Blockchain Adoption in Supply Chain Management and Logistics

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Summary

The tight integration of materials flow with the flow of information remains a challenge in supply chain and logistics (SC&L). Blockchain is an emerging technology concept that could be a tool to solve end-to-end information flow. It provides a distributed, decentralized ledger of transaction records that are tamper-resistant due to cryptographic methods. Transaction data in SC&L could be a history of state changes, ownerships, or manufacturing steps.

This dissertation addresses the adoption of Blockchain solutions in the SC&L context in three complementary studies. In Study 1, the existing literature is analyzed. A sample of 135 articles is mapped to the use cases and the industries they address. In Study 2, practitioners' anticipations of Blockchain are surveyed. An online questionnaire yielded 153 responses regarding four use cases as well as barriers and beneficiaries. Finally, in the main study – Study 3 – qualitative data were collected to investigate how companies are adopting Blockchain using an exploratory Grounded Theory approach.

The literature review in Study 1 showed that, overall, there has been little empirical work to date. However, the sample yielded eight major use cases that predominantly address the food and the pharmaceutical industries. Study 2 illustrated that while practitioners expect Blockchain solutions to take hold throughout the industry, regulatory uncertainties regarding the technology's uses and legal validity as well as the need for collaboration with new partners along the supply chain remain barriers. Study 3 allowed for the creation of a typology of companies' motivations for starting to work with Blockchain solutions and a model of which adoption paths they choose, the learnings they derive, and the barriers they face.

The conclusion that Blockchain will shape SC&L in the future emphasizes the need to further explore this space. On the one hand, more empirical data should be collected to describe tailor-made concepts that also fit such ecosystems. On the other hand, this also requires solutions for the existing barriers and general strategies for supply chain-wide Blockchain solution deployment. In the long run, Blockchain solutions could develop into a very valuable, massive infrastructure tool that allows one to drive efficiency by aligning supply chain partners worldwide. Further, it could allow for multi-supply chain ecosystems as a basis to offer a range of value-added services, for instance, providing identities, certification, or anti-counterfeiting solutions.

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List of Abbreviations

API application programming interface

B/L bill of lading

CEP courier express parcel

CRM customer relationship management software

CSCMP Council of Supply Chain Management Professionals

DAO decentralized autonomous organization

DLT distributed ledger technology

EDI electronic data interchange

ERP enterprise resource planning

EU 30 European Union member states, Norway, Switzerland, and the UK

FTL full truckload

GDPR General Data Protection Regulation

HACCP hazard analysis and critical control points

IoT Internet of things

IP intellectual property

ISO international organization for standardization

LTL less-than-truckload

NFC near-field communication

NGO non-governmental organization

PAT principal-agent theory

PLS partial least squares structural equation modeling

PoC proof of concept

RBV resource-based view

RFID radio-frequency identification

SC&L supply chain management and logistics

SME small and medium-sized enterprises

TAM technology acceptance model

UK United Kingdom

WMS warehouse management system

Chapter 1

Introduction

"On the Internet, nobody knows you are a dog," Steiner's 1993 cartoon reads. Entirely feasible at the time, in 2020 it requires enormous effort for people to remain anonymous online, with no guarantee of success (Marx et al. 2018; Lufkin 2017; Snowden 2019, pp. 248–252). It could be expected that the same applies to the origins and locations of goods and materials, since information–sharing is considered crucial for supply chain management and logistics (SC&L) (Cooper et al. 1997). Nonetheless, for most supply chains, the tight integration of the material flow with the information flow remains wishful thinking (Kersten et al. 2017; Huong Tran et al. 2016). For instance, it's almost impossible to track the journey of an avocado's journey from the supermarket shelf back to the tree that gave it life (Park 2018; Popper et al. 2017).

Effective information-sharing, for instance about the demand changes and the inventory levels of different supply chain tiers, would improve the entire supply chain's competitiveness (Christopher 2016). It also allows for swift reactions to disruptions that cascade across tiers and the entire supply network (Donadoni et al. 2019). For instance, the Great East Japan Earthquake in March 2011, which ultimately resulted in the meltdown of the Fukushima nuclear power plant, severely disrupted supply chains in different industries (Hendricks et al. 2020). Unexpected demand changes, such as the spike in thermometer sales during the COVID-19 pandemic (Corkery et al. 2020) or more local natural disasters, necessitate immediate overviews over inventory levels, production volumes, and goods in transit if one is to decide on countermeasures. However, optimally organizing the information flow is crucial beyond disruptions. It can benefit supply chain performance and is also a key enabler of future concepts such as closed-loop supply chains in a circular economy (Shekarian 2020).

Electronic data interchange (EDI) – a data standard designed in the 1960s and already split into more than 10 sets (e.g., the UN/EDIFACT or the GS1 EDI standard) is far from widely used within SC&L (Huong Tran et al. 2016; Hermes Germany GmbH 2017; Ferrantino et al. 2017). Further, even EDI use does not mean the full integration of the flows of information and material. It is more common in practice to use less integrated methods (e.g., telephone and e-mail communication) instead of fully integrated solutions (Hermes Germany GmbH 2017; Huong Tran et al. 2016; Kersten et al. 2017). One consequence is the creation of different versions of the same records in various places: Copies of the relevant information are exchanged through specialized platform providers, or directly from one company to another via physical documents or electronic interfaces (Jabbar et al. 2018; Madenas et al. 2014). For instance, the documentation of freight transports from East Asia to Europe involves around 30 actors, causing 15% of total shipment costs (Groenfeldt 2017; Jabbar et al. 2018).

Blockchain could change this; it is a technology concept that provides a distributed, decentralized ledger of transaction records that is tamper-resistant due to the use of cryptographic methods (The Economist 2015; Popper et al. 2017; Nakamoto 2008; Tapscott et al. 2016; Pilkington 2016). Transaction data in SC&L could be a history of state changes (e.g., locations or temperatures) and ownerships (e.g., shipment handlers, parts manufacturers, or raw material producers). The central promise of Blockchain is that it creates a single and shared data repository, allowing all network members to read or write to its ledger. Its decentralization makes it especially useful in multistakeholder environments with short-lived business relationships (Wüst et al. 2018; Wang et al. 2018; Petersen et al. 2018).

Thus, Blockchain could be the long-sought-after tool that will solve end-to-end information flow for SC&L. First practical concepts include record keeping for the production of jewelry diamonds, shadowing documentation of international container transports, handling and production records of leafy green vegetables and salads, and the identification of truck drivers for container release at the port of Antwerp (Stahlbock et al. 2018; Corkery et al. 2018; Groenfeldt 2017; Yarm 2019).