activity theory by investigating disruptive technology blockchain through its lens. In terms of managerial contribution, it is crucial to guide future implementation by unfolding tensions with blockchain implementation. Additionally, insight into tensions at different levels helps design blockchain-based practical solutions for TA.

The new tensions identified concerning the existing literature will be further explored in the next phases. How tensions are building on each other, how organisations are resolving, and how the tensions should be handled will be further analysed. This study also aims to further examine how the tensions relate to higher-level contradictions. An in-depth analysis of the collected data will be conducted to unveil all the related tensions with blockchain implementation in the supply chain network. Additionally, the opinions of blockchain experts will be analysed to provide recommendations for solving the identified tensions.

6 References

Bedo, S. (2018). Dodgy food items passed off as the real thing are making their way onto supermarket shelves. Retrieved from https://rb.gy/omclvs

Chia, S. (2018). Transparency, food and the global supply chain. Retrieved from https://tinyurl.com/4a3b5p6f

Clohessy, T., & Acton, T. (2019). Investigating the influence of organizational factors on blockchain adoption: An innovation theory perspective. Industrial Management & Data Systems.

Cole, R., Stevenson, M., & Aitken, J. (2019). Blockchain technology: implications for operations and supply chain management. Supply Chain Management, 24(4), 469-483. doi:10.1108/SCM-09-2018-0309

Costa, C., Antonucci, F., Pallottino, F., Aguzzi, J., Sarriá, D., & Menesatti, P. (2013). A Review on Agri-food Supply Chain Traceability by Means of RFID Technology. Food and Bioprocess Technology, 6(2), 353-366. doi:10.1007/s11947-012-0958-7

Duan, J., Zhang, C., Gong, Y., Brown, S., & Li, Z. (2020). A content-analysis based literature review in blockchain adoption within food supply chain. International Journal of Environmental Research and Public Health, 17(5), 1784.

Eisenhardt, K. M., & Graebner, M. E. (2007). Theory building from cases: Opportunities and challenges. Academy of management journal, 50(1), 25-32.

Engestrom, Y. (1987). 1987 Learning by Expanding: An Activity-Theoretical Approach to Developmental Research. Helsinki: Orienta-Konsultit.

Engeström, Y., & Sannino, A. (2011). Discursive manifestations of contradictions in organizational change efforts: A methodological framework. Journal of Organizational Change Management.

Ferdows, K. (2018). Keeping up with growing complexity of managing global operations. International Journal of Operations & Production Management.

Foot, K., & Groleau, C. (2011). Contradictions, transitions, and materiality in organizing processes: An activity theory perspective. First Monday, 16(6). Retrieved from https://tinyurl.com/ycyycxm4

Friedman, N., & Ormiston, J. (2022). Blockchain as a sustainability-oriented innovation?: Opportunities for and resistance to Blockchain technology as a driver of sustainability in global food supply chains. Technological Forecasting and Social Change, 175. doi:10.1016/j.techfore.2021.121403

Frizzo-Barker, J., Chow-White, P. A., Adams, P. R., Mentanko, J., Ha, D., & Green, S. (2020). Blockchain as a disruptive technology for business: A systematic review. International Journal of Information Management, 51. doi:10.1016/j.ijinfomgt.2019.10.014

Furlonger, D., & Valdes, R. (2017). Practical Blockchain: A Gartner Trend Insight Report. . Retrieved from https://tinyurl.com/4ccwwt8b

Helo, P., & Hao, Y. (2019). Blockchains in operations and supply chains: A model and reference implementation. Computers & Industrial Engineering, 136, 242-251. doi:10.1016/j.cie.2019.07.023

Hoek, R. v. (2019). Exploring blockchain implementation in the supply chain. International Journal of Operations & Production Management, 39(6/7/8), 829-859. doi:10.1108/IJOPM-01-2019-0022

Ivanov, D., Dolgui, A., & Sokolov, B. (2019). The impact of digital technology and Industry 4.0 on the ripple effect and supply chain risk analytics. International Journal of Production Research, 57(3), 829-846.

Karanasios, S. (2018). Toward a unified view of technology and activity. Information Technology & People, 31, 134-155. doi:10.1108/ITP-04-2016-0074

Lin, J., & Lanng, C. (2020). Here's how global supply chains will change after COVID-19. Retrieved from https://www.weforum.org/agenda/2020/05/this-is-what-global-supply-chains-will-look-like-after-covid-19/

Lustenberger, M., Malešević , S., & Spychiger, F. (2021). Ecosystem Readiness: Blockchain Adoption is Driven Externally. Frontiers in Blockchain, 4. doi:10.3389/fbloc.2021.720454

Miettinen, R., Paavola, S., & Pohjola, P. (2012). From Habituality to Change: Contribution of Activity Theory and Pragmatism to Practice Theories. Journal for the Theory of Social Behaviour, 42(3), 345-360. doi:10.1111/j.1468-5914.2012.00495.x

Pan, S. L., & Tan, B. (2011). Demystifying case research: A structured–pragmatic–situational (SPS) approach to conducting case studies. Information and Organization, 21(3), 161-176. doi:10.1016/j.infoandorg.2011.07.001

Patton, M. Q. (1990). Qualitative evaluation and research methods: SAGE Publications, inc.

Rana, R. L., Tricase, C., & De Cesare, L. (2021). Blockchain technology for a sustainable agri-food supply chain. British Food Journal.

Ronaghi, M. H. (2021). A blockchain maturity model in agricultural supply chain. Information Processing in Agriculture, 8(3), 398-408. doi:10.1016/j.inpa.2020.10.004

Rossi, M., Mueller-Bloch, C., Thatcher, J. B., & Beck , R. (2019). Blockchain Research in Information Systems: Current Trends and an Inclusive Future Research Agenda. Journal of the Association for Information Systems, 20(09), 1390-1405. doi:10.17705/1jais.00571

Saberi, S., Kouhizadeh, M., Sarkis, J., & Shen, L. (2019). Blockchain technology and its relationships to sustainable supply chain management. International Journal of Production Research, 57(7), 2117-2135. doi:10.1080/00207543.2018.1533261

Seebacher, S., & Schüritz, R. (2019). Blockchain–just another it implementation? A comparison of Blockchain and interorganizational information systems. Paper presented at the In Proceedings of the 27th European Conference on Information Systems (ECIS), , Stockholm & Uppsala, Sweden.

Shakir, M. (2002). The selection of case studies: strategies and their applications to IS implementation case studies.

Sternberg, H., & Baruffaldi, G. (2018). Chains in chains–logic and challenges of blockchains in supply chains. Paper presented at the Proceedings of the 51st annual Hawaii international conference on system sciences.

Treiblmaier, H. (2019). Toward more rigorous blockchain research: recommendations for writing blockchain case studies. Frontiers in Blockchain, 2, 3.

Vadgama, N., & Tasca, P. (2021). An Analysis of Blockchain Adoption in Supply Chains Between 2010 and 2020. Frontiers in Blockchain, 4. doi:10.3389/fbloc.2021.610476

Vivaldini, M. (2021). Blockchain in operations for food service distribution: steps before implementation. International Journal of Logistics Management, 32(3), 995-1029. doi:10.1108/IJLM-07-2020-0299

Yang, L., Zhang, J., & Shi, X. (2021). Can blockchain help food supply chains with platform operations during the COVID-19 outbreak? Electronic Commerce Research and Applications, 49. doi:10.1016/j.elerap.2021.101093

Yin, R. K. (2009). Case study research: Design and methods (Vol. 5): sage.

Zheng, P., Zheng, Z., Luo, X., Chen, X., & Liu, X. (2018). A Detailed and Real-Time Performance Monitoring Framework for Blockchain Systems. Paper presented at the 2018 IEEE/ACM 40th International Conference on Software Engineering: Software Engineering in Practice Track (ICSE-SEIP).