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1 Blockchain's roles in meeting key supply chain management objectives

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ABSTRACT

Arrival of blockchain is set to transform supply chain activities. Scholars have barely begun to systematically assess the effects of blockchain on various organizational activities. This paper examines how blockchain is likely to affect key supply chain management objectives such as cost, quality, speed, dependability, risk reduction, sustainability and flexibility. We present early evidence linking the use of blockchain in supply chain activities to increase transparency and accountability. Case studies of blockchain projects at various phases of development for diverse purposes are discussed. This study illustrates the various mechanisms by which blockchain help achieve the above supply chain objectives. Special emphasis has been placed on the roles of the incorporation of the IoT in blockchain-based solutions and the degree of deployment of blockchain to validate individuals' and assets' identities.

1. Introduction

Blockchain deployment outside finance has been largely experimental. Some of the most promising non-finance applications of blockchain are expected to include those in supply chain, power and food/agriculture. These areas are arguably strong fits for blockchain. These industrial use cases are believed to deliver real ROI at an early stage of blockchain development (Bünger, 2017).

Among many activities that are likely to be transformed by blockchain, supply chain thus deserves special attention. An increasing reliance on the use of Internet-of-things (IoT) applications is among the trends that will affect supply chain management (SCM). With IoT, radio-frequency identification (RFID) tags, sensors, barcodes, GPS tags and chips, the locations of products, packages and shipping containers can be tracked at each step. This allows an enhanced, real-time tracking of goods from their origins.

In this regard, for one thing, there is a deep thirst for a foolproof method for confirmed identity in IoT applications. The first of blockchain's direct benefits is that it provides a possible solution to identity management (Alam, 2016). Blockchain can be used in a supply chain to know who is performing what actions. Additionally, time and location of the actions can be determined.

Blockchain facilitates valid and effective measurement of outcomes and performance of key SCM processes. Once the inputs tracking data are on a blockchain ledger, they are immutable. Other suppliers in the chain can also track shipments, deliveries, and progress. In this way, blockchain produces trust among suppliers. By eliminating middleman auditors, efficiency can be increased and costs can be lowered. Individual suppliers can perform their own checks and balances on a near real time basis (Koetsier, 2017).

Blockchain also provides an accurate way of measuring product quality during transportation. For instance, by analyzing data on the travel path and duration, stakeholders in a supply chain can know whether the product was in a wrong place or whether it remained in a location for too long. This is especially important for refrigerated goods, which cannot be left in warm environments. This value proposition is even more appropriate for countries such as China, where meat smuggling has led to serious health risks and a significant loss in tax revenue. In this way, blockchain-based solutions may give the consumers more confidence that the products are genuine and of high quality and make them significantly more willing to purchase the brand.

In order to emphasize the importance of blockchain in food supply chain, the proponents of blockchain offer an example of the 2015 E.coli outbreak at Chipotle Mexican Grill outlets. The crisis left 55 customers ill. The company suffered a reputation loss due to negative news stories, restaurant shutdowns, and investigations. Sales reduced dramatically and its share price dropped by 42%. The roots of the problem lie partly in the reliance of Chipotle and other food companies on multiple suppliers to deliver parts and ingredients. There is a severe lack of transparency and accountability across complex supply chains. Food companies such as Chipotle are not in a position to monitor their suppliers in real time. It is thus impossible for Chipotle to prevent the contamination or contain it in a targeted way after it is discovered (Casey

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and Wong, 2017). Chipotle's value proposition is centered on fresh and locally sourced ingredients. The non-blockchain methods of securing the Chipotle food supply chain are expensive and cumbersome. The process involves manual verification and massive record keeping. Blockchain can reduce the workload and ensure traceability. Besides the obvious value of traceability, huge benefits can be reaped in terms of reduced labor costs and food wastes. The above examples can be generalized to any industry such as aircraft, electronics or drugs. In short, blockchain-led total value chain visibility can offer huge gains to operations for any firm (O'Marah, 2017).

These benefits accrue to all the parties involved in the supply chain such as the retail warehouses and individual stores. For instance, stores know the details of arrival of a shipment so they are prepared to receive it (Groenfeldt, 2017). In the food product supply chain, for instance, when it is confirmed that a load of apples would arrive at a juice factory, a code is generated and stored remotely. The code is available for verification at any time. Information about the apples and the factory that receive them is 'chained' together by this code. Theoretically the data can be portrayed as color-coded maps of inputs, conversion steps and outputs from "farm to fork" (O'Marah, 2017).

Prior researchers have noted various key objectives of supply chain. They include cost, quality, speed, dependability, risk reduction (Baird & Thomas, 1991; Bettis & Mahajan,1985), sustainability (Bowen, Cousins, Lamming, & Faruk, 2001) and flexibility (Goldbach, Seuring, & Back, 2003; Kovács, 2004; Meyer & Hohmann, 2000; Rao & Holt, 2005; White, 1996). The above discussion suggests that blockchain has a potential to help achieve these objectives.

Some have touted blockchain as the biggest innovation in computer science (Tapscott, 2016). Others consider this technology to be "the biggest disruptor to industries since the introduction of the Internet" (PWCHK.com, 2016). The World Economic Forum (WEF, 2015) considers blockchain to be among six computing "mega-trends" that are likely to shape the world in the next decade. It would be unreasonable to expect that blockchain can transform key supply chain activities. Researchers have begun to grapple with this nascent trend of blockchain deployment in various organizational objectives, but scholars have not systematically assessed the effects of blockchain on supply chain.

In light of the above observations, a key objective of our research is to illustrate blockchain's impact in SCM. To achieve this, we offer a framework[1] that considers how blockchain can help firms meet key SCM objectives. This article therefore offers the promise of filling many important gaps in the sparse literature on blockchain deployment in supply chain.

The paper is structured as follows. We proceed by first providing a literature review of key supply chain objectives. Next, we discuss the methods employed in the paper. Then, we provide brief descriptions of the selected cases. The section following this looks at the roles of blockchain in achieving various strategic supply chain objectives. It is followed by a section on discussion and implications. The final section provides concluding comments.

2. Literature review: supply chain objectives

Logistics services often play a key role in a firm's ability to deliver customer value (Mentzer, Flint, & Hult, 2001). Among the key goals of an effective logistics within supply chain management involves getting the product in the right condition, in a timely manner and at the lowest possible costs (Flint, 2004). Measurement of supply chain management performance is often described in terms of objectives such as quality, speed, dependability, cost and flexibility (Goldbach & Back, 2003; Kovács, 2004; Meyer & Hohmann, 2000; Rao & Holt, 2005; White, 1996).

In addition to the above objectives, prior researchers have addressed the role of supply chain management for sustainable products, which has become a notable research area in marketing and supply chain management (Bowen et al., 2001). This trend is partly driven by consumers' increasing concern about the source of their food and beverages (Scott, 2017). Quak and de Koster (2007) looked at retailers' sustainability policies in logistics by focusing on social and environmental issues such as those related to noise pollution, congestion, and carbon dioxide emissions. Prior researchers have also argued that sustainability-related issues in supply chain, which often deal with natural environment and social causes are less quantifiable (Linton, Klassen, & Jayaraman, 2007).

Global supply chains are complex and face multiple uncertainties (Manuj & Mentzer, 2008). A major objective of supply chain management is also to reduce risks. Among the various risks that organizations face include relational risks such as a business partner's engagement in opportunistic behavior (e.g., cheating, distorting information) (Baird & Thomas, 1991; Bettis & Mahajan, 1985). According to Svensson (2000), the sources of risk in supply chains can be classified into two main categories, namely, atomistic or holistic. In order to deal with atomistic sources of risk, a selected and limited part of the supply chain need to be looked at in order to assess risk. This approach is suitable for components and materials that are of low-value, less complex, and easily available. On the other hand, holistic sources of risk require an overall analysis of the supply chain in order to assess risk. This approach is preferable for high-value, complex, and rare components and materials (Svensson, 2000).

To achieve the various objectives noted above, it is important to evaluate suppliers. Due to increased competition, globalization and outsourcing, the number of players in a typical supply chain has increased significantly. In response, firms have introduced supplier evaluation programs using environmental and social criteria (Beske, Koplin, & Seuring., 2008; Koplin, Seuring, & Mesterharm, 2007). Some use supplier self-evaluation, in which supply chain partners declare how they have tackled environmental and social issues (Trowbridge, 2001).

3. Method

The approach of this study can be described as theory building from multiple case studies, which is becoming increasingly popular in social science (Eisenhardt & Graebner, 2007; Kshetri, 2016a,b). Compared to a single-case study, multiple-case studies are likely to provide a stronger base for theory building (Rowley, 2002; Yin, 1994).

Connection with related literatures, establishment of theoretical gap that exists in the literature, and explicit statement of research questions to address the gap are the key features of strong empirical research (Eisenhardt & Graebner, 2007). In qualitative research, it is also important to make a strong case for the importance of the research questions that have been raised (Bansal & Corley, 2012). We have established theoretical and practical importance of research on the use of blockchain in supply chain.

There has been a good deal of debate on whether case research should be based on theory specified a priori or on grounded theory. Whyte (1984) argues that, to be valuable, research should be guided by" good ideas about how to focus the study and analyze those data" (p. 225). On the contrary, Glaser and Strauss (1967) suggested that evolution of a theory from the data is the basis for development of grounded theory rather than an imposition of a priori theory. Likewise, Van Maanen, Dabbs, and Faulkner (1982, p. 16) suggested that investigators avoid prior commitment to any theory. In this study, we follow Whyte's approach. As such, in order to guide the focus of the

[1] Following Anderson (1993), we distinguish between theory and a framework in this paper's context as follows: Frameworks consist of a set of constructs that define key aspects of and make general claims about the roles of blockchain in meeting key supply chain objectives. Frameworks, however, are not specified sufficiently to enable predictions. Framework do not involve a hypothesis-testing research agenda (Anderson, J.R. 1993. *Rules of the mind*. Mahwah, NJ: Lawrence Erlbaum).