# How Blockchain can help in Supply Chain Sustainability

*Full Paper*

**Anulipt Chandan**
Discipline of Business Information Systems,
School of Management, Curtin Business School,
Curtin University
Perth, Australia
Email: Anulipt.chandan@postgrad.curtin.edu.au

**Vidyasagar Potdar**
Discipline of Business Information Systems,
School of Management, Curtin Business School
Curtin University,
Perth, Australia
Email: v.potdar@curtin.edu.au

**Michele Rosano**
Sustainable Engineering Group,
School of Civil and Mechanical Engineering
Curtin University,
Perth, Australia
Email: M.Rosano@curtin.edu.au

## Abstract

Supply chains sustainability has become one of the significant interests in the industries as well as academia. It has gained significant interest amongst academics and practitioners. Not only are business dimensions of the supply chain important for sustainable supply chains but expanding the focus to environmental and social dimensions has made for a more generalisable and holistic perspective on the supply chain. The promising features of blockchain technology might be a panacea for such complexity in the Triple Bottom Line of sustainability: economic, social, and environmental bottom lines.

Blockchains technology potentially utilizes in design, operations, and general management of supply chains. Blockchain's ability to guarantee the reliability, traceability, and authenticity of the information is the key driver for the development of a sustainable supply chain. In this article, key challenges in the sustainable supply chain are presented and their possible solution using the blockchain is discussed.

**Keywords:** Supply chain sustainability, Blockchain, Smart contracts, Triple bottom line

# 1 INTRODUCTION

This Supply chain management (SCM) can be described as a dynamic process of managing flow of material, information and funds among different businesses within entities and with external entities. Primary focus of an SCM is to efficiently control the flow of goods, however, it also involves various other business functional aspects like risk management, performance, business integration, information sharing, supply chain governance, and product sustainability (Seuring and Müller 2008). However, an optimal supply chain has all these functionalities well-coordinated among all supply chain stakeholders.

Among these, information sharing among the supply chain partners are very critical to create more value, to improve efficiency and to make supply chain transparent (Dubey et al. 2019). The supply chain encompasses whole cycle of a product starting from raw material to finished deliverable goods. The product passes through various process during its production and each process added some value in it. Considering this, it is a very challenging task to determine product sustainability throughout its lifecycle.

Sustainability can be described as fulfilling needs of the present generation without compromising future generations requirement (Ahvenniemi et al. 2017). Definition of sustainability is dynamic in nature and changes accordingly to subject in discussion. Considering vagueness and uncertainties around its definition, complications arise frequently whenever efforts are made to apply sustainability principles in practice. Generally, sustainability in context of various businesses can be determined using Triple Bottom Line (TPL) concept, i.e. economic, social, and environmental sustainability (Ahi and Searcy 2013).

Supply chain sustainability is becoming a growing concern for industries. In literature, sustainable supply chain management, green supply chain management are two terms under which supply chain sustainability was discussed in large (Ashby, Leat, and Hudson-Smith 2012). Numerous theories are proposed to implement sustainability principles into supply chain. Studies showed that organizations satisfy the demand for internal and external stakeholders and meet their expectations to reach specific social goal and improve economic performance by addressing social issues (Brandenburg et al. 2014). The companies' relationship with external actors like investors, bankers can improve, if they practice good social responsibility (Brandenburg et al. 2014). With growing concern about environment and social welfare among consumers, they started looking for sustainable products. Consumer demand pushing companies to bring more sustainable products and pass sustainability information to the consumers.

Companies are using a suite of next-generation digital technologies like IoT (Internet of Things), web applications, mobile application, digital sensors, real-time tracking using GPS, and blockchain to provide relevant information to consumers. Blockchain is one of the latest technologies that companies are looking to implement in their supply chain network to harness its unique features like decentralize network, smart contracts, data immutability, real-time transaction, traceability, and transparency (Carlozo 2017).

Blockchain is a decentralized ledger that stores data in form of blocks which records transaction data and the blocks are appended to each other, which creates a chain of blocks, hence termed blockchain. The blocks are appended only that make blockchain data immutable. Data immutability makes this technology unique and distinguishes itself from others. In other words, a blockchain is an append-only database, where data once stored cannot be manipulated or deleted. Thus, data will remain unchanged.

Blockchain technology was first used in bitcoin to create a cryptocurrency (Dai et al. 2017). Initially, with primary application of this technology started in financial sector, but the promising features like decentralization, data immutability attracted other sectors like retail (Aitzhan and Svetinovic 2018), healthcare (Ekblaw et al. 2016), supply chain (Kshetri 2018), energy (Sikorski, Haughton, and Kraft 2017), real state (Kshetri 2018). Although blockchain technology is in its development phase it shows a promising value in these sectors.

This article will specifically discuss how and where blockchain technology can be applied to achieve supply chain sustainability. Prior research on blockchain and supply chain did not cover this aspect thoroughly. Therefore, through this article, we will explore how blockchain can be utilized in improving supply chain sustainability.

# 2 SUPPLY CHAIN SUSTAINABILITY

Supply chain sustainability can be started from raw material and goes all the way up to final product consumption. Hence, product sustainability needs to measure along whole supply chain to draw a final picture of product sustainability performance that could be done by measuring of sustainability

performance at each processing stage and summed it up to find a products' final sustainability score. The sustainability performance data can be collected from each partner in supply chain. However, lack of trusted infrastructure for information sharing and inconsistency in shared information makes the job challenging to find a product sustainability score during its lifecycle. Therefore, there is a need for a transparent system to fill this void. The future system must be secure, tamperproof, and shared among supply chain partners so that supply chain partner can have trust on each other and rely on data provided by others. A tamperproof system can help in verifying the sustainability score of a product at each stage during lifecycle. However, in a business environment with continuously changing trading partners, information and communication models are very crucial.

Supply chains sustainability becomes one of the significant interests in industries as well as academia. It has gained substantial attention amongst practitioners and academics (Fahimnia, Sarkis, and Davarzani 2015). On sustainability under TBL concept, businesses are more concern about economical dimension whereas the overall holistic sustainability can only be achieved by considering environmental and social dimensions equally. However, to design an optimal system that can help in balancing all three dimensions of sustainability is challenging task. The blockchain might solve complexity of TBL.

Industries are facing different challenges to comply with sustainability requirement. Like in case of a larger supply chain where there is a focal firm across which whole supply chain revolved around and there is other small other supply chain partner, in this scenario consumer blames only the focal farm for sustainability. Whereas the fact is that it is combined response of all stakeholder. Nevertheless, from consumers points, focal farm is responsible for unsustainable supplier behaviour. Regardless of supply chain complexity, consumer always expected to the focal firms to provide information on sustainability during its purchasing decisions (Fahimnia, Sarkis, and Davarzani 2015). Similarly, industries are also facing other sustainability challenges. Details of these challenges and how blockchain can be utilized to solve them are discussed under TBL in the following section.

## 2.1 Economic sustainability challenges in the supply chain

From a business point of view, the most important performance assessment indicator of a supply chain is profits earning due to expectation of return of investment from a shareholder who is a most important stakeholder of the supply chain (Pagell and Shevchenko 2014). Stated that if the business has a negative impact on economic front of sustainability, no matter how good it is in environmental or social performance, the overall business is not sustainable. Thus, economic sustainability is most important among TBL. Supply chain includes various inter and intra business activities. Each activity is associated with some economic value and it need to be analysis to make an economically sustainable supply chain. Some of the important challenges that are being faced by supply chain industries in economic front of sustainability are a procurement contract, insurance claims, higher oversee financial transaction cost, cost of monitoring sustainability, and investment.

Blockchain technology can provide a solution to these challenges. Blockchain technology has some general characteristics like decentralisation, security, auditability, immutability and smart execution. These features of blockchain technology separate it from similar information technology (Carlozo 2017). The blockchain technology brings transparency in supply chain which in return reduce cost of auditing, monitoring. Smart contract feature of blockchain technology can be utilized to create a contract among entities or with insurance provider. The smart contract can describe as digitally written rules stored in blockchain that execute automatically when condition written on contract fulfilled. Besides, this transparency also increases trust of consumer in business thus give a competitive advantage over others and benefit the firm financially. So, blockchain adoption can benefit a firm and its supply chain partner from different business dimensions that will affect their economic performance (Saberi et al. 2018). Table 1 present issues in the supply chain concerning economical sustainability and how blockchain can solve these challenges.

| | **Sustainability issue in supply chain** | **Solution using blockchain** |
|---|---|---|
| **Economic Sustainability** | Insurance claim (Klibi, Martel, and Guitouni 2010) | A smart contract is the best way to make insurance contract so; insurance claim can be efficiently executed when condition written on contract fulfilled, thus saving cost. |
| | Supply chain procurement Contract (Ghosh and Shah 2015) | Use of smart contract makes procurement contract simple and also cost-effective. |
| | High overseas financial transaction fee (Niepmann and Schmidt-Eisenlohr 2017) | Using cryptocurrencies like bitcoin will reduce international money transfer fee |

| | Sustainability issue in supply chain | Solution using blockchain |
|---|---|---|
| | Report falsification for financial gain (Giannakis and Papadopoulos 2016) | The periodically stored report/data on blockchain cannot be changed, so it is impossible to manipulate data at later stage. |
| | Loss due to discrepancy in information sharing among supply chain stakeholder in real-time (Dubey et al. 2019). | Authorised entities in real-time can easily access information stored on blockchain. |
| | Enterprises Resource Planning (ERP) | A smart contract-based ERP will reduce cost as well as prove history of a product. |
| | Cost of monitoring sustainability (Kshetri 2018) | The data automation with a smart contract can easily monitor sustainability criteria thus removing third parties for this job. |
| | Bribery (Giannakis and Papadopoulos 2016) | Transaction record on blockchain is transparent. So, any discrepancy can easily be detected by the auditing agency. |

*Table 1. Economic issue in supply chain and possible solutions using the blockchain*

## 2.2 Social sustainability issues in the supply chain

Social sustainability is regarded as social resource management that includes employee welfare, social values, employee relationship. Social Sustainability should be view as ethical code for survival and progress of mankind to achieve "an inclusive, connected, equitable, prudent and secure manner" (Mani, Gunasekaran, and Delgado 2018). Back in nineties, business only considers economic element of sustainability for their long-term success. But now sustainability concept is changed, and business are looking for other two aspect i.e. environment and social also. The business has a legitimate concern about human resource, ethical practices, and social values. In supply chains industries social sustainability can be achieved by preventing social exclusion, giving equal treatment to all employee, improving employee safety, protecting employee health, (Mani, Gunasekaran, and Delgado 2018).

Some of the challenges, which is faced by supply chain industries in context with social sustainability is forced labour, child labour, impact of living standard and decent wages for employee (Rodríguez et al. 2016). Therefore, these critical issues need greater attention in supply chain social sustainability. This issue mainly arises due to unethical industry practices like bribery, corruption, misleading information etc.

Blockchain technology can help in checking these unethical practices. Blockchain provides a platform to store history of a product in an immutable manner that helps buyers to be confident enough that product being purchased coming from ethical sources (Saberi et al. 2018). Blockchain technology can support to store the product provenance data that have access to other supply chain partner. With blockchain technology, it is easier for supply chain partner to bring transparency, trust, security, reliability in supply chain that can potentially contribute to social sustainability.

One of the ways to bring social sustainability in supply chain by making information stable and immutable (Kouhizadeh and Sarkis 2018). The immutable information stored on blockchain can only be modified with consent from authorised actors, it supports to prevent of seizing of any assets by a corrupt individual or organization. This also supports to identify nefarious actors in supply chain. Product traceability also promises of human rights and safe work practices.

Table 2 present issues in the supply chain concerning social sustainability and how blockchain can solve these issues.

| | Sustainability issue in supply chain | Solution using blockchain |
|---|---|---|
| **Social Sustainability** | Child Labour (Giannakis and Papadopoulos 2016; Mani, Gunasekaran, and Delgado 2018) | Buyer has access to product data provenance and can make informed decision not to buy a product which involves child labour practices. |
| | Employee Wages (Giannakis and Papadopoulos 2016; Mani, Gunasekaran, and Delgado 2018) | Wages updated on blockchain are stored in an immutable way. Therefore, company will not do any irregularities in paying to employee otherwise they will face consequences. |

| | Sustainability issue in supply chain | Solution using blockchain |
|---|---|---|
| | Corruption (Giannakis and Papadopoulos 2016) | Blockchain makes the supply chain transparent thereby preventing or reducing corruption. |
| | Sourcing from local communities (Mani, Gunasekaran, and Delgado 2018; Rodríguez et al. 2016) | The transparent sourcing information of a product will assist in identifying the source of the products, and if raw materials to make the product is originate from local area, it improves economy of local community. |
| | Public health (Giannakis and Papadopoulos 2016; Mani, Gunasekaran, and Delgado 2018; Mao et al. 2018; Tian 2016) | The food traceability is accessible to general public thus they know origin of goods as well as they can know production and expiry date. |

*Table 2 Social issue in supply chain and possible solution using blockchain*

## 2.3 Environmental sustainability issues in the supply chain

The supply chain has traditionally been dominated by economic, quality and delivery, whereas environmental sustainability is rarely seen as a critical factor for long-term business success. Environment sustainability management is regarded as policies and action taken by industries in response to change in natural environment (Golicic and Smith 2013). With increasing concern to global warming, environmental sustainability is gaining attention of industry as well as from academia in last decades. Increasing competition and input cost push industries for outsourcing and operate at global level. Outsourcing increase number of companies operate on a supply chain that makes it difficult to identify the actual source or cause for environmental damage. To tackle this challenge in global supply chain some industries adopt supplier evaluation scheme which integrates the social and environmental criteria to evaluate sustainability (Golicic and Smith 2013). The supplier evaluation scheme helps industries to identify potential suppliers who are not adhering the sustainability guideline.

Sustainability can be improved along the supply chain by sharing information that will help in resource planning and policy making which lead to reducing natural resource consumption (Kouhizadeh and Sarkis 2018). Digital technologies and data analysis have improved supply chain management sustainability. But visibility and transparency are still lacking in the supply chain, which is exploited by a few industries and do not look for environmental sustainability (Dubey et al. 2019).

Blockchain technology can help in improving environmental sustainability in the supply chain. It has potential to improve transparency, traceability in supply chain that leads to improving environmental sustainability. Since Blockchain stores data in immutable form, various data like product movement data, supplier data, transaction data, sustainability report can be stored on blockchain that makes hard to modify or manipulate. This will help in sustainability auditing and enable to trace carbon footprints, recyclability and green quality. The data store on blockchain will not only help the supply chain industries but also enable consumer for better decision making. The final consumer can access sustainability data from blockchain and select a sustainable product (Mao et al. 2018). Blockchain-based information label on the product will also enhance green marketing.

Another use case of blockchain in improving environmental sustainability by using it as a carbon credit trading platform. The supply chain partner can trade their carbon credit with each other. A carbon negative partner can trade with carbon positive partner and thus reducing overall environmental impact and benefiting from each other. Similarly, waste management is very crucial in the supply chain. In case of hazardous waste, waste management is even more critical. With increasing use of battery and another electronic item, hazardous waste is increasing rapidly. The supply chain partner is responsible for safe disposal of this hazardous material. However, due to lack of poor tracking of used product and less transparent systems, the manufacturer is getting rid of disposal cost. Blockchain technology can help in tracking hazardous waste management and check-in fraud and manipulation done by the manufacturer.

Table 3 present issues in the supply chain concerning environmental sustainability and how blockchain can solve these issues.

| | Sustainability issue in supply chain | Solution using the blockchain |
|---|---|---|
| **Environmental Sustainability** | Supply chain wastage | Information shared on the blockchain can be easily accessed by all stakeholder, thereby limiting wastage (sharing paperwork by couriers resulting in pollution, or data backups on servers using electricity etc.) and improving environmental sustainability. |
| | Pollution (Giannakis and Papadopoulos 2016) | Pollution data stored on blockchain can easily be monitored by auditing authority as well as by general public, and thus the industry will comply will pollution norms. |
| | Freight inefficiencies (Tang and Musa 2011) | The real-time data sharing ensures efficient planning of freight, and if in case any stakeholder deviates from planned schedule then they will be penalised. The penalty mechanism can be implemented using a smart contract.<br>Planning, limited storage, better utilization of transportation, limited waiting time reduce pollution, land space. |
| | Procurement (Tang and Musa 2011) | Procurement of the local product will improve environmental sustainability, so, procurement process using blockchain technology provides transparency and auditability of local procurement.<br>Pollution, non-renewable energy consumption in freight etc. |
| | Carbon Footprint (Giannakis and Papadopoulos 2016) | The carbon footprint can be automatically calculated using the smart contract using input-output analysis data stored on blockchain. Thus, industries cannot manipulate it in their favour. |
| | Illegally traded animal parts or plants | The authority can check illegal trading of a product by tracing of the product origin. |

*Table 3 Environmental issue in supply chain and possible solution using the blockchain*

# 3 DISCUSSION AND CONCLUSION

Blockchain technology can exactly fit in context with supply chain sustainability. Blockchain's transparent and immutable characteristics are advocating ethical business practices by empowering consumers to know about a product history and its sustainability performance through supply chain. With this hand on information of product history consumer can know product's provenance, therefore, have better decision-making capabilities to choose sustainable product. Blockchain has potential to solve different challenges in the supply chain as described in section 2, still, it is in the development phase and going through rapid changes (Saberi et al. 2018). There are certain limitations like scalability (Croman et al. 2016), interoperability (Hardjono, Lipton, and Pentland 2018) associated with this technology that needs to be sorted out first in order to implement it in real use case scenario. For ensuring a seamless integration of blockchain technology in supply chain operation, blockchain technology needs to evolve to address specific supply chain challenges. One such challenge is data interoperability among supply chain partners. It is expected that different suppliers in supply chain may or may not use the same blockchain platform for their business and hence data transfer among them becomes a critical challenge to ensure optimal and efficient performance supply chain and its sustainability (Kshetri 2018; Saberi et al. 2018). Other challenges with the blockchain technology implementation in supply chain are handling of big data. Since volume of data generated in supply chain is very large that requires an efficient data management plan.

Other than technological challenges, there are other non-technical challenges that are impeding blockchain application in the supply chain. Among non-technical challenges, most prominent one is government regulation around the technology, environment, application and trading. Government laws and regulation regarding use of blockchain technology is still unclear. Lack of standard implementation

framework is also one of the adoption hurdles (Kouhizadeh and Sarkis 2018). Governmental across the world still working on making law regarding use of blockchain technology.

Another challenge for industries is to analyse and achieve a better return of investment for their effort to meet sustainability criteria and information provides to user (Giannakis and Papadopoulos 2016). One way to support the innovation and research done by industries for sustainable practices is through consumer demand for sustainable product and process and willing to pay extra. However, the lack of consumers' awareness is a barrier to sustainability implementation and development. For example, lack of knowledge of consumers to understand sustainability label on a product alter their decision to buy a sustainable product (Ghosh and Shah 2015). In addition, uncertainty over demand of sustainable products and customers behaviour towards buying a sustainable product may affect competition among the industries thus impede the use of blockchain technology to provide product sustainability information (Ghosh and Shah 2015). Therefore, before integration of blockchain technology, industries would make ensure that investment in sustainable product, process and technology will be compensated by their consumers. Another major non-technical challenge is lack of business models and best practices (Mao et al. 2018). There is different pilot project like pork traceability by Walmart (Visser and Hanich 2017), tuna traceability (Kamath 2018) was done in the past but still, their best practice model is not available.

The integration of blockchain in supply chain brings dramatic change in information sharing amongst supply chain partners which will help in making the supply chain more sustainable. The governance framework of blockchain is a major concern for supply chain partner. The information present on a blockchain will be fully transparent thus a strong governance framework required to ensure a secure data exchange among the supply chain partners to keep business ethics intact. Governance frameworks includes which model of blockchain e.g. private, public and consortium to be choose, how to upload supply chain data on blockchain, what sustainability information needs to be put on blockchain, who will own data stored on blockchain, which information need to made public and which one kept private to protect privacy and business secret.

# 4 REFERENCES

Ahi, Payman, and Cory Searcy. 2013. "A Comparative Literature Analysis of Definitions for Green and Sustainable Supply Chain Management." *Journal of cleaner production* (52), pp329–341.

Ahvenniemi, Hannele, Aapo Huovila, Isabel Pinto-Seppä, and Miimu Airaksinen. 2017. "What Are the Differences between Sustainable and Smart Cities?" *Cities* (60), pp 234–245.

Aitzhan, Nurzhan Zhumabekuly, and Davor Svetinovic. 2018. "Security and Privacy in Decentralized Energy Trading through Multi-Signatures, Blockchain and Anonymous Messaging Streams." *IEEE Transactions on Dependable and Secure Computing* (15:5), pp 840–852.

Ashby, Alison, Mike Leat, and Melanie Hudson-Smith. 2012. "Making Connections: A Review of Supply Chain Management and Sustainability Literature." *Supply Chain Management: An International Journal* (17:5), pp497–516.

Brandenburg, Marcus, Kannan Govindan, Joseph Sarkis, and Stefan Seuring. 2014. "Quantitative Models for Sustainable Supply Chain Management: Developments and Directions." *European Journal of Operational Research* (233:2), pp 299–312.

Carlozo, Lou. 2017. "What Is Blockchain?" *Journal of Accountancy* (224:1), pp 29.

Croman, Kyle et al. 2016. "On Scaling Decentralized Blockchains." In *International Conference on Financial Cryptography and Data Security*, Springer, pp 106–125.

Dai, Fangfang et al. 2017. "From Bitcoin to Cybersecurity: A Comparative Study of Blockchain Application and Security Issues." In *Systems and Informatics (ICSAI), 2017 4th International Conference On*, IEEE, pp 975–979.

Dubey, Rameshwar et al. 2019. "Can Big Data and Predictive Analytics Improve Social and Environmental Sustainability?" *Technological Forecasting and Social Change* (144), pp 534-545

Ekblaw, Ariel, Asaph Azaria, John D. Halamka, and Andrew Lippman. 2016. "A Case Study for Blockchain in Healthcare:'MedRec' Prototype for Electronic Health Records and Medical Research Data." In *Proceedings of IEEE Open & Big Data Conference*, pp 13.

Fahimnia, Behnam, Joseph Sarkis, and Hoda Davarzani. 2015. "Green Supply Chain Management: A Review and Bibliometric Analysis." *International Journal of Production Economics* (162), pp101–114.

Ghosh, Debabrata, and Janat Shah. 2015. "Supply Chain Analysis under Green Sensitive Consumer Demand and Cost Sharing Contract." *International Journal of Production Economics* (164) pp 319–329.

Giannakis, Mihalis, and Thanos Papadopoulos. 2016. "Supply Chain Sustainability: A Risk Management Approach." *International Journal of Production Economics* (171), pp 455–470.

Golicic, Susan L., and Carlo D. Smith. 2013. "A Meta-Analysis of Environmentally Sustainable Supply Chain Management Practices and Firm Performance." *Journal of supply chain management* (49:2), 78–95.

Hardjono, Thomas, Alexander Lipton, and Alex Pentland. 2018. "Towards a Design Philosophy for Interoperable Blockchain Systems." *arXiv preprint arXiv:1805.05934*.

Kamath, R., 2018. "Food traceability on blockchain: Walmart's pork and mango pilots with IBM." *The Journal of the British Blockchain Association*, (1:1), pp 47-53.

Klibi, Walid, Alain Martel, and Adel Guitouni. 2010. "The Design of Robust Value-Creating Supply Chain Networks: A Critical Review." *European Journal of Operational Research* (203:2), pp 283–293.

Kouhizadeh, Mahtab, and Joseph Sarkis. 2018. "Blockchain Practices, Potentials, and Perspectives in Greening Supply Chains." *Sustainability* (10:10), pp 3652.

Kshetri, Nir. 2018. "1 Blockchain's Roles in Meeting Key Supply Chain Management Objectives." *International Journal of Information Management* (39), pp 80–89.

Mani, Venkatesh, Angappa Gunasekaran, and Catarina Delgado. 2018. "Enhancing Supply Chain Performance through Supplier Social Sustainability: An Emerging Economy Perspective." *International Journal of Production Economics* (195), pp 259–272.

Mao, Dianhui, Zhihao Hao, Fan Wang, and Haisheng Li. 2018. "Innovative Blockchain-Based Approach for Sustainable and Credible Environment in Food Trade: A Case Study in Shandong Province, China." *Sustainability* (10:9), pp 3149.

Niepmann, Friederike, and Tim Schmidt-Eisenlohr. 2017. "International Trade, Risk and the Role of Banks." *Journal of International Economics* (107), pp 111–126.

Pagell, Mark, and Anton Shevchenko. 2014. "Why Research in Sustainable Supply Chain Management Should Have No Future." *Journal of supply chain management* (50:1), pp 44–55.

Rodríguez, Jorge A., Cristina Giménez Thomsen, Daniel Arenas, and Mark Pagell. 2016. "NGOs' Initiatives to Enhance Social Sustainability in the Supply Chain: Poverty Alleviation through Supplier Development Programs." *Journal of Supply Chain Management* (52:3), pp 83–108.

Saberi, Sara, Mahtab Kouhizadeh, Joseph Sarkis, and Lejia Shen. 2018. "Blockchain Technology and Its Relationships to Sustainable Supply Chain Management." *International Journal of Production Research* (57:7), pp 1–19.

Seuring, Stefan, and Martin Müller. 2008. "From a Literature Review to a Conceptual Framework for Sustainable Supply Chain Management." *Journal of cleaner production* (16:15), pp 1699–1710.

Sikorski, Janusz J., Joy Haughton, and Markus Kraft. 2017. "Blockchain Technology in the Chemical Industry: Machine-to-Machine Electricity Market." *Applied Energy* (195) (Supplement C), pp 234–46.

Tang, Ou, and S. Nurmaya Musa. 2011. "Identifying Risk Issues and Research Advancements in Supply Chain Risk Management." *International journal of production economics* (133:1), pp 25–34.

Tian, Feng. 2016. "An Agri-Food Supply Chain Traceability System for China Based on RFID & Blockchain Technology." In *Service Systems and Service Management (ICSSSM), 2016 13th International Conference On*, IEEE, pp 1–6.

Visser, C. and Hanich, Q.A., 2017. "How blockchain is strengthening tuna traceability to combat illegal fishing." The Conversation 1-4. Retrieved from https://ro.uow.edu.au/lhapapers/3359/

## Acknowledgements

This research is supported by Curtin University's Innovation Central Perth Scholarship and Food Agility CRC Scholarship and is conducted within the Blockchain Research & Development Lab at Curtin University's Faculty of Business & Law.