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Blockchain Technology Based Supply Chain Systems and Supply Chain Performance: A Resource-Based View

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BLOCKCHAIN TECHNOLOGY BASED SUPPLY CHAIN SYSTEMS AND SUPPLY CHAIN PERFORMANCE: A RESOURCE-BASED VIEW

A Thesis

by

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ABSTRACT

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Blockchain technology (BCT) is set to transform firms' present ways of managing supply chains. This thesis explores how the efforts by firms to integrate BCT into their supply chain systems and activities, can enable certain supply chain capabilities and subsequently, improve supply chain performance. Using an abductive research approach, qualitative content analyses of 126 cases of firms' efforts in BCT-based supply chain systems (BCT-SCS) across multiple industries are conducted to identify the BCT-enabled supply chain capabilities and their performance outcomes. Findings reveal that the present BCT-SCS efforts are mainly oriented towards improving the operational-level capabilities namely, information sharing and coordination capabilities rather than strategic-level capabilities namely, integration and collaboration capabilities. The predominant performance outcomes resulting from these capabilities along with the BCT-SCS are quality compliance and improvement, process improvement, flexibility, reduced cost, and reduced process time. However, the performance outcomes vary with industry type, based on the risks that the industry faces. Based on the study's findings, an integrated framework of research propositions is presented to facilitate future empirical research.

DEDICATION

This thesis is dedicated to my husband Santosh and my two daughters Shamitha and Keya. My heartfelt thanks to all of you for nurturing and maintaining such a great learning intensive environment in the family alongside with your caring, sharing and loving. I express my gratitude to my parents for always extending their unconditional support in all my professional and personal endeavors.

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CHAPTER I

INTRODUCTION

1.1 Statement of Problem

During the last two decades, complex supply chains have evolved thanks to the advances in information technology and the liberalization of trade in various countries. Firms are now increasingly relying on outsourcing various value transformation processes to other firms in different geographical regions, or setting up their production or service facilities in low-cost regions (Gereffi & Lee, 2012). Consequently, the management of material, information, and financial flows has become complicated with an increased number of entities participating in the value transformation processes associated with a firm's supply chain (Power, 2005). In this background, supply chain management as an area of interest has attracted several practitioners and researchers from varied disciplines (Arshinder & Deshmukh, 2008). Supply chain management mainly focuses on increasing the performance of a supply chain by the integration and management of three critical flows viz. material flows, information flows, and financial flows among the process links in a supply chain.

Several studies in the past have shown that an effective use of information technology (IT) for information sharing at both intra-organizational and inter-organizational levels is critical for developing supply chain capabilities and improving supply chain performance (Prajogo &

Olhager, 2012). Supply chain systems comprising of enterprise resource planning (ERP) systems and radio frequency identification (RFID) devices have substantially contributed to improvement in supply chain performance through the facilitation of information exchange at an intra-organizational level (Themistocleous, Irani, & Love, 2004). ERP systems enabled information exchange within an organization by integrating the information flows across the functional units, while RFID systems helped in gathering information on the product flows. Information exchange at inter-organizational level however, still remains a concern for present-day supply chain systems due to several constraining factors. The first constraining factor is the lack of supply chain system integration among the participating entities. Present-day supply chains have a large number of participants using a variety of supply chain systems built on different technological platforms. Integrating all these systems to enable a seamless information exchange is technologically an arduous task. The emergence of web and enterprise application integration technologies have resolved the integration challenges to some extent. The second constraining factor is the concern over security of the information being exchanged, especially when the information is exchanged using web-based networks. The third constraining factor pertains to resource investments into the required system integration. Supply chain system integration usually requires huge amounts of financial, system, and process-related investments. Not all the participating entities may be willing to make these investments due to disparate industry standards, business processes, and organizational policies (Yee & Oh, 2013). Due to the above constraints, information remains distributed and inaccessible across the supply chain, leading to poor forms of interaction, and information asymmetries (Rai et al., 2006).

Consequently, several companies still suffer from lack of sufficient supply chain capabilities to monitor their suppliers in real-time (Casey & Wong, 2017).

In recent years, blockchain technology (BCT) has been touted as an important technology disruption that is expected to improve operational efficiency of businesses, especially in the

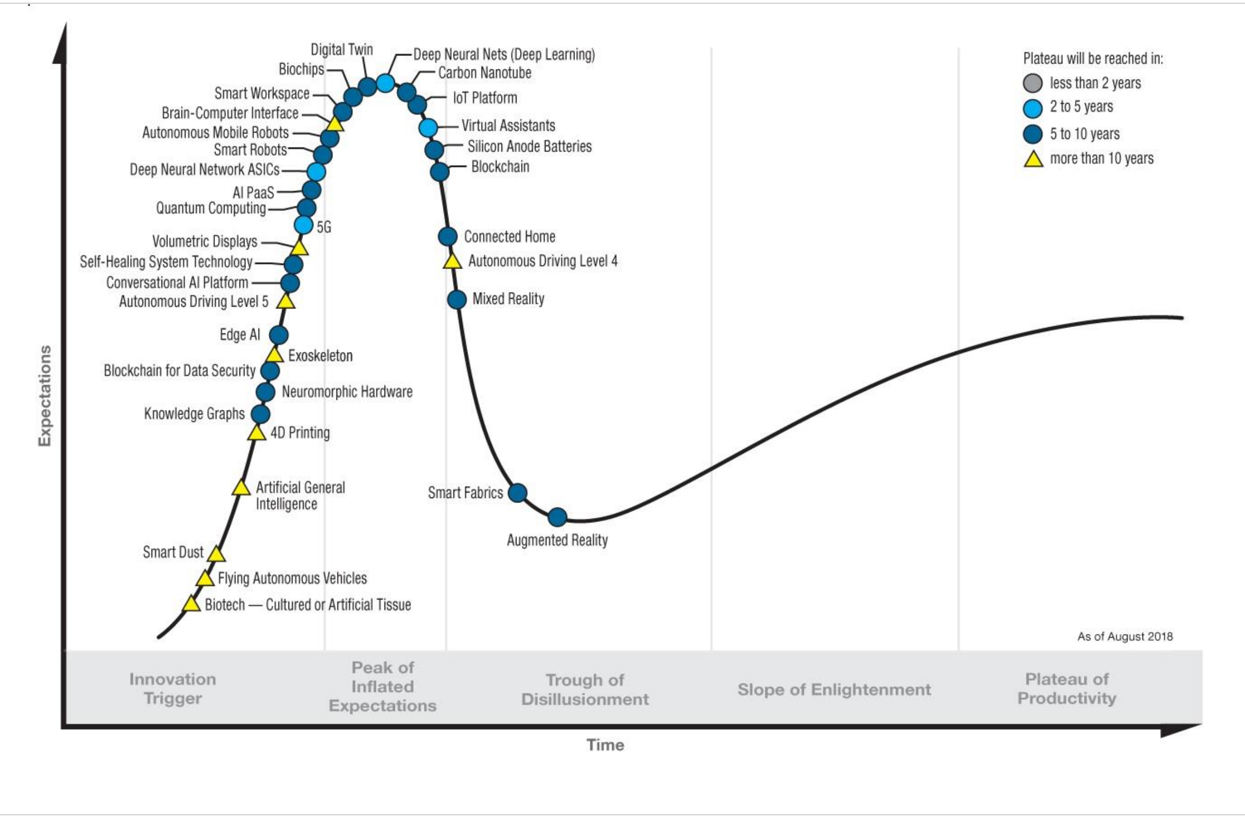

Figure 1-1. Gartner hype cycle for emerging technologies - 2108 (Source: https://www.gartner.com)

realm of supply chain management. BCT is about to enter the “trough of disillusionment” phase in 2018 Gartner’s hype cycle for emerging technologies as shown in Figure 1-1. This new technology is expected to reach the plateau of productivity, if the industry efforts succeed in meeting the goals set for the BCT applications (Gartner, 2018). The worldwide spending on BCT solutions are valued at USD 945 million in the year 2017 and is expected to reach USD 11.7

billion by the year 2022 (Goepfert & Shirer, 2018). These investments on BCT span across several organizations in multiple sectors and geographies. At present, documentation of BCT developments is mainly available through industry reports and articles, which is voluminous and scattered. While there has been growing emphasis for conducting academic research on BCT developments across several disciplines (Kshetri, 2018; Treiblmaier, 2018), academic literature in the area of supply chain management is scarce due to its nascency. Specifically, there are no studies that offer guidance on what supply chain capabilities are enabled by BCT based supply chain systems (BCT-SCS) and how these capabilities result in supply chain performance improvements.

1.2 Statement of Purpose

The first objective of this study is to identify supply chain capabilities that are facilitated by BCT-SCS (hereafter referred to as 'BCT-enabled supply chain capabilities') and their performance outcomes. The second objective is to integrate the identified capabilities and performance outcomes into a coherent *framework*. More specifically, this study fills the gap in blockchain and SCM literature by responding to the following research questions:

1. What are the BCT-enabled supply chain capabilities?
2. What are the supply chain performance outcomes resulting from the bundles of BCT-SCS and BCT-enabled supply chain capabilities?
3. What is the impact of industry type on the relationship between BCT-enabled supply chain capabilities and their performance outcomes?

The research questions are investigated using the lens of 'resource-based view', which suggests that a firm's resources and capabilities are crucial to derive desired performance outcomes. The study builds upon SCM literature that uses resource-based view (RBV) in the context of supply chain systems, to identify their corresponding supply chain capabilities. Thereafter, content analyses are conducted on the industrial literature on BCT to relate supply chain capabilities in the context of BCT-SCS and their expected performance outcomes.

1.3 Thesis Contribution

The thesis study contributes to the literature on supply chain management by offering an integrated conceptual model on the relationship between BCT-SCS and supply chain performance and corresponding propositions. The proposed conceptual model is backed by theoretical and empirical evidence. Future research can extend upon the present study by testing the proposed conceptual model with larger datasets and unique BCT-SCS contexts.

The thesis study is relevant to practitioners as well. Several innovative firms across industries are taking a first leap into developing and using BCT to manage their supply chain activities, while several others are still struggling to understand the technical and functional aspects of BCT and its implications. The thesis facilitates better understanding of the BCT-SCS by presenting an elaborate discussion on the basic functionality of the BCT and synthesizing a huge volume of industry literature on BCT-SCS. Also, the proposed conceptual model uncovers some unique insights about the relationship between BCT-SCS and supply chain performance. These insights are expected to be useful to supply chain practitioners in terms of identifying the right opportunities for applying BCT-SCS and reap the benefits of the BCT.

1.4 Thesis Organization

The thesis is organized in 5 chapters. In Chapter 2, the theoretical background of the study including a discussion on functional details of BCT, BCT-SCS, and RBV of firms is presented. In Chapter 3, the methodology used to achieve the research objectives of the study including the data collection method, the development of guiding frameworks for content analysis, and the data analysis methods is presented. In Chapter 4, the findings of the analysis for each research objective are discussed. In Chapter 5, the study's theoretical and managerial contributions, limitations, and directions for future research are presented.

CHAPTER II

THEORETICAL FOUNDATIONS FOR THE THESIS

In this chapter the theoretical foundations relevant to the thesis are discussed. The chapter is divided into two sections. The first section focuses on concepts related to BCT in general, BCT literature in the context of supply chain management and BCT-SCS. The section includes discussion on the basic characteristics of blockchain, how a blockchain works, types of blockchains, review of BCT literature in the context of supply chain management, description of the research gap, and the definition of BCT-SCS. The second section focuses on the theoretical underpinning for the study namely resource based view of the firm. This section on RBV includes a discussion on RBV concepts that are relevant to the study's objectives.

2.1 Blockchain Technology

BCT is an upcoming area of research and practitioner interest having implications to multiple business domains. Even though this topic is currently getting sufficient exposure in the news and other media, the literature does not offer a comprehensible view about the basic characteristics of blockchains, their functioning and the available types of blockchain. The purpose of this section is to fill this gap in the understanding of BCT through a brief literature review.

2.1.1 Basic Characteristics of BCT

A blockchain may be described as a distributed, tamper-proof ledger shared within a network of entities, where the ledger holds a record of transactions between the entities (Lai & Chuen, 2018). The concept of blockchain, which evolved from the paper published by Satoshi Nakamoto (2008), hinges upon two basic characteristics, namely, ***distributed ledger system*** and ***cryptographic tools*** (Nakamoto, 2008). The ***distributed ledger system*** is the mechanism for verification of transactions using a predefined consensus mechanism among the participating entities, thus avoiding the need for intermediary auditing entities such as Central Banks, notaries, and other governmental institutions (Sikorski, Haughton & Kraft, 2017; Yarmack, 2017). All participants of a blockchain have access to the entire database of transactions and can verify the records of the transaction partners directly, without relying on the intermediary entities (Sikorski et al., 2017). This type of ledger system eliminates single party control on the database, while resolving the problems of disclosure and accountability between multiple entities involved in a transaction (Halaburda & Sarvary, 2016). Data can be updated in real-time without the need for reconciliation with each other's internal records, thus eliminating effort, time lag and associated costs of each entity involved in the transaction approval process (Casey & Wong, 2017). ***Cryptographic tools*** are another significant mechanism associated with blockchains that enable maintaining data security and integrity. Blockchains use hash functions, which is a type of cryptography that transforms data into a hexadecimal code of a fixed length and cannot be inverted to recover the original input (Yarmack, 2017).

2.1.2 Functionality of BCT

This section describes the functioning of decentralized public blockchains. A public blockchain is a decentralized ledger, comprising a chain of "blocks" arranged in chronological sequence with hash functions. The ledger is available to all the participant nodes and is managed by them (Garzik & Donnelly, 2018). Each block contains a group of transactions, the hash of itself, the hash of the previous block, the Merkle root of constituent transactions, a nonce, which is a critical component for miners' proof-of-work, and the timestamp (Yarmack, 2017). Details about these components and other key terms related to BCT are presented in Table 2-1 and a sample block is shown in Figure 2-1. A typical block bundles up to 1 MB volume of transactions from the network, and currently, a new block is created approximately every 10 minutes. For a given asset, the path of all its associated transactions can be traced by a string of alphanumerical code. The identities of entities associated with the transactions are masked and secured by this alphanumerical code. Also, the blockchain records every transaction indefinitely, and each transaction is linked to the previous transaction. With this linking of transactions, each transaction can be easily traced back and audited (Garzik & Donnelly, 2018).

As shown in Figure 2-2, the journey of a block to the blockchain starts when a node in the network makes a transaction specifying the asset to be transferred and the recipient address, which is a string of 26 to 35 alphanumeric characters that is publicly shared. *Asset* in blockchain context refers to a digital token corresponding to a physical asset or a cryptocurrency unit that is registered on the blockchain. The transaction along with a signature are then broadcasted to the network. The signature consists of the sender's private alphanumeric key and the receiver's address. The sender’s private key is mathematically linked to the prior transactions of the asset, and therefore serves as a proof of the sender’s ownership of the asset.

The transaction along with other transactions in the queue are randomly picked up by the miner nodes. A miner bundles a group of transactions into a block and verifies the legitimacy of the associated assets. The verification is followed by adding the timestamp and reference to the previous block and generating the Merkle root of the constituent transactions. The miner along with other miners then proceed to solving a computationally intensive hash puzzle posted by the system, to complete the “proof-of-work” (Halaburda & Sarvary, 2016).

Table 2-1. Key components and terms associated with BCT

	Key term	Details
1	Blockchain	Chain of “blocks” arranged in chronological sequence using hash functions. Blockchain acts as the ledger, containing all the transactions that occur within the network.
2	Block	Group of transaction bundled together up to a size limit. Comprises of hash of itself, the hash of previous block, the Merkle root of constituent transactions, a nonce, and the timestamp.
3	Genesis block	The first block in the ledger. Does not contain hash pointer to the previous block.
4	Node	A participating entity in the blockchain network.
5	Transaction	A mutual contract struck between any set of entities in the blockchain network is generally termed as a transaction. Every transaction is associated with a hash along with other necessary details. Referred to as smart contracts when the utility of the transaction is extended by specifying complex conditions in the input and output scripts.
6	Hash function	A type of cryptography that transforms data into a hexadecimal code of fixed length which cannot be inverted to recover the original input.
7	Hash pointer	A hash pointer is a pointer that also has a hash of what it points to. It is used both to look up the transaction and to verify that the transaction retrieved has not been tampered with since it was stored.
8	Merkle tree	Hierarchical system of hash pointers. The tree is constructed by hashing paired data (the leaves), then pairing and hashing the results until a single hash remains, which is the Merkle root.
9	Nonce	The nonce is a random number which, when added to the other information in a block, generates a hash with a certain number of leading zeroes. Integral part of the mining process.

10	Proof-of-work	The purpose of proof of work (POW) is to create distributed trustless consensus and solve the double-spend problem. It is a piece of data which is computationally difficult (costly, time-consuming) to produce for the first time but easy for others to verify thereafter. POW deters hackers from attempting to update the blockchain with fraudulent data.
11	Turing completeness	Refers to the programming feature of the blockchain that allows to write “smart contracts” incorporating their own rules for ownership, transaction formats and state transition functions. Whereas Bitcoin blockchain network is Turing Incomplete, other blockchains developed in the recent times claim to be Turing Complete including Ethereum and Hyperledger.


```
{
"hash":"0000000000000000079c58e8b5bce4217f7515a74b170049398ed9b8428beb4a",
"size":479,
"height":371623,
"version":3,
"merkleroot":"01a5f8b432e06c11a32b3f30e6cc9a12da207b9237fddf77850801275cf4fe01",
"tx":["ee6bc0e5f95a4ccd0f00784eab850ff8593f9045de96c6656df41c8f9f9c0888","29c59ec39fc19afd84d928272b3290bbe54558f7b51f75feb858b005dea49c10"],
"time":1440604813,
"nonce":3431621579,
"bits":"181443c4",
"difficulty":54256630327.88996,
"chainwork":"0000000000000000000000000000000000000000000998b7adec271cd0ea7258",
"confirmations":137105,
"previousblockhash":"0000000000000000027d0985fef71cbc05a5ee5cdbdc4c6baf2307e6c5db8591",
"nextblockhash":"000000000000000013677449d7375ed22f9c66a94940328081412179795a1ac5",
"reward":25,
"isMainChain":true,
"poolInfo":{}
}
```


Figure 2-1. Sample block (Source: www.blockexplorer.com)

The puzzle relates to finding the “nonce” that hashes with the new block by “hit and try”. The first miner that solves the puzzle publishes its hash to the network, which is verified by other miners. Upon successful validation, the block is appended to the ledger. The miner then gets incentive for the successful completion of proof-of-work and appending the block to the blockchain.

In cases when more than one miner solve the hash puzzle at the same time, the blockchain may “fork” leading to parallel chains. Such a scenario is eventually resolved by the miners picking the longest chain (Lai & Chuen, 2018; Sikorski et al., 2017). The competitive hash puzzle solving associated with proof-of-work is often referred to as “mining”, and the level of difficulty of hash puzzles and incentives associated vary with blockchain networks. The proof-of-work process resolves an important challenge of the decentralized ledger keeping system, that is the possibility of double spending (Extance 2015; Garzik & Donnelly, 2018). The transactions carried out on blockchain are tamper-proof since the hashtags contain timestamps of all the constituent transactions and the precedent blocks. A minor difference in any of the input values results in a major difference

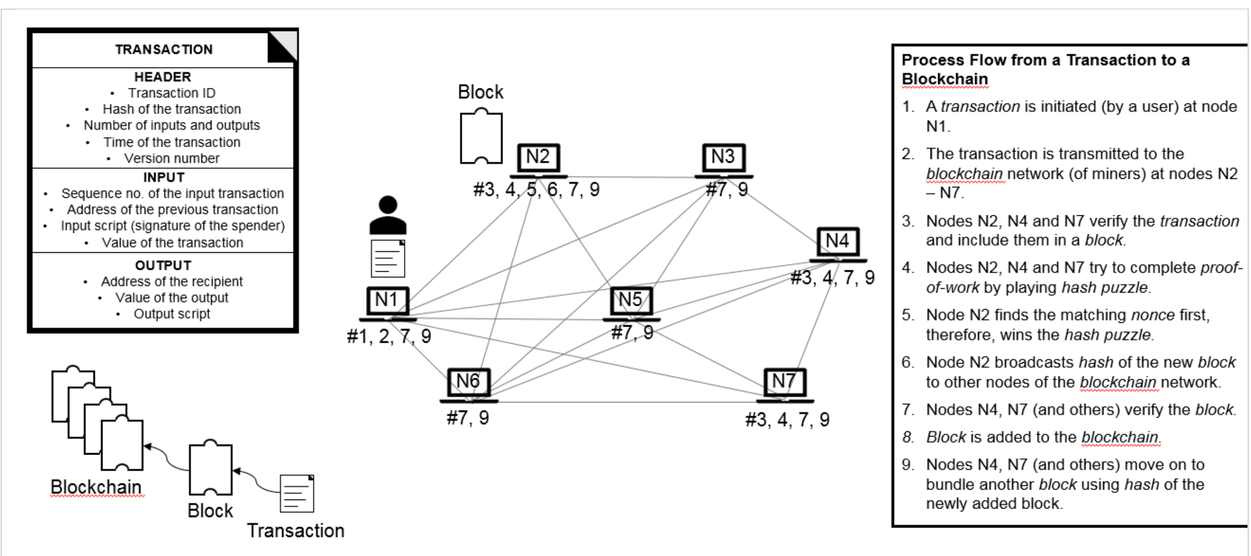

Figure 2-2. Functioning of a BCT system

in the generated hash tag, thus allowing easy identification of the tampered block.

2.1.3 Types of Blockchains

Different variants of blockchain networks are available or can be created, based on accessibility of the network for conducting transactions and participation in mining as shown in Figure 2-3. A blockchain network can be classified as public or private blockchain, based on its accessibility for conducting the transactions (Olnes, Ubacht, & Janssen, 2017). A public

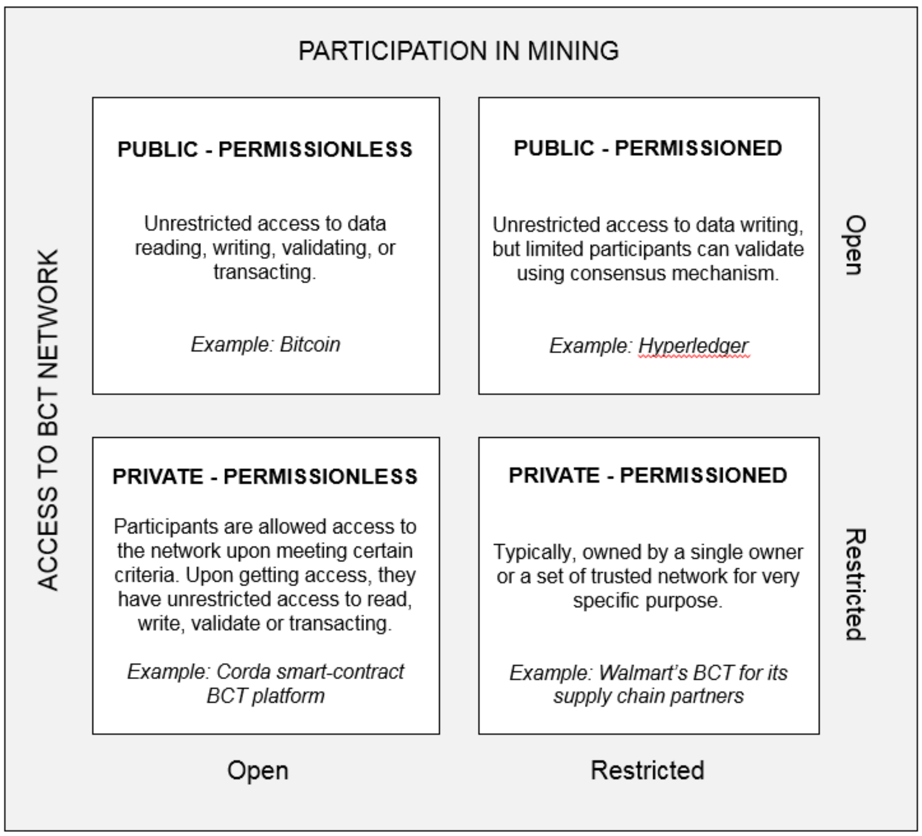

Figure 2-3. Types of blockchain (Adapted from Olnes et al., 2017)

blockchain is open to all the entities to register as a node and transact using the network. A private blockchain, on the other hand, imposes restrictions on who can access and transact on the network. Based on access to mining, a blockchain can be permissioned or permissionless. Any registered node can participate in the mining process in a permissionless blockchain, while registered nodes in permissioned blockchains require authentication to participate in mining activity (Olnes et al., 2017).

Public blockchains offer network power and resiliency to handle greater volumes of transaction approvals. However, these blockchain networks may not be dependable in terms of consistent technical performance and customized transaction procedures required for operations of business firms. Business firms, therefore, are exploring ways to design other variants of blockchains mentioned earlier, by allowing predetermined authorized entities to access the network and/or mining activity (Lai & Chuen, 2018). Firms are also exploring various types of proof-of-work procedures to suit their industry and business requirements (Staples et al., 2017).

2.1.4 Academic Literature on BCT and Supply Chain Management

BCT has been widely acknowledged as an upcoming disruptive technology, especially in the realm of SCM (Casey & Wong, 2017; Korpela, Hallikas, & Dahlberg, 2017; Kshetri, 2018). Some of the positive attributes of BCT based supply chain systems include:

- Faster transaction approvals through decentralized consensus mechanisms,
- Ability to track the history of transactions,
- Instantaneous information access, and
- Data security.

While industry reports and articles profoundly discuss blockchain's role in SCM, scholarly literature is yet to gain momentum. The countable papers that are presently available touch upon varied themes on BCT-based supply chain systems including proposals of various architecture, supply chain user attitudes, adoption drivers and barriers in specific industries, and their role in achieving supply chain sustainability, resilience and supply chain performance.

Some of the papers proposed different architectures of BCT-based supply chain systems that accommodate specific supply chain requirements such as processing efficiency and data privacy. Gao et al. (2018) proposed a BCT-based supply chain system comprising of two block chain layers to effectively cope with processing of large volumes of supply chain transactions. In this system, one blockchain layer caters to processing the transaction requests of the supply chain users while another blockchain layer caters to data storage processes. The researchers proposed to use a rigorous consensus mechanism for the transaction blockchain layer and a relatively less rigorous one for the data storage blockchain layer. Kaijun et al. (2018) also proposed a double chain architecture BCT-based supply chain system catering to the needs of agricultural supply chains. The proposed system is expected to enhance the credibility and overall efficiency of the system by leveraging on the double-chain structure. Wu et al. (2017) proposed an add-on blockchain system that complements the existing enterprise supply chain systems. The proposed system is a layered system comprising of a set of private enterprise blockchains and a single public blockchain. The transaction information is shared among the partners using private blockchains, to ensure information privacy. The public blockchain maintains the meta-data of the private events besides other pseudo-location monitoring events. The researchers suggest that this architecture prototype is well-suited for chemical, pharmaceutical and other high-end product supply chains. Sikorski, Haughton, and Kraft (2017) show cased a pilot implementation of a BCT-based trading system for chemical industry. The system enables secure machine-to-machine interactions facilitating automated transaction settlements.

Kamble, Gunasekharan, and Arha (2018) focused upon the user attitudes about BCT-based supply chain system. The researchers surveyed the Indian supply chain practitioners about their perceptions towards utility of BCT for performing the supply chain tasks and their intentions to adopt. The survey results revealed that the practitioners considered the BCT to be useful for performing the supply chain activities and had favorable intentions to adopt BCT-based supply chain systems. Gausdal, Czachorowski, and Solesvik (2018) studied the drivers and barriers to adopt the BCT-based supply chain systems in Norwegian offshore industry. The study discovered that scope for cost reduction, high levels of regulation in the offshore industry and large amounts of data that needs to be processed are among the drivers for adoption of BCT-based supply chain systems. The barriers for the adoption included high implementation cost, lack of good quality Internet connections at offshore locations, reluctance of the old-aged decision-makers and the low levels of blockchain diffusion within the offshore industry supply chain.

Some of the studies focused on the role of blockchain-based supply chain systems in achieving supply chain sustainability, resilience and supply chain performance. Saberi et al. (2018) examined how BCT and smart contracts can contribute to supply chain sustainability. The researchers suggested that the BCT can contribute to social and environmental supply chain sustainability by eliminating the activities of nefarious agents in the supply chain and enabling easy mechanisms for verifying product source and quality standards. Min (2019) discussed about how BCT and smart contracts can be applied for managing supply chain risk in the context of order fulfillment process. Kshetri (2018) studied 11 cases of blockchain deployment for supply chain activities and discussed the role of BCT in achieving the supply chain performance objectives.

This thesis study extends upon the study by Kshetri (2018) and adds to the scarce literature on BCT and supply chain management by conducting a theory-based analysis of a larger dataset of case-studies of BCT-SCS developments around the world using the RBV theoretical perspective. Tise study is also a response to a recent call by Treiblmaier (2018) for conducting theory-based research on potential implications of the BCT for supply chain management using the existing inter-organizational theories namely principal agent theory, transaction cost analysis, resource-based view and the network theory.

2.2 Resource-Based View of a Firm

Rooted in management strategy literature, RBV of the firm describes, explains, and predicts how a firm can achieve sustainable competitive advantages through acquisition of and control over its bundles of "unique" resources and capabilities (Bharadwaj, 2000; Barratt & Oke, 2007; Wernerfelt, 1984). These unique resources and capabilities offering competitive advantage to the firm are valuable, rare, difficult to imitate, non-substitutable by other resources, and are heterogeneously distributed among firms within an industry (Barney 1991; Bharadwaj, 2000). A firm's resources refer to those assets, both tangible (e.g. IT infrastructure) and intangible (e.g. information or process knowledge), possessed by a firm that enable the production and delivery of goods and services (Barratt & Oke, 2007; Grant, 1991). Capabilities, in contrast, refer to a firm's approach to resource utilization, that is, deployment of resources in combination with organizational processes to effect a desired end (Amit & Schoemaker, 1993; Liu, Srai, & Evans, 2016). RBV argues that while possessing a unique resource, a firm must also possess capabilities to develop and configure these resources so as to maximize its competitive potential (Eisenhardt & Martin, 2000). As such, RBV is theoretically apt in explaining how a firm can achieve competitive advantages by transforming its unique resources into capabilities through systematic building, integrating and reconfiguring its resources into its organizational processes and routines (Fawcett et al., 2011).

Several studies investigated the different supply chain capabilities enabled by information and communication technology (ICT) resources such as e-business, electronic data interchange and radio-frequency identification systems (Angeles, 2009; Bi et al., 2013; Devraj, Krajewski, & Wei, 2007). To our best knowledge, no study to this date has focused on how BCT-SCS can contribute to the competitive advantage of a firm. The BCT-enabled supply chain infrastructure and the know-how expertise are expected to serve as unique and valuable resources for the innovative firms that are currently experimenting with the technology. However, from RBV perspective, merely possessing technical and knowledge resources of advanced ICT by the firms does not automatically translate into supply chain performance improvements (Fawcett et al., 2011; Trkman et al., 2007; Wu et al., 2006; Zhang, van Donk, & van der Vaart, 2011). Rather, the ICT resources facilitate the creation of firm-level and supply chain level capabilities, which thereby create differential returns based on their unique value and inimitability (Bharadwaj, 2000; Zhang et al., 2011). In this backdrop, it is assumed that the impact of BCT-SCS on supply chain performance is mediated by the presence of supply chain capabilities. Accordingly, the research questions for the thesis study are framed as follows:

Research Question 1: *What are the BCT-enabled supply chain capabilities?*

Research Question 2: *What are the supply chain performance outcomes resulting from BCT-SCS and BCT-enabled supply chain capabilities?*

Research Question 3: *What is the impact of industry type on the relationship between BCT-enabled supply chain capabilities and their performance outcomes?.*

CHAPTER III

METHODOLOGY

In this chapter, the research approach used for the study is discussed. To start with, the three approaches for conducting a research study namely inductive, deductive, and abductive research approaches are discussed. Later, the research methodology used for the thesis study is elaborately discussed including the choice of research approach and research methods used for the study.

3.1 Research Approaches

New knowledge can be acquired using three research approaches namely inductive, deductive, and abductive research approaches. The three research approaches can be distinguished on three parameters:

- The starting point of the research process that is, whether the research process began with a theoretical base or empirical base;
- The aim of the research that is, whether the research objectives are oriented towards theory development or theory testing;
- The point in time at which hypotheses or propositions are introduced in the research.

Inductive research approach begins with collection of observations of specific instances as shown in Figure 3-1. Studies using this research approach may use existing theory to the extent of setting boundaries to the phenomenon being studied and data collection or may not use any theory at all (Kovacs & Spens, 2005). The research process using this approach seeks to identify common patterns emerging from the empirical observations and establish generalizations about the phenomenon being studied. Therefore, the research objectives for studies using inductive research approach are oriented towards theory development. The hypotheses or propositions are developed on the basis of collected empirical data rather than from the existing theory.

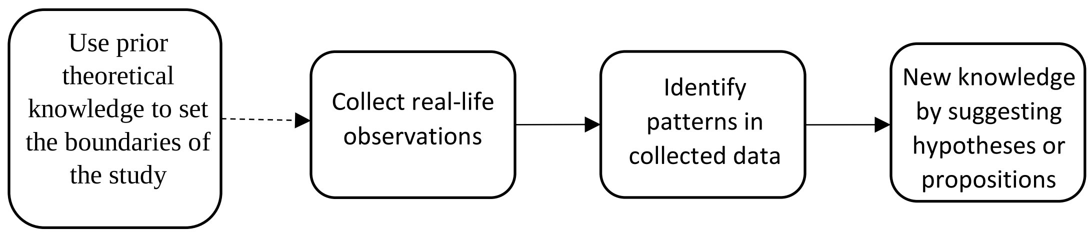

Figure 3-1. Inductive research process

The deductive research approach, on the other hand begins with an established theoretical base and seeks to apply the theoretical base to a specific context, as shown in Figure 3-2. The research objectives for studies using this research approach are oriented towards theory testing. The hypotheses are developed by scanning theories appropriate to the research context, followed by collection of data sample to test the hypotheses or propositions (Kovacs & Spens, 2005). The hypotheses are accepted or abandoned based on the results from data analyses, thus extending upon the existing theoretical knowledge for a specific research context.

Abductive research approach is a process of reasoning in which explanations to a real-life phenomenon are formed and evaluated iteratively moving back and forth between existing theory

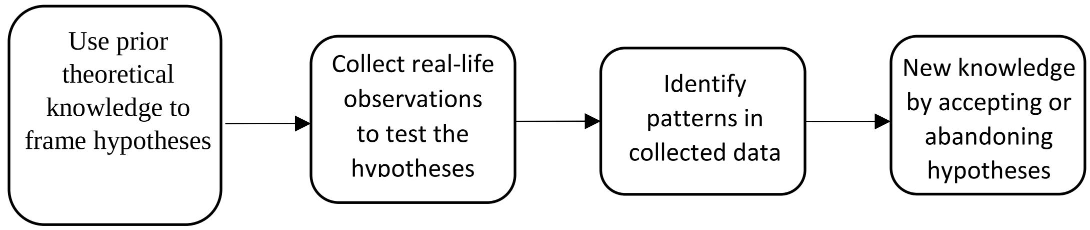

Figure 3-2. Deductive research process

on the phenomenon and real-world data (Dunne & Dougherty, 2016; Magnani, 2001), as shown in Figure 3-3. The real-life phenomenon studied using this approach are usually deviations from the general structure, which cannot possibly be examined by adopting pure inductive or deductive approaches (Danermark, 2001). Abductive research approach allows the researcher to anchor findings to an initial theory, which is then developed and refined as data collection and analysis progresses (Karatzas, Johnson, & Bastl, 2017). Theory development, data collection, and analysis are symbiotically linked in abductive approach (Karatzas, Johnson, & Bastl, 2017). New knowledge in this research approach is generated suggesting hypotheses or propositions

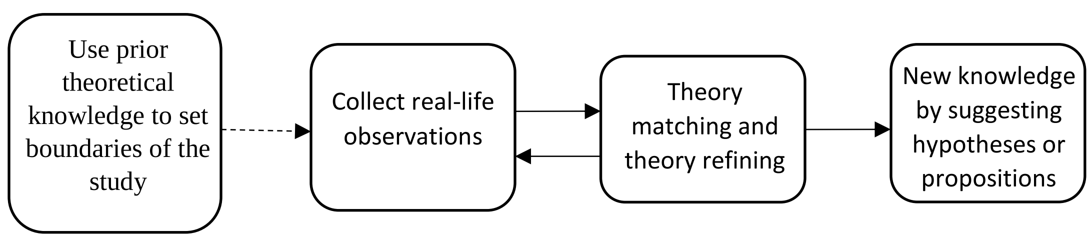

Figure 3-3. Abductive research process

that can later be tested using deductive research methods.

3.2 Choice of Research Approach and Method

The thesis adopted an abductive research approach to achieve the study's research objectives. The abductive approach is considered to be apt for this study for several reasons. First, the phenomenon being investigated in this study pertains to potential implications of enormous investments made by firms on BCT systems development, to supply chain performance. Since the phenomenon is nascent, complex, and inaccessible, it is not suited for drawing inferences using pure deductive or inductive approaches (Krippendorf, 2004). Second, the research questions of the study are oriented more towards theory development. That is, they are aimed towards analyzing and refining the existing theory on supply chain capabilities in an emergent technological context rather than inventing a new theory (Dubois & Gadde, 2002). These questions are suited for drawing inferences abductively by examining a body of text describing the phenomenon (Krippendorf, 2004). Third, the expected output of the study is a set of propositions corroborated by both theoretical and empirical evidence (Lin, Kuei, & Chai, 2013). These propositions are expected to create new knowledge that could be used by practitioners and researchers for further theory refinement and evaluation.

A qualitative content analysis was conducted following the logic of abduction as depicted in Figure 3-4. Sample data for the study includes industry reports on BCT use-cases and development efforts by various firms across the world. Supply chain problems that have been or are expected to be resolved by BCT systems and their corresponding performance outcomes were identified from the data and matched with guiding frameworks developed from the existing academic literature. These guiding frameworks of supply chain capabilities and performance outcomes evolved as the study progressed through the analysis, and simultaneously served as a theoretical guideline throughout the analysis. In this way, the analysis was neither constrained by theory nor overwhelmed by data, and the output was reinforced both by theory and empirical data in a balanced way (Dubois & Gadde, 2002; Karatzas et al., 2017).

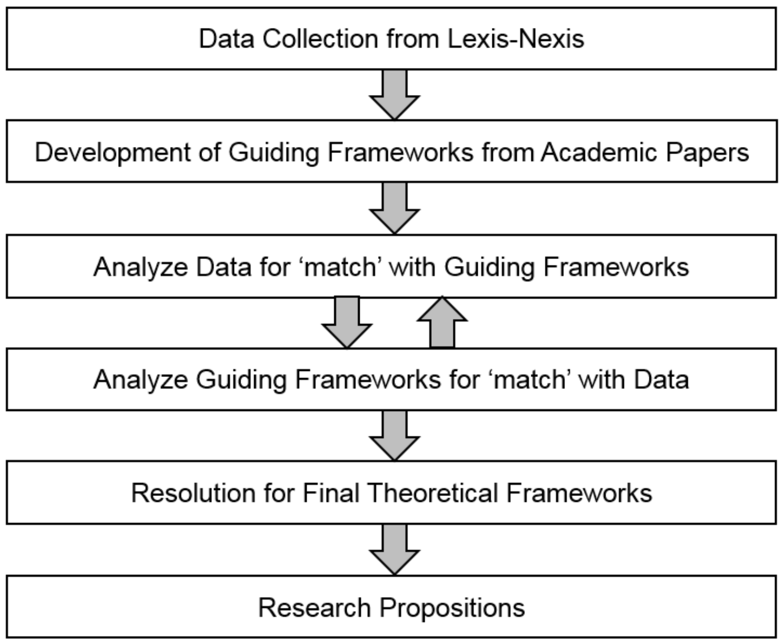

Figure 3-4. Research Methodology

3.3 Data Collection

Data for the study was obtained from a leading business news database, Lexis-Nexis database, which covers all prominent newspapers, professional magazines, and business wire news across the world. The combination of keywords 'blockchain' and 'supply chain'. were used to identify the relevant data from the database. The search was limited to news and wire news articles during the time period 2016-2018, since significant BCT developments happened during this timeline. News articles pertaining to general discussions on BCT and cryptocurrencies, announcements of BCT focused symposiums and conferences, and repetitive content on industrial efforts were screened out. After the screening, the final dataset comprised of 118 news articles discussing 126 industry efforts by firms across the globe. The industry efforts, henceforth referred to as ‘sample-cases’, included BCT-enabled supply chain solution deployments and developments including green papers, white papers, proof-of-concepts, prototyping, pilot testing, beta testing, and other efforts that involve commitment of investment by firms.

3.3.1 Guiding Frameworks for Data Collection and Analysis

A guiding framework for identifying BCT-enabled supply chain capabilities was developed by referring to the academic papers that focused on supply chain capabilities enabled by various types of ICT resources. Similar supply chain capabilities are grouped and labelled based on the definitions and measurement items used in the academic papers. The framework of capabilities as presented in Table 3-1, included two operational supply chain capabilities - information sharing and coordination capabilities, and two strategic supply chain capabilities - integration and collaboration capabilities. Operational capabilities allow a firm to make a living in the present, by facilitating the performance of its day-to-day operational activities (Fainshmidt et al., 2016; Teece, 2014). Strategic capabilities allow a firm to confer competitive advantages by altering the resource base, constantly improving operational capabilities, and/or initiating change in its external environment (Fainshmidt et al., 2016; Teece, 2014).

Using a similar method, a guiding framework was developed to identify supply chain performance outcomes resulting from BCT-SCS and capabilities. Supply chain performance outcomes refer to the measurement metrics that enable quantification of the overall effectiveness

Table 3-1. Guiding framework of supply chain capabilities

	Supply Chain Capability	Definition	Source(s)
1	Information Sharing Capabilities	Operational capabilities that enable a firm to share information and knowledge within its organizational units as well as its supply chain partners in an effective and efficient manner.	Bi et al. (2013); Fuchs et al. (2018); Sanders (2008); Wu et al. (2006).
2	Coordination Capabilities	Operational capabilities that enable a firm to coordinate transactional related activities with its functional units and supply chain partners from order-taking to order follow-up.	Bi et al. (2013); Sanders (2008); Wu et al. (2006).
3	Integration Capabilities	Strategic capabilities that accrue from strategic alignment of a firm's activities with its upstream and downstream supply chain partners.	Angeles (2009); Bi et al. (2013); Bruque-Camara, Moyano-Fuentes, & Maqueira-Marin (2016); Devraj et al., (2007); Hong, Tran, & Park (2010); Li et al. (2009); Paulraj & Chen (2007); Paulraj, Lado, & Chen (2008); Rai, Patnayakuni, & Seth (2006); Wu et al. (2006); Yu et al. (2017).
4	Collaboration Capabilities	Strategic capabilities that accrue from long term supply chain relationships that enable supply chain partners to jointly deal with the market demand, planning business activities, and chalking out mutual short-term and long-term goals.	Fawcett et al. (2011); Kim & Lee (2010); Peng et al. (2016); Sanders (2008).

and efficiency of supply chain processes. The guiding framework presented in Table 3-2 contains six performance outcomes - cost reduction, quality improvement and compliance, process time reduction, process improvement, flexibility, and innovativeness.

Table 3-2. Guiding framework of supply chain performance outcomes

	Supply Chain Performance Outcome	Definition	Source(s)
1	Cost reduction	Reduction in material costs, processing costs, information costs, distribution costs, overhead costs, cost per operation hour, risk costs, and other intangible costs.	Cho et al. (2012); Gunasekharan, Patel, & McGaughey (2004); Shepherd & Gunter (2006); Zhang et al. (2011).
2	Quality compliance and improvement	Customer product and service expectation fulfilment, reduction in process and products errors, quality differentiation, reduction in data errors.	Cho et al. (2012); Gunasekharan et al. (2004); Shepherd & Gunter (2006); Zhang et al. (2011).
3	Process time Reduction	Reduction in product/service delivery time, supplier lead time, pre-sale and after-sale service time, supply chain process cycle times, product development cycle time, and transaction times.	Cho et al. (2012); Gunasekharan et al. (2004); Shepherd & Gunter (2006); Zhang et al. (2011).
4	Process improvement	Increased capacity, inventory utilization, and resource utilization.	Cho et al. (2012); Gunasekharan et al. (2004); Shepherd & Gunter (2006).
5	Flexibility	Response to changes in customer demands and environmental challenges, delivery flexibility, service systems flexibility, supplier risk sharing initiatives, and supply chain agility.	Cho et al. (2012); Gunasekharan et al. (2004); Kim & Lee (2010); Shepherd & Gunter (2006); Zhang et al. (2011).
6	Innovativeness	Product innovation, process innovation, and exploration of new market opportunities by supply chain firms.	Zhang et al. (2011); Shepherd & Gunter (2006).

3.4 Data Analysis

Data analysis for the study involved a non-linear path between data, data sources and theory. Content for each sample-case was carefully examined and matched with guiding frameworks, independently by three coders including the author of this thesis study. The coders had good academic knowledge and understanding of supply chain management and BCT. The coders independently coded all the sample-cases into three categories, namely ‘less likely’, ‘not sure’, ‘more likely’, based on their assessment of each industrial effort’s potential to enable the capabilities listed in the guiding framework. In several instances, they consulted other data sources to attain complete understanding of the concepts being discussed in the sample-case content. For example, to understand how BCT smart contracts are used in different scenarios, the coders consulted literature covering supply chain contracts and concepts of smart contracts. Similarly, for understanding the mentioned implications of BCT on internet of things (IoTs), the researchers reviewed academic literature on the issues with IoTs implementations, in the present scenario. Overall, academic papers of various disciplines were reviewed by the coders, including computer engineering, SCM, information systems, and industrial engineering, to ensure thorough analysis and reliability of the research output. Disagreements among the three coders were resolved by consulting an academic expert of operations management area. The expert referred to the text data of the sample-case and relevant academic papers to resolve the disagreement. The interrater agreement among the coders was 91.8%.

A similar procedure of coding and analysis was followed for identifying supply chain performance outcomes relevant for BCT-SCS and capabilities. The interrater agreement among the coders for supply chain performance outcomes was 94.9%. To examine the influence of industry type, sector-wise analyses of the identified supply chain performance outcomes were conducted.

CHAPTER IV

RESULTS AND PROPOSITIONS

In this chapter, the results for the analyses corresponding to the three research questions are presented. Initially, the BCT-enabled supply chain capabilities identified from the abductive content analysis are presented in detail, followed by the details on the identified supply chain performance outcomes resulting from the BCT-SCS and BCT-enabled supply chain capabilities. In the end, the impact of industry type on the relationship between the BCT-enabled supply chain capabilities and the supply chain performance outcomes is presented. The relevant propositions corresponding to results of the analyses are presented throughout the chapter.

4.1 BCT-enabled Supply Chain Capabilities

In this section, the findings for the first research question that deals with identification of BCT-enabled supply chain capabilities are presented. The analysis of sample-cases revealed that BCT-enabled supply chain capabilities include all the four supply chain capabilities present in the guiding framework: information sharing, coordination, integration, and collaboration capabilities. However, the enabled supply chain capabilities differed in the sample-cases based on type of BCT application that was being developed or deployed, and the type of supply chain problems that were addressed. It was observed that, BCT-enabled supply chain efforts at present mainly enabled operational supply chain capabilities, which are information sharing capabilities and coordination capabilities. Strategic supply chain capabilities namely, integration capabilities and collaboration capabilities, were observed in a comparatively smaller number of sample-cases as shown in Figure 4-1. Specifically, BCT applications in 99% of the sample-cases enabled information sharing capabilities, 81% of them enabled coordination capabilities, 21% of them enabled integration capabilities, and 9% of them enabled collaboration capabilities. Elaborate discussion on the analysis results for each of these capabilities is presented in the following sections.

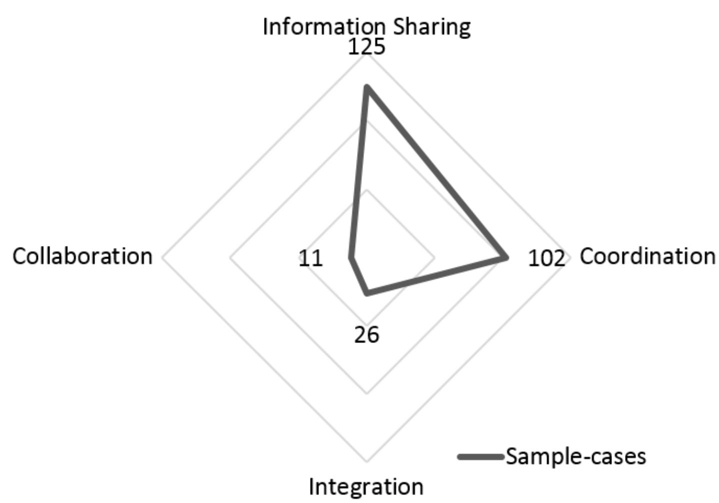

Figure 4-1. Analysis for BCT-enabled supply chain capabilities

4.1.1 Information Sharing Capabilities

Information sharing capabilities refer to the ability of a firm to share information and knowledge within its organizational units as well as its supply chain partners in an effective and efficient manner. A firm can be more proactive in identifying and mitigating potential problems, if it has knowledge of the location and status of its products downstream, or its raw materials upstream in the supply chain (Kaynak & Carr, 2012; Stenger, 2011). One of the key challenges for present supply chain information systems is to incorporate, and make accessible, information on the status of orders, inventories, and products outside the firm (Kaynak & Carr, 2012; Stenger, 2011). This information needs to come from a credible source and in an adequate format (Wu et al., 2006). BCT-SCS are expected to effectively resolve the information gaps at the inter-firm links. Details of the issues resolved by BCT-SCS that emerged from sample-case analysis are presented in Table 4-1. For better comprehension, the issues are detailed in supply chain system scenarios with and without BCT. Among 126 sample-cases of BCT-SCS efforts, 99% of them are oriented towards resolving information gaps across the supply chain links and enabling information sharing capabilities of supply chain firms. BCT-SCS efforts in the sample-cases resolved information sharing issues in the following ways:

- By facilitating interoperability among organizational ERP systems and IoTs,
- By ensuring information security, and
- By facilitating inclusion of supply chain entities at downstream and upstream ends.

Present day supply chains can be likened to an uprooted tree-like structure comprising numerous networks of firms participating in upstream and downstream value transformation activities (Lambert & Cooper, 2000). In most supply chains, information flows among the participating firms are hindered by information systems functioning in disparate technological and operational environments (Yee & Oh, 2013). Achieving interoperability among these systems requires expensive integration and standardization efforts, which may not be affordable by all the participating firms (Kembro & Selviaridis, 2015; Tenhiäläa & Helkiö, 2015). In BCT-SCS, the blockchains serve as an independent layer linking participating ERP systems, enabling communication of information on a real-time basis. The information is verified by the BCT network for its authenticity and is readily accessible to all the relevant entities that are part of the

Table 4-1. Information sharing capabilities in BCT-SCS (Sample-cases: 99%)

Scenario without BCT	Scenario with BCT	Reference from sample-cases
Information silos due to issues with interoperability of ERP systems of supply chain firms.	Seamless information sharing with BCT linking the ERP systems of the supply chain firms.	▪ SAP integrating BCT into their core ERP products. ▪ Industry consortium alliance BiTA, formed to set up common standards and practices for BCT-SCS in logistics industry.
Interoperability and data security concerns of IoTs.	Interoperability and data security ensured with BCT linking the IoTS.	▪ Pilot project by JD.com to track transport and storage conditions of meat products using BCT. ▪ Deployment of IoTs systems integrated with BCT by ABB for effective and secure information sharing among utility system devices. ▪ Development of BCT compatible micro-computer technology devices called 'crypto anchors'.
Security concerns in sharing sensitive data.	Cryptographic tools are integral part of BCT-SCS ensuring security of information.	▪ Development of BCT-based Keyless Signature Infrastructure by Guardtime and Estonian eHealth Foundation for secure retrieval of patient records.
Non-inclusion of supply chain entities on the far ends of value-chain that is, customer on the downstream end, and raw material supplier on the upstream end, due to technical complexities	Easier integration of customers and suppliers enabling information transparency and feedback.	▪ BCT integrated mobile app 'Travel Ezee' developed by Bajaj Allianz General Insurance for easier claims settlements in case of flight delays. ▪ Pilot project by JD.com involving HW Greenhan & Sons Pty Ltd. to track source, transport and storage information of meat products using BCT.

network. Efforts of leading ERP vendors to integrate BCT with their core ERP and other enterprise products is a major milestone in realizing seamless information flows among interoperable systems in BCT-SCS (Bjorlin, 2017; Bloomberg, 2017). Another important issue affecting interoperability among the supply chain information systems pertains to lack of standardized operational practices and data formats for effective data exchange (Yee & Oh, 2013). During the last three years, several industry consortia such as BiTA, AdLedger, BankChain, and Trusted IoT Alliance, comprising firms in logistics, advertising, and banking respectively, have been created to develop common industrial processes and data exchange formats for BCT-SCS (Andrews, 2018; Commendatore, 2018; Dua, 2017; Trusted IoT Alliance, 2017). BCT-SCS are expected to resolve a major concern in IoTs communication related to information security (Khan & Salah, 2017; Kshetri, 2018). Development of micro-technology devices such as 'Crypto Anchors' and 'Crypto Seals' by IBM and Chronicled, are expected to further enhance IoTs communication in BCT-SCS (Chronicled, 2016; Mearian, 2018b). Pilot tests on supply chain traceability carried out by firms in different sectors, especially in the food, logistics and financial sectors, show-case the possibility of seamless information flows and inclusion of upstream and downstream supply chain entities by overcoming the interoperability and integration issues, with BCT-SCS.

Apart from interoperability issues, information flows among firms are also hindered by concerns on information security, especially for organizations in healthcare, utility and government services sectors (Yee & Oh, 2013). Cryptographic tools, which are an inherent part of BCT-SCS, are expected to effectively address these information security concerns (Korpela et al., 2017). The chaining of a transaction with its precedent transactions ensures data integrity and enables traceability of events. Thus, BCT-SCS can play a key role in ensuring availability, accessibility, and credibility of the information necessary for supply chain processes (Casey & Wong, 2017). The initiative by Estonian eHealth Foundation to develop Keyless Signature Infrastructure and other similar efforts clearly point out the potential of secure information sharing using BCT-SCS (Frost & Sullivan, 2017). By addressing concerns of interoperability and data security, BCT-SCS also facilitate firms to achieve end-to-end visibility of supply chain, which otherwise, is a challenge in the present supply chain systems without BCT (Sithole, Silva, & Kavelj, 2016). The reasonable costs of setting up BCT infrastructure are yet another boosting factor to enable active participation of the supply chain entities in information sharing. Hence, the first proposition of the thesis study is:

Proposition 1: BCT-SCS are more likely to develop information sharing capabilities than supply chain systems without BCT.

4.1.2 Coordination Capabilities

Coordination capabilities enable a firm to coordinate transaction related activities with its functional units and supply chain partners from order-taking to order follow-up (Bi et al., 2013; Wu et al., 2006). Coordination capabilities are an integral part of supply chain governance to achieve optimal performance across the supply chain partners by reducing opportunism, conflict and market uncertainties, and by increasing cooperation (Lumineau & Henderson, 2012; Xue et al., 2007). These capabilities can be achieved by bringing in information transparency across the supply chain and by effectively designing and executing supply chain contracts (Arshinder, Kanda, & Deshmukh, 2008). Among the sample-cases analyzed, BCT-SCS efforts in 81% of the cases are oriented towards enhancing coordination capabilities. These efforts, as shown in Table 4-2, contribute to enhancement of coordination capabilities in the following ways:

- By reducing time delays of document verification processes at the hand-off points of the physical material flows,
- By shortening the time required for cross-border financial settlements,
- By providing platforms for supply chain entities to connect and transact,
- By increasing scope for process automation using smart contracts and integrated IoTs,

Table 4-2. Coordination capabilities in BCT-SCS (Sample-cases: 81%)

Scenario without BCT	Scenario with BCT	Reference from Sample-case
Time delays due to cumbersome document verification processes (bills of lading, letter of credit, and so on) at the supply chain hand-off points.	Instantaneous access to trustable information, with inclusion of government entities and third-party service providers as nodes in BCT-SCS.	▪ Pilot project of BCT-enabled supply chain system by the consortium Maersk, IBM, EU Commission services, US Dept. of Homeland security, US customs and border protection to eliminate time delays in the information verification processes.
Time delays in cross-border financial settlements due to longer cross-border remittance processes of banks.	Faster cross-border remittance processes with banks and other financial firms participating in BCT-enabled payment platforms.	▪ Development of the largest BCT-enabled payment network Interbank Information Network (IIN) by J.P. Morgan.
Involvement of third-party intermediaries in trading products and services due to lack of platforms that connect the supply chain entities.	BCT-enabled supply chain platforms enable supply chain entities to connect with each other and trade for the required products and services using smart contracts.	▪ Launch of BCT-based primary issuance and secondary trading platform for illiquid real estate securities and properties by Silver Portal Capital LLC.
Limited automation in inter-firm and intra-firm workflows due to	Scope for automation using IoTs and smart contracts to coordinate inter-firm and	▪ Venture by Sun Pacific Holdings to use BCT-enabled system to monitor energy grid, handle load

information security concerns.	intra-firm work flows in BCT-SCS.	balancing, asset management, and billing processes.
Cumbersome auditing processes due to lack of auditable information trails for the transactions.	Linked structure of BCT enables maintaining auditable information trails for the transactions.	▪ Development of BCT-enabled platform ‘Petrobloq’ dedicated for oil and gas industry by Petroteq Energy Inc, predominantly to enable peer-to-peer transactions, ensure transparency of transactions and auditable trail for regulators.

- By enabling easier auditing processes by providing trusted transaction trails.

Several BCT efforts are underway by firms to smoothen the verification and transaction processes at the hand-off points of the physical supply chain, especially for the international shipments. Presently, these processes involve several third-party intermediaries and paper documents, owing to lack of reliable information and to regulatory compliances (Mearian, 2018a). By including the necessary third-party service providers and government entities as nodes on BCT networks, the required information for verification and compliance processes can be easily communicated, thus eliminating paper documents and time delays (Sahoo, 2017). The pilot project carried out by the consortium led by Maersk and IBM is a good example for representing the utility of BCT-enabled systems in coordinating process flows at the hand-off points. The international shipping process being piloted involved 30 intermediary entities and 200 pieces of information exchange (Mearian 2018a; Sahoo, 2017). All the concerned entities participated as nodes on the BCT platform in the pilot project. The project results indicated significant improvements in terms of reduced process-span and wastage of perishable goods (Mearian 2018a; Sahoo, 2017). Encouraged by the results of this pilot project, several other firms are following the suite by testing out the potential of BCT-enabled systems to improve international shipping processes (Ngai, 2018; Silkchain, 2018).

On the payment side, numerous consortia comprising financial institutions across the globe are developing BCT-enabled payment platforms to address the time-delays in cross-border payments. For example, the consortia led by J. P. Morgan developed and launched the largest BCT-enabled payment network Interbank Information Network (IIN), that can reduce the cross-border payment settlement processes from weeks to hours, thereby reducing costs associated with resolving payment delays (Mearian, 2018c). Numerous firms and consortia in various industries are developing BCT-enabled platforms for trading products and supply chain finance. These platforms are expected to facilitate trading and transactions by connecting the required entities and eliminating reliance on third-party intermediaries (BW Online Bureau, 2018; XinFin FinTech, 2018).

On the internal process front, BCT-SCS can facilitate process automation by effective integration with IoTs and self-executing smart contracts. For instance, the venture by Sun Pacific Holdings to use a BCT-enabled system to monitor energy grid, handle load balancing, asset management and billing processes show-cases the utility of BCT-SCS in process automation (Mearian, 2018c). Further, BCT-enabled systems are widely recognized by firms for their potential to facilitate internal and external process audits by providing information trails of the transactions (BW Online Bureau, 2018a). Hence, the second proposition of the thesis study is:

Proposition 2: BCT-SCS are more likely to develop coordination capabilities than supply chain systems without BCT.

4.1.3. Integration Capabilities

Integration capabilities are strategic capabilities that accrue from tactical alignment of a firm's activities with its upstream and downstream supply chain partners (Wu et al., 2006). These capabilities are achieved by integration of informational, financial, and physical flows among the supply chain partners as part of a firm's business strategy. Such integration enables firms to reduce the negative effects of variations in supply and demand (often referred to as bull-whip effect), improve overall supply chain process efficiencies, improve product designs by effectively interpreting customer needs, and offer customized services to the customers (Li et al., 2009; Rai et al., 2006). Supply chain integration capabilities are indicators of high levels of process maturity and are crucial for achieving sustainable supply chain performance. They hinge upon strategic orientation of supply chain processes and commitment of resources by participating supply chain partners (Trkman et al., 2007). Among the 126 sample-cases analyzed, efforts in 21% of the cases are found to be contributing to development of integration capabilities. As presented in Table 4-3, these efforts contribute to integration capabilities in the following ways:

- By providing scope for linking of supply chain partners' information systems,
- By ensuring security of the information shared, and subsequently,
- By allowing supply chain partners to effectively engage in design and execution of supply chain processes.

An exemplary BCT effort relevant to integration effort is the implementation of a comprehensive BCT-enabled coffee bean procurement system by Coda Coffee and its supply chain partners (Vu, 2018). This system developed by Bext 360 involves a BCT platform linked

Table 4-3. Integration capabilities in BCT-SCS (Sample-cases: 21%)

Non-BCT scenario	BCT scenario	Reference from sample-cases
Technology constraints for strategic coupling of information systems of supply chain partners' systems.	BCT systems are easy to couple with supply chain partners' systems and smart devices.	▪ Coda Coffee and its supply chain partners' implementation of a comprehensive BCT-enabled coffee bean procurement system, which links with mobile apps, mobile robots and cloud-based IT applications to integrate the physical, informational and financial flows in coffee-bean procurement processes.
Less scope for engaging and empowering supply chain partners.	More scope for engaging and empowering supply chain partners, with ensured data security by cryptographic tools and enhanced access security on permissioned BCT networks.	▪ Pilot project of BCT-enabled system called VeriPart by ST Aerospace and Moog Inc. to enable secure digital distribution of 3D print files of critical aircraft parts as part of aftermarket services (Moog Inc., 2018)

with mobile apps, mobile robots and cloud-based IT applications, thus enabling the farmers and other intermediaries to actively engage and participate in the supply chain processes. The process begins with farmers recording their identities using mobile robots. The coffee bean produce is then submitted to the mobile robots for quality assessment. Based on the quality report generated by mobile robots, a fair price for the produce is negotiated between the buyers and farmers, using the system's mobile app. Transactions are then completed using BCT-enabled digital wallets. As the coffee beans move along the downstream, supply chain intermediaries trace the product information and conduct the transactions using the BCT-enabled cloud application plug-ins (Vu, 2018). Overall, this comprehensive system leveraging on artificial intelligence, information visibility and data security enables engagement of all the supply chain entities, thus achieving integration capabilities and global supply chain performance outcomes. Hence, the third proposition of the thesis study is:

Proposition 3: BCT-SCS are less likely to develop integration capabilities than supply chain systems without BCT.

4.1.4. Collaboration Capabilities

Collaboration capabilities refer to the strategic capabilities accrued from long term relationships that enable supply chain partners to jointly deal with the market demand, planning business activities, and chalking out mutual short-term and long-term goals (Kim & Lee, 2010; Sanders & Premus, 2005). Firms possessing these capabilities usually have co-operative and more exclusive relationships with their partners, compete in markets jointly rather than as individual firms, and therefore, cooperatively share market risks and performance rewards (Gunasekharan et al., 2004). Firms aspiring to possess these capabilities tend to build and maintain mature IT systems that are compatible with each other and effectively utilize them for planning and executing their supply chain activities (Kim & Lee, 2010). Among the sample-

Table 4-4. Collaboration capabilities in BCT-SCS (Sample-cases: 9%)

Scenario without BCT	Scenario with BCT	Reference from sample-cases
Lack of platforms that enabled collaborative interactions due to technical and security concerns.	BCT systems provide trustable platforms for engaging in collaborative and confidential interactions among the participants with their easy coupling and enhanced security.	▪ Deployment of BCT-enabled production system platform for receivable financing by the consortium comprising of MonetaGo, Reserve Bank of India, Receivables Exchange of India Limited, M1xchange, Axis bank and Mjunction.

cases analyzed, efforts in 9% of the sample-cases are found to be augmenting shared objectives and activities of the supply chain partners. As presented in Table 4-4, these efforts typically involved synergistic engagement of the supply chain partners in business activities and economic benefits to all the partners. The business activities in these set-ups are oriented towards building and/or sustaining long-term relations without compromising on confidentiality of business-critical information.

An example industry effort show-casing the facilitating role of BCT systems in developing collaborative capabilities is the deployment of a BCT-enabled production system platform for receivable financing by the consortium comprising MonetaGo, Reserve Bank of India, Receivables Exchange of India Limited, M1xchange, Axis bank and Mjunction (MonetaGo, 2018). This system provides a common platform to securely and confidentially share information and conduct transactions pertaining to receivable financing. The platform provides a competitive marketplace for small businesses to obtain required finances through discounting of invoices from corporate organizations, government departments, and public-sector undertakings. The security attributes of the BCT platform help in mitigating risks arising from multiple financing of the same bills across the platforms (MonetaGo, 2018). The success of the system involves collaboration of all the entities in the design and execution of the supply chain processes and is not controlled by any one entity. In this background, the fourth proposition of the thesis study is:

Proposition 4: BCT-SCS are less likely to develop collaboration capabilities than supply chain systems without BCT.

4.2 BCT-SCS and Supply Chain Performance

In this section, the findings for the second research question section that deals with identification of supply chain performance outcomes resulting from BCT-SCS and capabilities are presented. The findings of the sample-case analysis along with the specific metrics representing the performance outcomes are presented in Table 4-5. Our sample-case analysis revealed that BCT-SCS in combination with BCT-enabled capabilities supported in achieving both effectiveness and efficiency-oriented performance outcomes. *Quality compliance and improvement*, and *flexibility* are the predominant effectiveness-oriented performance outcomes that are quoted in 69% and 46% of the sample-cases. With regards to the efficiency-oriented performance outcomes, *process improvements*, *cost reductions* and *process time reductions* are cited in 60%, 27%, and 19% of sample-cases respectively. *Innovativeness* is the least likely performance outcome that is cited in 4% of the sample-cases.

BCT-SCS, with their inbuilt cryptographic tools, linked transactions, and decentralized structure help in mitigating process risks, information risks and counterfeiting risks (Mearian, 2018a). Consequently, they are expected to have the greatest impact on quality related outcomes such as information security, assurance of regulatory compliance, trusted verification processes, and avoidance of fraudulent activities in the supply chain. Kodak, for example is developing a BCT-enabled image rights management platform to create an encrypted, digital ledger of rights ownership for photographers (Rogers, 2018). This platform helps in verifying the authenticity of imagery licenses and eliminating frauds by easily detecting unlicensed imagery usage. With regards to the outcome of process improvement, BCT platforms help in connecting the supply chain firms and information systems and enable direct interactions among the entities, thus eliminating the need for intermediaries that broker these interactions (Rogers, 2018). The interoperability of BCT-SCS with IoTs and other systems and smart contracts helps in process automation and elimination of information bottlenecks, thus enhancing process efficiencies (Kshetri, 2018; Mearian, 2017). Enabling information transparency across the supply chain is yet another major benefit of the BCT-SCS. Information transparency helps supply chain firms to be more responsive to customer demands and environmental conditions through easier identification of abnormal conditions and managing the response to such conditions. For example, one of the motivations for firms in the food and beverage industry to develop BCT-SCS is to be able to track the conditions of food products as they move along the supply chain, identify any incidences of contamination, and recall the contaminated products before they are consumed by the customers (Vestvik-Lunde, 2018).

Performance outcomes pertaining to cost reduction and process cycle time reduction are other important performance outcomes that have been cited in fairly good number of sample-cases. The quoted cost reductions are derived mainly from eliminated process intermediaries, avoided legal costs, or avoided fraud costs (Mearian, 2018a). The reduction in process cycle times mainly correspond to reduced number of intermediaries, paper work and the amount of time taken for information exchange. The performance outcome of innovativeness has been quoted in less than 5% of the sample-cases. These sample-cases represent efforts to create a novel tool or solution specific to their industry, using BCT platforms and involve active engagement and commitment of their customers or supply chain partners to achieve the goal (Frost & Sullivan, 2017). However, at this point, the majority of BCT efforts in the industry are pointed at resolving typical supply chain issues at operational and tactical level rather than creating something novel by using the BCT platforms. This could be due to nascency of the BCT, complexity of the supply chain structures, and the complexity associated with implementing BCT-SCS for achieving innovativeness. Thus, innovativeness is a less likely outcome that firms target to achieve in their present efforts of BCT-SCS. Hence, the fifth proposition of the thesis study is:

Proposition 5: BCT-SCS and their capabilities are more likely to result in process improvements, product/service quality improvements, flexibility, cost reductions, and process time reductions than those without BCT.

Proposition 6: BCT-SCS and their capabilities are less likely to result in innovativeness than those without BCT.

Table 4-5. Supply chain performance outcomes resulting from BCT-SCS and capabilities

Supply Chain Performance Outcome (% sample-cases)	Measurement metrics in the guiding framework	Measurement metrics from sample-cases
Cost Reduction (27%)	Reduction in material costs, processing costs, information costs, distribution costs, overhead costs, cost per operation hour, risk costs, and other intangible costs.	Reduction in overall costs, information risk costs, intermediary costs, product wastage costs, administrative costs, global financial and infrastructural deficit, transaction fees, holding and transport costs, carbon assets development costs; Avoidance of legal costs, fraud costs.
Quality Compliance and Improvement (69%)	Customer product and service expectation fulfilment, reduction in process and product errors, quality differentiation, reduction in data errors.	Improvement in information security, integrity, exchange, access, quality; Improved billing accuracy, service quality, verification processes, safety, trust, customer service experience, process stability and control, self-sufficiency, accountability, product tracking, supply chain connectivity; Avoidance of fraudulent practices, counterfeit products; Reduction in counterparty risk; Assurance of regulatory compliance, fair payment, intellectual property confidentiality.
Process Cycle Time Reduction (19%)	Reduction in product/service delivery time, supplier lead time, pre-sale and after-sale service time, supply chain process cycle times, product development cycle time, and transaction times.	Reduction of time delays in documentation and approval processes, transaction settlement, business registration times, contract management processes, pre-lease diligence, transfer of land ownership, administrative procedures, turn-around time, product investigation and recall, payments using cryptocurrencies, and product delivery.
Process Improvement (60%)	Increased capacity, inventory utilization, and resource utilization.	Reduction in number of process intermediaries, manual processes, paper work, payment times using cryptocurrencies, process complexity and time, work stoppages due to lack of funding, process bottlenecks, task duplication; Improvement in capacity planning, information tracking; Handling large work

		volumes, ad campaign reconciliation, productivity, inventory management; Process automation using smart contracts; Effective measurement tools, planning of inputs, process flows and process standards; Information collection and visibility enabled by interoperability with IoTs and other supply chain information systems; Simplification of processes; Ease of liquidizing assets.
Flexibility (46%)	Supply chain firms to responding cooperatively to customer demands and environmental challenges, delivery flexibility, service systems flexibility, supplier risk sharing initiatives, and supply chain agility.	Real-time information; Transparency; Audit trail for regulators; avoidance of power black-outs; Supply chain visibility.
Innovativeness (4%)	Product innovation, process innovation, invent/implement new process technology, exploring new market opportunities by supply chain firm consortia.	Development of tool to assess life-cycle impact of all inputs and outputs of animal protein production, collaborative tools on permissioned BCT; Incentivizing customers for healthy behaviors; Facilitation for data collection on effects of Cannabis of different types and potency for medicinal research, collaboration of life sciences organizations through the drug development, secure data-sharing between healthcare providers and suppliers on use and effects of nutritional supplements.

4.3 Impact of Industry Type

In this section, the findings for the third research question that deals with assessing the impact of industry type on the relationship between BCT-enabled supply chain capabilities and their outcomes are presented. The sector-wise analysis of BCT sample-cases and their supply chain performance outcomes is presented in Table 4-6. From the analysis, it is evident that firms from all the sectors are exploring the potential of BCT-SCS. However, firms belonging to industrial, healthcare, financial, and consumer staple sectors are clearly dominating the list of BCT supply chain efforts. The analysis also reveals several insights related to the influence of industry context on the firms' anticipated performance outcomes from their BCT-enabled supply chain efforts. BCT originated from crypto-currencies and thus, the dominance of financial sector firms in BCT efforts comes as no surprise. Several banks and payment firms have deployed BCT-enabled platforms for payment settlements and reconciliations. Information and process risks are main concerns for industries in the financial sector. Firms in this sector are counting on BCT-enabled systems to enhance process efficiencies without compromising on information security. Firms in the industrial sector, especially those in the transportation industry, are faced with process risks and inefficiencies arising from document work at hand-off points, interfaces with numerous government and local intermediaries, and difficulty in tracking of information on shipment conditions. BCT-SCS are expected to reduce the information processing costs and eliminate process related frauds and losses. The anticipated performance outcomes for this sector are therefore, an increase in process efficiencies, quality compliance and improvement, cost reduction, and flexibility.

Table 4-6. Sector-wise analysis (a*dapted from Global Industry Classification Standard (GICS) industry taxonomy*).

	Sector	Predominant industry	Total sample-cases	C	Q	T	PI	F	I
1	Industrials	Transportation, Capital Goods	25	11	18	4	19	11	0
2	Healthcare	Pharmaceuticals, Healthcare Providers & Services	25	1	21	2	14	7	5
3	Financials	Banking & Diversified Finance	18	3	8	7	15	6	0
4	Consumer Staples	Food & Beverage	16	1	13	1	3	12	0
5	Consumer Discretionary	Advertising, Publishing	12	6	9	2	7	7	0
6	Information Technology	Technology, Hardware & Equipment, Software and Services	8	0	3	1	7	2	0
7	Government	Government Departments	7	2	4	5	3	3	0
8	Materials	Metals & Mining	5	0	5	0	5	0	0
9	Utilities	Electric Utilities, Independent Power and Renewable Electricity Producers	4	2	3	0	3	2	0
10	Energy	Oil, Gas & Consumable Fuels	3	3	2	1	3	3	0
11	Real Estate	Real Estate Management & Development	2	0	0	1	2	0	0

C – Cost reduction; Q – Quality compliance & improvement; T – Process time reduction; PI – Process improvement; F – Flexibility; I – Innovativeness.

On the other hand, delivering high quality of products and services, while ensuring information security and authenticity of information access, is a major concern for firms in the healthcare sector. BCT-enabled tools and platforms are expected to mitigate the information and counterfeiting risks, while enabling secure coordination and collaboration among the healthcare supply chain partners. Consequently, quality compliance and improvement and increase in process efficiencies are the most cited performance outcomes by firms belonging to this sector. One worthy point to note is that some of the firms in this sector are also able to achieve innovativeness by securely collaborating on BCT platforms to conduct health related research. Sample-cases in the consumer staples sector are dominated by firms in food and beverage industry. Quality and safety of food products has gained much attention after numerous health related incidents due to contaminated food products. Firms in food and beverage industry, therefore, are implementing BCT-SCS primarily to ensure quality and safety of the food products along the supply chain and be able to respond to any violations in the safety conditions of the food products. Based on the findings of this analysis, the study posits that the supply chain performance outcomes from BCT-enabled supply chain capabilities vary with industry type. Hence, the sixth proposition of the thesis study is:

Proposition 7: The relationship between BCT-enabled supply chain resources and capabilities and supply chain performance outcomes is moderated by industry type.

CHAPTER V

CONCLUSION

5.1 Thesis Summary

The thesis study aimed to understand how BCT-SCS impacts supply chain performance. Using RBV theoretical lens, the study contended that BCT-SCS positively impact supply chain performance through BCT-enabled supply chain capabilities. The study sought to identify the BCT-enabled supply chain capabilities and the relevant supply chain performance outcomes. Using abductive research methodology, content analysis of news articles on BCT industry efforts was conducted using guiding frameworks of supply chain capabilities and performance outcomes developed from the existing theory. The study also examined the influence of industry type on the relation between BCT supply chain capabilities and the performance outcomes. An integrated framework of the study's propositions is shown in Figure 5-1 and the observations from the analyses are summarized below:

- Supply chain capabilities relevant to BCT-SCS include information sharing, coordination, integration and collaboration capabilities. However, from the data analysis, it is noted that the operational capabilities of information sharing, and coordination are more prevalent in BCT-SCS than are the strategic capabilities of integration and collaboration.

- Supply chain performance outcomes relevant to BCT-SCS and capabilities include improved process efficiencies, product/service quality, and flexibility, reduced cost, and reduced process time. The supply chain performance outcome of innovativeness has been observed in relatively fewer cases.
- The relationship between BCT-SCS and their capabilities and supply chain performance

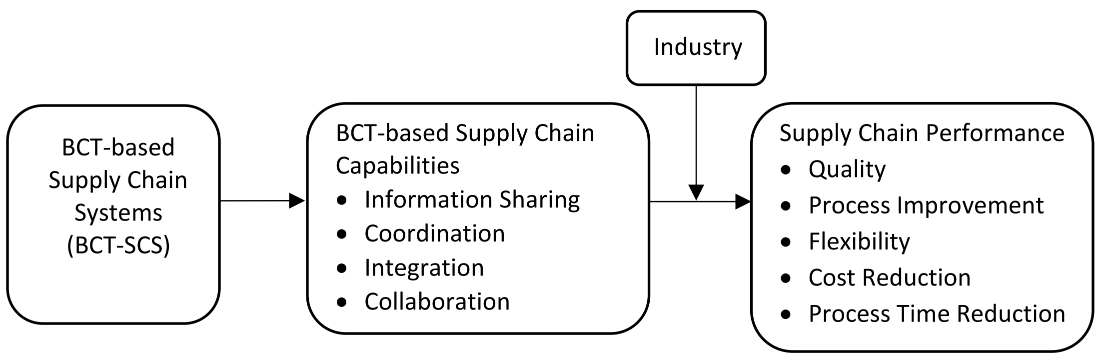

Figure 5-1. Integrated research framework

outcomes is moderated by the industry type. Sector-wise analysis of supply chain performance outcomes revealed that the anticipated outcomes from BCT-SCS and capabilities varied with the types of risks faced by different industries.

5.2 Thesis Contributions

This study offers three main contributions to current research and practice on SCM. First, it presents an exhaustive overview of BCT, which is a recent technological phenomenon touted to transform the facet of SCM. The overview includes in-depth functional details of BCT and ongoing industry efforts of using this technology for various supply chain activities. The conceptual and analytical insights offered in this study are expected to benefit both researchers and practitioners in better comprehension of state-of-the-art developments of BCT applications in the domain of SCM.

Second, it contributes to SCM theory by focusing on the emergent concept of BCT-SCS. At present, very few studies exist touching upon this concept. The study identifies BCT-enabled supply chain capabilities and performance outcomes based on 126 sample-cases of BCT efforts. In doing so, it provides rich description of the identified capabilities by comparing these capabilities in non-BCT scenario and BCT scenario. The comparison is further corroborated by providing relevant empirical evidences from the current industry efforts. The study also provides specific metrics for measuring supply chain performance outcomes pertinent to BCT-SCS. It delineates the outcomes based on the industry type as well. The insights offered in this study are expected to serve as basis for several other future studies in the area, especially with regards to conceptualizing and operationalizing BCT-enabled supply chain capabilities and corresponding supply chain performance outcomes.

Third, it systematically examines the phenomenon of BCT-SCS from an existing theoretical perspective and offers an integrated framework of how BCT can help in enhancing supply chain performance. As BCT-enabled supply chain applications mature in future, future research studies are encouraged to adapt and test the proposed framework in different real-world settings.

5.3 Thesis Limitations

As is the case with any research endeavor, this study has some limitations. One of the main limitations is related to the nascence and complexity of the phenomenon being studied. The study's results are based on the early developments of BCT applications, which at present are showing positive results. However, the success of full-blown implementations of BCT-SCS is dependent on synchronized efforts of all the supply chain entities, governments, technology firms, and BCT networks. Achieving this convergence may take long periods of preparation and negotiation. Therefore, the findings of the study must be interpreted in the light of this limitation. Another important limitation of this study relates to the methodology being used. As mentioned earlier, the concept of BCT-SCS is still emerging and accessibility to primary data on the ongoing BCT efforts is limited. Therefore, the study is constrained to rely on secondary data (i.e., the news content on BCT efforts). Even though, utmost care is taken in collecting, coding, and analyzing the content, the study findings should be treated as tentative. This limitation however, leaves scope for future studies to test the proposed framework, and further contribute to the body of knowledge in the domain.

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APPENDIX – A

Table A-1. Sample cases used for the analyses

Data Item-Code	Sector	Consortium/Company	Blockchain Use-case/Effort	Addressed Issue	Benefits claimed
1	Consumer Discretionary	AdLedger consortium	Setting Rules and Standards for BCT networks and use; developing two proof-of-concept projects—one is a media campaign executed through its entire lifecycle on blockchain, the other concerns GDPR compliance	Opaque middleware, fraud mitigation	Transparency, Cost reduction
2, 12	Industrials	BiTA, ORBCOMM (Telematics)	Blockchain in Transport Alliance; Setting common standards for trucking BCT solutions	Multiple verifications of business transactions, information not in sync among business partners,	Transparency, Hand-off visibility, Better capacity planning, automate business policies by smart contracts, data security and integrity,
3	Consumer Discretionary	Salon Media, IBM, AdLedger	**Salon media**: proof-of-concept blockchain project for ad campaign reconciliation on Salon properties	Lack of control over ad inventory, inefficiencies in long and complex supply chain	Transparency (record contractual conditions like recording impression data and how much Salon will be paid)
3	Consumer Discretionary	Unilever, IBM	Using IBM's blockchain platform to make buys with part of its U.S. ad spend, as well as to validate agreed-upon figures and clear discrepancies	Lack of measurement tools and transparency	Ad spend reduced by 17%
4	Information Technology	IBM, Amazon, Microsoft	Offering Block-chain-as-a-service	Contract lifecycle management	Seamless information and document flow by plugging in Blockchain API in there is

5, 67	Healthcare	BASF, Arc-NET	Preliminary phase of Pilot of AgBalance Livestock blockchain tool	Tracking sustainability measures for Regulatory compliance	Traceability and Transparency by Assessment of life cycle impact of all inputs and outputs of animal protein production
6	Consumer Discretionary	Kodak	Launched KODAKOne image rights management platform KODAKCoin	Frauds in imagery use	Detect unlicensed use of imagery, faster payment using cryptocurrencies
7	Financials	FoxCONN, ChainedFinance	Prototype completed on private permissioned blockchain, to provide loans to suppliers from non-bank lenders	Lack of supply chain lending or delays/frauds in supply chain lending	fewer work stoppages due to lack of funding, even prevent the closure of entire factories.
8, 10, 13, 31	Industrials	Maersk, IBM, EU Commission services, US Dept. of Homeland security, US customs and border protection	Completed proof-of-concept of blockchain-based electronic shipping system on Hyperledger; Developing a trade digitization SCM platform built on blockchain technology for the sprawling global shipping ecosystem	Delays due to paper work and lack of information across supply chain; Antiquated systems and standards; Many hand-off points, interactions during the transit and time delays	Faster documentation and approval processes, information visibility; Real-time information, Transparency, Audit trail for regulators, enabler of peer-to-peer trading models, cost reduction; Transparency, trusted information access, reduction of waste due to delays, reduction in processing costs, reduction in errors and frauds
9, 38	Real estate	Staten Island Multiple Listing Service, ShelterZoom	Proof-of-concept for real estate listing on blockchain platform	Lack of information across multiple entities in the supply chain, and paper work	Information visibility and reduction in inefficiencies due to paper work
9	Utilities	ABB, Xage, Utility Companies	Providing Cyber security for IoTs (at edge gateways in components of power substations)	Lack inter-connectivity among devices controling substation, potential security breaches	The mesh network enables secure, remote access to IoT devices to control substations, allowing for everything from viewing maintenance data to rerouting power.
9	Information Technology	Dell Boomi and cloud service providers	Beta testing blockchain as a method for securing data being exchanged between disparate cloud services	Issues with Interoperability	Interoperability

10, 70, 74	Energy	Petroteq Energy Inc	developing oil and gas industry's first dedicated blockchain-based based SCM platform, PetroBloq	Antiquated systems and standards	Real-time information, Transparency, Audit trail for regulators, enabler of peer-to-peer trading models, cost reduction, safer operations, IOT integration
10, 74	Energy	BP, Royal Dutch Shell	Formed a powerhouse consortium to deliver a blockchain-based platform for trading energy commodities	Antiquated systems and standards	Real-time information, Transparency, Audit trail for regulators, enabler of peer-to-peer trading models, cost reduction
11	Information Technology	SAP	Integrating blockchain technology into its core manufacturing and supply chain products, and bringing together IoT data and information in the systems of record. 5 use cases with BCT. Creating a layer and set of unique APIs and capabilities to enable blockchain-based applications independent of the protocol	Integration with other systems and IOTS, Interoperability	Integration with other systems and IOTS, Interoperability
14	Consumer Staples	IBM, Walmart, Nestle, Unilever and 7 other firms	Pilot various aspects of food traceability	Food contamination along the supply chain	end-to-end transparency in the global food system
15	Energy	Energy Eco Chain	Developing a blockchain based digital platform for energy trading using public and private blockchains	Secure handling of large volumes of business sensitive data,	Stable system securely handling large volumes of data i.e. Increased transparency, efficiency, and safety, Cost reduction, faster transactions
16, 32	Financials	IBM, Mahindra	Prototype (proof-of-concept) supply chain finance platform for tracking SC transactions	Issues with information access of supply chain finance	Security, transparency, consistency, trust, operational efficiency
17	Government Services	NIST	Setting up of guidelines to usage of BCT in Government services	Data security	Secure internal messaging; Drawback – No credential storage as part of design

18, 21	Industrials	IBM	Created micro-computer technology devices called crypto anchors.	Counterfeit products, Lack of information access across SC links, linkage between sensors and blockchain	Prevention of counterfeit goods, efficiency, information access, IOT linkage to Blockchain
19, 36	Materials	Everledger, IBM	Developing application to track provenance of diamonds using IBM blockchain	Issues with information access and security	Information access and security, source verification
20	Information Technology	Google, Hyperledger	Piloting blockchain based transaction services for delivery of their cloud services	Issues with trust and information security	Enhanced trust and information security
22	Government Services	IBM, Dubai Govt., Consensys	working on a city-wide blockchain pilot to streamline ID verification	Data security and access issues, delays in documentation processes	reduce business registration times, and is digitizing and tracking citizens' health records, wills and contracts, among other assets
23, 32	Government Services	Andhra Pradesh Government, Belfrics Global	POC in supply chain logistics, tender issuance and bidding	Delays and lack of security with paper systems	Efficiency, Process automation
24	Real estate	Silver Portal Capital LLC, Fundamental Interactions Inc	Developed a blockchain based primary issuance and secondary trading platform for illiquid real estate securities and properties	Difficulty in liquidizing assets, delays in creating, authenticating and auditing contracts, inaccess to real estate sponsors and issuers	Faster contract management process, automation with smart contracts, faster pre-lease diligence, ease of liquidizing assets, information access to available assets and sponsors.
24	Government Services	UK Government	Digital street - Initiative to move country's land registry to blockchain by 2022.	lengthy process of recording and transferring titles	Expedited transfer of land ownership, transparency, data security
24	Government Services	Governments of Sweden, Dubai, and Republic of Georgia	Trials with blockchain for land record management	lengthy process of recording and transferring titles	Expedited transfer of land ownership, transparency, data security
25	Financials	Genpact	Blockchain service using smart contracts to record details of the order placed by a customer to an organization	Tracking and tracing order details	Immutability, transparency

25, 38	Financials	JP Morgan	Created Interbank Information Network (IIN)- the largest blockchain based payment network	Time delays and costs associated with international payments - takes upto weeks	Enhanced customer service experience, reduced costs, and time delays, transaction information security
25, 38	Financials	Master Card	Launched its own blockchain based payment network	Time delays and costs associated with international payments - takes upto weeks, redundant administrative tasks associated with credit card services	Enhanced customer service experience, reduced costs, and time delays, transaction information security, automation of credit card services, faster transaction settlement
25, 26	Utilities	LO3 Energy, Siemens Digital Grid Division, Residents of Park Slope of Brooklyn, Next47 (for financing)	Launched Brooklyn Micogrid - a blockchain enabled microgrid to sell power generated from rooftop solar panels to neighbors and local utlity firms	Crisis when a blackout occurs due to natural disasters, intermediaries in energy trading	Independent grid control, Trading of small-scale of renewable energy, self-sufficiency, cost-efficiencies, data immutability, cut-down on intermediaries in energy trading
25	Utilities	Sun Pacific Holdings	Use a blockchain based system to monitor grid, handle load balancing, asset management, and billing	Cumbersome authentication processes in billing	Real-time fulfilment of customer demands, cost efficiencies, avoidance of black-outs
25	Financials	KlickEx, IBM	Blockchain based electronic exchange for cross-border electronic payments	Time delays due to transaction volumes	reduced time delays
25, 27	Healthcare	MintHealth	Launched blockchain based health record platform, vidamints - digital health tokens to enable healthcare related payments	Issues with data access due to security concerns	Secure access of health data by the patients, incentivization of individual healthy behaviors
25, 38	Healthcare	IBM Watson Health, US FDA	exploring Blockchain enabled patient data exchange, and other sensitive information	Time delays and costs associated with international payments - redundant administrative tasks associated with credit card services	Enhanced customer service experience, reduced costs, and time delays, transaction information security, automation of credit card services, faster transaction settlement

28, 32	Consumer Staples	JD.com, HW Greenhan & Sons Pty Ltd.	Implemented Blockchain based traceability system for meat products	Issues with data access across the supply chain	Transparency of product source and processing data
29	Government Services	Andhra Pradesh Government, Consensys	Signed MoU for piloting blockchain based systems for land title management, EHR management, and identity management	Security, transparency and efficiency issues of land title system	Data security, reduction in time delays and real-time information access
30	Financials	Consortium of 30 banks in India and middleeast, and Primechain Technologies	Formed BankChain consortium and launched 5 blockchain based platforms for cross-border remittances, peer-to-peer money transfers, and share corporate KYCs	Identifying fraudulent transactions of customers, issues with sharing customer information	Simple and automated transaction processes, cost savings
30	Financials	Yes Bank, Bajaj Electricals, and 32 other vendors, Cateina Technologies	Rolled out blockchain based invoice financing system	Long manual document verification and reconciling processes	Simple and automated loan processing supported by smart contracts for KYC on the vendors, checking credit limits of vendor and customer, cost savings, interoperability with ERP systems
30	Financials	Axis Bank, RAK Bank, Standard Chartered Bank, Ripple Network	Blockchain based electronic exchange for cross-border electronic payments	Two to three-day settlement process in the current system	Transparency and faster settlements
30	Financials	ICICI Bank, Emirates NBD, Edgeverve	Blockchain based system for cross-border remittances, and trade finance	Identifying fraudulent transactions of customers, issues with sharing customer information	Simple and automated transaction processes, cost savings
30	Financials	Bajaj Allianz General Insurance	Developed a blockchain based mobile app called Travel Ezee for oversees flight delay claims settlement	Long manual document verification and reconciling processes	Simple and automated loan processing supported by smart contracts for KYC on the vendors, checking credit limits of vendor and customer, cost savings, interoperability with ERP systems

33	Information Technology	Oracle, Microsoft	Formation of Oracle Blockchain Cloud Service, Microsoft - Partnership with R3 consortium to deploy BCT on Azure cloud	Interoperability and integration issues with ERP systems	Interoperability, integration with ERP
34	Government Services	US Central Bank, Bank of England, PBoC, Bank of Japan, European Central Bank, Singapore's Monetary Authority	Experimenting with Government backed cryptocurrencies called as "stablecoins"	Process delays in global trade settlements and huge administrative costs.	Elimination of time delays and administrative delays
35	Financials	R3 CEV, Intel, and consortium of 100 financial institutions	Developing BCT based Corda platform for financial and banking solutions, TradeIX platform for trading	Interoperability issues, complex paper-based processes	Develop a "fully interoperable" open-source trade finance network which intends to eliminate or at least simplify existing paper processing across supply chain processes
36	Consumer Discretionary	BitTeaser	Launched a block-chain based system to track ad click-throughs in real-time	Information opaqueness due to intermediaries and frauds	Information transparency, effective ad spending
37	Financials	Digital Trade Chain group and bank consortium of Deutsche Bank, HSBC, KBC, Natixis, Rabobank, Societe Generale and UniCredit	Building a BCT based commerce platform that connects a buyer, sellers, banks and intermediaries to simplify transaction management and tracking	Lack of simple and open platform for conducting transactions	Accessibility of a simple and open platform for conducting transactions, simplified transaction management and tracking
39	Financials	XinFin, Assocham	Launched TradeFinex, a beta platform to enable contracting between financiers, suppliers, and beneficiaries, with native digital tokens XDC	Lack of access to the different parties, inefficiencies due to intermediaries,	Real-time information, increased process efficiencies, reduce global financial and infrastructural deficit

40	Information Technology	Hewlett Packard Enterprise and R3's Corda; SAP	HP-Launched BaaS for financial firms on R3 Corda platform; SAP-Launched BaaS on its Leonardo platform	Interoperability and integration issues with ERP systems	interoperability among erp systems and blockchains
41	Consumer Discretionary	UN, Microsoft, Accenture	Developed a blockchain based tool to combine data of travelers and create a permanent, verifiable digital identity for each user	Delays in immigration processes due to unavailability of required information, lack of tracking data of travelers	Effective immigration and border security processes, and data security
42	Materials	De Beers	Investing on a blockchain based traceability system	Frauds in supply chain (blood diamonds)	Data immutability and security, transparency on the source details of the diamonds
43	Financials	Payments Canada, the Bank of Canada, TMX Group and Accenture	Working on Project Jasper, an integrated securities and payment settlement platform based on BCT. Completed POC of clearing and settlement of securities on-ledger process	Delays in clearing and settlement of securities	Faster payment settlements
44	Industrials	DAFZO, Galaxy E-Solutions Hybrid	Implemented Blockchain based P2P logistics platform	Long turn-around period, heavy transaction fees	Reduced turn-around time and transaction fees, eliminate intermediaries
45	Consumer Staples	Soil Association, Provenance	Pilot traceability system for organic food (on Eversfield Organic Bacon)-customers were able to trace details with their smart phones	Frauds in supply chain, inaccess to information	Transparency, Trusted information access
46	Consumer Staples	IBM, Dole, Driscoll’s, Golden State Foods, Kroger, McCormick and Company, McLane Company,	Collaboration for developing blockchain based traceability solutions	Food safety, lack of traceability	Enhanced food safety, regulatory compliance, transparency

		Nestlé, Tyson Foods, Unilever and Walmart			
47	Consumer Staples	Belgium supermarket Carrefour	Launched Belchick'n, a block-chain based traceability system	Information silos and lack of infra-structure for information gathering, opaqueness	Traceability from source to the shelf, information gathering at every supply chain link
48	Industrials	ZK International, x-Sigma, TNT Blockchain Inc	Implementing blockchain solutions in manufacturing processes of water pipelines including track-n-trace system, developing smart pipes	IoT and ERP interoperability and integration issues	Improvements in process efficiencies, automation, IoT integration, cost reductions
49	Industrials	Cargo Chain Solutions	Developing BCT based logistics solutions platform		Transparency, interoperability and integration
50	Consumer Discretionary	Lucidity	Developing BCT based digital advertising solutions platform	Information inaccuracy, billing inefficiencies, fraud	Transparency, reduction in errors, faster billing and reconciliation
51	Industrials	Koopman Logistics Group, IBM	Implementing Digitalization strategy that includes BCT	VAT fraud, opaqueness with cross-border procedures	Supply chain visibility, cost savings, data security
52	Information Technology	Transparency One	Developed BCT compatible analytic solutions for supply chain data	Interoperability issues such as lack of process and technical standards	Transparency, intelligence, compliance and interoperability and integration
53, 54	Materials	Cobalt Blockchain Inc, DLT Labs Inc, DRC	Joint venture to develop a platform to track and certify the provenance of metals and minerals	Supply chain frauds, questionable practices at source	Ttransparency
55	Healthcare	start-up Mytigate, GFT Technologies SE, Frankfurt university of Applied Sciences	Developing a BCT based traceability and planning system for pharmaceutical sector	Issues with tracking information on logistic conditions and delays	Enables users to document the planning of medication shipments and to then track them around the world in order to identify risks and both clearly monitor and better understand problems that may occur during transportation

56	Industrials	Document Security Systems (DSS), Hong Kong R&D Centre for Logistics and Supply chain management	Develop BCT based brand protection products integrating AuthentiGuard	Counterfeit products, Lack of information access across SC links, linkage between sensors and blockchain	Eliminating fraud, data security
57	Consumer Staples	AgreCoin	Green Paper to provide BCT based solution for Tequila industry supply chain	Lack of link between production and consumption of agave plants (raw material for tequila)	Effective planning
58	Information Technology	Vanig International, HyperLedger	Integrated its E-Commerce platform with BCT based supply chain management solution	Manual processes and presence of intermediaries	Eliminate intermediaries and manual processes, transparency, data security, shortening of recall processes
59	Consumer Discretionary	Kochava Labs SEZC, PeerStream, Inc., Receptiv, EQ Works, FeedMob, Heart Media, Instal, Zedge, Sulvo, and Mobidays, Datastream Group, Inc.,	formed consortium and developing open source blockchain framework XCHNG for digital advertising industry. Prototype testing going on	Brand safety and fraud, lack of transparency	Transparency, data security and elimination of fraud
60, 61	Consumer Staples	bext360, Great Lakes coffee, and Coda coffee	Piloted a comprehensive system using BCT, AI, and IoT for analyzing and tracing coffee beans along the whole supply chain	Quality inconsistencies, information opaqueness	Transparency, Quality control, faster payments to the farmers
62	Materials	Yamana, Emergent Technology	Implemented BCT based supply chain solution 'Responsible Gold' for gold industry	Fraudulent mining practices,	Transparency on product provenance

63	Healthcare	Emerald Health Therapautics, Emerald Health Sciences Inc, DMG Blockchain Solutions	Developing "Cannachain", a BCT based SCM system and e-commerce marketplace for legal Cannabis industry (LOI)	Issues with tracking information on credibility of the producer, quality ttributes of the product	Transparency on product provenance, data security, regulatory compliance
64	Healthcare	Blox Labs, Liberty Leaf Holdings	Developing "cannaBlox", a BCT based scm platform for legal Cannabis industry (Whitepaper)	Logistical bottlenecks, issues with tracking information on safety and quality of the product and fraudulent activties	Ease and obliterate logistical bottlenecks, ensure product safety and quality, minimize fraud and regulatory compliance
65	Healthcare	LiveWire Erogogenics Inc	Developing 7X Pure Cannabis Compliance and Dosage Verification System which uses BCT	Availability of reliable information on product origin, dosage, quality and security	Protect confidentiality of intellectual property of growers and manufacturers, and achieve regulatory compliance, seed-to-sale tracking
66	Healthcare	MassRoots Inc	Developing a BCT based traceability system for legal Cannabis industry	Issues with information transparency, supply chain efficiency	Greater degree of reliability and accuracy on the metadata associated with products- times, dates, locations, quantities - which have the potential to reduce friction in the cannabis market-place, save businesses valuable resources, and provide greater transparency to government regulators.
67	Industrials	South Korea Customs Service (KCS), Chosun, Matrix Tobi Co. Ltd., Nomad Connection Co. Ltd., and CJ Korea Express Co. Ltd.	Pilot a blockchain-based platform to improve the process of clearing items through customs.	Prevent smuggling and trade finance fraud	Increase communication and transparency through real-time information sharing.

68	Consumer Discretionary	TRUTH, Avocet, and others	Deployed advertisement campaign using a BCT-based system and smart contracts.	Lack of trust between advertisers, media owners and media agencies	Transparency, information access across the supply chain links
69	Consumer Staples	Farm2Kitchen	Developing Farm2K, a bct based platforms to bring all food supply chain entities together	lack of access to information and other entities	Enhanced food safety, information security and transparency
71, 73	Healthcare	One Network Enterprises	Developed Chain-of-Custody traceability system for pharma industry	Counterfeit products, product diversion, grey market distribution, unauthorized introductions, substandard products	transparency, trusted information, end-to-end tracking, regulatory compliance
72	Consumer Staples	Coca Cola, US State Department, Blockchain Trust Accelerator, Bitfury group	Launched a BCT based secure registry for workers	forced labor in countries growing sugarcane	Transparency on worker contracts
75	Utilities	Qtum Foundation Pte Ltd., Energo Foundation Pte Ltd. First Gen	Implemented Qtum blockchain platform, launched CubeSat, a satellite carrying Qtum's blockchain software on a Raspberry pi device, has a comparatively lighter proof of stake algorithm	IoT linkage, power balancing and transaction settlements	IoT linkage, power balancing and transaction settlements
76	Consumer Discretionary	Juliene Fourne and DasCoin	Developing BCT based solution for fashion valuechain		Auditability, verification, provenance and security for exchange of designs
77	Industrials	Holt Logistics Corporation, Maersk, IBM	Conducted a pilot testing of BCT based trading system developed by IBM and Maersk	Elimination of paper work, inaccessibility of data at supply chain links	Information velocity and validity, process efficiencies, cost reduction

78	Healthcare	Humana, MultiPlan, Quest Diagnostics, Optum, and UnitedHealthcare	launched a pilot program to see if blockchain can improve their data quality	Issue with information security and sharing	to improve accuracy, streamline activities, and create better access
79	Industrials	Skuchain, Supply Chain Working Group (Wells Fargo, Bank of Australia)	Established Trusted IoT alliance to develop frameworks for use of IoT and SmartContracts for SCM, completed a pilot with the banks for Letter of Credit transaction	Integration with other systems and IOTS, Interoperability	integration with other systems and IOTS, Interoperability, information visibility and security
80	Industrials	International Trade Digitalization Commission (ITDC)	Launched SilkChain project, a blockchain based platform to conduct international trade	Fragmented systems	Scalability, cost reduction, efficiency
81	Healthcare	IBM, Sichuan Hejia Co. Ltd.	Launch of Yijian Blockchain Technology Application System, a permissioned blockchain platform that includes pharmaceutical retailers, hospitals, and banks	Financing challenges in China such as underdeveloped credit systems, lack of established credit evaluation and risk control mechanisms. Cycle time for pharma companies to recover payment is 60-90 days	efficiency, transparency, connecting parties, faster verification of transactions and credibility
82	Healthcare	Nuvus Corp	Developing BCT platform for legal Cannabis industry	lack of information access on the usefulness of Cannabis treatments	transparency on effects of Cannabis of different types and potency

83	Financials	MonetaGo, RBI, Receivables Exchange of India Limited, M1xhange, A.TREDS (Axis bank and metal junction)	Deployment of BCT based production system platform for receivable financing	Frauds related to bill doscounting, sharing required sensitive data, duplicity of transactions	Low cost, secure information sharing, transparency, process efficiencies
84	Industrials	Marine Transport International	Proof-of-Concept for Integrating the UK recycling software with BCT	Inadequate information sharing and access	process efficiencies, real-time information access, data integrity
85	Industrials	AB InBev, Accenture, APL, Kuehne + Nagel and a European customs organization	successfully tested a blockchain solution that can eliminate the need for printed shipping documents on 12 shipments	Costs and time delays associated with physical documents (20 different documents), document heavy approach limits data quality and real-time visibility to all parties involved in the trade and this can also delay the financial settlement on goods.	save the freight and logistics industry hundreds of millions of dollars annually, speed up the entire flow of transport documents, reduce the requirement for data entry by up to 80 percent, simplify data amendments across the shipping process, streamline the checks required for cargo and reduce the burden and risk of penalties for customs compliance levied on customers
86	Healthcare	Chronicled Inc., Cellotape Smart Products	released tamper-evident CryptoSeal prototype	IoT integration and interoperability, frauds	CryptoSeals have the ability to securely verify sender identity and timestamp shipment deliveries, and provide a secure chain of custody in the supply chain, IoT integration with BCT, elimination of fraud
87	Healthcare	Chronicled Inc.	the MediLedger Project - developed a blockchain-based system for tracking legal change of ownership of prescription medicines in compliance with the Drug Supply Chain Security Act (DSCSA)	Frauds, issues with security in information sharing	transparency on provenance of the pharma products, expedite investigations and recalls, making illicit drug movement detectable and greatly strengthening safety capabilities in the industry

88	Healthcare	Chronicled Inc.	launch of its secure, smartphone and bct -enabled temperature logging platform	IoT integration and interoperability, frauds	integration and interoperability of smart devices
89	Healthcare	Guardtime, Estonian eHealth Foundation	Developed proprietary Keyless Signature Infrastructure (KSI) platform for securely retrieving patient records	Issues with access control of patient information	data security
89	Healthcare	PokitDok Inc, Intel	Developed a software development platform with API endpoints that facilitate eligibility checks, claims submissions, appointment scheduling, payment optimization, patient identity management, pharmacy benefits, and other business processes	Fragmented systems	Information visibility
89	Healthcare	Gem Health, Philips and Capital One	Developed enterprise platform GemOS and conducted use-cases partnering with Philips and Capital One	IoMT information sharing issues	Interoperable enterprise platform GemOS enabling secure enterprise and IoMT information sharing
89	Healthcare	Patientory, Kaiser Permanente	Developed blockchain-based distributed electronic medical record storage computing software-as-a-service platform to store patient data	Issues with secure storage of medical information	Secure storage of medical information
89	Healthcare	iSolve, LLC	Developed blockchain platform, ADLT™, supports life sciences organizations through the drug development lifecycle	Lack of smart marketplace for entrepreneurs, tech transfer offices, investors, and service providers to connect and transact	Supports life sciences organizations through the drug development lifecycle with secure information sharing and transaction settlement
90	Healthcare	DHL, Accenture	Developed working prototype which tracks pharmaceuticals from the point of origin to the consumer	errors, fraud, risk of counterfeits	highlighting tampering, reducing the risk of counterfeits, restructure business processes while reducing cost and complexity

91	Industrials	Moog Inc., National Center for Manufacturing Sciences (NCMS)	Integrate VeriPart solution with Microsoft Azure Blockchain	Security risks of the defense data	Authentication and traceability of 3D print resources for additively manufactured (AM) parts used by DoD, data security and information sharing
92	Industrials	Moog Inc. (Moog), ST Aerospace Ltd.	Collaborating on the 3D printing of aircraft parts to leverage Moog's VeriPart® solution – a blockchain-enabled point-of-use and ST Aerospace's capabilities in 3D printing design, fabrication and certification. Pilot test complete	Security risks of business-critical data	Secure transaction for purchase and sharing of 3D designs of valuable parts
93	Healthcare	Sweetbridge, Natural Partners	Piloting Sweetbridge's blockchain technology on its healthcare practitioner service platform, NP Script, to help empower healthcare providers and patients with verifiable and comprehensive information about source and use	Information security issues	Transform the NP Script online platform into a highly secure means of distributing professional-grade supplements to healthcare providers. In addition, the innovative blockchain mechanism will provide healthcare providers and suppliers with valuable data-sharing capabilities without sacrificing patient privacy
94	Materials	Lucara	Acquired of Clara, a secure, digital, rough diamond sales platform that combines proprietary analytics with existing cloud and blockchain technologies to modernize the current diamond supply chain	Lack of accessible and secure supply chain platform to conduct high value product transactions	Transparency of product source and data security
95	Consumer Staples	OriginTrail, Chinese online food store Yimishiji	Developed the first blockchain protocol for data exchange between organizations along the supply chain and piloted with Yimishiji	Lack of information and fragmented information	enhance transparency, safety, fairness, and trustworthiness in food supply chains by empowering customers to verify the traceability

					streamline the supply chain, improve efficiency, provide transparency and simplify cross border transactions from Licensed Producers (LP's), distributors, dispensaries, pharmaceutical companies and various government agencies right down to approved end users.
96	Healthcare	Easton Pharmaceuticals , Inc	Development of a blockchain platform to streamline the supply chain of medicinal / recreational marijuana	Lack of information and fragmented information	
97	Healthcare	BriefTrace Ltd., DSV	Begun a blockchain IoT shipment tracking pilot to track environmental variables such as temperature, humidity and light exposure as well as outdoor/ indoor location on Traceum	Fragmentation and the information discrepancies in the present supply chain structures	provide a better service for our customers, through a superior real-time tracking capability, transparency, and trustworthiness created by blockchain environment. We believe that a connected supply chain will serve both our customers and our vendors
98	Consumer Staples	Organto Foods Inc, AppsforAgri	Collaboration to utilize AppsforAgri's existing technology for sourcing and supply chain operations	Lack of information and fragmented information	expected to allow Organto to track weather and field conditions, as well as improve product traceability and authenticity claims to customers and consumers
99	Consumer Staples	Romana Food Brands Corp	developing the blockchain food traceability and control application.	Fragmented information and complexities leading to lack of access to information	competitive advantage
100, 101	Industrials	Pacific International Lines (PIL), port group PSA International (PSA) and IBM Singapore	Completed a proof of concept (POC) exercise, built on IBM Blockchain Platform, applying and then testing the platform to track and trace cargo movement from Chongqing to Singapore via the Southern Transport Corridor	Issues with perating efficiencies, security and transparency	greater operating efficiencies, security and transparency, transparent and reliable multimodal logistics capacity booking, as well as the regulatory-compliant execution of the multimodal logistics capacity booking process, Real-time tracking

102	Financials	African Potash Limited (“AFPO”) and FinComEco	signed a Master Collaboration Agreement to jointly develop a range of platforms, projects and initiatives in the agricultural commodity markets sector across Sub-Saharan Africa	Inaccess to finances and real-time information	facilitate microloans direct to Small Scale Farmers, improved access to inputs plus associated financing and a better price for their produce
103	Industrials	MTI, Agility Sciences	Piloted Container Streams system in a supply chain environment using BCT	fragmented links	improved connectivity, efficiency and security, transparency, interoperability with existing legacy infrastructure
104	Industrials	Bosch, BNY Mellon, Cisco, Gemalto, U.S. Bank along with Bitse, Chronicled, ConsenSys, Ledger, Skuchain, Slock.it	launch of the Trusted IoT Alliance to catalyze the development of a blockchain-enabled, trusted Internet of Things (IoT), and to develop and set the standard for an open source blockchain protocol to support IoT technology	issues of interoperability and integration due to lack of common exchange and process standards	Common standards for IoT
105	Healthcare	TheraCann International Benchmark Corporation, Tokes Platform	Integrating blockchain based "provenance" features into the FinCEN compliant cannabis seed-to-sale Enterprise Resource Platform (ERP), TheraCannSYSTEM™.	Interoperability and integration issues with ERP systems, IoTs	Supply chain visibility with IoT and ERP integration
106	Consumer Staples	DNV GL	Developing My Story, an off-the-shelf blockchain based digital assurance solution for the food and beverage industry	fragmented or no information	Transparency, information access across the supply chain links
107	Consumer Staples	Tianmei Beverage Group Corporation Limited	commissioned a specialist independent blockchain solution company to design and implementation a new blockchain system to synergise and integrate with the existing enterprise systems	lack of tracing information and	improve information transparency in Tianmei's entire production, supply chain and sales networks, minimising paperwork errors, improving logistic and inventory management to minimise holding and transport costs, improved food safety, and recall

108	Industrials	Yangtze River Port and Logistics Limited, Yangtze River Blockchain Logistics Limited	Established the subsidiary Yangtze River Blockchain Logistics Limited to facilitate the Company's initiatives in "blockchain" solutions. Joined BiTA	Fragmented systems and heavy documentation and verification	Help manage and track documentation relating to shipping containers by digitizing the supply chain process to enhance transparency and to allow for greater security for the sharing of information among trading partners
109	Industrials	Gazprom Neft,	Completed pilot project of integrating IoTS with BCT - Section isolation valves fitted with RFID tags and GPS sensors, resulting in a document — containing all information on the delivery . The GPS receiver subsequently allowed full tracking of the consignment to storage facilities in Murmansk, as well as monitoring its speed in transit, and the number and frequency of stops. All data received from the devices was confirmed under a "smart contract" and reflected in the blockchain.	Fragmented systems and heavy documentation and verification	IoT integration and creation of an ecosystem allowing collaboration between all participants in the process — producers, inspectors, logistics operators, warehousing and the consumer
110	Consumer Staples	OwlTing USA	Developed blockchain based platform, OwlChain Provenance, to track a product's lifecycle from its origin to the customer. Planning to create more BCT based solutions for global food market	Issues with information security, reliability and accessibility	provides secure and auditable supply chain information to all stakeholders
111	Industrials	Bourque Logistics	Developing BCT platform RAILChain™ for rail shipping using Ethereum. Links to other systems RAILTRAC®, RateServer®, RAILAcct®.	working now to make our rail operations and freight payment systems blockchain compatible	will allow shipping parties to securely exchange bill of lading information, as well as settle freight, repair, and lease costs using smart contract technology

111	Industrials	Bourque Logistics and Tank and Container Management Systems, LLC (TCMS)	Developed NaviChain, a blockchain network designed for international, intermodal chemical shipments	Issues with secure information sharing	will allow shipping parties to securely exchange bill of lading information, as well as settle freight, repair, and lease costs using smart contract technology
112	Industrials	Louis Dreyfus Company (LDC), Shandong Bohi Industry Co., Ltd (Bohi), ING, Societe Generale and ABN Amro	developed a blockchain platform Easy Trading Connect (ETC) and successfully completed the first full commodity transaction on the platform. (a soybean shipment transaction from the United States to China)	task duplication and manual checks, complexity with large number of participants	eliminated task duplication and manual checks. accommodates the agricultural sector’s complex and rigorous documentation chain flows, covering not only the financing aspects, but also the full set of relevant documents pertaining to a transaction, such as the signing and processing of the sales contract at the start.
113	Industrials	Energy-Blockchain Labs, IBM	Completed POC and developing a platform for green asset management	Lack of carbon-asset management platform that connects supply chain partners	Platform will significantly shorten the carbon assets development cycle and reduce the cost of carbon assets development by 20 to 30 percent, enabling cost-effective development of a large number of carbon assets,
114	Consumer Discretionary	Interactive Advertising Bureau	released “Blockchain for Video Advertising: A Market Snapshot of Publisher & Buyer Use Cases,” an in-depth whitepaper	Information sharing issues due to several layers of supply chain participants	enables increased efficiencies and a more trustworthy supply chain, as well as reducing cost and fraud for publishers and buyers
115	Consumer Discretionary	Spotify, Mediachain Labs	Spotify acquired Mediachain Labs. working to leverage blockchain technology in order to help solve problems with attribution.	Supply chain fraud	Resolve problems with attribution.
116	Financials	Ripple and 61 Japanese banks	Ripple developed a payment app "Money Tap" that settles transactions instantly, in partnership with a consortium of	Payment and transaction settlement delays	Remove the need for an intermediary to clear and settle money transfers

			61 Japanese banks. About to go live soon		
117	Consumer Staples	Gate Meat Company, Grass Roots Farmer's Cooperative, Provenance	implemented BCT based food traceability solution developed by Provenance	Lack of transparency and access to information on food product quality	Increase transparency in food supply chains, to improve access to information so that customers feel empowered by their choices

BIOGRAPHICAL SKETCH

Madhavi Latha Nandi is an Adjunct Faculty of Management at University of South Carolina - Sumter. She has earned her Ph.D. in Information Management from Xavier University (formerly, XIMB in India) in 2013. After her Ph.D., she continued with her education in engineering and completed her Master of Science in Manufacturing and Industrial Engineering from University of Texas Rio Grande Valley in May, 2019. She has a diverse industry and academic work experience of over 10 years. Her research interests include technology applications in supply chain management, sustainable manufacturing, enterprise systems, analytics and human computer interactions.

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