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Blockchain and supply chain relations: A transaction cost theory perspective

Christoph G. Schmidt, Stephan M. Wagner*

Chair of Logistics Management, Department of Management, Technology, and Economics, Swiss Federal Institute of Technology Zurich, Weinbergstrasse 56/58, 8092 Zurich, Switzerland

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Blockchain is projected to be the latest revolutionary technology and is gaining increasing attention from academics and practitioners. Blockchain is essentially a distributed and immutable database that enables more efficient and transparent transactions. The consensus-based record validation can eliminate the need for a trusted intermediary. We utilize the transaction cost theory to create a better understanding of how blockchain might influence supply chain relations, specifically in terms of transaction costs and governance decisions. Conceptually developing a set of six propositions, we argue that blockchain limits opportunistic behavior, the impact of environmental and behavioral uncertainty. Blockchain reduces transaction costs, as it allows for transparent and valid transactions. We explore several areas for future research on how blockchain might shape supply chain management in the future.

1. Introduction

Blockchain is projected to be the latest transformative innovation and is increasingly gaining attention from academics, practitioners and regulators across various industries. The concept of blockchain first emerged as the underlying technology of the cryptocurrency Bitcoin, introduced by Nakamoto (2008). Blockchain is essentially a distributed, consensus-based and (mostly) immutable ledger of transaction records (Notheisen et al., 2017; Pilkington, 2016). The consensus-based validation eliminates the need for a trusted third party. Since enterprises are just starting to understand the technology and explore the potential benefits and challenges, most blockchain initiatives are still in an early stage. Regardless, corporate spending on blockchain solutions is expected to reach $2.1 billion by the end of 2018, up from $945 million in 2017, according to the International Data Corp. Distribution (Nash, 2018). In a recent Gartner survey, two-thirds of the respondents believe that blockchain is a business disruption and plan investments in the future (Burton and Barnes, 2017). Consequently, academic investigation on how and when blockchain might create businesses value is needed.

In the media, blockchain is often called a “game changer” (Johnson, 2018). In fact, the story could be similar to the Internet. For instance, both technologies are inherently transformative, yet foundational. While the Internet was revolutionizing global information transfer, alternative approaches, such as Electronic Data Interchange (EDI) protocols, were already widely adopted (Boyer and Olson, 2002). In contrast to the established approaches, the Internet did provide a new layer of functionality and became accessible to and usable for everyone. Similarly, almost every company maintains a system of databases storing transactions and other firm data (Elmasri and Navathe, 2015). However, blockchain potentially adds transparency and immutability across firm boundaries to current database functionalities and may revolutionize how we transact digital and physical goods and services, just like the Internet changed how we exchange information. While the Internet did connect people globally, blockchain might change fundamentally how we trust on a global scale. Luhmann (1979) distinguishes two forms of trust, personal trust, as in individual but also organizational relationships, in contrast to system trust. Blockchain facilitates the declaration of a true system state via networked computation and consensus rules, thus replacing the need for human intervention and personal trust, affecting the characteristics of every transactional exchange relationship (Zhao et al., 2016). In other words, system trust replaces personal trust with a wide range of implications. The Economist (2015) even talks about “the truth machine”.

In reality, examples of successful blockchain applications are scarce. Only 8% of the 26,000 blockchain projects started in 2016 were still actively developed in 2017 (Browne, 2017). Technological uncertainty, scalability issues and development cost create major challenges. The technology seems far from reaching its ascribed potential. In 2018, blockchain shows symptoms similar to the Internet bubble, which burst in 2000. The Internet then went on to become a mainstream technology after the initial difficulties were overcome. Blockchain could follow a

* Corresponding author.
E-mail address: stwagner@ethz.ch (S.M. Wagner).

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similar path (Babich and Hilary, 2019; Treiblmaier, 2018). We believe that academia and practice should join forces to take the technology through the sea of challenges to a productive stage by exploring the technology's strength and weaknesses and developing its potentials in the context of various application domains.

Blockchain might substantially affect supply chain management, its relations and governance structures (Kshetri, 2018). Blockchain also influences the purchasing and supply management (PSM) function, as global transactions are non-transparent and prone to delays, inefficiencies and human errors (Casey and Wong, 2017; Rosenbush, 2018). Tracking goods, such as food or diamonds, through the production and delivery process to ensure quality and authenticity or automated compliance to freight and trade regulations, exemplify just two promising applications of blockchain. Walmart, for example, has 1.1 million items, mostly food products, on its blockchain and traces their journey from manufacturer to retailer (Mims, 2018). Maersk, a global shipping company, cooperates with IBM and uses their blockchain cloud services to track its shipping containers, making the customs process significantly faster and more secure (Moise and Chopping, 2018). Research on the effects of blockchain on supply chain management and the PSM function is called for explicitly (Foerstl et al., 2017; Treiblmaier, 2018).

The rising interest in blockchain is part of a greater global digitalization trend, in a business context sometimes referred to as “Industry 4.0”. Digitalization is understood as a bundle of disruptive technologies, including big data analytics, machine learning, 3D printing, robotics and drones, which are expected to radically transform the business landscape (Vendrell-Herrero et al., 2017). Information and communication technologies have always played an important role in supply chain and PSM innovation (e.g. Akın Ateş et al., 2018; Blome et al., 2013; Wagner and Bode, 2014). The digitalization trend is already influencing the supply chain. It is crucial for academia and practice to understand the impact of digitalization technologies. We focus on blockchain, as a prominent component of the digital transformation, and advance knowledge on supply chain relations under a digital paradigm.

In the context of the digitalization, new information and communication technologies will influence supply chain structures and processes (Srai and Lorentz, 2019), as they have done in the past (Schoenherr and Speier-Pero, 2015; Waller and Fawcett, 2013). New technologies can exert disruptive power on a more fundamental level and thus drive changes in governance structures. Governance structures are at the core of any supply chain relation creating the setting for interactions between buyer and supplier and facilitating their value creation process (Fawcett et al., 2006; Gereffi et al., 2005). Shifts in governance structures pose a major challenge for firms in highly dynamic and complex supply chain networks (e.g. Ashenbaum, 2018; Brito and Miguel, 2017; Huang and Chiu, 2018). Consequently, understanding how new technologies can fundamentally change governance structures in the supply chain is becoming increasingly important for academia and practice. Given its novel functionalities, blockchain holds the potential to reduce governance cost and shift the optimal governance structure under given conditions. Following the above line of argument, the objective of this article is to answer the following question:

Research question. How does blockchain affect supply chain relations?

As there is limited literature on the topic and rarely any mature implementations in practice, we take a conceptual approach to answer our research question. Spina et al. (2016) explicitly encourage the use of established grand theories when exploring new supply chain phenomena to advance theoretical maturity of the field and pave the way for the development of more specific mid-range theories. Specifically, we extend transaction cost theory, which examines business decisions on the optimal governance structure that minimizes transaction costs under a set of conditions (Coase, 1937; Williamson, 1981), to a blockchain environment. The approach is deemed appropriate since blockchain and transaction cost theory demonstrate significant conceptual overlap. First, transactions and their cost are a key construct for supply chain relations (Ellram et al., 2008; Tate et al., 2011) and blockchain is most fundamentally a ledger of transactions (Notheisen et al., 2017). Second, transaction cost theory is concerned with any problem that can be posed directly or indirectly as a contracting problem (Williamson, 1987) and blockchain provides a new approach to digital contracting in the form of smart contracts (Christidis and Devetsikiotis, 2016).

Blockchain does not fundamentally change or invalidate transaction cost theory. The theory is still fully applicable to supply chain governance decisions. However, the outcome of its application, the optimal governance structure, may be different with blockchain. We attempt to synthesize the characteristics of blockchain with drivers and assumptions of the transaction cost theory in order to explore how blockchain can affect transaction costs and thus influence governance decisions. Deriving a set of six propositions, we find that blockchain can reduce transaction costs and enable more market-oriented governance structures for buyer-supplier transactions. Specifically, blockchain limits opportunistic behavior, environmental and behavioral uncertainty, which drive transaction costs. Reducing costs and allowing for immutable and transparent transactions as well as validated records, blockchain can enable more market-oriented supply chain relations.

Our contribution to the literature is threefold. First, we are among the first to theoretically link blockchain and transaction cost theory in detail. We add to the literature by discussing the elements of transaction cost theory under a new technological paradigm. Second, we conceptually develop a framework of how blockchain characteristics influence transaction costs and supply chain governance. The framework provides a starting point to understand the blockchain phenomenon and its implications, as the supply chain community moves toward building new theory. Our framework provides a reference for practitioners trying to evaluate potential applications and the usefulness of blockchain for their organization. Third, we present an overview of critical issues deriving an agenda for future research at the intersection of blockchain and supply chain management in general.

2. Distributed ledger technology and blockchain

Blockchain is a particular instance of the Distributed Ledger Technology (DLT) and understood as “a database architecture which enables the keeping and sharing of records in a distributed and decentralized way, while ensuring its integrity through the use of consensus-based validation protocols and cryptographic signatures” (Benos et al., 2017, p. 1). Other DLT types include Hashgraphs and Directed Acyclic Graphs (DAG). Ethereum[1] and Hyperledger[2] are the most prominent active blockchain platforms in 2018. Since blockchain is a complex stack of various computational algorithms and cryptographic approaches, we will only provide a brief overview of its core design principles and elements. See Beck et al. (2016), Hilary (2018), and Notheisen et al. (2017) for more details on blockchain.

Blockchain is, in essence, a database of transactional records (Christidis and Devetsikiotis, 2016). In traditional databases, records are kept at a single location, usually within an organization. A central authority controls the database, ensures the integrity of the transactions and manages user access (Redmond and Wilson, 2012). A distributed database acts as one physical database, where all nodes (entities in a network) have equal rights (Elmasri and Navathe, 2015). Blockchain is an advanced type of distributed ledger with a set of unique qualities. First, maintaining a historical record of all valid transactions at each

[1] https://www.ethereum.org/.

[2] https://www.hyperledger.org/.