Effect of blockchain technology adoption on supply chain adaptability, agility, alignment and performance

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Abstract

Purpose – The purpose of this paper is to illustrate how blockchain technology can improve supply chain adaptability, alignment and agility which collectively enhance competitive advantage which in turn influences firm performance.

Design/methodology/approach – The conceptual framework of the present study is developed by conducting an extensive literature review on blockchain technology, supply chain adaptability, alignment, agility and competitive advantage. The sample data were collected from 397 supply chain practitioners in India to validate the conceptual model. Confirmatory factor analysis was conducted to ascertain the validity of the measures used and a structural model was analyzed for testing the proposed conceptual framework.

Findings – The results of the present study show that blockchain technology can improve supply chain adaptability, alignment, agility which lead to competitive advantage, which leads to better firm performance. Besides, trust generated through blockchain use also increases firm performance.

Research limitations/implications – Currently, the respondents do not have practical experience of using blockchain technology. They have responded based on their knowledge about supply chain and blockchain which they acquired from published sources. Different supply chains require different strategic choices and different information needs. But the present study assumes that all supply chain needs are identical. The present study assumes that government regulations regarding blockchain technology are favorable; however, currently, there is no legal framework to address blockchain technology. The findings of the current study indicate that companies not only should create more awareness regarding blockchain but also should actively work with IT companies that are engaged in developing blockchain-based supply chain solution. Managers, as well as IT companies and academicians, should join hands to study and develop a framework for regulating blockchain technology and suggest these to the policy actors.

Practical implications – The present study shows that supply chain practitioners are confident that blockchain technology will help improve supply chain parameters. These findings can help IT companies and their marketers for developing and promoting blockchain-based IT applications. In addition, the important implication for supply chain practitioners is that blockchain helps in creating a competitive advantage and increases firm performance.

Originality/value – The effect of IT on important supply chain variables has been studied in the past; however, there is not a single study which sheds light on how disruptive technologies such as blockchain will affect supply chain adaptability, alignment, agility and firm performance.

Keywords Information technology, Competitive advantage, Alignment, Firm performance, Adaptability, Supply chain management, Agility, Blockchain, Production and operations management

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1. Introduction

Technological disruptions are critical for improving business performance in all sectors and the supply chain is not an exception (Craighead *et al.*, 2017). Efficiency and responsiveness are two critical components of a modern supply chain. Today's supply chain use modern technology to gain a competitive advantage over competitors (Gunasekhran *et al.*, 2008). Modern supply chains are more complex than traditional ones due to increased customer demand, low product life cycle and businesses at the global level. Retailers also practice lean and keep minimum inventory. Due to this predicting accurate demand, production planning and scheduling has become a challenging task in the current business environment (Pereira, 2009). Digitization of supply chains may be a solution to meet such challenges. There is a paradigm shift from traditional manufacturing to intelligent and sustainable manufacturing (Bi, 2011; Ranganathan *et al.*, 2011; Long *et al.*, 2017; Michael, 2017). Traditional manufacturing firms are looking for modern information technology solutions to improve firm performance and improve collaboration and coordination between supply chain members (Farooq and O'Brien, 2012). Blockchain is one of the latest internet-based application which, due to its special characteristics, can be used in the supply chain. Not just integrated business processes, but synchronized operation between supply chain members has become a must. Such tight integration cannot be achieved without modern inter-organizational information system (Williamson *et al.*, 2004), and blockchain can be a promising technology to accrue such benefits to the firm.

Blockchain is a modern internet-based technology that provides better visibility and transparency in transactions among supply chain members (Pilkington, 2016). Blockchain stores transactional data in blocks which can be shared between members. These blocks can be added together in a chronological sequence which forms a chain. After confirmation from shared members, the stored data in this chain cannot be erased and this characteristic makes blockchain perfect for record keeping (Underwood, 2016). Different entities which are involved in a transaction act as nodes and transaction validation is done through cryptography (Crosby *et al.*, 2016). There is a centralized ledger which is recorded sequentially and can be shared among supply chain partners. Redundancy in accounting can create trust related issues among supply chain members. Blockchain technology provides a transactional platform to supply chain members with greater speed, accuracy and shared records, so trust-related disadvantages can be eliminated between members (Davidson *et al.*, 2016a). Transactions through blockchain are much cheaper than by any other means (Peters and Panayi, 2016). The outcome of this technological architecture is better traceability and resolution of trust related issues among supply chain members (Kshetri, 2018).

Blockchain can bring improvements in transactions which can be useful for supply chain members (Tapscott and Tapscott, 2017). As per an estimation, approximately 33 per cent of supply chain activities can be improved with the help of blockchain technology (Camerinelli, 2016). Despite several advantages, blockchain has many practical challenges also, namely, firms lack an organized ecosystem to increase the scale of this technology, training to employees, governance, privacy and a high cost of implementation, etc. In addition, this technology has not proved its worth in any sector till date except for finance, so people remain slightly skeptical about the adoption of this technology (Koteska *et al.*, 2017). Managers are not fully aware of the impact and benefits of blockchain which can give a competitive advantage to their supply chain and subsequently to the firm. There exists an opportunity to create many common applications which are blockchain technology based (Huckle *et al.*, 2016). Poor understanding of blockchain is also a reason for lower adoption rate (Mthethwa, 2016). Managers are not fully aware of the impact and benefits of blockchain which can give a

competitive advantage to their supply chain and subsequently to the firm. There exists an opportunity to create many common applications which are blockchain technology based (Huckle *et al.*, 2016). Poor understanding of blockchain is also a reason for lower adoption rate (Mthethwa, 2016). Most existing literature on blockchain is based on conceptual exposition, and empirical evidence is meager (Ying *et al.*, 2018). The present research will try to fill this gap by linking blockchain with supply chain parameters which give a competitive advantage to the firm, which results in better supply chain performance which results in better organizational performance.

2. Literature review

The following sub-sections present the literature on how blockchain can play a vital role in various supply chain activities.

2.1 Blockchain in supply chain management

Blockchain is expected to augment the speed and reliability of business processes (Kim and Laskowski, 2016). Blockchain is an internet-based technology which creates value to the users (Froystad and Holm, 2016). In a supply chain, there is a continuous flow of material, money and information between its members. All supply chain members must be aligned to make supply chain effective and efficient, but due to redundancy in finance and record keeping trust related issues cannot be avoided (Ammous, 2016). Blockchain has the inherent capacity to integrate all supply chain processes (Korpela *et al.*, 2017a). Blockchain can be used to develop a digital ledger and all stakeholders can execute, access and share data with greater reliability. In traditional supply chain, it is too difficult to keep track of all purchases of supply chain members but by using blockchain volume tracking is easy due to the presence of a shared digital ledger (Joshi, 2017). Blockchain technology is helpful in making a more accurate demand forecast, inventory management, back-up at demand disruption, etc. (Ivanov *et al.*, 2018). Blockchain improves the scale and scope of tracking and tracing of inventory (Hofmann *et al.*, 2018).

2.2 Blockchain in purchasing activity of supply chain

The purchasing activity prevalent in traditional supply chain follows analog contracts. The main drawback of this system is the difference in timing in the delivery of goods and invoice generation which leads to delay in payment (Kamble *et al.*, 2018). Traditional and modern purchasing has this problem. Blockchain is able to reduce and/or eliminate this payment gap with digital trust among contracting parties. The smart contracts of blockchain can integrate delivery and payment in digital contract with logistics and appointed banks. This integration not only simplifies finance operations but reduce working capital requirement also. The smart contracts act as an agreed rule book and assist payment related decisions (Sreehari *et al.*, 2017). Blockchain enables to trace the origin of goods among supply chain partners. This results in real-time settlement and better purchase order management (DeCovny, 2015). Samsung and IBM are some of the leading organization which are engaged in developing blockchain-based systems in which smart contract provisions are also there (Cohn *et al.*, 2017).

2.3 Blockchain in manufacturing activity of supply chain

Blockchain technology can play a crucial role in implementing lean manufacturing, six sigma, etc. Blockchain helps to validate manufacturing related parameters which are a challenging task to implement. Smart contracts with blockchain bring automation in the

plant (Shanly, 2017). New manufacturing technologies which are based on IoT and big-data can be synchronized with blockchain. Besides this, all quality documents can be standardized and shared with all supply chain members that improve decision-making (Apte and Ptrovsky, 2016). Blockchain can be used to share design related documents (Holland *et al.*, 2017). There are reports that some firms have already started to integrate manufacturing with blockchain (Xu *et al.*, 2018). WIPRO (Wipro, 2017), which is an Indian software firm is currently developing blockchain-based applications for the manufacturing sector, which can be customized according to customer's need. The system can create a unique ID so that an unauthorized party cannot access and participate. The items are scanned at every stage of manufacturing and data is recorded in the system (Wipro, 2017).

2.4 Blockchain in logistics domain of supply chain

Blockchain improves tracking and brings transparency in logistics which leads to an improved delivery cycle. In the traditional supply chain, if the supply chain is spread widely, then chances of discrepancy are more, and blockchain technology can be very useful in this case to overcome such discrepancies (Haoyan *et al.*, 2017). Vehicle tracking devices such as GPS which can be integrated with blockchain. Such devices can provide input data to blockchain and such data cannot be erased. Blockchain makes tracking of the vehicle easy (Tian, 2016), and it subsequently improves operational efficiency, especially for outbound logistics.

3. Hypothesis development

The following subsections present how the hypothesis for the current study is developed on the basis of the literature review on supply chain management and blockchain technology.

3.1 Blockchain and trust among supply chain members

Trust represents the willingness to be vulnerable to another (Mayer *et al.*, 1995). In accounting, the double entry system is in use since the fifteenth century. Due to redundancy in record keeping (using double entry system), there is always a presence of trust related issues among the supply chain members (Ammous, 2016). Blockchain can remedy trust related issues and can smoothen the transaction process (Davidson *et al.*, 2016b). Blockchain can integrate all functions of the supply chain and work as a single source of information to supply chain members (Korpela *et al.*, 2017b). Blockchain reduces opportunistic behavior in terms of distortion of information and cheating among trading members (Baird and Thomas, 1991; Bettis and Mahajan, 1985). Blockchain introduces transparency in transactions among trading partners and thus inculcates trust. There is a lot of previous studies which proved that acceptance of vulnerability is associated with performance (Colquitt, Scott and LePine, 2007; De Jong, Dirks and Gillespie, 2016; Dirks and Ferrin, 2002).

The present study focuses on operational and economic performance indicators which are established in previous studies (Chan and Qi, 2003; Chavez *et al.*, 2013; Gunasekaran *et al.*, 2004, 2001; Prajogo *et al.*, 2016). Past scholarship has established the following parameters of operational and economic performance, such as transaction cost (Devaraj *et al.*, 2007) (economic parameter), level of services provided to customer (Jayaram *et al.*, 2000) (operational parameter), supply chain operation speed (Devaraj *et al.*, 2007) (operational parameter) and value creation in the supply chain – (Wang and Li, 2007; Wang *et al.*, 2008) (economic parameter).

Therefore, on the basis of the above discussion, it is hypothesized that blockchain will improve trust which will result in better firm performance.

H1. Trust generated by using blockchain technology leads to better firm performance.

3.2 Adaptability, agility, alignment, competitive advantage and blockchain

Resource-based view (RBV) argues that a firm can maintain its competitiveness when it maintains certain resources which are rare, valuable and un-substitutable (Penrose, 1995; Wernerfelt, 1984; Barney, 1991; Teecee *et al.*, 1997). RBV is an appropriate explanation of IT flexible capabilities of a firm (Hsu *et al.*, 2009; Zhang *et al.*, 2011). If we consider firm's competitiveness, which is accrued through resources which lie within the boundary of the firm then mutual benefits which are accrued through shared capability of other partner firms cannot be justified (Wade and Hulland,2004; Lavie, 2006; Kraijenbrink *et al.*, 2010). To overcome the limitations of RBV, researchers added "relational" and "dynamic" terms to expand its application in inter-firm settings (Lavie, 2006; Jin *et al.*, 2014; Teece *et al.*, 1997; Teece *et al.*, 2007; Fawcett *et al.*, 2011). The relational extension argues that in a networked environment, which exists in a supply chain, a firm's capability to maintain relations with its partner firms play an important role to maintain its competitive position (Lavie, 2006). The dynamic extension emphasizes the need to integrate and reconfigure internal and external competencies in a volatile market to maintain competitive position (Eisenhardt and Martin, 2000; Teece, 2007).

Adaptation, alignment and agility are essential elements which provide a competitive advantage to an organization (Lee, 2004). Agility refers to how quickly the organization responds to short-term changes in the market due to uncertainties in upstream and downstream supply chains. Agility is the ability of the supply chain to meet with unexpected changes in the market demand and convert them into business opportunities (Swafford *et al.*, 2008). Agility enables a firm to gain a competitive advantage in a volatile operating business environment (Swafford *et al.*, 2006,2008; Ngai *et al.*, 2011; Blome *et al.*, 2013; Yusuf *et al.*, 2014; Brusset, 2016). Agility has been approached either by theoretical perspective or empirical based research. The concept of agility was introduced by the Lacocca Institute (Iacocca Institute, 1991) and later refined by Yusuf *et al.*, 1991. Christopher (2000) has identified certain characteristics which make a firm truly agile, these are, market sensitivity, network-based (It relies on shared information across all supply chain partners), and process integration.

Supply chain alignment refers to the process integration of several supply chain members for better firm performance. It is very important to have alignment between supply chain strategies and internal and external supply chain partners (Gattorna, 1998). Later studies also express the importance of supply chain alignment for improving customer value and competitive advantage which translates into better firm performance (Johnson and Scholes, 1999; Christopher *et al.*, 2004; Pagell, 2004; Baier *et al.*, 2008; Wong *et al.*, 2012).

Supply chain adaptability refers to the ability of the firm to adapt according to the market, in terms of strategies, products, and technologies (Lee, 2004). Adaptation can also be defined as the ability of the firm to change its state in a timely and cost-effective manner (Swafford *et al.*, 2006). Majority of researchers use adaptability and agility interchangeably (Gligor and Holcomb, 2013; Schoenherr and Swink, 2015) and theory about the effect of supply chain adaptability and agility remain fragmented (Lee, 2004; Ketchen and Hult, 2007). Past scholarship has recognized adaptation as a dynamic capability (Teece *et al.*, 1997; Schoenherr and Swink, 2015). Adaptation as a dynamic capability provides the context for the development and refinement of a firm's product innovation capability and reduceS product risk (Pavlou and El Sawy, 2011). Firms practicing adaptation have an advantage of being the first mover and thus, remain competitive (Eisenhardt and Martin, 2000).

The literature highlights the role of IT in supply chain integration and firm performance (Prajogo and Olhager, 2012; Liu *et al.*, 2016; Qrunfleh and Tarafdar, 2014). IT enables collaboration and sharing of data which helps to identify shifts in the market and take

corrective actions, e.g. changing facilities, changing suppliers and outsourcing (Ketchen and Hult, 2007). IT makes the supply chain agile (Ngai *et al.*, 2011). But IT has its own limitations and cannot create strategic value on its own(Garr, 2003). IT unless and until complemented with the organizational and human resource cannot generate value (Coltman and Devinney, 2013; Coltman *et al.*, 2011). The role of IT is widely recognized but much is still unknown (Fosso-Wamba *et al.*, 2015). The role of IT in the supply chain will continue to be a key issue among researchers (Grover and Kohli, 2012; Wang *et al.*, 2012). The above findings indicate the potential of IT. Blockchain is an advanced internet-based IT application which enables sharing of documents and transaction of supply chain members with speed, accuracy, and reliability. Blockchain can be connected with advance IT applications such as IoT, big data, artificial intelligence and do analysis of the data generated by business operations.

3.3 Blockchain and adaptability (AD)

Supply chain adaptability refers to the ability of the firm to adapt according to market change in terms of strategies, products and technologies (Lee, 2004). Blockchain has the inherent capacity to integrate all supply chain processes quickly (Korpela *et al.*, 2017a). Blockchain is helpful in making a more accurate demand forecast, inventory management and back-up as the market situation changes (Ivanov *et al.*, 2018). Blockchain empowers the organization to swiftly change suppliers, design, etc. Besides this, all quality documents can be standardized and shared with all supply chain members that improve decision making (Apte and Petrovsky, 2016). Blockchain can enable to share and use all design related documents (Holland *et al.*, 2017). There are reports that some firms have already started to integrate manufacturing with blockchain (Xu *et al.*, 2018). Similarly, logistics can be better managed by blockchain. There are vehicle tracking devices such as GPS which can be integrated with blockchain. They can provide input data to blockchain and such data cannot be tampered (Tian, 2016). Therefore, the following can be hypothesized:

H2. Blockchain-enhanced supply chain adaptability of a firm leads to competitive advantage.

3.4 Blockchain and alignment (SCA)

Supply chain alignment refers to the process integration of several supply chain members. Blockchain has the inherent capacity to integrate all supply chain processes of member partners (Korpela *et al.*, 2017b). All member partners can see all partners internal processes. Blockchain also increases the speed of execution of business processes with greater accuracy and reliability (Kim and Laskowski, 2016). Blockchain enables to share records with trading partners which eliminate trust related issues between members (Davidson *et al.*, 2016). This makes the entire supply chain aligned toward a single common goal. Therefore, it can be hypothesized that:

H3. Blockchain-enhanced supply chain alignment of a firm leads to competitive advantage.

3.5 Blockchain and agility (AG)

Agility is the ability of the supply chain to meet with unexpected changes in the market demand and convert them into business opportunities (Swafford *et al.*, 2008). Blockchain

enables trading partners to share documents, design, quality documents and transaction data with faster speed, accuracy and reliability. Such sharing of data will improve demand forecasting, better inventory management and backup (Ivanov *et al.*, 2018). Blockchain continuously collects data from different sources, processes it and shares it with supply chain partners. Therefore, it can be hypothesized that:

H4. Blockchain-enhanced supply chain agility of a firm leads to competitive advantage.

Dynamic capabilities are important intangible resources that enable firms to sustain superior performance in a dynamic environment (Wilden, Gudergan, Nielsen and Lings, 2013; Ambrosini and Bowman, 2009; Li and Liu, 2014; Prahalad and Bettis, 1986). In a dynamic business environment, product and business model life cycles are short (Stewart and Hamel, 2000), so firms need to constantly search for new opportunities and such kind of characteristics can lead firms to improved performance (Prahalad and Krishnan, 2008). These practices respond and adapt to volatile environmental conditions through building integrating and reconfiguration of organizations resources, we refer them as dynamic capabilities (Prahalad, 2004; Teece, 2007). Alignment, adaptability and agility are important capabilities which give a competitive advantage (Gunasekaran, 2016; Lee, 2004). A resource that contributes to the creation of sustainable competitive advantage must be valuable, rare, inimitable and non-substitutable (Barney, 1991; Line and Runyan, 2014). Dynamic capabilities of the firm are intangible and valuable resources of the firm and can explain firm competitiveness (Zahra *et al.*, 2006). Dynamic managerial capabilities enable business organizations to create, allocate and protect the intangible assets that support superior long-run business performance (Helfat and Peteraf, 2009). Past scholarship has shown that improvement in competitive advantage accrue superior firm performance (Pavlou and El Sawy, 2011; Wong *et al.*, 2012; Baier *et al.*, 2008; Brusset, 2016; Yusuf *et al.*, 2014; Blome *et al.*, 2013).

H5. Competitive advantage (C) obtained from using blockchain technology positively affects firms performance (FP) (Figure 1).

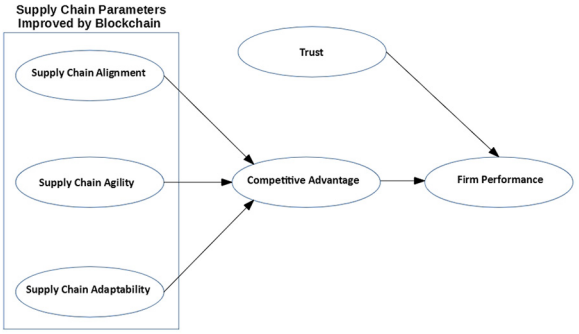

Figure 1.
Proposed conceptual model for blockchain and supply chain performance linkage

4. Methodology and analysis

The responses from the participants were collected through an email survey, and the participation was kept voluntary with follow up emails. The survey questionnaires were sent to supply chain practitioners (companies identified from CMIE (Center for Monitoring Indian Economy, https://www.cmie.com) database). The present study only sought responses from supply chain professionals who are working at the Manager or Assistant Manager level and are engaged in the supply chain, warehousing and logistics activities.

The measurement instrument for the survey was sent to 600 supply chain professionals with the URL of the survey mentioned in the email. The survey period lasted for two months from mid-October 2018 to mid-December 2018. After the data tabulation and cleaning, 397 valid responses were obtained which were used for further analysis.

The questionnaire was developed in English language and the statements measuring all the constructs were anchored on five-point Likert scale. The scales were subjected to content validity. Although, the items used were adopted from the previously done studies and were modified for studying blockchain's effect on these constructs, still, it was pretested with subject experts to ensure that questions are relevant with respect to blockchain technology implementation in the supply chain. The measures used and their sources are shown in Table I.

4.1 Measurement model

Firstly, confirmatory factor analysis was conducted to get information about convergent validity, composite reliability and discriminant validity of the measures used. The six constructs demonstrate satisfactory convergent validity, i.e. all the factor loadings are statistically significant (Table I), composite reliability of all the constructs is greater than 0.70 and average variance extracted is greater than 0.50 (Hair *et al.*, 2017) (Table III).

The fit indexes (CFI – comparative fit index, RMSEA – root mean square error of approximations) of the measurement model are also within the acceptable limits as per Hair *et al.* (2017) (Table II).

Table III shows the average variance extracted and composite reliability for all the constructs.

Discriminant validity was checked by comparing the square roots of the AVE's with the correlation for each of the constructs, i.e. using the Fornell and Larcker (1981) criterion. The square root AVE of the selected construct should be higher than the correlations between a construct and all the other constructs in the model. The diagonal items in the table represent the square root of AVE's, which is a measure of variance between the construct and its indicators, and the off-diagonal items represent the correlation between constructs (Kamble *et al.*, 2018). It is observed from Table IV that the square root of AVE is higher than the correlation between the constructs indicating that all the constructs exhibit discriminant validity. The measurement model obtained is shown in Figure 2.

Table V summarizes the descriptive statistics (mean and standard deviation) for each of the constructs

The measurement model is shown in Figure 2.

4.3 Structural model analysis

Table VI shows the results of the structural model analysis for testing the hypotheses of the current study. The structural model has an overall acceptable fit with CFI: 0.954; RMSEA: 0.054; PCLOSE: 0.125, indicating that the proposed conceptual framework fits the observed data reasonably well (Hair *et al.*, 2017). Table VI summarizes the results of the path analysis

Construct	Source of items used	Items	Factor loading (standardized)
Supply chain agility (AG)	Sharifi and Zhang, 1999	AG1: Blockchain is helpful in reducing manufacturing lead time	0.654
	Goldman *et al.*, 1994	AG2: Blockchain is helpful in reducing development cycle time	0.631
	Sharifi and Zhang, 1999	AG3: Blockchain is helpful in improving frequency of introducing new product	0.619
	van Hoek *et al.*, 2001	AG4: Blockchain is helpful in increasing product customization	0.665
	Sharifi and Zhang, 1999	AG5: Blockchain is helpful is increasing delivery capabilities	0.624
	Sharifi and Zhang, 1999; Sharifi and Zhang, 1999	AG6: Blockchain is helpful in increasing customer service	0.621
	Sharifi and Zhang, 1999	AG7: Blockchain is helpful in delivery reliability	0.611
	Sharifi and Zhang, 1999	AG8: Blockchain is helpful in adjusting changing market needs	0.633
Supply chain alignment (SCA)	Ettlie and Stoll, 1990; Narasimhan and Das, 2001; Narasimhan and Kim, 2001	SCA1: The firm's capability for process integration will improve by using blockchain	0.699
	Narasimhan and Kim, 2001	SCA2: The firm's capability to integrate sourcing, transport, service process and other internal areas will be improved by using blockchain	0.827
	Anasai *et al.*, 1999; Narasimhan and Das, 2001	SCA3: The firm's capability to integrate sourcing, transport, service process and other areas with suppliers will improve by using blockchain	0.882
	Watts *et al.*, 1992	SCA4: The firm's capability to integrate sourcing, transport, service process and other areas with customers will improve by using blockchain	0.685
Supply chain adaptability (AD)	Gerwin, 1993	AD1: We can quickly change design as per market requirement by using blockchain (Gerwin, 1993)	0.746
	Sethi and Sethi, 1990	AD2: We can quickly adjust our production mix by using blockchain	0.792
	Sethi and Sethi, 1990; Narasimhan and Das, 2001	AD3: We can change the quantity and quality mix of purchasing by using blockchain	0.783
Firm performance (FP)	Devaraj *et al.*, 2007	FP1: Transaction cost of supply chain operations will be reduced by using blockchain	0.721
	Jayaram *et al.*, 2000	FP2: Level of service provided to customers will be improved by using blockchain	0.610
	Devaraj *et al.*, 2007	FP3: Speed of supply chain operations will be improved by using blockchain	0.694
	Wang *et al.*, 2007	FP4: Value creation in the supply chain will be improved by using blockchain	0.549
Trust (T)	Hofstede *et al.*, 1980	T1: Supply chain members generally believe that supply chain transactions are more reliable through blockchain	0.962

(*continued*)

Table I. Confirmatory factor analysis and source of measures used

Construct	Source of items used	Items	Factor loading (standardized)
	Pilkington, 2016; Zand, 1972	T2: Blockchain provide better visibility and transparency of transactions in supply chain	0.980
	Kshetri, 2018; Zand, 1972	T3: Blockchain provides benefits of better traceability to resolve transaction related issues among supply chain members	0.962
	Kshetri, 2018; McFall, 1987	T4: Blockchain provides tamper proof data about transactions among supply chain members which can be shared and analyzed between members	0.964
Competitive advantage (C)	Pavlou and El Sawy, 2011	C1: Block Chain will help to improve capability to respond according to customer need give competitive advantage to the firm	0.974
	Wong *et al.*, 2012; Baier *et al.*, 2008	C2: Capability to integrate internal and external processes give competitive advantage to the firm	0.960
	Brusset, 2016; Yusuf *et al.*, 2014; Blome *et al.*, 2013	C3: Capability to convert market uncertainties into opportunities give competitive advantage to the firm	0.945

Table I.

Fit index	CFI	TLI	RMSEA	PCLOSE
*Acceptable value**	Greater than 0.90	Greater than 0.90	Less than 0.06	Greater than 0.05
Obtained value	0.964	0.959	0.048	0.694

Note: *Byrne (2010)

Table II.
Fit indexes for the measurement model

Construct	AVE	CR	Cronbach's alpha
Supply chain agility	0.55487	0.80411	0.8417382
Supply chain alignment	0.77325	0.85822	0.8528688
Supply chain adaptability	0.77366	0.81743	0.8159006
Firm performance	0.64350	0.74023	0.7404268
Trust	0.72650	0.97019	0.98277
Competitive advantage	0.95966	0.97223	0.9720649

Table III.
Reliability

Constructs	A	B	C	D	E	F
A. Supply chain agility	*0.74489*					
B. Supply chain alignment	0.187	*0.87934*				
C. Supply chain adaptability	0.292	0.373	*0.87957*			
D. Firm performance	0.477	0.298	0.165	*0.80218*		
E. Trust	0.107	0.183	0.249	0.249	*0.85234*	
F. Competitive advantage	0.255	0.289	0.322	0.347	0.320	*0.95966*

Table IV.
Discriminant validity

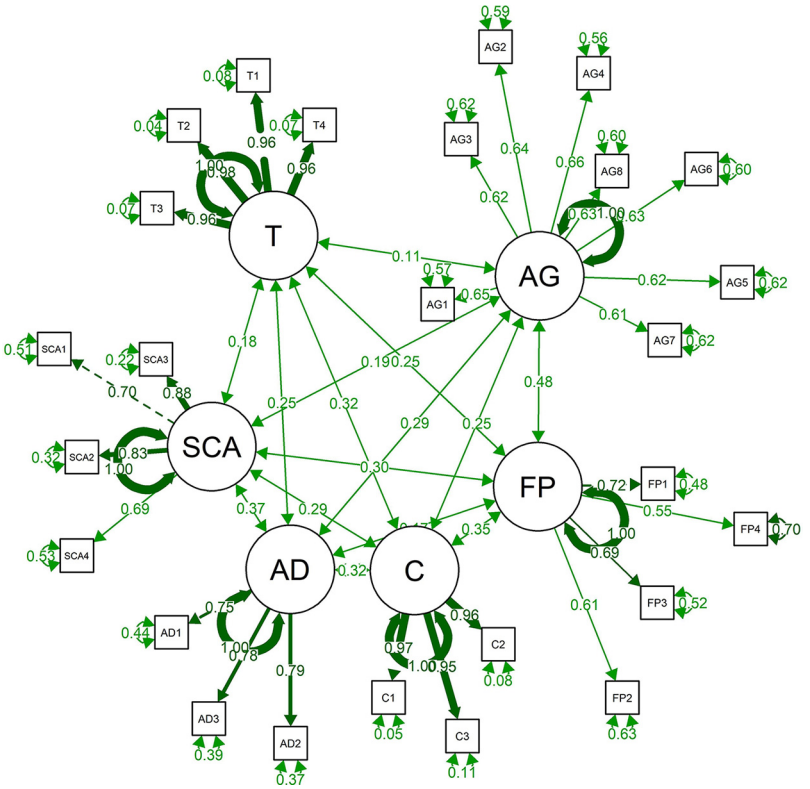

Figure 2.
Measurement model

Construct	Mean	Standard deviation
Supply chain agility	4.025	0.6053045
Supply chain alignment	4.273	0.617344
Supply chain adaptability	4.259	0.6676116
Firm performance	3.949	0.6559837
Trust	4.283	0.6974345
Competitive advantage	4.414	0.575107

Table V.
Descriptive statistics

and hypothesis testing results. All five hypothesis are found to be accepted ($p < 0.05$) (Table VI).

6. General discussion

The result of data analysis (Figures 3 and 4, Table VI) shows that blockchain-enhanced supply chain parameters such as supply chain alignment (0.191, $p < 0.05$); supply chain adaptability (0.209, $p < 0.05$) and supply chain agility (0.165, $p < 0.05$) are having a

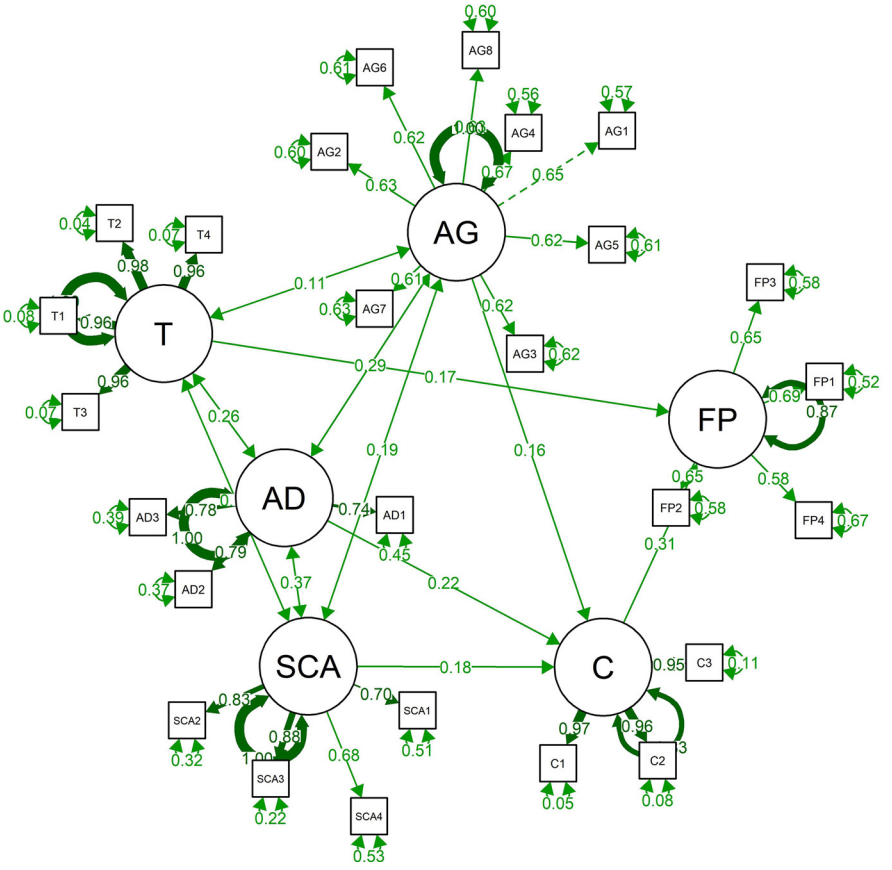

Figure 3.
Structural model

significant positive effect on competitive advantage. It means the managers are having a perception that blockchain will help them in making their business agile by reducing manufacturing lead times, improving frequency of new product development, increasing delivery capabilities as well as increasing customer satisfaction. Similarly, with respect to alignment, the managers are also certain that by adoption of blockchain technology they will be better able to integrate sourcing, transport, service process and overall the firm's capability for process integration will improve. With regards to adaptability, it is evident that the manager holds the perception that adopting blockchain technology will help them to have a better control over product mix as per the market requirements. Overall, as there is significant positive relationship between blockchain improved adaptability, agility alignment and competitive advantage, we can conclude the managers have high hopes of efficiency with regards to using blockchain-based IT applications in the supply chain. Adaptation, alignment and agility are essential elements which provide a competitive advantage to an organization (Lee, 2004; Johnson and Scholes, 1999; Christopher *et al.*, 2004; Pagell, 2004; Baier *et al.*, 2008; Wong *et al.*, 2012; Swafford *et al.*, 2006, 2008; Ngai *et al.*, 2011; Blome *et al.*, 2013; Yusuf *et al.*, 2014; Brusset, 2016). Conclusively blockchain improves competitive

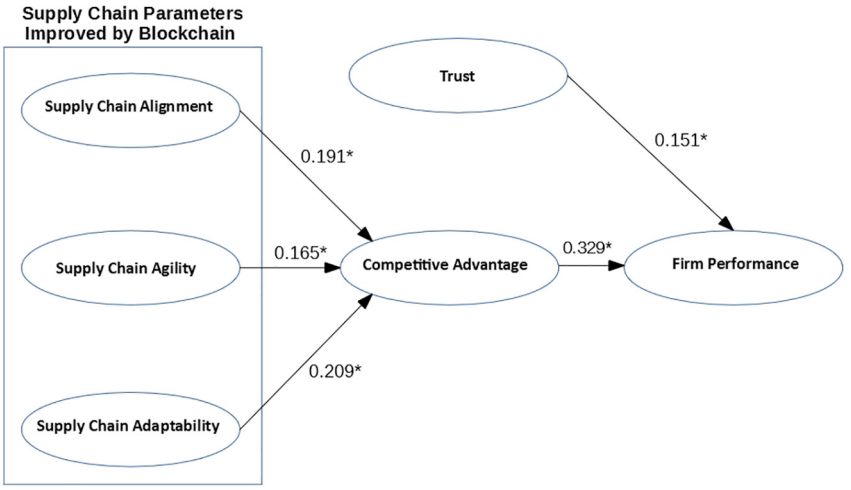

Figure 4.
Estimated model

Hypothesis	Path	Estimate	Std. Error	z	Sig.*	Result
H5	FP← C	0.329	0.064	5.176	0.000	Accepted
H1	FP← T	0.151	0.051	2.956	0.003	Accepted
H3	C← SCA	0.191	0.059	3.220	0.001	Accepted
H4	C← AG	0.165	0.057	2.900	0.004	Accepted
H2	C← AD	0.209	0.058	3.605	0.000	Accepted

Notes: *Significant at 0.05 level; CFI: 0.954; RMSEA: 0.054; PCLOSE: 0.125

Table VI.
Structural model analysis

advantage to the organization. As per RBV, a firm can maintain its competitiveness when it maintains certain resources which are rare, valuable and un-substitutable (Penrose, 1995; Wernerfelt, 1984; Barney, 1991; Teecee *et al.*, 1997). Blockchain-based applications can be a resource which can provide competitive advantage to the firm and accrues differential firm performance. There is plethora of previous studies which argue that improvement in competitive advantage accrue superior firm performance (Pavlou and El Sawy, 2011; Wong *et al.*, 2012; Baier *et al.*, 2008; Brusset, 2016; Yusuf *et al.*, 2014; Blome *et al.*, 2013).

Trust generated by using blockchain is also having a significant positive effect on firm performance (0.151 $p < 0.05$). As result indicates that managers have the perception that adoption of blockchain technology will help in increasing reliability of transactions and that it will increase transparency, they will have better traceability of inventory items, and blockchain will provide a tamper proof source of data recording and retrieval. All these attributes of blockchain will lead to better firm performance.

Blockchain enables the focal firm to share confidential data and designs quickly which not only integrate entire supply chain process but also helpful in reducing new product development time and helps in making accurate demand and inventory forecasts. Blockchain improves decision-making capability of the focal firm and such a firm can

quickly change their positioning according to current market requirement. Blockchain also improves the speed of execution of business processes and through this all trading partners can check any partner's transaction; so blockchain enables all trading partners to align as per current market requirement. Blockchain enable trading partners to synchronize all business operations according to market requirement. Blockchain continuously collect data from various sources, process and disseminate to trading partners in real time.

6.1 Theoretical implications

There is curiosity everywhere about blockchain technology, and there is a growing call from reputed journals for research on various aspects of blockchain technology. The present study contributed the literature in two ways. Till date, there is no empirical study which connects blockchain with important supply chain performance parameters such as supply chain alignment, agility and adaptability. The present model connecting alignment, agility and adaptability is adapted from an established model developed by Gunasekaran *et al.* (2017) and Lee (2004). The model's overall fit is satisfactory (CFI: 0.964, RMSEA: 0.048), and it provides vital insights to the researchers. The present study adopts the establish model developed by Gunasekaran *et al.* (2017) and augments it with blockchain, and this advances the supply chain literature with reference to the blockchain. There are many upcoming technologies which can be used in the supply chain, such as artificial intelligence, big-data analytics, internet of things (IoT). The present study can be used as a reference for studying the effects of these technologies with the supply chain. Future studies should also probe in detail specific supply chains (such as agro-foods, downstream petroleum supply chains, etc.) on how blockchain technology can improve such supply chains. The generic framework suggested by the present study can serve as a base for such future research. In addition, future studies can also probe the effect of blockchain technology adoption on other important supply chain parameters such as flexibility, marketing and supply chain orientation, logistic and process integration.

6.2 Managerial implications

The findings of the current study indicate that companies not only should create more awareness regarding blockchain, but should also actively work with IT companies that are engaged in developing blockchain-based supply chain solution so that expectations of supply chain managers can be fulfilled with respect to blockchain technology and its utility for supply chain management. IT companies along supply chain and logistics managers should hold training programs for personnel and motivate them to learn more about blockchain how it can improve business processes. For example, blockchain can be used in logistics as it can improve tracking and brings transparency in logistics which leads to an improved delivery cycle. There are vehicle tracking and logging devices such as GPS and RFID which can be integrated with blockchain. Their location and tracking data serve as input data to blockchain, and these data cannot be tampered. This will make tracking of the shipments easy (Tian, 2016) and such a step will improve operational efficiency, especially for outbound logistics. Similarly, blockchain is useful in manufacturing also, all quality documents can be standardized and shared with all supply chain members, and such a step will improve decision making (Apte and Petrovsky, 2016). As blockchain is a meta-technology, it always needs other technologies, e.g. IoT, Big Data, etc., to enhance its application. The present study will enhance interest of managers in associated technologies also. Finally, supply chain managers and IT companies who wish to adopt and develop blockchain-based IT solutions for the supply chain should start pressuring regularity actors for drafting a legal framework for governing blockchain technology. As without a legal

framework, the technology will remain very risky from an adoption standpoint. Currently in a nation like India, there is no concrete legal framework to address blockchain technology. Managers as well as IT companies and academicians should join hands to study and develop a framework for regulating blockchain technology and suggest these to the policy actors.

7. Conclusion and limitations

The major contribution of the present study is empirically linking blockchain with supply chain parameters that affect firm performance. The present model is adapted from the works of Gunasekaran *et al.* (2017) about firm performance and supply chain parameters, i.e. alignment, adaptability and agility. The model's path coefficients were estimated by collecting a sample from supply chain practitioners spread in many sectors in India. The present study gives insight about how blockchain improves firm performance through alignment, adaptability, agility and trust.

Like all studies, the present study also has some limitations. Such limitations are due to inherent features of blockchain technology and the assumptions made for this study. These assumptions and limitations are as follows:

- Currently, the respondents do not have practical experience of using blockchain technology. They have responded based on their knowledge about supply chain and blockchain which they acquired from published sources. The present study is thus only perception based.
- Blockchain technology is applicable to all types of supply chains for different types of products such as consumer durable, retail chains, agro-foods, etc. Different supply chains need different strategic choices and different information needs. But the present study assumes that all supply chain needs are identical. It is imperative to develop different applications for different supply chains according to their needs and then different adoption models should also be tested.
- Government regulations regarding blockchain – The present study assumes that government regulations regarding blockchain technology are favorable and all regulatory framework is in place to support blockchain technology. However, in India currently, there is no official framework to regulate and govern blockchain technology and its applications.
- Blockchain is not a standalone technology – The present study assumes this which is not correct. Blockchain depends upon qualitative data collection technologies. These include big-data and internet of thing (IoT). The successful adoption of blockchain heavily depends upon real-time and accurate data collection from multiple sources and requires massive data warehouses from several firms; this is the reason why blockchain is very costly technology.
- Familiarity with blockchain – The present study assumes that all respondents are fully aware of blockchain technology. But the fact is that currently in India not a single sector is practically using blockchain. Respondents have knowledge about blockchain due to their interest, but they lack practical knowledge and experience about using blockchain in a business scenario. In addition, in India, some software firms have taken a lead by developing applications using blockchain. But still, respondent's answers are based on their knowledge which they have collected from multiple sources rather than actual practical experience.

8. Future scope of work

A lot of research work needs to be done regarding blockchain when different applications based on specific supply chains will come in the market. The adoption models will be different for different applications. The effects of blockchain on supply chain's important parameters such as flexibility and agility need to be studied. In addition, the effect on transaction cost, trust and supply chain alignment between supply chain members are areas which need to be continuously explored. The success of blockchain technology in improving supply chain management should be studied through longitudinal studies in the future. Another area of study can be integrating blockchain with IoT, RFID, Bigdata, artificial intelligence, etc., and its effect on supply chain management.

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