EUI SCHOOL OF TRANSNATIONAL GOVERNANCE

BLOCKCHAIN'S WEAKEST LINKS: A Modified UTAUT Model Analysis of the TradeLens Case.

Clarke Sumbule WAFULA.

Thesis submitted for assessment with a view to obtaining the degree of Master of Arts in Transnational Governance of the European University Institute

Florence, 15th May 2023.

Supervisor

Prof. Andrea Renda, School of Transnational Governance, European University Institute.

Student declaration to accompany the submission of written work School of Transnational Governance

I **Clarke Sumbule WAFULA** certify that I am the author of the work BLOCKCHAIN'S WEAKEST LINK: A Modified UTAUT Model Analysis of the TradeLens Case.

I have presented for examination for the Master of Arts in Transnational Governance at the European University Institute. I also certify that this is solely my own original work, other than where I have clearly indicated, in this declaration and in the thesis, that it is the work of others.

I warrant that I have obtained all the permissions required for using any material from other copyrighted publications.

I certify that this work complies with the Code of Ethics in Academic Research issued by the European University Institute (IUE 332/2/10 (CA 297).

I declare that this work consists of 10,341 words.

Signature:

Date: 15/05/2023, Florence.

ABSTRACT

The recent withdrawal of TradeLens, an enterprise blockchain consortium, emphasizes that, while blockchain can revolutionize the supply chain industry, its successful deployment and adoption remain limited. I analyse the factors that enterprise blockchain consortia experience in their efforts to achieve industry-wide diffusion. I use a case study research approach and a modified Unified Theory of Acceptance and Use of Technology (UTAUT) model with empirical evidence gathered from in-depth interviews and secondary data sources. The thesis finds that the cost of implementing blockchain technology, platform governance issues and a lack of international cooperation poses significant challenges to achieving industry-wide adoption of this solution.

TABLE OF CONTENT

1. Introduction

International trade relies on complex supply chains that involve multiple actors, processes, and often massive paperwork spanning numerous jurisdictions[1]. For example, shipping a container of avocados from Kenya to the Netherlands involves over forty actors and twenty-five centimetres of paperwork, accounting for up to twenty per cent of the total shipping cost[2]. Furthermore, various supply chain actors supply and rely on raw materials from various countries to develop products.

Successful supply chain management means the harmonised flow of products, processes, information, and money[3]. Maintaining these flows, however, is costly, especially in the case of widely dispersed supply chains. Further, customers, governments, and producers demand more reliable information flows regarding quality, characteristics, and provenance along the supply chain due to the risks of error and fraud. Thus, efforts to find an innovative solution to the challenges to reduce costs and improve customer satisfaction while maintaining a competitive edge[4].

Innovation has historically benefited the supply chain, primarily by reducing trade costs. Dimitra Petropoulou defines trade cost as a cost incurred in trading other than the cost of production[5]. Trade cost includes transportation, regulatory, and information costs[6]. Innovations like the container in 1955 are estimated to have significantly decreased transportation costs[7].

---

[1] Seyda Serdarasan, 'A Review of Supply Chain Complexity Drivers', *Computers & Industrial Engineering* 66, no. 3 (November 2013): 533–40, https://doi.org/10.1016/j.cie.2012.12.008.

[2] Thomas Jensen, Ravi Vatrapu, and Niels Bjørn-Andersen, 'Avocados Crossing Borders: The Problem of Runaway Objects and the Solution of a Shipping Information Pipeline for Improving International Trade', *Information Systems Journal* 28, no. 2 (2018): 408–38, https://doi.org/10.1111/isj.12146.

[3] Yanling Chang, Eleftherios Iakovou, and Weidong Shi, 'Blockchain in Global Supply Chains and Cross Border Trade: A Critical Synthesis of the State-of-the-Art, Challenges and Opportunities', *International Journal of Production Research* 58, no. 7 (2 April 2020): 2082–99, https://doi.org/10.1080/00207543.2019.1651946.

[4] Seyda Serdarasan, 'A Review of Supply Chain Complexity Drivers', *Computers & Industrial Engineering* 66, no. 3 (November 2013): 1, https://doi.org/10.1016/j.cie.2012.12.008.

[5] Dimitra Petropoulou, 'Information Costs and Networks in International Trade', *CEPR*, 2005, 2.

[6] Darcy W.E. Allen et al., 'International Policy Coordination for Blockchain Supply Chains', *Asia & the Pacific Policy Studies* 6, no. 3 (September 2019): 3, https://doi.org/10.1002/app5.281.

[7] Daniel M. Bernhofen, Zouheir El-Sahli, and Richard Kneller, 'Estimating the Effects of the Container Revolution on World Trade', *Journal of International Economics* 98 (1 January 2016): 36–50, https://doi.org/10.1016/j.jinteco.2015.09.001.

Additionally, trade coordination bodies address regulatory costs leaving out information costs[8]. Digital innovations like the Internet are estimated to have impacted international trade significantly by lowering information, search and networking costs[9].

However, in recent years, international trade has seen little innovation[10]. The innovation is limited to organizational management ideas like just-in-time and lean procurement. The fourth industrial revolution, which includes digitalisation and several related disruptive technologies such as blockchain, big data analytics, machine learning, 3D printing, robotics, and drones, will drastically change this lack of innovation[11].

Given its characteristics, Blockchain technology is a game changer in the supply chain sector, potentially revolutionising global supply chains[12]. Blockchain is a distributed system for cryptographically capturing and storing information in an immutable, sequential, and synchronized manner between peer-to-peer networks[13]. Scholars and experts view blockchain

---

[8] Allen et al., 'International Policy Coordination for Blockchain Supply Chains'.

[9] George Clarke, Scott Wallsten, and World Bank, *Has the Internet Increased Trade? Evidence from Industrial and Developing Countries* (World Bank Publications, 2004), https://doi.org/10.1596/1813-9450-3215; Caroline L Freund and Diana Weinhold, 'The Effect of the Internet on International Trade', *Journal of International Economics* 62, no. 1 (1 January 2004): 171–89, https://doi.org/10.1016/S0022-1996(03)00059-X.

[10] Emmanuelle Ganne, *Can Blockchain Revolutionize International Trade?* (Geneva: World Trade Organization, 2018), 10.

[11] Klaus Schwab, *The Fourth Industrial Revolution* (Penguin UK, 2017); Christoph G. Schmidt and Stephan M. Wagner, 'Blockchain and Supply Chain Relations: A Transaction Cost Theory Perspective', *Journal of Purchasing and Supply Management* 25, no. 4 (1 October 2019): 100552, https://doi.org/10.1016/j.pursup.2019.100552.

[12] Ganne, *Can Blockchain Revolutionize International Trade?*; Chang, Iakovou, and Shi, 'Blockchain in Global Supply Chains and Cross Border Trade'; Gowri Sankar Ramachandran et al., 'Blockchain in Supply Chain: Opportunities and Design Considerations', in *Handbook on Blockchain*, ed. Duc A. Tran, My T. Thai, and Bhaskar Krishnamachari, Springer Optimization and Its Applications (Cham: Springer International Publishing, 2022), 541–76, https://doi.org/10.1007/978-3-031-07535-3_17; Weidong Shi, Eleftherios Iakovou, and Vincent Iacopella, 'Transforming Trade and Ensuring Global Supply Chain Security with Blockchain and Smart Contracts', Project Report (Houston, Texas: Border, Trade, and Immigration Institute at the University of Houston, March 2020), https://uh.edu/bti/research/shi-iakovou-blockchain/bti-writtendeliverables-blockchainshi-final-reduced1.pdf; Stefan Tönnissen and Frank Teuteberg, 'Analysing the Impact of Blockchain-Technology for Operations and Supply Chain Management: An Explanatory Model Drawn from Multiple Case Studies', *International Journal of Information Management* 52 (1 June 2020): 101953, https://doi.org/10.1016/j.ijinfomgt.2019.05.009; Samuel Fosso Wamba and Maciel M. Queiroz, 'Blockchain in the Operations and Supply Chain Management: Benefits, Challenges and Future Research Opportunities', *International Journal of Information Management* 52 (June 2020): 102064, https://doi.org/10.1016/j.ijinfomgt.2019.102064.

[13] Primavera De Filippi and Aaron Wright, *Blockchain and the Law: The Rule of Code* (Harvard University Press, 2018), https://doi.org/10.2307/j.ctv2867sp; Marten Risius and Kai Spohrer, 'A Blockchain Research Framework', *Business & Information Systems Engineering* 59, no. 6 (1 December 2017): 385–409, https://doi.org/10.1007/s12599-017-0506-0; Kevin Werbach, 'Trust, but Verify: Why the Blockchain Needs the Law', *Berkeley Technology Law Journal* 33, no. 2 (2018): 487–550, https://www.jstor.org/stable/26533144;

as disruptive, potentially revolutionising international trade and supply chains[14]. Blockchain attributes facilitate information sharing in the supply chain networks, providing a shared truth and eliminating the need for a central authority[15]. This benefit helps supply chain actors reduce trade costs.

Thus, many supply chain stakeholders are looking at the potential of blockchain to increase efficiency in the various supply chain stages. The most common blockchain application is enterprise blockchain, a type of permissioned blockchain used to streamline different processes at scale in the supply chain ecosystem[16]. Matt Kaufmann defines consortium blockchain as interorganizational systems integrating business operations and data using blockchain technology[17].

Individual companies like Walmart have implemented blockchain solutions to track their supply chain products[18]. However, given the number of actors in the supply chain ecosystem, consortium solutions are increasingly common, where different actors work together to benefit from information sharing via blockchain. However, many enterprise blockchain applications in the supply chain industry have been withdrawn or are facing slow adoption[19]. For example, only 8% of new blockchain projects 2016 reached 2017[20]. This withdrawal raises many questions about the potential of blockchain use cases in the supply chain. The notable failures in the supply chain industry include TradeLens, Marco Polo, and we.Trade.

Michèle Finck, *Blockchain Regulation and Governance in Europe* (Cambridge: Cambridge University Press, 2018), https://doi.org/10.1017/9781108609708.

14 Chang, Iakovou, and Shi, 'Blockchain in Global Supply Chains and Cross Border Trade'; Ramachandran et al., 'Blockchain in Supply Chain'; Tönnissen and Teuteberg, 'Analysing the Impact of Blockchain-Technology for Operations and Supply Chain Management'; Shi, Iakovou, and Iacopella, 'Transforming Trade and Ensuring Global Supply Chain Security with Blockchain and Smart Contracts'.

15 Werbach, 'Trust, but Verify'.

16 Michel Rauchs et al., '2nd Global Enterprise Blockchain Benchmarking Study', *SSRN Electronic Journal*, 2019, https://doi.org/10.2139/ssrn.3461765.

17 Matt Kaufman, 'Consortium Capabilities for Enterprise Blockchain Success', *The Journal of The British Blockchain Association* 4, no. 2 (1 October 2021): 1, https://doi.org/10.31585/jbba-4-2-(4)2021.

18 Ganne, *Can Blockchain Revolutionize International Trade?* Kim S. Nash, 'Wal-Mart Turns to Blockchain for Tracking Pork in China', *Wall Street Journal*, 19 October 2016, sec. CIO Journal., http://blogs.wsj.com/cio/2016/10/19/wal-mart-turns-to-blockchain-for-tracking-pork-in-china/.

19 Tahereh Nodehi et al., 'EBDF: The Enterprise Blockchain Design Framework and Its Application to an e-Procurement Ecosystem', *Computers & Industrial Engineering* 171 (1 September 2022): 108360, https://doi.org/10.1016/j.cie.2022.108360.

20 Ryan Browne, 'There Were More than 26,000 New Blockchain Projects Last Year – Only 8% Are Still Active', *CNBC*, 9 November 2017, https://www.cnbc.com/2017/11/09/just-8-percent-of-open-source-blockchain-projects-are-still-active.html.

Despite research on the factors that influence and obstruct the use of blockchain in the supply chain sector, such as technical constraints, interoperability issues, and the absence of an international legal and regulatory framework to support blockchain, there is limited empirical research on how and why enterprise blockchain consortia (EBC) fail to take off in the sector despite the advantages they offer. The thesis aims to fill this gap by explaining TradeLens' failure to reach industry-wide adoption in the supply chain ecosystem and shutting down despite early success.

1.1 Research Questions

Therefore, based on a modified Unified Theory of Acceptance and Use of Technology (UTAUT), the thesis asks: How and why do enterprise blockchain consortia fail to diffuse in the supply chain ecosystem? How do performance expectancies, effort expectancies, facilitating conditions, price, and governance contribute to the success or failure of enterprise blockchain adoption in the supply chain ecosystem? The thesis uses a case study research design to address the "how and why" research question that requires in-depth observation and analysis of the phenomenon. This method is appropriate as the phenomenon is recent, and the researcher does not intentionally manipulate the causal factors but is rather observational[21]. The thesis uses expert interviews and secondary data as the empirical basis for analysis. The analysis is based on explanation building suggested by Robert Yin for case study research[22].

1.2 Structure

The rest of the thesis is structured as follows: Part 2 thoroughly reviews the literature on utilising blockchain technology in supply chain management. Part 3 develops an analytical framework which builds upon the modified UTAUT model. Part 4 outlines the methodology employed in the research. Part 5 offers an overview of the case findings. Part 6 undertakes an in-depth analysis of the case based on the literature review and analytical framework. Finally, Part 7 presents the conclusion.

---

[21] Robert K. Yin, *Case Study Research and Applications: Design and Methods*, Sixth edition (Los Angeles: SAGE, 2018); John Gerring, *Case Study Research Principles and Practices*, Second edition, Strategies for Social Inquiry (Cambridge University Press, 2017), 29.
[22] Yin, *Case Study Research and Applications*.

2. Literature Review

2.1 Blockchain

2.1.1 *What is blockchain?*

Blockchain is a subset of distributed ledger technologies (DLTs). However, the term increasingly refers to the entire family of technologies, a practice this thesis will adopt. For most people, blockchain is synonymous with Bitcoin. This confusion is because Satoshi Nakamoto popularised the technology through bitcoins during the 2009 global financial crisis. However, blockchain technology has many applications besides bitcoins, and its disruptive nature has nothing to do with the future of cryptocurrencies[23].

Generically, blockchain technology refers to a distributed system for cryptographically capturing and storing information in an immutable, sequential, and synchronised manner between peer-to-peer networks[24]. In its simplest functional form, a blockchain is a ledger in which data is stored across numerous nodes, organised into blocks containing multiple transactions, and uses cryptographic hashing to add new blocks to the existing database[25]. Thus, at the core, the technology relies on peer-to-peer networks, cryptography, and a consensus mechanism to maintain the ledgers[26].

The blocks containing information about network transactions are chained together sequentially through hashing[27]. The blocks have a header containing a hash with the transaction's data, time stamps and a previous block's hash, enabling information organisation on the shared ledger[28]. A hash is a unique fingerprint representing information as a string of characters and numbers. Further, the blocks are append-only, meaning they can only be added and never removed.

[23] Trent MacDonald, 'Blockchains and the Boundaries of Self-Organized Economies- Predictions for the Future of Banking', 2016, 4.
[24] De Filippi and Wright, *Blockchain and the Law*; Risius and Spohrer, 'A Blockchain Research Framework'; Werbach, 'Trust, but Verify'; Finck, *Blockchain Regulation and Governance in Europe*, 2018.
[25] Finck, *Blockchain Regulation and Governance in Europe*, 2018, 24.
[26] De Filippi and Wright, *Blockchain and the Law*, 14.
[27] De Filippi and Wright, *Blockchain and the Law*; Finck, *Blockchain Regulation and Governance in Europe*, 2018; Werbach, 'Trust, but Verify'.
[28] De Filippi and Wright, *Blockchain and the Law*, 22.

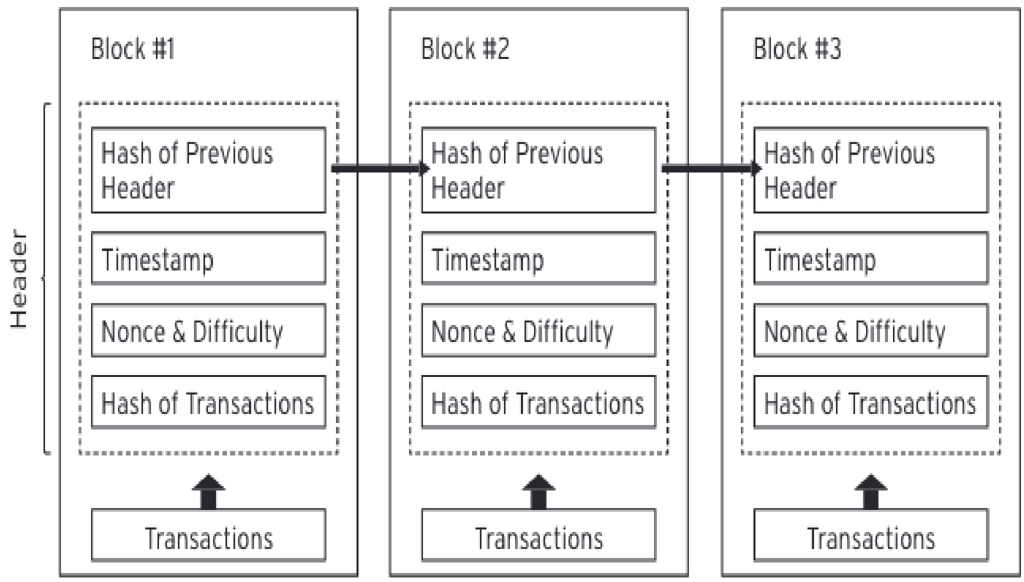


Figure 1: Simplified blockchain illustration adopted from De Filippi & Wright, 2018[29]

The technology uses a game-theoretic consensus mechanism to synchronise data across multiple nodes, incentivising network actors to agree on the current state of the ledger, such as the blocks to add[30]. Through rewards like proof-of-work, computers try to solve a mathematical problem for rewards. The consensus algorithms make it difficult to record fake transactions on the ledger. This process is called mining and consumes computer resources and energy.

The technology is tamper-proof due to cryptography, which ensures that the data in the ledger is unalterable. This attribute guarantee enables "single truth" across the network's various nodes, which may otherwise not trust each other[31]. These attributes led to the Economist calling blockchain "the trust machine"[32].

The recent addition to the technology is smart contracts which are self-executing programs that follow the logic "if X, then Y". Nick Szabo first introduced smart contracts in the 1990s as a

[29] De Filippi and Wright, 23.
[30] Werbach, 'Trust, but Verify', 491.
[31] Roman Beck, Christoph Müller-Bloch, and John Leslie King, 'Governance in the Blockchain Economy: A Framework and Research Agenda', *Journal of the Association for Information Systems*, 2018, 1020–34, https://doi.org/10.17705/1jais.00518.
[32] 'The Trust Machine', *The Economist*, 2015, https://www.economist.com/leaders/2015/10/31/the-trust-machine.

combined protocol with user interfaces to formalise and secure relationships over computer networks[33]. The use of this solution in blockchain came in 2014 when Vitalik Buterin introduced Smart Contract 2.0 Ethereum and addressed the potential use of smart contracts in a way that can aid automation on blockchains[34]. Smart contracts can execute the terms of a specific agreement automatically, providing trustless transactions through integrated enforcement mechanisms and reducing the need for an intermediary even further[35].

2.1.2 What are the types of blockchain?

Permissionless vs Permissioned

Blockchain technology can be permissioned or permissionless. Whereas permissionless networks, such as Bitcoin and Ethereum, can be joined by anyone, permissioned networks require a central authority or a consortium to select who is eligible and imposes limits on the data they can access and record. Most permissioned blockchains are purpose-driven, like Ripple, used in the USA for foreign exchange, and Hyperledger, mainly used on industrial applications like in the case of TradeLens[36]. Enterprise blockchain is a permissioned blockchain tailored to streamline organizational processes and can be private or consortium[37]. It is essential to differentiate the type of blockchain as they follow different diffusion paths[38]. Thus, the thesis will proceed with consortium enterprise blockchain for analysis.

Public vs Private

Blockchain can be private or public. This category covers user authentication, network management, and user anonymity. The degree of decentralisation, therefore, varies among the networks. Public ones are more decentralised than private ones[39]. At the same time, most public

---

[33] Nick Szabo, 'Formalizing and Securing Relationships on Public Networks', *First Monday*, 1 September 1997, https://doi.org/10.5210/fm.v2i9.548.
[34] Vitalik Buterin, 'Ethereum: A Next-Generation Smart Contract and Decentralized Application Platform.', 2014.
[35] Primavera De Filippi and Samer Hassan, 'Blockchain Technology as a Regulatory Technology: From Code Is Law to Law Is Code' (arXiv, 8 January 2018), http://arxiv.org/abs/1801.02507.
[36] De Filippi and Wright, *Blockchain and the Law*, 31.
[37] Rauchs et al., '2nd Global Enterprise Blockchain Benchmarking Study'; Alyssa Hertig, 'What Is an Enterprise Blockchain?', 19 February 2021, https://www.coindesk.com/tech/2021/02/19/what-is-an-enterprise-blockchain/.
[38] Christine V. Helliar et al., 'Permissionless and Permissioned Blockchain Diffusion', *International Journal of Information Management* 54 (1 October 2020): 102136, https://doi.org/10.1016/j.ijinfomgt.2020.102136.
[39] Ganne, *Can Blockchain Revolutionize International Trade?*

networks are permissionless. Further, in some, like Ethereum, only those who meet a specific criterion (e.g., how many coins they own and for how long) can validate transactions. Thus, the consensus mechanism in this blockchain is "proof-of-stake". In a private network, a highly trusted central actor validates the transactions contradicting the blockchain's original design.

A hybrid of the variations is commonly called consortium blockchain, where a group of individuals rather than an individual operates the network. According to Vitalik Buterin, a pre-selected group of nodes in consortium blockchain controls the consensus process. Classifying these blockchains as "partially decentralised"[40] is possible as some network members collaborate on its management and determine how it is operated and implemented[41]. For clarity, the thesis differentiates between the consortium blockchain described above and the use of the technology in the supply chain governed by a consortium. The thesis refers to the latter as an enterprise blockchain consortium (EBC).

A notable advantage of a consortium blockchain is the increased speed of the transactions. Further, since business information is sensitive, most actors in supply chain prefer this type of blockchain over sharing the information on a permissionless and public one where everyone can access the information[42]. This choice entails a trade-off between scalability and decentralisation. For example, private blockchains can use more lightweight consensus mechanisms than public blockchains by depending on a certain level of participant trust and thus are more scalable[43]. What remains certain is that both types of technology will continue developing for the foreseeable future. The most common type of blockchain in supply chains is the consortium one.

---

[40] Vitalik Buterin, 'On Public and Private Blockchains', *Ethereum Foundation Blog* (blog), 2015, https://blog.ethereum.org/2015/08/07/on-public-and-private-blockchains.
[41] Shi, Iakovou, and Iacopella, 'Transforming Trade and Ensuring Global Supply Chain Security with Blockchain and Smart Contracts'.
[42] Ganne, *Can Blockchain Revolutionize International Trade?*
[43] Shi, Iakovou, and Iacopella, 'Transforming Trade and Ensuring Global Supply Chain Security with Blockchain and Smart Contracts'.

2.1.3 What type of technology is blockchain?

There are several ongoing debates on the type of technology implemented in blockchains. The first debate regarding the kind of technology borrows from Clayton Christensen, who argued that innovations could be sustaining or disruptive[44]. Sustaining innovations are incremental and involve a co-evolutionary process of change, whereas disruptive innovations are often causing discontinuous effects and possibly displacement of dominant firms and institutions[45].

Most scholars see blockchain as a disruptive technology[46]. Understanding technology as disruptive in the Schumpeterian sense has its implications. For example, disruptive technologies often perform poorly first and take time to show the benefits, but they also present a different value proposition[47]. Blockchain is disruptive because it eliminates the need for an intermediary and guarantees trust[48].

However, other scholars go beyond this discussion and present blockchain as more than just a general-purpose disruptive technology but rather an institutional technology[49]. They contend that blockchain is a new protocol that allows economic coordination. This definition differs from the general-purpose technology that looks at how technology improves existing economic institutions[50]. Thus, while it is too early to predict the technology's disruptive potential, they suggest blockchain will usher in a new era of economic coordination.

---

[44] Clayton M. Christensen, *The Innovator's Dilemma: The Revolutionary Book That Will Change the Way You Do Business; [with a New Preface]*, 1. Harper Business paperback publ (New York, NY: Harper Business, 2011).

[45] Nicholas Askounes Ashford and Ralph P. Hall, *Technology, Globalization, and Sustainable Development: Transforming the Industrial State* (New Haven, Conn.; London: Yale University Press, 2011), 337–43.

[46] Finck, *Blockchain Regulation and Governance in Europe*, 2018; Risius and Spohrer, 'A Blockchain Research Framework'; Wamba and Queiroz, 'Blockchain in the Operations and Supply Chain Management'.

[47] Christensen, *The Innovator's Dilemma*; Finck, *Blockchain Regulation and Governance in Europe*, 2018; Calestous Juma, 'Gales of Creative Destruction', in *Innovation and Its Enemies: Why People Resist New Technologies*, ed. Calestous Juma (Oxford University Press, 2016), 0, https://doi.org/10.1093/acprof:oso/9780190467036.003.0002.

[48] Werbach, 'Trust, but Verify'.

[49] Allen et al., 'International Policy Coordination for Blockchain Supply Chains'; Chris Berg, 'What Diplomacy in the Ancient Near East Can Tell Us About Blockchain Technology', *Ledger* 2 (18 December 2017): 55–64, https://doi.org/10.5195/ledger.2017.104; Sinclair Davidson, Primavera De Filippi, and Jason Potts, 'Blockchains and the Economic Institutions of Capitalism', *Journal of Institutional Economics* 14, no. 4 (August 2018): 639–58, https://doi.org/10.1017/S1744137417000200; MacDonald, 'Blockchains and the Boundaries of Self-Organized Economies- Predictions for the Future of Banking'.

[50] Davidson, Filippi, and Potts, 'Blockchains and the Economic Institutions of Capitalism', 641.

Table 1: Blockchain types adapted from Ganne[51].

Degree of centralization	Public		Consortium		Private
Management	No centralized management		Multiple organizations		Single entity
Access	**Permissionless**	**Permissioned**	**Permissioned**	**Permissionless**	**Permissioned**
	Open read/open validation of transactions	Open read/permissioned validation of transactions	Permissioned OR open read/permissioned validation of transactions	Open read/open validation of transactions	Permissioned read/ validation of transactions
Participants	Anonymous/ pseudonymous	Anonymous/ pseudonymous	Identified	Usually identified	Identified
Validation based on consensus protocol	Open to every participant in the network	Open to every participant in the network, subject to certain conditions	By pre-approved participants (across the organizations involved)	Depending on the consensus protocol chosen for the platform	By pre-approved participants (within the single entity)
Speed of validation	Slow	Quicker	Quick	Quick	Quick
Users' level of privacy	None	None	Tailored to the needs of participants	Tailored to the needs of participants	Tailored to the needs of participants
Computing power required (energy consumption)	High (but variable depending on the consensus mechanism)	Intermediate. Variable depending on the consensus mechanism	Lower	Lower	Lower
Transaction fees	Yes	Yes	Optional – depending on the rules of the blockchain	Optional – depending on the rules of the blockchain	Optional – depending on the rules of the blockchain
Scalability	Low	Slightly higher	Higher	Higher	Higher
Example(s)	Proof of Work (Bitcoin, Ethereum)	Proof of Stake (Nxt)	Blockchains built on Hyperledger Fabric. Permissioned blockchains built on Ethereum.	FastTrackTrade	Private blockchains built on Ethereum

[51] Ganne, *Can Blockchain Revolutionize International Trade?* 12.

2.2 Blockchain and Supply Chain

The literature on blockchain use in the supply chain covers three main issues: the potential of blockchain and drivers of usage, the limitations and barriers of usage, and the use cases.

2.2.1 Potential of blockchain

Whereas in the early days of the technology, there was a paucity of knowledge regarding how the technology could impact various sectors of the economy[52], the disruptive nature meant blockchain was an innovative technology in search of use cases[53]. Blockchain is novel because it eliminates the need for a central transaction authority and offers a 'shared truth' among various network actors[54]. These attributes facilitate information sharing, which has many advantages in a fragmented supply chain sector.

According to Chang et al., successful supply chain management depends on the flow of products, processes, information, and money across the chains[55]. Further, critical supply chain challenges include traceability, dispute resolution, cargo integrity, digitisation, compliance, trust, and stakeholder management. Therefore, blockchain offers potential solutions through capabilities such as auditability, smart contracts, verifiability, automation, immutability, transparency, and disintermediation.

Nir Kshetri takes a similar stance and investigates blockchain's potential to achieve supply chain objectives such as cost, quality, speed, dependability, risk reduction, sustainability, and flexibility[56]. Wamba & Queiroz found that the technology can help improve transparency, accountability, trust, security, and efficiency, ultimately reducing the cost of transactions[57]. Other impact areas include trust[58], privacy[59], and cyber security[60].

[52] Risius and Spohrer, 'A Blockchain Research Framework'.
[53] Florian Glaser, 'Pervasive Decentralisation of Digital Infrastructures: A Framework for Blockchain Enabled System and Use Case Analysis', 2017, https://doi.org/10.24251/HICSS.2017.186.
[54] Werbach, 'Trust, but Verify', 507–12.
[55] Chang, Iakovou, and Shi, 'Blockchain in Global Supply Chains and Cross Border Trade'.
[56] Nir Kshetri, '1 Blockchain's Roles in Meeting Key Supply Chain Management Objectives', *International Journal of Information Management* 39 (1 April 2018): 80–89, https://doi.org/10.1016/j.ijinfomgt.2017.12.005.
[57] Wamba and Queiroz, 'Blockchain in the Operations and Supply Chain Management'.
[58] Schmidt and Wagner, 'Blockchain and Supply Chain Relations'.
[59] Davit Marikyan et al., 'THE ROLE OF PRIVACY AND SECURITY THREATS IN THE ADOPTION OF A BLOCKCHAIN', 2021.
[60] Marikyan et al.; Nir Kshetri, 'Blockchain's Roles in Strengthening Cybersecurity and Protecting Privacy', *Telecommunications Policy*, Celebrating 40 Years of Telecommunications Policy – A Retrospective and Prospective View, 41, no. 10 (1 November 2017): 1027–38, https://doi.org/10.1016/j.telpol.2017.09.003.

Further, Shi et al. observe that EBC is helping businesses open new opportunities through automation and cost reduction by adopting distributed ledgers in the global supply chains[61]. However, Ramachandran et al. note that whereas this new model promises opportunities, it comes with additional operational costs associated with deploying nodes and managing consensus mechanisms[62].

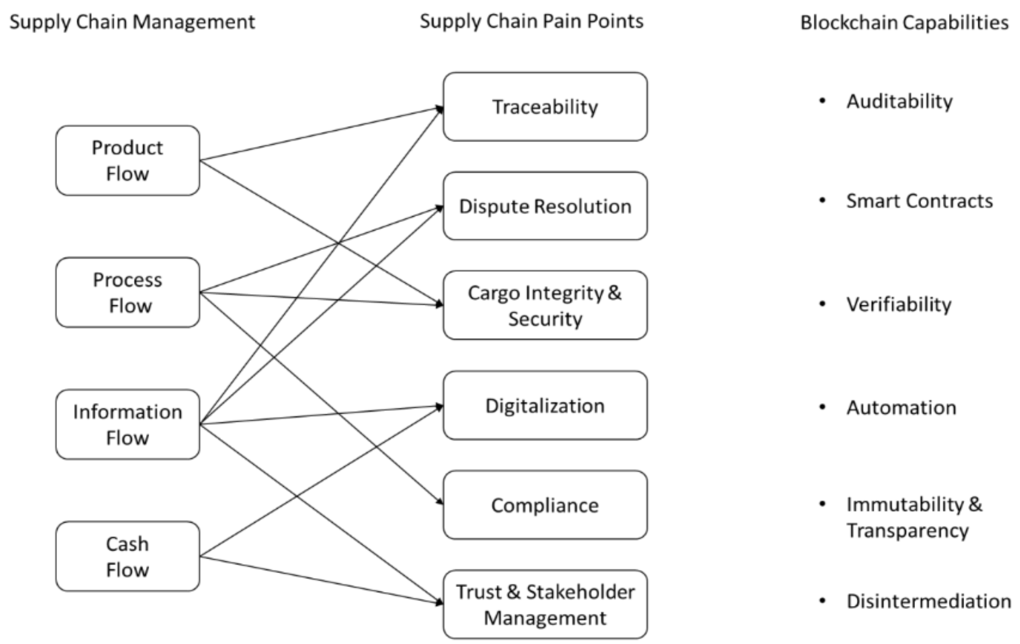


Figure 2: Adopted from Chang et al., 2020, p. 2[63]

More niche research focuses on the potential of blockchain to lower the cost of trade. Trade cost is the cost incurred other than in producing goods and services like transportation, regulatory and information costs[64]. With this understanding, innovations such as containerisation and global trade coordinating bodies have reduced the cost of transportation and regulation, leaving information as the significant transaction cost in supply chains, and

[61] Shi, Iakovou, and Iacopella, 'Transforming Trade and Ensuring Global Supply Chain Security with Blockchain and Smart Contracts'.
[62] Ramachandran et al., 'Blockchain in Supply Chain', 569.
[63] Chang, Iakovou, and Shi, 'Blockchain in Global Supply Chains and Cross Border Trade', 2.
[64] Petropoulou, 'Information Costs and Networks in International Trade'.

blockchain lowers this information cost which includes contract enforcement information, networking cost, search cost and information on the goods[65].

Catalini and Gans demonstrate that blockchain can potentially reduce two supply chain costs: verification and networking. Verification costs are associated with the low-cost proof of past transaction information and current ownership. Networking costs refer to running a decentralised marketplace without a central intermediary[66]. Finally, Schmidt and Wagner use a transaction cost theory perspective to argue that blockchain helps limit opportunistic behaviours and uncertainty, ensuring transparent and valid transactions at a lower cost[67]—a viewpoint shared by De Filippi and Wright [68].

2.2.2 Barriers and Challenges

The second research strand focuses on the barriers to adopting blockchain in the supply chain ecosystem. There are three broad categories of barriers: technical, interoperability and legal and regulatory framework. First, since blockchain is decentralised and distributed, it requires massive computational power. This feature makes blockchain consume enormous energy and thus limited scalability[69]. Whereas scalability is a challenge in generic blockchain, consortium blockchain has more resources and can scale more effectively[70].

Blockchain security is also a challenge, as decentralisation and distribution mean the involvement of many actors. For example, in the public blockchain, actors can undertake a 51% attack and alter recorded contents[71]. Further, smart contracts exhibit a degree of transparency that may be unappealing to the parties involved[72]. Additionally, blockchain has latency which refers to the delay between adding new transactions and receiving confirmation of the updated information[73].

The limitations are related to the nascency of the technology, and most scholars acknowledge that the development of the technology will overcome these challenges[74]. However, consortium

---

[65] Allen et al., 'International Policy Coordination for Blockchain Supply Chains', 4.
[66] Christian Catalini and Joshua S. Gans, 'Some Simple Economics of the Blockchain', *Communications of the ACM* 63, no. 7 (18 June 2020): 80–90, https://doi.org/10.1145/3359552.
[67] Schmidt and Wagner, 'Blockchain and Supply Chain Relations'.
[68] De Filippi and Wright, *Blockchain and the Law*, 133.
[69] Ramachandran et al., 'Blockchain in Supply Chain', 563.
[70] Ganne, *Can Blockchain Revolutionize International Trade?* 91.
[71] De Filippi and Wright, *Blockchain and the Law*, 113.
[72] De Filippi and Wright, 83.
[73] Ramachandran et al., 'Blockchain in Supply Chain', 563.
[74] Finck, *Blockchain Regulation and Governance in Europe*, 2018, 50.

blockchain comes with novel challenges related to the cost of operation[75] and governance challenges[76]. The thesis covers these challenges in detail in the next chapter.

The second challenges relate to interoperability which creates digital silos of blockchain data. There is a need for both blockchain platforms and data interoperability[77]. The first challenge refers to the ability of platforms to communicate based on some form of technical compatibility. For example, Hyperledger Fabric, Ethereum and R3 use different programming languages, and consensus mechanisms and smart contracts have different bounding mandates, thus creating interoperability challenges[78]. Potential solutions to the interoperability challenges include using Application Programming Interface (API) and sidechains[79].

The second interoperability challenge is how the various platforms and parties understand the shared information[80]. This challenge results from a lack of common data standards or slow adoption, like the UNCITRAL Model Law on Electronic Transferable Records (MLETR)[81], Uniform Rules for Digital Trade Transactions (URDTT)[82] and the ISO 8000[83]. Since blockchain technologies are transnational by nature and design[84], there is a need for the availability of these standards and international cooperation as the technology is used in various jurisdictions.

The third barrier relates to legal and regulatory challenges. Epps and Carey evaluate the current international rules in the supply chain and find that they create a potential barrier to using

[75] Ramachandran et al., 'Blockchain in Supply Chain', 569.
[76] Rosa Caiazza, 'A Cross-National Analysis of Policies Affecting Innovation Diffusion', *The Journal of Technology Transfer* 41, no. 6 (1 December 2016): 1406–19, https://doi.org/10.1007/s10961-015-9439-2; Marijn Janssen et al., 'A Framework for Analysing Blockchain Technology Adoption: Integrating Institutional, Market and Technical Factors', *International Journal of Information Management* 50 (February 2020): 302–9, https://doi.org/10.1016/j.ijinfomgt.2019.08.012.
[77] Ramachandran et al., 'Blockchain in Supply Chain', 562.
[78] micobo GmbH, 'Technical Difference between Ethereum, Hyperledger Fabric and R3 Corda', *Medium* (blog), 16 November 2018, https://micobo.medium.com/technical-difference-between-ethereum-hyperledger-fabric-and-r3-corda-5a58d0a6e347.
[79] Ramachandran et al., 'Blockchain in Supply Chain', 562.
[80] Ganne, *Can Blockchain Revolutionize International Trade?* 94.
[81] UNCITRAL – United Nations Commission on International Trade Law-, 'UNCITRAL – United Nations Commission on International Trade Law- UNCITRAL Model Law on Electronic Transferable Records (MLETR)', 1 January 2010, https://doi.org/10.1163/ej.9789004180048.i-962.595.
[82] International Chamber of Commerce, 'Uniform Rules for Digital Trade Transactions', 2021, https://www.ccpit.org/image/1331845279825047554/73f151fe9623443ebbe223a4a2d324cd.pdf.
[83] International Standards Organization (ISO), 'ISO 8000-1:2022', accessed 13 May 2023, https://www.iso.org/standard/81745.html.
[84] Georgios Dimitropoulos, 'The Law of Blockchain', *SSRN Electronic Journal*, 2020, https://doi.org/10.2139/ssrn.3559970; De Filippi and Wright, *Blockchain and the Law*.

blockchain solutions[85]. First, there is no agreement on the legal validity of blockchain transactions[86]. This barrier means that paper documents are still favoured to verify transactions. Some promising initiatives like the MLETR, but the adoption remains limited. Second, blockchain transactions are subject to data localization and privacy laws in multiple jurisdictions, given their transnational nature[87]. Ferracane & Lee-Makiyama show that data localization legislation is in the rise across the globe in recent years[88]. Whereas there is consensus that the advancement of technology will overcome technical challenges, there are calls for international coordination to address the second and third challenges[89].

Finally, some studies examine supply chain-related blockchain use cases and provide research frameworks for evaluating the phenomenon. Agi and Jha develop a framework for comprehending the organizational adoption factors of blockchain technology in supply chains by combining the innovation diffusion theory and the Decision-Making Trial and Evaluation Laboratory (DEMATEL) method[90]. Hamed Taherdoost conducts a systematic literature review on innovation and diffusion theories to explain the adoption of blockchain technologies[91]. However, although supply chain actors continue to desire the use of blockchain technologies, the is still a gap in empirical studies[92]. There is an acknowledgement of limited literature providing an opportunity for contribution[93]. Jovanovic et al. conduct a case study of TradeLens to understand the intricacies of managing EBC to achieve industry-wide adoption calling for further research on platform value and governance. The thesis covers this gap by evaluating the platform's governance challenges and the implication of its adoption.

---

[85] Tracey Epps, Blake Carey, and Tess Upperton, 'Revolutionizing Global Supply Chains One Block at a Time: Growing International Trade with Blockchain: Are International Rules Up to the Task?', 2019.
[86] Ganne, *Can Blockchain Revolutionize International Trade?* 98.
[87] Ganne, 100.
[88] Martina Francesca Ferracane and Hosuk Lee-Makiyama, 'Digital Trade Restrictiveness Index', 2022.
[89] Emmanuelle Ganne, 'Blockchain for Trade: When Code Needs Law' 115 (ed 2021): 419–24, https://doi.org/10.1017/aju.2021.64; Allen et al., 'International Policy Coordination for Blockchain Supply Chains'; Werbach, 'Trust, but Verify'.
[90] Maher A. N. Agi and Ashish Kumar Jha, 'Blockchain Technology in the Supply Chain: An Integrated Theoretical Perspective of Organizational Adoption', *International Journal of Production Economics* 247 (1 May 2022): 108458, https://doi.org/10.1016/j.ijpe.2022.108458.
[91] Hamed Taherdoost, 'A Critical Review of Blockchain Acceptance Models—Blockchain Technology Adoption Frameworks and Applications', *Computers* 11, no. 2 (February 2022): 24, https://doi.org/10.3390/computers11020024.
[92] Wamba and Queiroz, 'Blockchain in the Operations and Supply Chain Management'; Julie Frizzo-Barker et al., 'Blockchain as a Disruptive Technology for Business: A Systematic Review', *International Journal of Information Management* 51 (April 2020): 102029, https://doi.org/10.1016/j.ijinfomgt.2019.10.014.
[93] Samuel Fosso Wamba and Maciel M. Queiroz, 'The Role of Social Influence in Blockchain Adoption: The Brazilian Supply Chain Case', *IFAC-Papers Online* 52, no. 13 (2019): 1715–20, https://doi.org/10.1016/j.ifacol.2019.11.448.

3. Theoretical Framework

Information systems research has long studied how and why individuals and organisations adopt innovations, with several theories addressing the adoption and diffusion of innovations. Nevertheless, at the core, the basic concepts underlying concept underlying user acceptance models account for individuals' reactions to using technologies, intentions to use the technology, and the actual use of technology, thus overlapping on the constructs of the theories[94].

These theories define innovation as an idea, practice, or object perceived as new, and diffusion is the process by which an innovation is communicated through specific channels over time among members of social systems. Finally, the adoption rate is the relative speed with which social system members adopt an innovation[95].

UTAUT combines the eight innovation and diffusion theories into a unified model and theorises that performance expectancy, effort expectancy, and social influence behavioural intention to use technology, while behavioural intention and facilitating conditions determine technology use[96].

In its original form, the model is moderated by age, experience, voluntary use, and gender; however, recent research has dropped the moderators because they are unsuitable in all contexts. A view the thesis will adopt is that moderators are not suitable for observing organisations[97]. Several studies use innovation diffusion theories in their original, extended or combined models to explain the drivers and barriers of blockchain technologies in the supply chain context[98].

---

[94] Viswanath Venkatesh et al., 'User Acceptance of Information Technology: Toward a Unified View', *MIS Quarterly* 27, no. 3 (2003): 427, https://doi.org/10.2307/30036540.
[95] Everett M. Rogers, *Diffusion of Innovations, 5th Edition* (Simon and Schuster, 2003).
[96] Viswanath Venkatesh, James Y. L. Thong, and Xin Xu, 'Consumer Acceptance and Use of Information Technology: Extending the Unified Theory of Acceptance and Use of Technology', *MIS Quarterly* 36, no. 1 (2012): 157–78, https://doi.org/10.2307/41410412.
[97] Samuel Fosso Wamba and Maciel M. Queiroz, 'The Role of Social Influence in Blockchain Adoption: The Brazilian Supply Chain Case', IFAC-Papers Online 52, no. 13 (2019): 1716, https://doi.org/10.1016/j.ifacol.2019.11.448.
[98] Taherdoost, 'A Critical Review of Blockchain Acceptance Models—Blockchain Technology Adoption Frameworks and Applications', 8–11.

For example, using the model, Kamble et al. evaluate the adoption factors affecting the use of blockchain in the supply chain in India[99]. Queiroz and Wamba use a modified UTAUT model based on their extensive literature review to compare the use of blockchain in the supply chain in India and the USA adding trust among stakeholders as a variable[100]. Wong et al. use the UTAUT model to look at the effect of facilitating conditions on the behavioural intention of blockchain adoption in the supply chain in Malaysia[101]. Finally, Orji et al. base their analysis of blockchain adoption in freight and logistics and prioritise the variables using the analytic network processes [102].

The following sections will evaluate the constructs of this theoretical model in the EBC context in the supply chain ecosystems adding two critical variables from the literature review; price value and governance.

3.1 Performance Expectancy

This construct refers to the degree to which potential adopters believe that using the innovation will help them attain gains in their job performance and is the strongest predictor in the model[103]. This construct includes outcome expectations from the social cognitive theory, perceived usefulness from the Technology Acceptance Model (TAM) and relative advantage from the Innovation Diffusion Theory (IDT), as they have similarities conceptually. Previous studies have used root constructs like cost, time, quality, quantity, and competence to measure performance expectancy[104].

---

[99] Sachin Kamble, Angappa Gunasekaran, and Himanshu Arha, 'Understanding the Blockchain Technology Adoption in Supply Chains-Indian Context', *International Journal of Production Research* 57, no. 7 (3 April 2019): 2009–33, https://doi.org/10.1080/00207543.2018.1518610.

[100] Maciel M. Queiroz and Samuel Fosso Wamba, 'Blockchain Adoption Challenges in Supply Chain: An Empirical Investigation of the Main Drivers in India and the USA', *International Journal of Information Management* 46 (1 June 2019): 70–82, https://doi.org/10.1016/j.ijinfomgt.2018.11.021.

[101] Lai-Wan Wong et al., 'Unearthing the Determinants of Blockchain Adoption in Supply Chain Management', *International Journal of Production Research* 58, no. 7 (2 April 2020): 2100–2123, https://doi.org/10.1080/00207543.2020.1730463; Taherdoost, 'A Critical Review of Blockchain Acceptance Models—Blockchain Technology Adoption Frameworks and Applications'.

[102] Ifeyinwa Juliet Orji et al., 'Evaluating the Factors That Influence Blockchain Adoption in the Freight Logistics Industry', *Transportation Research Part E: Logistics and Transportation Review* 141 (1 September 2020): 102025, https://doi.org/10.1016/j.tre.2020.102025; Taherdoost, 'A Critical Review of Blockchain Acceptance Models—Blockchain Technology Adoption Frameworks and Applications'.

[103] Venkatesh, Thong, and Xu, 'Consumer Acceptance and Use of Information Technology'.

[104] Deborah Compeau, Christopher A. Higgins, and Sid Huff, 'Social Cognitive Theory and Individual Reactions to Computing Technology: A Longitudinal Study', *MIS Quarterly* 23, no. 2 (1999): 145–58, https://doi.org/10.2307/249749; Gary C. Moore and Izak Benbasat, 'Development of an Instrument to Measure the Perceptions of Adopting an Information Technology Innovation', *Information Systems Research* 2, no. 3

IDT posits that performance gaps explain why organizations adopt innovation. The performance gap is the difference between a firm's performance and its performance expectations[105]. As discussed in the literature review, blockchain attributes could help supply chain actors cover this gap. Blockchain offers security, privacy, and transparency. These attributes create a trustworthy environment allowing information sharing. Sharing information, in turn, helps lower trade cost.

Other desirable outcomes of using blockchain technology in the supply chain ecosystem include traceability, cargo integrity, and compliance[106]. The supply chain already uses technologies like Electronic Data Interchange (EDI) and Enterprise Resources Planning (ERP). However, the existing systems create digital silos and are thus inefficient. Thus, the following proposition emerges:

Proposition 1: Enterprise blockchain consortium's performance expectancy positively affects its adoption rate.

3.2 Price Value

However, research shows that the performance expectancy of innovation can also be reverse-scored[107]. Early innovation research shows that the pricing of an invention affects its perceived quality[108]. The UTAUT model also adopts price as one of the constructs when used in the consumer context[109]. This model extension is necessary because, unlike in an organisational setting where employees do not incur technology costs, consumers usually bear this cost. Therefore it is logical that supply chain actors and potential clients of a blockchain consortium will consider the price. Chan et al. also adopt price to the UTAUT model to study the adoption of SMS in China and Hong Kong[110].

(1991): 192–222, https://www.jstor.org/stable/23010883; Ronald L. Thompson, Christopher A. Higgins, and Jane M. Howell, 'Personal Computing: Toward a Conceptual Model of Utilization', *MIS Quarterly* 15, no. 1 (1991): 125–43, https://doi.org/10.2307/249443; Venkatesh et al., 'User Acceptance of Information Technology', 448–49.

[105] Rogers, *Diffusion of Innovations, 5th Edition*, 469.

[106] Chang, Iakovou, and Shi, 'Blockchain in Global Supply Chains and Cross Border Trade', 2.

[107] Thompson, Higgins, and Howell, 'Personal Computing'.

[108] Valarie A. Zeithaml, 'Consumer Perceptions of Price, Quality, and Value: A Means-End Model and Synthesis of Evidence', *Journal of Marketing* 52, no. 3 (1988): 2–22, https://doi.org/10.2307/1251446.

[109] Venkatesh, Thong, and Xu, 'Consumer Acceptance and Use of Information Technology'.

[110] Kwok Yue Chan et al., 'Examining User Acceptance of SMS: An Empirical Study in China and Hong Kong', 2008.

Pre-selected actors centrally manage EBC. Since this kind of blockchain is permissioned and private, the verification is not by consensus but rather by trusted parties, in this case, the platform's managers. This means a party uses resources to set up and run the platform. The operational cost of running the EBC is typically high[111]. Shi et al. agree with this view and are concerned about the cost of joining the blockchain consortia[112]. Since the potential adopters are likely to incur the cost, the price might affect their adoption rates, the following proposition emerges:

Proposition 2: Enterprise blockchain consortium's prices negatively affect its adoption.

3.3 Effort Expectancy

Effort expectancy is the degree of ease associated with using an innovation[113]. This definition captures variables like perceived ease of use under the TAM and complexity under the IDT, a similarity widely noted in adoption and diffusion studies[114]. Given that blockchain is a nascent technology, effort expectancy constructs are expected to be more salient in the early stages of the technology[115]. The items used to measure the constructs include ease of learning how to use the technology, ease of using the technology, understandability, degree of automation and time spent using the technology[116].

The complexity of the technology is one of the potential barriers to its adoption in the supply chain ecosystem[117]. Janssen et al. analyse blockchain adoption factors in the supply chain and show that there is a lack of understanding on the side of authorities, businesses and consumers regarding the potential use cases of the technology and how the technology operates, affecting adoption[118].

---

111 Ramachandran et al., 'Blockchain in Supply Chain'.
112 Shi, Iakovou, and Iacopella, 'Transforming Trade and Ensuring Global Supply Chain Security with Blockchain and Smart Contracts'.
113 Venkatesh et al., 'User Acceptance of Information Technology'.
114 Venkatesh et al.; Fred D. Davis, 'Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology', *MIS Quarterly* 13, no. 3 (1989): 319–40, https://doi.org/10.2307/249008; Moore and Benbasat, 'Development of an Instrument to Measure the Perceptions of Adopting an Information Technology Innovation'.
115 Davis, 'Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology'.
116 Davis, Moore and Benbasat, 'Development of an Instrument to Measure the Perceptions of Adopting an Information Technology Innovation'; Thompson, Higgins, and Howell, 'Personal Computing'; Venkatesh et al., 'User Acceptance of Information Technology', 451.
117 Caiazza, 'A Cross-National Analysis of Policies Affecting Innovation Diffusion'; Frizzo-Barker et al., 'Blockchain as a Disruptive Technology for Business'; Janssen et al., 'A Framework for Analysing Blockchain Technology Adoption', February 2020; Kamble, Gunasekaran, and Arha, 'Understanding the Blockchain Technology Adoption in Supply Chains-Indian Context'.
118 Janssen et al., 'A Framework for Analysing Blockchain Technology Adoption', February 2020, 303.

However, whereas blockchain technology is complex, users, in most cases, consider the technology a black box and focus on what it does more than how it does it[119]. An example is that not most people understand how smartphones work when there is a user-friendly interface on top of the technology. Further, the thesis focuses on the diffusion of EBC based on blockchain technology but not necessarily similar to blockchain. In EBC, a few organisations run the network and internalise the complexity, only offering value to the potential adopters. Thus, the following proposition emerges.

Proposition 3: Enterprise blockchain consortium's effort expectancy will not affect its adoption rate.

3.4 Facilitating Conditions

Facilitating conditions are the degree to which an individual believes that an organizational and technical infrastructure exists to support the use of the system[120]. This construct has the compatibility construct from the IDT, which refers to the degree to which an innovation is perceived as consistent with existing values, needs and experiences with potential adopters[121]. The items in this construct include control over the innovation, resource availability, compatibility with existing systems and the availability of guidance and training[122].

Regarding compatibility, given some similarities in the features of supply chains and technology, blockchain and supply chains seem like a natural partnership. The common features include transnationality and distributedness. De Filippi and Wright show that blockchain is transnational as it transcends geographical borders[123]. This feature is present in supply chains. Second, due to decentralisation, Ramachandran et al. argue that blockchain is compatible with multistakeholder applications like supply chains[124].

---

[119] Marikyan et al., 'THE ROLE OF PRIVACY AND SECURITY THREATS IN THE ADOPTION OF A BLOCKCHAIN', 3.
[120] Venkatesh et al., 'User Acceptance of Information Technology', 453.
[121] Moore and Benbasat, 'Development of an Instrument to Measure the Perceptions of Adopting an Information Technology Innovation'.
[122] Venkatesh et al., 'User Acceptance of Information Technology'; Thompson, Higgins, and Howell, 'Personal Computing'; Moore and Benbasat, 'Development of an Instrument to Measure the Perceptions of Adopting an Information Technology Innovation'.
[123] De Filippi and Wright, *Blockchain and the Law*, 34–35.
[124] Ramachandran et al., 'Blockchain in Supply Chain'.

Further, research has shown that blockchain's value is compatible with the needs of the supply chain ecosystem[125]. Additionally, many supply chain actors already use information technology infrastructure and are compatible with blockchain technology[126]. Technologies and standards like EDI are compatible with blockchain through APIs.

However, some aspects of the technology are incompatible with supply chain ecosystems, experiences, architecture, values, and needs. Perhaps a significant concern is raised on the inability of the technology to offer binding physical and digital information meaning that information stored on the blockchain should be able to reflect reality[127]. This is challenging as the supply chain involves a lot of physical goods.

However, this incompatibility also affects other digital technologies and results from a lack of internationally recognised standards and laws governing blockchain use in the supply chain. International laws and standards are important as research has shown that regulatory framework moderates facilitating conditions in the UTAUT model[128].

At the technical level, a lack of standards affects interoperability. For example, Hyperledger Fabric, Ethereum and R3 use different programming languages, and consensus mechanisms and smart contracts have other bounding mandates, thus creating interoperability challenges[129]. However, it is critical to note that developing standards is slow and cumbersome. There is much going on to make the standards available. Thus, the following proposition emerges.
Proposition 4: Facilitating conditions affect the adoption of an enterprise blockchain consortium.

3.5 Governance

Innovation adoption and diffusion research require contextualisation[130]. Thus, it is common for researchers to combine or extend the existing models to account for the different technologies and contexts. For example, Venkatesh et al. contextualise the model in consumer set-up, adding

[125] Chang, Iakovou, and Shi, 'Blockchain in Global Supply Chains and Cross Border Trade'.
[126] Ramachandran et al., 'Blockchain in Supply Chain', 542.
[127] Chang, Iakovou, and Shi, 'Blockchain in Global Supply Chains and Cross Border Trade'.
[128] Wong et al., 'Unearthing the Determinants of Blockchain Adoption in Supply Chain Management'.
[129] GmbH, 'Technical Difference between Ethereum, Hyperledger Fabric and R3 Corda'.
[130] Viswanath Venkatesh, 'Adoption and Use of AI Tools: A Research Agenda Grounded in UTAUT', *Annals of Operations Research* 308, no. 1–2 (January 2022): 642, https://doi.org/10.1007/s10479-020-03918-9.

variables like price value, hedonic motivation and habit[131]. Further, Venkatesh et al., while evaluating the UTAUT model in an AI context, point out that the technology's characteristics can have both a direct effect as a predictor and moderating effect on the constructs of the model[132]. For blockchain consortia, governance is one of the unique characteristics. The thesis extends the model by discussing the governance of blockchain consortia as a critical factor affecting the use of the technology in supply chain ecosystems.

Whereas in its initial sense, blockchain is permissionless and public, the version used in most supply chains is the consortium variation where there is a central authority. This is counterintuitive as blockchain's significant disruption is disintermediation. Whereas there are ongoing debates on blockchain governance, there seems to be a consensus on the impact of on-chain and off-chain blockchain governance models on adoption.

Blockchain network governance is a complex interplay between stakeholders like token holders, network validators, core and application developers and founders. Blockchain governance is the process by which stakeholders—all those affected by and can affect the network—exercise bargaining power over the network[133]. To understand blockchain governance, Beck et al. extend the IT governance model of decision rights and accountability to include incentives. Decision rights are concerned with how decisions are made and by whom. Accountability relates to mechanisms that control decision-making, like ratification and monitoring. Finally, incentives are concerned with incentivising consensus and aligning incentives in the blockchain network[134].

Literature differentiates between on-chain and off-chain governance on blockchain networks. On-chain refers to the rules and decision-making embedded in the blockchain infrastructure's code[135]. This type of governance relates to calls the rule of code as discussed by Lawrence Lessig[136] and Primavera and Wright[137]. Off-chain governance refers to all other rules and

[131] Venkatesh, Thong, and Xu, 'Consumer Acceptance and Use of Information Technology'.
[132] Venkatesh, 'Adoption and Use of AI Tools'.
[133] Darcy W. E. Allen and Chris Berg, 'Blockchain Governance: What We Can Learn from the Economics of Corporate Governance', *The Journal of The British Blockchain Association*, 30 March 2020, https://doi.org/10.31585/jbba-3-1-(8)2020.
[134] Beck, Müller-Bloch, and King, 'Governance in the Blockchain Economy'.
[135] Wessel Reijers et al., 'Now the Code Runs Itself: On-Chain and Off-Chain Governance of Blockchain Technologies', *Topoi* 40, no. 4 (September 2021): 821–31, https://doi.org/10.1007/s11245-018-9626-5.
[136] Lawrence Lessig, *Code*, Version 2.0 (Basic Books, 2006).
[137] De Filippi and Wright, *Blockchain and the Law*.

decision-making processes affecting the operation and development of the blockchain system[138].

The World Economic Forum Blockchain Toolkit[139] calls for differentiating between business and operational governance in the blockchain consortia. Business governance includes decisions on legal entities, governance models, budgeting, commercial models, profit allocation, business lines, marketing strategy and adding members. Operational governance includes setting technical network standards like access rights, security, privacy, permissions, software standards and dispute resolutions.

Although effective governance is the most foundational element in blockchain consortium success, it can prove challenging as the partners might have different priorities, profit models and business processes[140]. Helliar et al. argues that how blockchain is structured and controlled is a potential driver of blockchain adoption, particularly in permissioned blockchain[141]. Janssen et al. say that adopting the technology may be impacted by the resistance of organisations to change and the lack of appropriate governance frameworks for blockchain applications[142].

Lu et al. use Multicriteria Decision Matrix and determine that governance is a factor for users in picking a blockchain platform for projects[143]. The finding shows that many actors, like clients, government ports and authorities, are interested in the network in a supply chain blockchain consortium. The governance challenge is to align the stakeholders' interests to ensure the network's success.

Wang et al. share the view and observe that given the large number of players involved, conflicting interests may arise, affecting usage[144]. Zavolokina et al. evaluate the development and management of EBC in the ecosystem based on the Cardossier case study[145]. The paper

---

[138] Reijers et al., 'Now the Code Runs Itself', 3.
[139] 'WEF Blockchain Toolkit', 2021, https://widgets.weforum.org/blockchain-toolkit/consortium-governance/index.html.
[140] Kaufman, 'Consortium Capabilities for Enterprise Blockchain Success', 6.
[141] Helliar et al., 'Permissionless and Permissioned Blockchain Diffusion'.
[142] Marijn Janssen et al., 'A Framework for Analysing Blockchain Technology Adoption: Integrating Institutional, Market and Technical Factors', *International Journal of Information Management* 50 (February 2020): 302–9, https://doi.org/10.1016/j.ijinfomgt.2019.08.012.
[143] Weisheng Lu, Liupengfei Wu, and Fan Xue, 'Blockchain Technology for Projects: A Multicriteria Decision Matrix', *Project Management Journal* 53, no. 1 (1 February 2022): 84–99, https://doi.org/10.1177/87569728211061780.
[144] Yingli Wang et al., 'Making Sense of Blockchain Technology: How Will It Transform Supply Chains?', *International Journal of Production Economics* 211 (May 2019): 221–36, https://doi.org/10.1016/j.ijpe.2019.02.002.
[145] Liudmila Zavolokina, Rafael Ziolkowski, and Ingrid Bauer, 'Management, Governance, and Value Creation in a Blockchain Consortium', *MIS Quarterly Executive* 19, no. 1 (1 March 2020): 1–17, https://doi.org/10.17705/2msqe.00022.

uses the paradox perspective to assess the tensions and their resolution and finds that whereas blockchain consortia encourage collaboration, they require initial mutual trust. Kaufmann equally discusses governance as a critical success factor in enterprise blockchain industry adoption[146]. Thus the following proposition emerges.

Proposition 5: Enterprise blockchain consortium governance affects its adoption.

3.6 Social Influence

This construct refers to how other people important to the users impact how users interact with a particular technology[147]. However, while examining the adoption of blockchain technology in Brazil's supply chain sector, Wamba & Queiroz found that social influence helps predict the other UTAUT constructs (performance expectancy, effort expectancy and facilitating conditions)[148]. The thesis will abandon this construct and concentrate on the moderating variables influenced by social influence. Therefore, the thesis will proceed with the following model, researching the three-variable identified as facilitating conditions, performance expectancy and effort expectancy together with the price and governance.

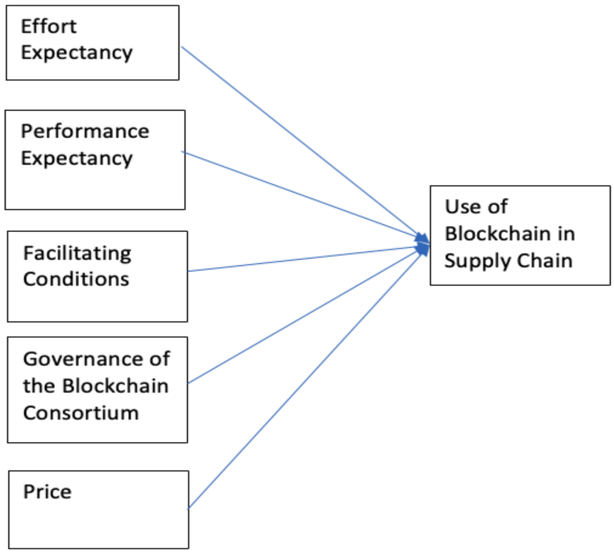


Figure 3: Analytical framework developed by the author based on the extended UTAUT model.

[146] Kaufman, 'Consortium Capabilities for Enterprise Blockchain Success'.
[147] Venkatesh et al., 'User Acceptance of Information Technology'.
[148] Wamba and Queiroz, 'The Role of Social Influence in Blockchain Adoption'.

3.7 Criticism

However, critics of innovation diffusions study critic it as having "pro-innovation bias". This bias is the idea that innovation should spread quickly, be embraced by all social system members, and not be rejected or reinvented[149]. This bias limits research on rejected and discontinued innovation when much can still be learnt from such cases. This thesis examines a failed case in an industry where technology adoption is slow. Previous innovation diffusion studies have used this approach. For example, innovation diffusion scholars have examined why the Drovak keyboard failed to diffuse despite being more efficient than the prevailing QWERTY keyboard[150].

The second bias of innovation studies relates to individual or system blame bias. The former refers to the tendency of researchers to side with change agents instead of the potential adopters of the technology. The result is blaming individual potential adopters for system challenges. The latter refers to the tendency to blame the system for individual challenges[151] The thesis was open to many ideas in the exploratory stage and looks at both barriers relating to the technology provider, the users and the supply chain ecosystem.

---

[149] Rogers, *Diffusion of Innovations, 5th Edition*, 142.
[150] Rogers, 43–51.
[151] Rogers, 155.

4. Methodology

4.1 Research Design

The thesis uses a case study research design to answer the research questions. A case study design is the intensive study of a single case or several small cases that promise to shed light on a larger population[152]. According to Yin, a case study is desirable if the research meets three conditions; it answers the how and why question, has no control over behavioural events and is a recent case. The thesis satisfies these criteria. A case study allows in-depth focus and retains holistic, real-world experiences[153]. This research design is helpful as blockchain and supply chain research are still in their initial stages. There is a need for an in-depth analysis of the phenomenon to provide grounds for future research work.

4.2 The Case

The thesis explains the failure of the TradeLens to attain industry-wide diffusion based on the model developed from combining the UTAUT model and the variable identified in the literature review. The case is purposefully chosen with two considerations: representativeness and theoretical variables variations[154]. Further, the thesis chose TradeLens due to practical reasons like data availability.

4.3 Data Collection

Data was collected from three sources: First, in-depth semi-structured interviews to understand the factors that led to the platform's initial success and eventual shutdown. Second, secondary data on the case like TradeLens documentation, presentations, news articles and blog posts. Third, informal conversations with blockchain, supply chain and TradeLens experts, as suggested by Jovanovic et al.[155]

---

[152] Gerring, *Case Study Research Principles and Practices*, 27.
[153] Yin, *Case Study Research and Applications*, 35.
[154] Jason Seawright, *Multi-Method Social Science: Combining Qualitative and Quantitative Tools*, Strategies for Social Inquiry (Cambridge: Cambridge University Press, 2016), 298, https://doi.org/10.1017/CBO9781316160831.
[155] Marin Jovanovic et al., 'Managing a Blockchain-Based Platform Ecosystem for Industry-Wide Adoption: The Case of TradeLens', *Technological Forecasting and Social Change* 184 (1 November 2022): 3, https://doi.org/10.1016/j.techfore.2022.121981.

4.4 Data Analysis

The thesis uses explanation building analytical technique, where the goal is to analyze the case study by building an explanation of the case[156]. Yin argues that to explain a case is to stipulate a presumed set of causal sequences about it, explaining how and why some outcome has occurred. This occurs narratively in case studies[157]. This technique is critical in understanding the underlying causal mechanism[158]. The technique is iterative, following a series of iterations that develops tentative propositions and alters them according to the data collected until the researcher reaches an explanation [159]. At every stage of data collection, the data were compared with the theoretical predictions until the tentative propositions reflected the findings in the data.

[156] Yin, *Case Study Research and Applications*, 228; George and Bennett, *Case Studies, and Theory Development in the Social Sciences*.
[157] Yin, *Case Study Research and Applications*, 228.
[158] Diana Panke, *Research Design and Method Selection : Making Good Choices in the Social Sciences* (Sage Publications Ltd (UK), 2018), 264.
[159] Yin, *Case Study Research and Applications*, 230.

5. Results

5.1 Formation and Shutdown

TradeLens is an open and neutral supply chain platform launched jointly by International Business Machines (IBM) and Maersk in 2018. Maersk announced the shutdown of the venture in November 2022, citing failure to reach a level of commercial viability necessary for a business. The platform had initial success in boarding up to 60% of the global ocean carriers like CMA-CGM, APL, ANL, CNC, Korea Marine Transport Company (KMTC), Ocean Network Express (ONE), Mediterranean Shipping Company (MSC), Seaboard Marine, Boluda, Pacific International Lines (PIL), ZIM, Namsung, Hamburg Sud, Safmarine and Hapag-Lloyd who joined as anchor carriers. Additionally, over 26 custom clearance authorities, 126 inland deport, and 19 trade finance institutions were on board and in the process of onboarding by the time TradeLens shut down.

5.2 Objectives

TradeLens sought to develop a supply chain technology platform to benefit the entire industry. This solution would help to connect the fragmented supply chain ecosystem by providing a trustworthy and secure environment for information sharing. Sharing information would, in turn, assist various supply chain actors in lowering costs, becoming more efficient, and providing better customer service.

5.3 Pricing

The platform has two participants: network members and TradeLens clients. Network members included ocean carriers, ports and terminals, intermodal operators, and government authorities. They were tasked with providing and accessing information but did not incur the service cost. TradeLens clients include shippers and beneficial cargo owners, freight forwarders and third-party logistics parties, and financial service providers like trade finance and insurance. Clients pay between eight to twenty dollars per container, depending on the level of services they need to access.

Further, the eBL cost twenty-five dollars. It is unclear how much the platform charged for trade finance services. Additionally, how much the anchor shipping companies contributed to running the platform remains unclear.

5.4 Technology

The platform relied on permissioned and private blockchain that allows parties to upload, view, edit and use specific data permissioned to the party. TradeLens achieves this through a unified permissioned matrix shown below, where the different actors are known and have their cryptographic identities. The platform uses the open-source permissioned Hyperledger Fabric, which offers immutability, privacy, and traceability of shipping documents.

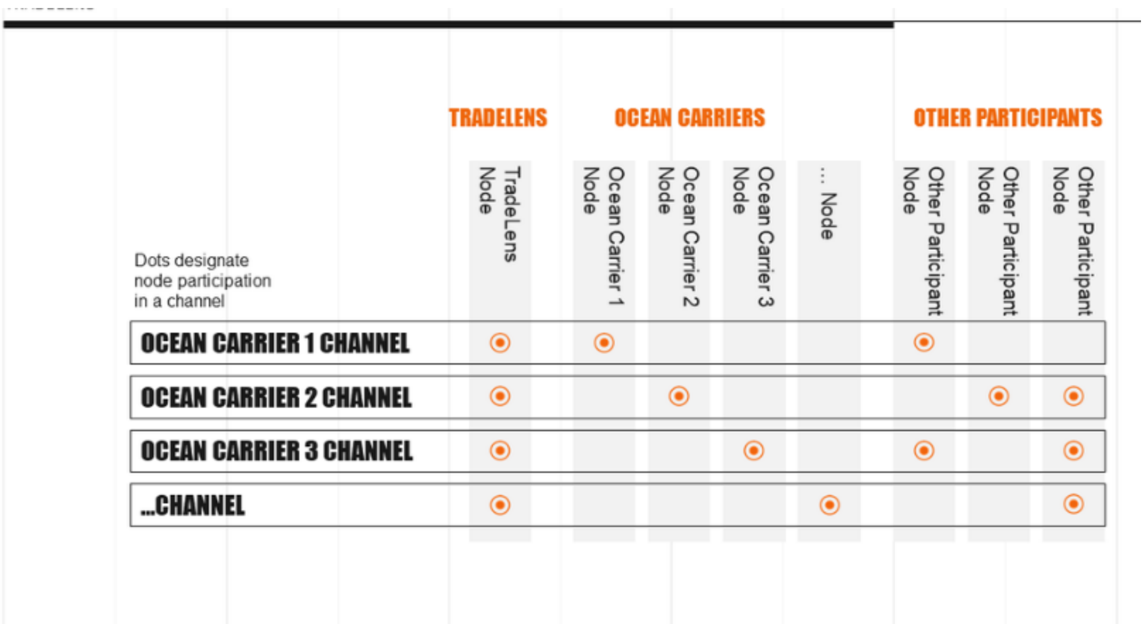


Figure 4: Shows the different blockchain nodes and TradeLens channel to access the information shared. The illustration is adopted from the IBM website[160].

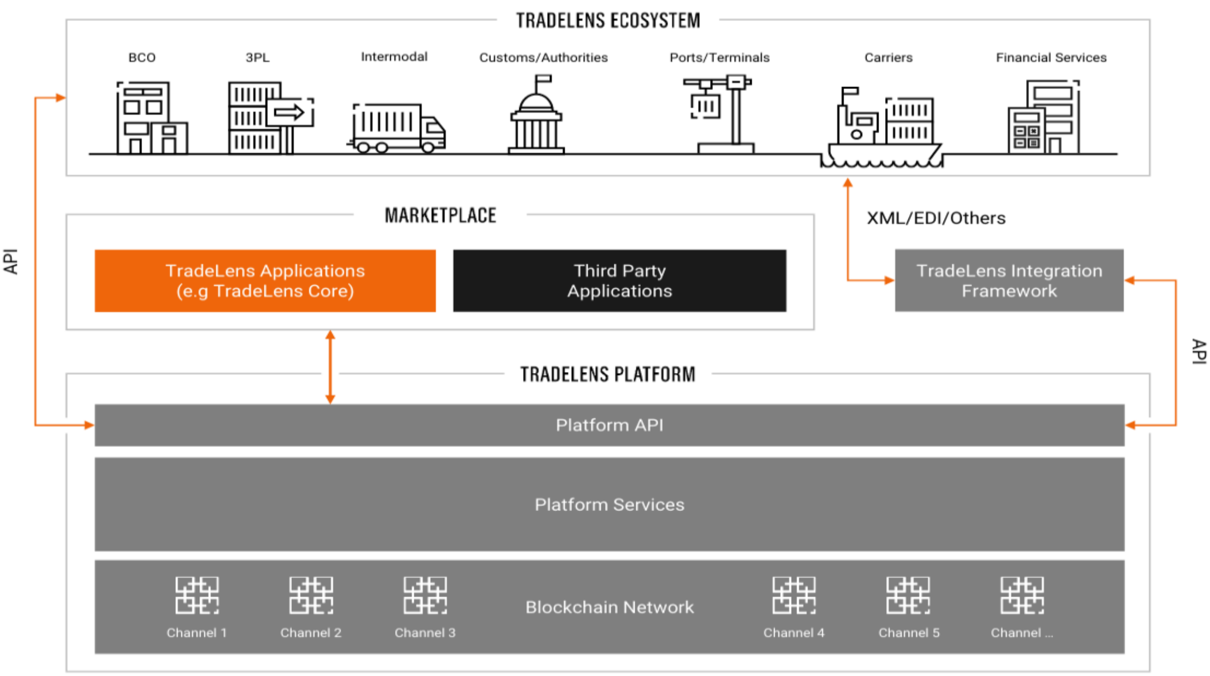
In the TradeLens, each ocean carrier hosts and manages a blockchain node offering the blockchain platform and allowing document sharing. The documents shared by a participant on one node are accessible to others via the TradeLens channel, depending on the level of permissions. The documents shared on the platform include sea waybill, commercial invoice, packing list, booking request, booking confirmation, shipping instructions, export declaration, bill of lading pro-forma invoice, arrival notice, import declaration, health certificate, phytosanitary certificate, veterinary certificate, fumigation certificate, inspection certificate, certificate of analysis, certificate of origin and dangerous goods declaration.

[160] TradeLens, 'About TradeLens | TradeLens', 2023, https://www.tradelens.com/about.

Events	Transport Service Buyer	Consignor	Consignee	Origin 3PL Agent	Destination 3PL Agent	Export Customs Broker	Import Customs Broker	Request Party	Import Authority	Transport Service Provider	Origin Marine Terminal
Planned stuffing start	○	◉	○	◉	○	○	○	○	○	○	◉
Planned stuffing completed	○	◉	○	◉	○	○	○	○	○	○	◉
Actual loaded on truck	○	○	○	◉	◉	○	○	○	○	◉	○
Estimated gate out	○	○	○	◉	◉	○	○	○	○	◉	◉
Actual gate in	○	○	○	◉	◉	○	○	○	○	◉	◉
• • •											
Documents											
Booking Confirmation	○	○	○	○	○	○	○	○	○	◉	◌
Shipping Instructions	○	◉	○	○	○	○	○	◉	○	○	◌
Bill of Lading	○	○	○	○	○	○	○	○	○	◉	◌
Sea Waybill	○	○	○	○	○	○	○	○	○	◉	◌
House Bill of Lading	○	○	○	◉	○	○	○	○	○	◉	◌
• • •											

◉ Participant has an obligation to provide (publish) the data, where relevant/applicable
○ Participant has read access (can subscribe) to the data
◌ Participant has no access to the data

Figure 5 shows TradeLens permissioned matrix adopted from the IBM website[161].



[161] 'TradeLens Overview' (IBM, 2021), https://www.ibm.com/downloads/cas/AAREDOBM.

Figure 5: TradeLens solutions architecture adopted from the IBM website[162].

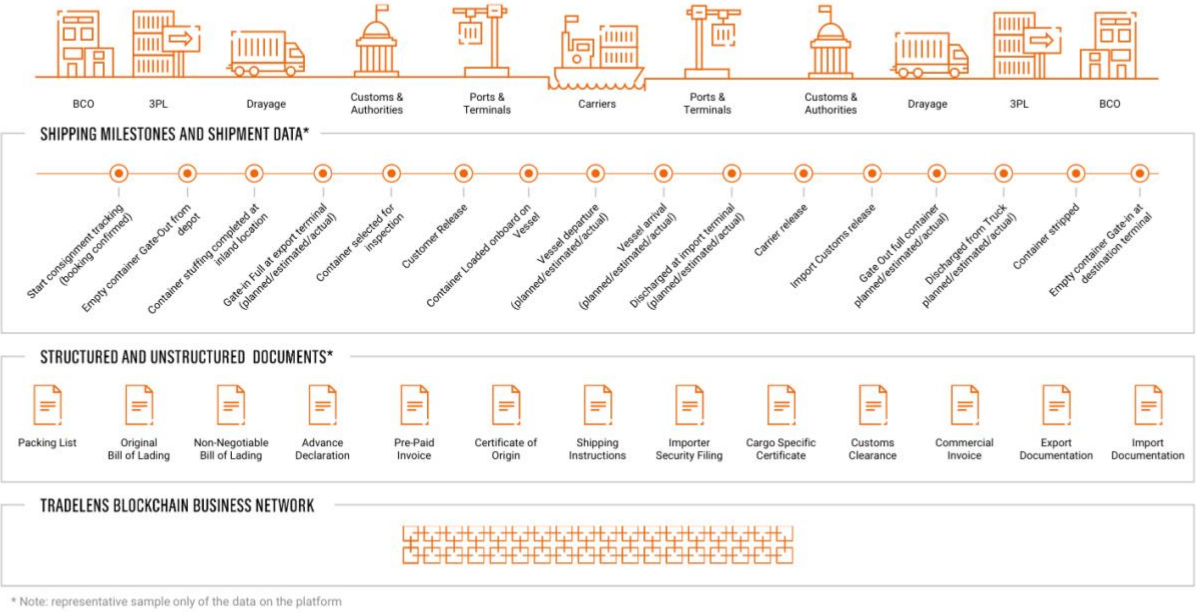


Figure 6: Simplified TradeLens platform business network adopted from the IBM website[163].

5.5 Standards and Interoperability

The platform is based on the UN/CEFACT standards, which define three objectives as units of global trade, shipments, consignments, and transport equipment. The firm further addresses industry interoperability by creating the API, which allows integration and sharing of actual data, reduces EDI costs and allows creativity.

[162] TradeLens, 'About TradeLens | TradeLens'.
[163] 'TradeLens Overview'.

6. **Analysis**

6.1 Proposition 1:

The literature review shows that blockchain attributes like immutability, resilience, decentralisation, distributedness, security, and privacy helps create trust in the blockchain network[164]. The trust, in turn, facilitates information sharing, creating efficiency and cost reduction. TradeLens case shows a similarity with this prediction. TradeLens was able to use blockchain to foster trust among the different supply chain actors and allow sharing of the permissioned information, ultimately lowering supply chain costs. Blockchain helped with securing the data, creating transparency and being auditable.

Permissioned access meant only allowed parties could access specific data points (Figure 5). This permission matrix created a trustworthy information-sharing environment. All the interviewees mentioned trust as a critical advantage of blockchain facilitating adoption. Further, documents from the adopters show that trust is a vital advantage of the technology.

For example, Interviewee 4 mentions that the most significant advantage of using blockchain in the supply chain is that it brings trust among the various stakeholders.

CMA-CGM's website show that TradeLens provides advanced visibility digitised supply chain ecosystem in a fully secure environment. Additionally, TradeLens will expand visibility, streamline processes, enhance collaboration, and save time and cost in shipping[165].

Additionally, the fact that TradeLens initially signed up governments, customs agencies, ports, terminals, intermodal operators, and up to 60% of the shipping sector supports this claim. Each actor had a duty to share the information shown in Figure 5. Here, the assumption is that the parties benefit from sharing their data on the platform and that they first trust it sufficiently.

---

[164] Finck, *Blockchain Regulation and Governance in Europe*, 2018; Werbach, 'Trust, but Verify'; De Filippi and Wright, *Blockchain and the Law*; Kongmanas Yavaprabhas, Mehrdokht Pournader, and Stefan Seuring, 'Blockchain as the "Trust-Building Machine" for Supply Chain Management', *Annals of Operations Research*, 5 August 2022, https://doi.org/10.1007/s10479-022-04868-0.

[165] CMA CGM, 'CMA CGM| Digitalize Your Global Supply Chain with TradeLens', 28 July 2021, https://www.cma-cgm.com/news/3847/digitalize-your-global-supply-chain-with-tradelens?cat=ebusiness.

The literature review adequately addressed the potential of blockchain in reducing trading costs in the supply chain[166]. The trusted information sharing brought many benefits to the different supply chain actors. The cost reduction was majorly in three ways. First, the availability of quality information means fewer administrative hours spent searching for information before blockchain information about various shipping events was shared via phone calls, EDI, emails, or Extensible Markup Language (XML). TradeLens reduces this cost by availing the data in almost real-time. For example, Drac Logistics shows that each of their employees spent close to 2 hours every morning on calls and emails tracking different shipping, and this changed with TradeLens[167].

The second way is that the information could be used in decision-making, reducing costs related to the uncertainty of supply chain information. For example, Van Den Ban, a global tyre wholesaler, claims to have saved up to $300,000 a year in demurrage and detention (D&D) costs with information shared about their shipping[168].

The third way relates to the fact that the availability of information makes supply chain processes like verification, networking, payment, and customs easy and timely, reducing unnecessary costs incurred. For example, Canada Border Service Agency simplified the entry process after onboarding using TradeLens[169].

Whereas the advantages of blockchain technology helped with the adoption of the technology, the platform also attracted members due to the network effects. Anyone joining the platform can access more data from the vast network. This factor was crucial for actors interacting with multiple service providers on the supply chain. An example is an intermodal carrier that works with various ocean carriers. Interviewee 2 mentions that at the formative stages of the platform, IBM had to convince Maersk to onboard the competitors to make the platform have a better value.

Finally, TradeLens used blockchain to facilitate the deployment of electronic bill of lading (eBL) to benefit the members. The eBL is a document central to international trade as it confers ownership. TradeLens creates great value by offering close to real-time eBL. This significantly reduced the delays associated with paper in the supply chain.

---

[166] Schmidt and Wagner, 'Blockchain and Supply Chain Relations'; Christian Catalini and Joshua S Gans, 'Some Simple Economics of the Blockchain', 2019.
[167] TradeLens, 'About TradeLens | TradeLens'.
[168] TradeLens.
[169] Hyperledger, 'Computer Business Review: Canada Border Services Agency Begins Pilot Using Blockchain – Hyperledger Foundation', 1 November 2018, https://www.hyperledger.org/news/2019/01/15/11-1-2018-computer-business-review-canada-border-services-agency-begins-pilot-using-blockchain.

For example, Avant, a shrimp exporting companying, shows that the TradeLens eBL helped the company avoid delayed, lost and stolen paper bills of lading. Further, eliminating the air courier of bills of lading saved the firm around fifty dollars per bill of lading[170].

Thus there is evidence that TradeLen's performance was relatively more advantageous than the existing solutions in the market hence the early adoption. The lack of performance expectancy on the platform does not explain the failure of TradeLens. On the contrary and as predicted by Proposition 1, the performance expectancy is the strongest explanation of the adoption. Nevertheless, it does not necessarily explain the failure of adoption.

Interviewee 1 states, *"Technology is the least of the problems in the TradeLens case in failure of TradeLens."*

6.2 Proposition 2:

As predicted by the literature review, the cost of TradeLens can be viewed as a barrier to its adoption and spread[171]. The cost impact is twofold: set-up costs and operational costs. TradeLens was a joint venture between Maersk and IBM. However, to achieve their objective of industry-wide adoption, TradeLens had to bring onboard other "anchor shippers" on the network as members together with customs authorities, intermodal carriers, ports, and terminals as opposed to clients.

According to the TradeLens pricing model, network members like ocean carriers were not charged per shipping. Additionally, ocean carriers were privileged to contribute to governance decisions. This is implied by Hapag-Lloyd in their joining statement when they state that "TradeLens was jointly developed by IBM and A.P. Moller–Maersk, with strong input from participating global shipping carriers, to accelerate the digitisation of maritime supply chains."[172] Interviewee 2 states that anchor shippers were to compensate the initial investors for being included in the platform's governance, and the cost was too high, leading to a disagreement.

The second cost is the operational related to running the platform and charged to clients of the platform. Blockchain networks are expensive to maintain. The managers of the platform pass the cost to the platform's clients. This cost is predicted in the literature and came up in all the interviews conducted as a potential reason that TradeLens shut down and thus has enough

[170] TradeLens, 'About TradeLens | TradeLens'.
[171] Ramachandran et al., 'Blockchain in Supply Chain'; Shi, Iakovou, and Iacopella, 'Transforming Trade and Ensuring Global Supply Chain Security with Blockchain and Smart Contracts'.
[172] 'Hapag-Lloyd' (Hamburg, 24 June 2021), https://www.hapag-lloyd.com/en/company/press/releases/2021/06/hapag-lloyd-joins-tradelens-platform.html.

evidence from the perspective of potential adopters. Additionally, the GSBN CEO blames the platform's failure on the focus on profit [173].

Interviewee 1 notes, *"It is hard for such a solution to scale, especially among SMEs, given the cost".*

However, interviewee 2 argues, "*The cost of tracking a container using TradeLens should be compared with what value it brings. First, you get to know exactly where your goods are. Second, the transportation of the goods will go smoother as the track does not miss the ship. Third, many costs at the port related to customs, waiting time, and track-ship connections can be optimised by TradeLens. Costs related to accessing documents with the information needed at the port can be stored in TradeLens. I think the benefits outweigh the cost".*

Adopters back this argument by stating that TradeLens lowers both time and cost of trade. For example, NKG, a European company that imports coffee from Brazil, claims TradeLens helped reduce courier fees of up to 50 monthly shipments. Peter Stockhammer, Puma, Senior Manager notes,

TradeLens has helped generate process efficiency savings of approximately eight hours per week. We are delighted with TradeLens notifications. It allows us to move from a reactive to a proactive decision-making process. TradeLens is fully integrated into our daily customs operations, and the team does not see themselves returning to the old way of working[174].

Interviewee 3 raised concerns about who pays the cost and the distribution of the benefits and value.

"Does the payer directly capture the benefits, or are they being spread and captured by multiple actors, some who do not have to pay."

Interviewee 4 notes,

"Despite the value TradeLens offered, the current supply chain actors are used to the current type of working, which impacts how they see the platform's value."

[173] Ledger Insights Ledger, 'Shipping Network GSBN Responds to TradeLens Blockchain Shutdown', *Ledger Insights - Blockchain for Enterprise* (blog), 7 December 2022, https://www.ledgerinsights.com/shipping-gsbn-tradelens-blockchain-shutdown/.

[174] TradeLens, 'About TradeLens | TradeLens'.

Literature review shows that cost affects how potential adopters view and evaluate technology's advantages[175]. Interviewee 2 acknowledges that blockchain is costly. If they were to do it again, they would advocate for using other technology. They will use blockchain in critical information sharing like eBL only. Adding that, towards the end, TradeLens was moving some of its operations out of blockchain.

Finally, interviewee 3 mentions that being part of a public blockchain infrastructure is cheaper than the enterprise blockchain model limiting adoption. This view came up across the interviewees that blockchain use should be limited to essential areas like the eBL that other cheaper technologies cannot, given the cost.

Therefore, in TradeLens, the cost of the technology plays a critical role in explaining the limited adoption. However, the data collected miss the views of potential adopters that could not adopt the technology due to cost implications.

Additionally, it is hard to measure the cost of the technology and the value it presents to the adopters. Cost is easy to follow, while the value can be spread over time and less accurately understood. For example, if a blockchain solution helps prevent a delay in delivery or fraud, it is hard to account for such instances. Rogers demonstrates that adoption rates of preventive technologies are slow as their relative advantages are not apparent to potential adopters[176]. Thus, there is a need for further research on this construct's effect on adoption, given the limitations of the thesis.

6.3 Proposition 3:

From the literature review, blockchain technology is nascent and expected to be complex[177]. However, TradeLens, in this case, internalises the blockchain's complexity and provides a simple interface for the different stakeholders. The case data was in line with the theoretical predictions. For example, Interviewee 4 confirmed that although not many companies' personnel understand blockchain as a technology, they are attracted by its value proposition.

[175] Venkatesh, Thong, and Xu, 'Consumer Acceptance and Use of Information Technology'; Zeithaml, 'Consumer Perceptions of Price, Quality, and Value'.
[176] Rogers, *Diffusion of Innovations, 5th Edition*, 274.
[177] Davis, 'Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology'.

TradeLens reduces complexity in two ways: First, IBM's technical team deals with blockchain technology and offers third-party access to the network members and clients (see Figure 6). The blockchain network supported the platform services, and the adopter could gain access to them via an API or a website. The platform could connect to existing technology, such as ERP and EDI, as shown in Figure 6. Clients confirmed TradeLens' compatibility with existing technological options in the supply chain ecosystem.

Interviewee 2 notes that "*In TradeLens, blockchain was behind the curtains. Although the data was stored on a blockchain, all the user needed was to type the container number. IBM ensured that the documents could be stored and retrieved from the blockchain and that the nodes worked. As others are concerned, it could also be any other technology.*"

A view shared with interviewee 4 noting, "*In TradeLens, there is a clear demarcation of the different roles actors play in the network. Not everyone needs to have a node as third-party access is possible.*"

Further, Sunghub Song, Team Lead at Highland Foods Company, notes that *"Through the TradeLens API integration, we can perform auto data synchronisation into our EDI system three times a day, which enables more effective inventory management. We can also better plan our warehouse schedule at the bonded area via real-time Estimated Time of Arrival (ETA) updates and notifications to the task owners."*

Second, TradeLens reduces complexity through training. There is evidence that TradeLens conducted training on using their platform for the different members of the supply chain ecosystem. However, it is hard to gather data from potential adopters that did not join because of the complexity. Most of the data collected on the case reflects the views of well-established firms with the necessary resources to potentially deal with the technology's complexity. However, from the data collected and the literature review, it remains clear that complexity does not adequately address the failure of TradeLens.

6.4 Proposition 4:

In terms of facilitating conditions, the literature makes two predictions. First, the architecture similarities between blockchain and supply chain, compatibility of supply chain needs and blockchain solutions, and the availability of existing solutions that work with blockchain facilitate blockchain technology adoption[178]. Second, environmental factors like lack of standards and international legal and regulatory framework will negatively affect the adoption of blockchain technologies in the supply chain ecosystem[179].

Supply chain architecture is highly fragmented, decentralised, and distributed, with different actors and spans multiple jurisdictions. This architecture highly resembles blockchain. Thus, the application is compatible. In line with the Chang et al. predictions, blockchain offers value consistent with supply chain actors' needs[180]. These include transparency, traceability, digitalisation, cargo integrity, compliance, and stakeholder management.

Proposition 1 addresses the advantages of TradeLens to network members and clients. Finally, supply chain existing technology like ERP, EDI and XML is compatible with blockchain as it already utilises data and can be linked using APIs, as shown in Figure 5. This compatibility is confirmed by Highland Foods Company, as shown under discussion in proposition 3.

Interviewee 3 raises the challenge that supply chain and blockchain are incompatible as it is hard to be fully digital in an analogue world. This challenge is based on a lack of global standards and legal and regulatory frameworks facilitating the use of blockchain, affecting its adoption. Although there is slow adoption, there are efforts to develop standards for using digital technologies in international trade and supply chains that might be useful to the blockchain. This prediction is backed by interviewees 1, 2 and 5. The standards and international laws include URDTT, MLETR and ISO 8000. Regarding standards, there is no evidence that TradeLens was interoperable with other blockchain-based consortia like GSBN, although both claim to have international and open standards.

[178] Ramachandran et al., 'Blockchain in Supply Chain'; Chang, Iakovou, and Shi, 'Blockchain in Global Supply Chains and Cross Border Trade'; De Filippi and Wright, *Blockchain and the Law*.
[179] Werbach, 'Trust, but Verify'; De Filippi and Hassan, 'Blockchain Technology as a Regulatory Technology'; Ganne, 'Blockchain for Trade'.
[180] Chang, Iakovou, and Shi, 'Blockchain in Global Supply Chains and Cross Border Trade'.

Finally, TradeLens encountered difficulties when navigating different legal jurisdictions. The problems were primarily related to the eBL. According to Interviewee 2, in some EU countries, submitting paper documents rather than digital copies is still necessary while countries like Canada were open to using TradeLens because it provided all the essential data points and more.

Interviewee 5 elaborates that there exist standards that could facilitate the use of blockchain in the supply chain, but there is limited adoption and use of the standards. These standards include ISO8000-117 and ISO8000-115, which offer standards on quality data identifiers between physical goods and data stored on the blockchain. The electronic trade document bill in the UK[181] gives digital transactions a similar legal standing to paper documents.

Thus, enterprise blockchain faces limited facilitating conditions in the supply chain ecosystem. However, the data collected does not show that this is the most crucial explanation for the failure of TradeLens. For example, interviewee 2 notes that most port entrances and customs, like Canada, were receptive to TradeLens data. The challenge here is not necessarily for TradeLens but for its value for customs. If a customs authority is fully integrated, it has more value than when only the information must be converted back to paper documents.

Although there is evidence that TradeLens faced challenges based on limited facilitating conditions, its factor does not adequately explain the platform's failure. TradeLens initially achieved success in what is considered a rather hostile legal framework compared to the one during its failure, as there is constant development in the area, although slow. Second, other platforms like GSBN operate on the current legal and regulatory landscape. However, it contributed to the failure as the entity could not scale where there were legal challenges.

[181] 'Electronic Trade Documents Bill [HL]' (2023), https://publications.parliament.uk/pa/bills/cbill/58-03/0280/220280.pdf.

6.5 Proposition 5:

Governance theoretically affects the adoption at two levels—the governance of the blockchain (on-chain) technology and the governance of the network (off-chain)[182]. Further, governance relates to decision-making, accountability and incentives[183]. Whereas there is limited evidence of on-chain governance challenges, off-chain challenges predicted were reflected in the case. The internalisation of blockchain complexities discussed in Proposition 3 can explain the lack of on-chain governance.

However, in line with the predictions on the effects of off-chain governance, the alignment of incentives presented a significant challenge in TradeLens.

Interviewee 2 raised a compelling argument on off-chain governance of the platform as one of the reasons for the failure by noting that "*misalignment of visions and incentives especially among the anchor carriers on the platform's vision is a critical explanation on the failure of TradeLens".*

Interviewee 2 says that in the beginning, IBM and Maersk made all the governance decisions but had a vision of an industry-wide solution that required the onboarding of the competitors. However, this meant that, unlike other clients, the anchor shipping companies demanded to be part of the governance mechanism, a decision that Maersk and IBM granted through the carrier board that helped the competitors act as one company. This argument is backed up by the fact that the shipping companies are identified as "anchor shipping companies" on the network. Further, the Hapag-Lloyd website gives a similar account[184] .

The idea was that with time the shipping companies would compensate Maersk and IBM for the initial cost. However, as joint governance, they had three disagreements that led to a fallout of the platform. The first disagreement was on the investment in the ocean terminal user interface, while others wanted to invest in the air terminal user interface. Second, some founding members wanted TradeLens to offer end-to-end services. This vision was not aligned with some of the ocean carriers on the platform with clients in that business, and some clients hoped TradeLens would remain an ocean carrier solution. Finally, some shippers already

---

[182] Reijers et al., 'Now the Code Runs Itself'.
[183] Beck, Müller-Bloch, and King, 'Governance in the Blockchain Economy'.
[184] 'Hapag-Lloyd' (Hamburg, 24 June 2021), https://www.hapag-lloyd.com/en/company/press/releases/2021/06/hapag-lloyd-joins-tradelens-platform.html.

offered an eBL, and TradeLens tried offering the same. All these disagreements were seen as a denial of revenue opportunities by competitors.

Thus, IBM and Maersk felt they were not entirely making the returns on investments for the cost they incurred. Interviewee 4 raises the issue of return on investment, an argument backed by the TradeLens final statement about shutting down the platform. Interviewee three equally presents the platform's governance as a significant challenge noting that since TradeLens was a Blockchain as a Service (BaaS), the founders expected to get income from the platform. Since there seems to be a denial of revenue by the competitor, the platform could not meet its commercial expectations.

This factor offers a potential explanation for the failure of TradeLens. The timing of the failure backs the factor. Since 2018 TradeLens has attracted many potential adopters, but the platform shut down in 2022. The critical governance issue in TradeLens is misaligned incentives and is linked to two factors: the size of the consortium and the highly competitive market structure.

7. Discussion and Conclusion

The thesis uses the UTAUT model to show that despite its immense potential benefits, enterprise blockchain solutions' adoption, use and diffusion in the supply chain remain low. Blockchain can positively impact the supply chain by eliminating the need for an intermediary, guaranteeing shared truth, and offering trust among the network members. These attributes facilitate information sharing among the different actors in the supply chain network, reducing costs like information, verification, and networking. Other benefits of blockchain relate to security, traceability, visibility, and better customer service.

Whereas EBC can bring onboard members of the supply chain industry, there are limitations that the model must overcome. Already, the consortium has done well in offering value to potential adopters of the innovation in a simple, understandable way. However, the major challenge remains. First is the cost of setting up and using blockchain. TradeLens used blockchain to support many functions, making the platform costly. Expert interviews point out that blockchain can be used with other technology and in limited use to reduce the cost of setting up and running the platform. Further, public blockchain could be considered for use in the supply chain but with a backing of a neutral actor that can guarantee trust and together with other technologies that can safeguard privacy.

Second is the challenge of navigating fragmented and overlapping international standards. This emerged as a challenge, especially in adopting the eBL in TradeLens. The solution to this challenge lies in international policy and regulatory coordination that can facilitate the adoption and use of blockchain in the supply chain. There are existing initiatives. However, they face slow adoption, and there is a lack of commitment by nations. However, in some countries, customs authorities, ports, and terminals are pushing the adoption of blockchain to support the implementation of single windows. These changes can factor the interoperability with initiatives like TradeLens.

Third is the novel challenge that comes with governing the consortium. Decision-making, accountability, and incentives are vital to the success of an EBC. In the case of TradeLens, there is evidence that an increase in the size of a consortium creates a challenge in aligning the incentives of different actors who, in some situations, are competitors.

7.1 Practical Implications

These findings mean blockchain solutions could do more in niche situations within actors with specific incentives than in industry-wide solutions. Further, the setting up and running of blockchain consortia should be done genuinely industry-wide with a multistakeholder approach. TradeLens banked on Maersk while aiming to bring on board the competitors. This proved a challenging endeavour.

The thesis sheds light on the potential drivers and barriers to using EBC solutions in the supply chain. For the sponsors of EBC, the thesis implies that they must consider costs and governance while setting up and operating the platforms in addition to their platforms' performance and effort expectations. The development of blockchain solutions can be limited to niche areas where the technology is needed, and where cheaper alternatives exist, there should be complementarity. This implementation will reduce the cost of implementing blockchain solutions while retaining the advantages the technology offers to the different stakeholders.

Governments must work on standards and international legal frameworks to support the adoption. The lack of an international legal and regulatory framework inhibits the adoption of blockchain in the supply chain, and international trade and governments must work towards a global framework. Similarly, the different actors should adopt the existing standards to enable interoperability.

7.2 Theoretical Implications

The thesis uses the UTAUT model to analyse blockchain technology adoption and diffusion. There is limited research and understanding of the failure factors that limit the adoption and diffusion of blockchain. Whereas the UTAUT model is one of the most used models in analysing the acceptance of technologies, it requires contextualisation. The thesis identifies cost and governance variables as critical in explaining the failure and adoption of EBC in the supply chain. The UTAUT model in the consumer context already covers price value as a factor affecting technology acceptance. The thesis explains how governance affects enterprise blockchain's acceptance, use and diffusion in a supply chain context. Empirical results from the thesis demonstrate that decision-making, accountability, and incentives are vital as governance items affecting the adoption. The size of a consortium complicates the governance items, and thus size might impact the governance challenges.

7.3 Limitations and Future Opportunities

The thesis aimed to explain how and why EBC fails to diffuse in the supply chain context. The empirical evidence gathered from the interviews, informal conversations, and secondary data like TradeLens documentation shed light on the research question with some limitations. First, the expert interviews need to be expanded to incorporate a diverse range of supply chain actors. Second, whereas a single case study helps create an in-depth understanding of a phenomenon, there is a need for more cases to understand the underlying causal mechanisms better. Third, according to Fosso Wamba and Queiroz, generalizations from findings must be carefully considered due to the scarcity of literature on blockchain adoption in the supply chain sector[185]. However, these limitations, the scarcity of literature, limited empirical research, and the technology's nascency present an opportunity for future research.

[185] Samuel Fosso Wamba and Maciel M. Queiroz, 'The Role of Social Influence in Blockchain Adoption: The Brazilian Supply Chain Case', *IFAC-Papers Online* 52, no. 13 (2019): 1715–20, https://doi.org/10.1016/j.ifacol.2019.11.448.

Annex

1. In-depth Expert Interviews

Interviewee	Organization	Role	Date	Means
1	Hyperledger Fabric	Supply Chain and Trade Finance Expert	27/04/2023	Google Meet
2	IBM/TradeLens	Digital Technology Expert and TradeLens Core Team	01/05/2023	Zoom
3	A blockchain in supply chain consultancy company*	Blockchain and Supply Chain Consultant	02/05/2023	Microsoft Teams
4	Blockchain Supply Chain Association	Supply Chain and Trade Finance Blockchain Expert	03/05/2023	Zoom
5	Electronic Commerce Code Management Association (ECCMA)	Blockchain and Digital Supply Chain Standards	03/05/2023	Zoom

BIBLIOGRAPHY

Agi, Maher A. N., and Ashish Kumar Jha. 'Blockchain Technology in the Supply Chain: An Integrated Theoretical Perspective of Organizational Adoption'. *International Journal of Production Economics* 247 (1 May 2022): 108458. https://doi.org/10.1016/j.ijpe.2022.108458.

Allen, Darcy W. E., and Chris Berg. 'Blockchain Governance: What We Can Learn from the Economics of Corporate Governance'. *The Journal of The British Blockchain Association*, 30 March 2020. https://doi.org/10.31585/jbba-3-1-(8)2020.

Allen, Darcy W.E., Chris Berg, Sinclair Davidson, Mikayla Novak, and Jason Potts. 'International Policy Coordination for Blockchain Supply Chains'. *Asia & the Pacific Policy Studies* 6, no. 3 (September 2019): 367–80. https://doi.org/10.1002/app5.281.

Ashford, Nicholas Askounes, and Ralph P. Hall. *Technology, Globalization, and Sustainable Development: Transforming the Industrial State*. New Haven, Conn. ; London: Yale University Press, 2011.

Beck, Roman, Christoph Müller-Bloch, and John Leslie King. 'Governance in the Blockchain Economy: A Framework and Research Agenda'. *Journal of the Association for Information Systems*, 2018, 1020–34. https://doi.org/10.17705/1jais.00518.

Berg, Chris. 'What Diplomacy in the Ancient Near East Can Tell Us About Blockchain Technology'. *Ledger* 2 (18 December 2017): 55–64. https://doi.org/10.5195/ledger.2017.104.

Bernhofen, Daniel M., Zouheir El-Sahli, and Richard Kneller. 'Estimating the Effects of the Container Revolution on World Trade'. *Journal of International Economics* 98 (1 January 2016): 36–50. https://doi.org/10.1016/j.jinteco.2015.09.001.

Browne, Ryan. 'There Were More than 26,000 New Blockchain Projects Last Year – Only 8% Are Still Active'. *CNBC*, 9 November 2017. https://www.cnbc.com/2017/11/09/just-8-percent-of-open-source-blockchain-projects-are-still-active.html.

Buterin, Vitalik. 'Ethereum: A Next-Generation Smart Contract and Decentralized Application Platform.', 2014.

———. 'On Public and Private Blockchains'. *Ethereum Foundation Blog* (blog), 2015. https://blog.ethereum.org/2015/08/07/on-public-and-private-blockchains.

Caiazza, Rosa. 'A Cross-National Analysis of Policies Affecting Innovation Diffusion'. *The Journal of Technology Transfer* 41, no. 6 (1 December 2016): 1406–19. https://doi.org/10.1007/s10961-015-9439-2.

Catalini, Christian, and Joshua S Gans. 'Some Simple Economics of the Blockchain', 2019.

Catalini, Christian, and Joshua S. Gans. 'Some Simple Economics of the Blockchain'. *Communications of the ACM* 63, no. 7 (18 June 2020): 80–90. https://doi.org/10.1145/3359552.

Chan, Kwok Yue, Min Gong, Yan Xu, and James Thong. 'Examining User Acceptance of SMS: An Empirical Study in China and Hong Kong', 2008.

Chang, Yanling, Eleftherios Iakovou, and Weidong Shi. 'Blockchain in Global Supply Chains and Cross Border Trade: A Critical Synthesis of the State-of-the-Art, Challenges and Opportunities'. *International Journal of Production Research* 58, no. 7 (2 April 2020): 2082–99. https://doi.org/10.1080/00207543.2019.1651946.

Christensen, Clayton M. *The Innovator's Dilemma: The Revolutionary Book That Will Change the Way You Do Business ; [with a New Preface]*. 1. Harper Business paperback publ. New York, NY: Harper Business, 2011.

Clarke, George, Scott Wallsten, and World Bank. *Has the Internet Increased Trade? Evidence from Industrial and Developing Countries*. World Bank Publications, 2004. https://doi.org/10.1596/1813-9450-3215.

CMA CGM. 'CMA CGM| Digitalize Your Global Supply Chain with TradeLens', 28 July 2021. https://www.cma-cgm.com/news/3847/digitalize-your-global-supply-chain-with-tradelens?cat=ebusiness.

Compeau, Deborah, Christopher A. Higgins, and Sid Huff. ‘Social Cognitive Theory and Individual Reactions to Computing Technology: A Longitudinal Study’. *MIS Quarterly* 23, no. 2 (1999): 145–58. https://doi.org/10.2307/249749.
Davidson, Sinclair, Primavera De Filippi, and Jason Potts. ‘Blockchains and the Economic Institutions of Capitalism’. *Journal of Institutional Economics* 14, no. 4 (August 2018): 639–58. https://doi.org/10.1017/S1744137417000200.
Davis, Fred D. ‘Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology’. *MIS Quarterly* 13, no. 3 (1989): 319–40. https://doi.org/10.2307/249008.
De Filippi, Primavera, and Samer Hassan. ‘Blockchain Technology as a Regulatory Technology: From Code Is Law to Law Is Code’. arXiv, 8 January 2018. http://arxiv.org/abs/1801.02507.
De Filippi, Primavera, and Aaron Wright. *Blockchain and the Law: The Rule of Code*. Harvard University Press, 2018. https://doi.org/10.2307/j.ctv2867sp.
Dimitropoulos, Georgios. ‘The Law of Blockchain’. *SSRN Electronic Journal*, 2020. https://doi.org/10.2139/ssrn.3559970.
Electronic Trade Documents Bill [HL] (2023). https://publications.parliament.uk/pa/bills/cbill/58-03/0280/220280.pdf.
Epps, Tracey, Blake Carey, and Tess Upperton. ‘Revolutionizing Global Supply Chains One Block at a Time: Growing International Trade with Blockchain: Are International Rules Up to the Task?’, 2019.
Ferracane, Martina Francesca, and Hosuk Lee-Makiyama. ‘Digital Trade Restrictiveness Index’, 2022.
Finck, Michèle. *Blockchain Regulation and Governance in Europe*. Cambridge: Cambridge University Press, 2018. https://doi.org/10.1017/9781108609708.
———. *Blockchain Regulation and Governance in Europe*. Cambridge University Press, 2018.
Freund, Caroline L, and Diana Weinhold. ‘The Effect of the Internet on International Trade’. *Journal of International Economics* 62, no. 1 (1 January 2004): 171–89. https://doi.org/10.1016/S0022-1996(03)00059-X.
Frizzo-Barker, Julie, Peter A. Chow-White, Philippa R. Adams, Jennifer Mentanko, Dung Ha, and Sandy Green. ‘Blockchain as a Disruptive Technology for Business: A Systematic Review’. *International Journal of Information Management* 51 (April 2020): 102029. https://doi.org/10.1016/j.ijinfomgt.2019.10.014.
Ganne, Emmanuelle. ‘Blockchain for Trade: When Code Needs Law’ 115 (ed 2021): 419–24. https://doi.org/10.1017/aju.2021.64.
———. *Can Blockchain Revolutionize International Trade?* Geneva: World Trade Organization, 2018.
George, Alexander L., and Andrew Bennett. *Case Studies and Theory Development in the Social Sciences*. BCSIA Studies in International Security. MIT Press, 2005.
Gerring, John. *Case Study Research Principles and Practices*. Second edition. Strategies for Social Inquiry. Cambridge University Press, 2017.
Glaser, Florian. ‘Pervasive Decentralisation of Digital Infrastructures: A Framework for Blockchain Enabled System and Use Case Analysis’, 2017. https://doi.org/10.24251/HICSS.2017.186.
GmbH, micobo. ‘Technical Difference between Ethereum, Hyperledger Fabric and R3 Corda’. *Medium* (blog), 16 November 2018. https://micobo.medium.com/technical-difference-between-ethereum-hyperledger-fabric-and-r3-corda-5a58d0a6e347.
‘Hapag-Lloyd’. Hamburg, 24 June 2021. https://www.hapag-lloyd.com/en/company/press/releases/2021/06/hapag-lloyd-joins-tradelens-platform.html.
Helliar, Christine V., Louise Crawford, Laura Rocca, Claudio Teodori, and Monica Veneziani. ‘Permissionless and Permissioned Blockchain Diffusion’. *International Journal of Information Management* 54 (1 October 2020): 102136. https://doi.org/10.1016/j.ijinfomgt.2020.102136.
Hertig, Alyssa. ‘What Is an Enterprise Blockchain?’, 19 February 2021. https://www.coindesk.com/tech/2021/02/19/what-is-an-enterprise-blockchain/.
Hyperledger. ‘Computer Business Review: Canada Border Services Agency Begins Pilot Using Blockchain – Hyperledger Foundation’, 1 November 2018.

https://www.hyperledger.org/news/2019/01/15/11-1-2018-computer-business-review-canada-border-services-agency-begins-pilot-using-blockchain.
Insights Ledger, Ledger. ‘Shipping Network GSBN Responds to TradeLens Blockchain Shutdown’. *Ledger Insights - Blockchain for Enterprise* (blog), 7 December 2022. https://www.ledgerinsights.com/shipping-gsbn-tradelens-blockchain-shutdown/.
International Chamber of Commerce. ‘Uniform Rules for Digital Trade Transactions’, 2021. https://www.ccpit.org/image/1331845279825047554/73f151fe9623443ebbe223a4a2d324cd.pdf.
International Standards Organization (ISO). ‘ISO 8000-1:2022’. Accessed 13 May 2023. https://www.iso.org/standard/81745.html.
Janssen, Marijn, Vishanth Weerakkody, Elvira Ismagilova, Uthayasankar Sivarajah, and Zahir Irani. ‘A Framework for Analysing Blockchain Technology Adoption: Integrating Institutional, Market and Technical Factors’. *International Journal of Information Management* 50 (February 2020): 302–9. https://doi.org/10.1016/j.ijinfomgt.2019.08.012.
———. ‘A Framework for Analysing Blockchain Technology Adoption: Integrating Institutional, Market and Technical Factors’. *International Journal of Information Management* 50 (February 2020): 302–9. https://doi.org/10.1016/j.ijinfomgt.2019.08.012.
Jensen, Thomas, Ravi Vatrapu, and Niels Bjørn-Andersen. ‘Avocados Crossing Borders: The Problem of Runaway Objects and the Solution of a Shipping Information Pipeline for Improving International Trade’. *Information Systems Journal* 28, no. 2 (2018): 408–38. https://doi.org/10.1111/isj.12146.
Jovanovic, Marin, Nikola Kostić, Ina M. Sebastian, and Tomaz Sedej. ‘Managing a Blockchain-Based Platform Ecosystem for Industry-Wide Adoption: The Case of TradeLens’. *Technological Forecasting and Social Change* 184 (1 November 2022): 121981. https://doi.org/10.1016/j.techfore.2022.121981.
Juma, Calestous. ‘Gales of Creative Destruction’. In *Innovation and Its Enemies: Why People Resist New Technologies*, edited by Calestous Juma, 0. Oxford University Press, 2016. https://doi.org/10.1093/acprof:oso/9780190467036.003.0002.
Kamble, Sachin, Angappa Gunasekaran, and Himanshu Arha. ‘Understanding the Blockchain Technology Adoption in Supply Chains-Indian Context’. *International Journal of Production Research* 57, no. 7 (3 April 2019): 2009–33. https://doi.org/10.1080/00207543.2018.1518610.
Kaufman, Matt. ‘Consortium Capabilities for Enterprise Blockchain Success’. *The Journal of The British Blockchain Association* 4, no. 2 (1 October 2021): 1–12. https://doi.org/10.31585/jbba-4-2-(4)2021.
Kshetri, Nir. ‘1 Blockchain’s Roles in Meeting Key Supply Chain Management Objectives’. *International Journal of Information Management* 39 (1 April 2018): 80–89. https://doi.org/10.1016/j.ijinfomgt.2017.12.005.
———. ‘Blockchain’s Roles in Strengthening Cybersecurity and Protecting Privacy’. *Telecommunications Policy*, Celebrating 40 Years of Telecommunications Policy – A Retrospective and Prospective View, 41, no. 10 (1 November 2017): 1027–38. https://doi.org/10.1016/j.telpol.2017.09.003.
Lessig, Lawrence. *Code*. Version 2.0. Basic Books, 2006.
Lu, Weisheng, Liupengfei Wu, and Fan Xue. ‘Blockchain Technology for Projects: A Multicriteria Decision Matrix’. *Project Management Journal* 53, no. 1 (1 February 2022): 84–99. https://doi.org/10.1177/87569728211061780.
MacDonald, Trent. ‘Blockchains and the Boundaries of Self-Organized Economies- Predictions for the Future of Banking’, 2016.
Marikyan, Davit, Savvas Papagiannidis, Omer Rana, and Rajiv Ranjan. ‘THE ROLE OF PRIVACY AND SECURITY THREATS IN THE ADOPTION OF A BLOCKCHAIN’, 2021.

Moore, Gary C., and Izak Benbasat. ‘Development of an Instrument to Measure the Perceptions of Adopting an Information Technology Innovation’. *Information Systems Research* 2, no. 3 (1991): 192–222. https://www.jstor.org/stable/23010883.
Nash, Kim S. ‘Wal-Mart Turns to Blockchain For Tracking Pork In China’. *Wall Street Journal*, 19 October 2016, sec. CIO Journal. http://blogs.wsj.com/cio/2016/10/19/wal-mart-turns-to-blockchain-for-tracking-pork-in-china/.
Nodehi, Tahereh, Aneesh Zutshi, Antonio Grilo, and Belma Rizvanovic. ‘EBDF: The Enterprise Blockchain Design Framework and Its Application to an e-Procurement Ecosystem’. *Computers & Industrial Engineering* 171 (1 September 2022): 108360. https://doi.org/10.1016/j.cie.2022.108360.
Orji, Ifeyinwa Juliet, Simonov Kusi-Sarpong, Shuangfa Huang, and Diego Vazquez-Brust. ‘Evaluating the Factors That Influence Blockchain Adoption in the Freight Logistics Industry’. *Transportation Research Part E: Logistics and Transportation Review* 141 (1 September 2020): 102025. https://doi.org/10.1016/j.tre.2020.102025.
Panke, Diana. *Research Design and Method Selection : Making Good Choices in the Social Sciences*. Sage Publications Ltd (UK), 2018.
Petropoulou, Dimitra. ‘Information Costs and Networks in International Trade’. *CEPR*, 2005.
Queiroz, Maciel M., and Samuel Fosso Wamba. ‘Blockchain Adoption Challenges in Supply Chain: An Empirical Investigation of the Main Drivers in India and the USA’. *International Journal of Information Management* 46 (1 June 2019): 70–82. https://doi.org/10.1016/j.ijinfomgt.2018.11.021.
Ramachandran, Gowri Sankar, Sidra Malik, Shantanu Pal, Ali Dorri, Volkan Dedeoglu, Salil Kanhere, and Raja Jurdak. ‘Blockchain in Supply Chain: Opportunities and Design Considerations’. In *Handbook on Blockchain*, edited by Duc A. Tran, My T. Thai, and Bhaskar Krishnamachari, 541–76. Springer Optimization and Its Applications. Cham: Springer International Publishing, 2022. https://doi.org/10.1007/978-3-031-07535-3_17.
Rauchs, Michel, Apolline Blandin, Keith Bear, and Stephen B. McKeon. ‘2nd Global Enterprise Blockchain Benchmarking Study’. *SSRN Electronic Journal*, 2019. https://doi.org/10.2139/ssrn.3461765.
Reijers, Wessel, Iris Wuisman, Morshed Mannan, Primavera De Filippi, Christopher Wray, Vienna Rae-Looi, Angela Cubillos Vélez, and Liav Orgad. ‘Now the Code Runs Itself: On-Chain and Off-Chain Governance of Blockchain Technologies’. *Topoi* 40, no. 4 (September 2021): 821–31. https://doi.org/10.1007/s11245-018-9626-5.
Risius, Marten, and Kai Spohrer. ‘A Blockchain Research Framework’. *Business & Information Systems Engineering* 59, no. 6 (1 December 2017): 385–409. https://doi.org/10.1007/s12599-017-0506-0.
Rogers, Everett M. *Diffusion of Innovations, 5th Edition*. Simon and Schuster, 2003.
Schmidt, Christoph G., and Stephan M. Wagner. ‘Blockchain and Supply Chain Relations: A Transaction Cost Theory Perspective’. *Journal of Purchasing and Supply Management* 25, no. 4 (1 October 2019): 100552. https://doi.org/10.1016/j.pursup.2019.100552.
Schwab, Klaus. *The Fourth Industrial Revolution*. Penguin UK, 2017.
Seawright, Jason. *Multi-Method Social Science: Combining Qualitative and Quantitative Tools*. Strategies for Social Inquiry. Cambridge: Cambridge University Press, 2016. https://doi.org/10.1017/CBO9781316160831.
Serdarasan, Seyda. ‘A Review of Supply Chain Complexity Drivers’. *Computers & Industrial Engineering* 66, no. 3 (November 2013): 533–40. https://doi.org/10.1016/j.cie.2012.12.008.
Shi, Weidong, Eleftherios Iakovou, and Vincent Iacopella. ‘Transforming Trade and Ensuring Global Supply Chain Security with Blockchain and Smart Contracts’. Project Report. Houston, Texas: Border, Trade, and Immigration Institute at the University of Houston, March 2020. https://uh.edu/bti/research/shi-iakovou-blockchain/bti-writtendeliverables-blockchainshi-final-reduced1.pdf.

Szabo, Nick. ‘Formalizing and Securing Relationships on Public Networks’. *First Monday*, 1 September 1997. https://doi.org/10.5210/fm.v2i9.548.
Taherdoost, Hamed. ‘A Critical Review of Blockchain Acceptance Models—Blockchain Technology Adoption Frameworks and Applications’. *Computers* 11, no. 2 (February 2022): 24. https://doi.org/10.3390/computers11020024.
The Economist. ‘The Trust Machine’. 2015. https://www.economist.com/leaders/2015/10/31/the-trust-machine.
Thompson, Ronald L., Christopher A. Higgins, and Jane M. Howell. ‘Personal Computing: Toward a Conceptual Model of Utilization’. *MIS Quarterly* 15, no. 1 (1991): 125–43. https://doi.org/10.2307/249443.
Tönnissen, Stefan, and Frank Teuteberg. ‘Analysing the Impact of Blockchain-Technology for Operations and Supply Chain Management: An Explanatory Model Drawn from Multiple Case Studies’. *International Journal of Information Management* 52 (1 June 2020): 101953. https://doi.org/10.1016/j.ijinfomgt.2019.05.009.
TradeLens. ‘About TradeLens | TradeLens’, 2023. https://www.tradelens.com/about.
‘TradeLens Overview’. IBM, 2021. https://www.ibm.com/downloads/cas/AAREDOBM.
UNCITRAL – United Nations Commission On International Trade Law-. ‘UNCITRAL – United Nations Commission On International Trade Law- UNCITRAL Model Law on Electronic Transferable Records (MLETR)’, 1 January 2010. https://doi.org/10.1163/ej.9789004180048.i-962.595.
Venkatesh, Viswanath. ‘Adoption and Use of AI Tools: A Research Agenda Grounded in UTAUT’. *Annals of Operations Research* 308, no. 1–2 (January 2022): 641–52. https://doi.org/10.1007/s10479-020-03918-9.
Venkatesh, Viswanath, Michael G. Morris, Gordon B. Davis, and Fred D. Davis. ‘User Acceptance of Information Technology: Toward a Unified View’. *MIS Quarterly* 27, no. 3 (2003): 425–78. https://doi.org/10.2307/30036540.
Venkatesh, Viswanath, James Y. L. Thong, and Xin Xu. ‘Consumer Acceptance and Use of Information Technology: Extending the Unified Theory of Acceptance and Use of Technology’. *MIS Quarterly* 36, no. 1 (2012): 157–78. https://doi.org/10.2307/41410412.
Wamba, Samuel Fosso, and Maciel M. Queiroz. ‘Blockchain in the Operations and Supply Chain Management: Benefits, Challenges and Future Research Opportunities’. *International Journal of Information Management* 52 (June 2020): 102064. https://doi.org/10.1016/j.ijinfomgt.2019.102064.
———. ‘The Role of Social Influence in Blockchain Adoption: The Brazilian Supply Chain Case’. *IFAC-PapersOnLine* 52, no. 13 (2019): 1715–20. https://doi.org/10.1016/j.ifacol.2019.11.448.
Wang, Yingli, Meita Singgih, Jingyao Wang, and Mihaela Rit. ‘Making Sense of Blockchain Technology: How Will It Transform Supply Chains?’ *International Journal of Production Economics* 211 (May 2019): 221–36. https://doi.org/10.1016/j.ijpe.2019.02.002.
‘WEF Blockchain Toolkit’, 2021. https://widgets.weforum.org/blockchain-toolkit/consortium-governance/index.html.
Werbach, Kevin. ‘Trust, but Verify: Why the Blockchain Needs the Law’. *Berkeley Technology Law Journal* 33, no. 2 (2018): 487–550. https://www.jstor.org/stable/26533144.
Wong, Lai-Wan, Garry Wei-Han Tan, Voon-Hsien Lee, Keng-Boon Ooi, and Amrik Sohal. ‘Unearthing the Determinants of Blockchain Adoption in Supply Chain Management’. *International Journal of Production Research* 58, no. 7 (2 April 2020): 2100–2123. https://doi.org/10.1080/00207543.2020.1730463.
Yavaprabhas, Kongmanas, Mehrdokht Pournader, and Stefan Seuring. ‘Blockchain as the “Trust-Building Machine” for Supply Chain Management’. *Annals of Operations Research*, 5 August 2022. https://doi.org/10.1007/s10479-022-04868-0.
Yin, Robert K. *Case Study Research and Applications: Design and Methods*. Sixth edition. Los Angeles: SAGE, 2018.

Zavolokina, Liudmila, Rafael Ziolkowski, and Ingrid Bauer. ‘Management, Governance, and Value Creation in a Blockchain Consortium’. *MIS Quarterly Executive* 19, no. 1 (1 March 2020): 1–17. https://doi.org/10.17705/2msqe.00022.

Zeithaml, Valarie A. ‘Consumer Perceptions of Price, Quality, and Value: A Means-End Model and Synthesis of Evidence’. *Journal of Marketing* 52, no. 3 (1988): 2–22. https://doi.org/10.2307/1251446.