Digital Supply Chain Transformation toward Blockchain Integration

Kari Korpela,
Lappeenranta University of Technology, Finland
kari.korpela@lut.fi

Jukka Hallikas,
Lappeenranta University of Technology, Finland
jukka.hallikas@lut.fi

Tomi Dahlberg,
University of Turku, Finland
tkmdah@utu.fi

Abstract

Digital supply chain integration is becoming increasingly dynamic. Access to customer demand needs to be shared effectively, and product and service deliveries must be tracked to provide visibility in the supply chain. Business process integration is based on standards and reference architectures, which should offer end-to-end integration of product data. Companies operating in supply chains establish process and data integration through the specialized intermediate companies, whose role is to establish interoperability by mapping and integrating company-specific data for various organizations and systems. This has typically caused high integration costs, and diffusion is slow. This paper investigates the requirements and functionalities of supply chain integration. Cloud integration can be expected to offer a cost-effective business model for interoperable digital supply chains. We explain how supply chain integration through the blockchain technology can achieve disruptive transformation in digital supply chains and networks.

1. Introduction

This paper focuses on business to business (B2B) integration within the supply chain, referring to the electronic data exchanged over the internet between business partners and value-added service providers. Even the biggest organizations lack the power, knowledge or capability to themselves design or deploy end-to-end information integration trough supply network. For that reason, companies have collaborated to accelerate integration under the concept of the Digital supply chain (DSC). DSC collaboration is a multi-stakeholder environment involving different needs and goals, in which big companies are seen as hub organizations that lead the integration work, along with their main suppliers. Even competing companies are collaborating to pursue integration of the entire supply network. Value-added service providers play different roles, collaborating with common interests to establish interoperability of systems across organizations. DSC should offer companies competitive advantage: intermediates should offer fast integration; logistics partners should offer visibility of deliveries, using tracking and tracing features; information and communication technology (ICT) companies should develop cost-effective cloud solutions; and finance providers should offer working capital through the transaction banking services.

The empirical study reported here is a case study of a consortium of companies operating in global supply chain environments. The project's main objective was to move all stakeholders jointly toward standardized integration of business transactions and collaboration processes. The key interest was to implement common solutions, technology and standards for integrating business processes within a large supply chain. The consortium included large companies, suppliers, logistics service providers, intermediate companies and banks providing supply chain finance. As the focus was on system-to-system integration, the case is representative of DSC initiatives.

In DSC transactions, organizations currently execute process and data integration through the trusted third parties, most often through the trade finance services of banks. However, several advocates of blockchain technology (BC) have promised to change this [1] by minimizing unnecessary use of third party intermediaries. Advantageous features of BC include a public ledger of transactions without transaction party identities, the use of public key infrastructure (PKI) to notify counterparties about executable transactions and the concept of the smart contract. The present article investigates how blockchain technology might support digital supply chain integration. The main research questions are i) how can we accelerate DSC integration and ii) how will blockchain technology support that integration?

Blockchain technology is regarded as a potential means of enhancing the security and cost effectiveness of DSC transactions. In general, blockchain technology is used to establish integration over the internet and can be understood as a many-to-many integration model, deployed in the public cloud to conduct secured transactions rapidly and at low cost. To develop a clear

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understanding of blockchain design principles and functionalities, the present study is grounded in a literature review and interviews with international experts in blockchain technology. The field study included focus group sessions with highly experienced business managers. While blockchain technology can clearly be used in both business to business (B2B) and Internet of Things (IoT) machine-to-machine (M2M) integration, this research focuses only on B2B transactions. In Section 2, we describe digital business ecosystem (DBE) architecture as a framework for designing requirements and functionalities for Digital supply chain integration. In Section 3, we describe the research process, including data collection and research methods. Results are presented in Section 4, followed by discussion and conclusions in Section 5.

2. Digital supply chains

The benefits of Digital supply chain (DSC) include cost-effectiveness of services and value-creating activities that are advantageous to many actors in the ecosystem, including firms and their suppliers, employees and customers [2]. According to Mentzer et al. (p.4.) [3], a supply chain can be defined as a set of three or more entities (i.e., organizations or individuals) directly involved in the upstream and downstream flows of products, services, finance, and/or information from a source to a customer. This definition highlights the role of information flows between firms, especially at activity and business process levels. It follows that effective integration between actors requires the integration of processes [4] and information [5] in the supply chain.

The DSC is characterized by the strategic and operative exchange of information between suppliers (financial, production, design, research, and/or competition) to enhance communication between actors in the chain [6]. In general, interorganizational coordination is achieved by means of electronic links between information systems, enabling automated and digitalized processing of source-to-pay processes involving suppliers and customers in the supply chain [7]. This supply chain information sharing and processing is not confined to the business process level but also includes a vast amount of data from devices and sensors (IoT) and from social media applications. Integrated supply chain information models are essential in modern DSCs, and the role of information integration and service automation has been identified as an important business driver [8].

The benefits and value drivers of digitalization for supply chains are considerable. According to Santos and Eisenhardt [9], the key motivation for supply chain integration is the efficiency associated with minimizing governance costs, including the costs of exchange with other ecosystem participants and with those within the individual organization. Information technology-based cost savings enable more information to be processed more accurately and more frequently, from more sources around the world [10]. When properly automated, these information flows eliminate the need for manual data entry and so reduce human error [11]. While it is widely acknowledged that B2B integration builds supply chain efficiency [12, 13, 14, 15, 16, 17, 18], current low levels of system interoperability continue to cause high investment costs, and the potential benefits have not yet been realized [19, 20].

Other identified benefits of DSC include reduced product or service costs, creating competitive advantage and barriers to competition, reduced supply chain lead times and increased flexibility in supply chain design [21]. Effectiveness of information sharing refers to how information brings new value to customers and supply chain actors in terms of services, decision making, visibility and prediction. Here, the key capability is to deliver the right information to the right people at the right time for decision-making purposes [22]. Previous research has highlighted how information integration and service automation serve as important drivers of business value in supply chains [23, 24, 21]) Additional value drivers include the systemic integration and bundling of information about products and services to create additional value for customers [24].

The present study continues to examine how value can be created from big data in industrial B2B supply network environments, and how interorganizational integration based on blockchain technology should be organized in this new economy. Novel information exchange services are likely to have a significant effect in broadening the functioning of supply chains and related business models. For example, Kagermann et al. [26] noted that, in Industry 4.0 environment, "manufacturing systems are vertically networked with business processes within factories and enterprises and horizontally connected to disperse value networks that can be managed in real time. Solid information integration introduces new systemic value elements, both for service providers and for industrial and public service users. Developing digital ecosystems for value creation in transactional supply chain business processes leads to significant business opportunities for actors in the ecosystem.

Earlier findings related to systemic global supply chain integration [8] identified four transformation requirements for digital business ecosystems, which constitute a foundation for business and innovation development, and for the present research.

1) Business model development: Companies must develop strategies and business models that maximize innovation and effectiveness in leveraging digitalization and supply chain integration services in their business offerings.

2) Information model platforms: Appropriate information models are needed to collect, store and deliver information in supply chains. This often requires the development of platforms and integration between multiple platforms.

3) Business process standards for supply chain connectivity: New competencies and solutions are needed for the development of business process connectivity and standards. This relates to how trading partners in the supply chain can be digitally connected to business process transactions.

4) Operator services for data transfer between actors: Integration channel intermediaries (e.g., operators) are needed to transfer and integrate information across actors and systems.

DSC establish the swift from manual transactions to digitalized information flows in both intrafirm and interfirm operations. Technology offers companies the option of reducing internal management costs and increasing efficiency through the digitalization or sustaining competitiveness by digitalizing external networks. These intra- and interfirm relations relate to such decisions as "make or buy", as extensively discussed in Transaction Cost Economics (TCE), In Coase's [26] theory, the "make-or-buy" decision concerns whether a firm executes business activities in-house or outsources them to the market [27]. In valuing and balancing factors in this decision, firms weigh the governance costs involved in production (the "make" decision) against the market transaction costs associated with market profits (the "buy" decision). In brief, the TCE perspective is that the firm economizes on transaction costs through the selection of internal governance costs for handling market transaction costs [28]. Technology focuses on where a transaction occurs and when goods, services or information are transferred across activities and systems. Well-designed interfaces enable this transfer to occur smoothly [29]. Global trade practices typically involve a range of business processes across organizational boarders. Data model needs to be designed so that the information flow can be transferred electronically end-to-end to secure interoperability within systems, as discussed in the electronic data integration literature.

The level of B2B integration and investment can be estimated by means of different models. The concept of investment cost is based on three variables: a) integration volume, b) total amount of process integration and c) volume of transactions. In terms of technology, standardization and service development, B2B integration models are categorized as Manual operations, EDI, HUB and Cloud models. These integration models are briefly described with the formula:

Manual transaction integration: At either end of this process, information has to be manually transferred from the document to the receiving system. Integration volume is formulated as $I = \sum t \times 2$, where t represents each process transaction.

EDI B2B integration model (Point-to-point): all integration has to be design between all companies and the number of processes integrated into the system. Integration volume is formulated as $i = n^2$, where n represents each process integration.

Hub B2B integration model (one-to-many); A single company can establish business process connections with intermediates. Integration volume is formulated as $i = \sum_{m=1}^{\infty} - 1$, where n represents each process integration.

Cloud B2B integration model (Many-to-Many): Software as a service (SaaS) is operated over the internet and integration can be delivery to all users. Integration volume is formulated as $i = 1 \sum_{m=1}^{\infty}$ where n represents each cloud process integration.

While two organizations may exchange supply chain documents directly via a document exchange platform, specialized intermediate companies are often used to conduct supply chain transactions with related exchange of documents [30, 31]. As well as the exchange of documents, payment(s) may form part of the transaction. Payment(s) and exchange(s) of supply chain document(s) can be conducted as a single (payment) transaction or as multi-tranche (payment) transactions. Where payments are involved, financial institutions (banks) usually act as the intermediate company (so-called "trusted third parties"). Banks refer to this line of business as trade finance [32], usually involving one bank for the seller and another for the buyer. In general, the seller's bank provides guarantees that the seller can supply and has delivered what was agreed, and the buyer's bank guarantees that the buyer has received what was delivered and is able to pay. Banks may provide letters of credit, document collection, buyer/seller credit, bank guarantees, trade insurance, factoring, forfaiting and other trade finance services to their customers (see [1] for instruments used).

Although these trade finance services are well established for the financing of domestic and international trade, they have significant limitations from a DSC perspective. First, fully automated data transfer between organizations—in traditional trade finance contexts, from the seller to the seller's bank, from the seller's bank to the buyer's bank and from the buyer's bank to the buyer, or vice versa—is possible for payments and to a lesser degree for invoices. Although document collection and especially letter of credit transactions may involve significantly more complicated exchange of trade documents between the parties, such as bills of lading, shipping documents and/or various certificates, a high proportion of supply chain documents are still exchanged using a computer-paper-computer manual operation model. Furthermore, both the letter of credit and document collection are trade finance services designed to release a payment (tranche) by detecting that certain conditions have been met—for example, that a shipment has been made and a bill of lading has been sent. These services were not designed for the exchange of supply chain documents between seller and buyer. As a consequence, a lot of documents are produced using the seller's information systems and are delivered on paper or in electronic formats incompatible with the buyer's information systems, requiring manual entry or scanning into those systems.

Second, the involvement of four parties in a transaction, and in the exchange of supply chain documents, makes such transactions cost-ineffective and slow. Although trade finance transactions are not bank-mediated securities trade transactions with strict post-trade clearing and settlement procedures, these models influence banks' thinking, and so many things can go wrong in the clearing and settlement of trade finance transactions that are in part manually executed. A third limitation relates to cybersecurity. Banks' information systems are among the most secure; data transfers of payments, invoices, settlement and clearing instructions between banks are conducted using standardized encrypted messages and message checking procedures over secure data transmission platforms such as SWIFT. Nevertheless, criminals have been able to exploit the vulnerabilities of these international banking networks to steal money [1]. Enhanced security programs, such as the recently launched SWIFT security programme, improve security but at the expense of cost and ease of use. The promoters of blockchain technology suggest that the underlying reason for security breaches is that the identities of parties to the transactions (and especially of trusted third parties or banks) are known. It is argued that because these data (including the bank account and security data of seller and buyer) form part of electronic transactions, it makes sense to cyber criminals to break in and steal such data, no matter how secure information systems are or how securely transactions are transmitted.

To address the limitations described above, we consider the use of blockchain technology [1], the following features of which can be seen as potential solutions: a public ledger of transactions copied to all nodes of the blockchain network without transaction party identities [34]; the use of public key infrastructure (PKI) to decrypt and encrypt a transaction and to notify counterparties about the existence of an executable transaction with unique single-time keys [34, 35]; and the concept of the smart contract [35].

One of the key features of blockchain technology is that it maintains an open distributed ledger of transactions without identifying parties to the transaction. In addition, the ledger is copied to all nodes of the network [1, 35]. If a transaction is changed, a new block is created and chained to previous blocks. Ledger data between nodes of the blockchain network are matched at random intervals (every ten minutes on average). As the consequence, there is no point in breaking into the ledger, as the data are already public and do not include information about the identities of the parties or their bank accounts. Even if one were able to break into the ledger data and change a transaction or add a new one, matching of the ledger data between nodes of the network would nullify such changes as invalid ledger transactions. At the same time, the seller may notify the buyer (or parties may notify each other) about the transaction and verify its existence from the public ledger. This blockchain feature may superficially appear a significant departure from current practice, where the identities of seller and buyer are known. In practice, a traditional business transaction involves two parts: a public ledger entry about the transaction and private messages between the parties about their identities, with security keys for transaction data and location [36]. Combining these makes it possible to bypass the trusted third party and to execute the transaction rapidly at very low cost.

The initiating party (seller) and the DSC document exchange need to notify the other party about the existence and exchangeability of documents, using public key infrastructure messaging. The initiator of the transaction (seller) sends the other party (buyer) a piece of PKI software to decrypt and encrypt the transaction identifier(s) attached to the documents exchanged. If the receiving party forgets this single key security message, the transaction must be repeated. This creates a new blockchain entry and a new security message. The solution depends on combining public and private keys [34].

To conduct DSC transactions and document exchange, parties must agree how that is to be done; this is where smart contracts enter the picture [35]. According to Zsabo's definition from the 1990s, "a smart contract is computerized transaction protocol that executes the terms of a contract. The general objectives of smart contract design are to satisfy common contractual conditions (such as payment terms, liens, confidentiality and even enforcement), minimize exceptions, both malicious and accidental, and minimize the need for trusted intermediaries. Related economic goals include lowering fraud loss, arbitration and enforcement costs, and other transaction costs.” [1] Blockchain technology has made smart contracts possible for single and multi-tranche transactions or document exchanges. In multi-tranche transactions, each tranche can be separately dealt with as part (i.e., sub-contract) of a smart contract. Clearly, there is a similarity between the concept of smart contract and letter of credit and documentation collection trade finance services. However, smart contracts, are extremely flexible and can be used to automate DSC transactions at a very detailed level. For example, a smart contract could be used to enable programmable transactions and machine-to-machine communication in IoT; one such platform is IBM’s ADEPT (Autonomous Decentralized Peer-To-Peer Telemetry) project. In general, requisite software components include ledger (e.g., Enigma), security (PKI) and smart contract (e.g., Ethereum or ADEPT) platforms, as well as software connectors [35].

Although some advocates of blockchain technology strongly commend the ability to avoid trusted third party intermediaries, this is not entirely necessary. Using a smart contract, the seller and buyer can mandate a trusted intermediary to “supervise” the execution of a transaction as in trade finance services. As part of a smart contract, the parties may even agree that the trusted third party receives necessary security key(s) to perform its role. Clearly, this is unnecessary in the context of direct exchange of documents between two organizations, whether at physical or IoT document level.

In summary, blockchain technology appears capable of providing security and flexibility at lower cost than traditional transactions. On the other hand, blockchain technology cannot meet the need for standardization of electronic supply chain documents; international document standards must be relied on for that purpose, probably requiring their further development to ensure fully automated transfer of documents between organizations. It should then be possible to use blockchain to execute transactions and document exchange quickly, reliably and at low cost.

This synthesis of the literature suggests that cost-effective DSC integration could be based on a cloud integration model, with ERP solutions based on a private cloud and SME suppliers based on public cloud services, using blockchain as an intermediate solution based on cloud integration. Our empirical research addresses these requirements and functionalities in more detail.

3. Research process

Data collection was designed to address the main research questions: i) how can we accelerate DSC integration and ii) how will blockchain technology support that integration?

This research is based on a case study approach, which is suitable for exploring business networks, and specifically business-to-business (B2B) relationships within digital supply integration, because it can capture the dynamics of the phenomenon and provide a multi-dimensional view of the situation in a specific context [36]. Data were collected from a large Finnish business consortium of 30 companies, represented by a focus group of executives, business managers and IT experts in the fields of industry, logistics, banking and ICT. The consortium operated in 36 countries, and the focus group members all played an active role in global business networks. Data were collected during three different workshops, each lasting four hours, during the period 2014–2016. Data was collected by using a web-based tool during the workshops, supporting anonymity of idea generation and ranking.

At the first focus group meeting, the objective was to identify requirements for digital supply chain B2B business process integration. Following an open discussion with 18 business managers, they developed 41 ideas as requirements for integration. Group members then prioritized the ideas on a 7-point Likert scale. Researchers analyzed the results and formed categories for further study.

At the second focus group meeting, the objective was to identify functionalities based on the requirements. Following an open discussion, 18 business managers generated 49 ideas about how system functionalities should be design to meet the requirements. Participants again prioritized the functionality ideas on a 7-point Likert scale. At the same time, we asked business managers to evaluate the current readiness of systems for these functionalities.

In the third phase (February 2016), the focus group workshop was dedicated entirely to blockchain technology. Experts in blockchain technology and focus group participants discussed the design principles and system functionalities of blockchain. The focus group members then generated ideas about how blockchain technology could support B2B integration.

In total, 31 business managers created 85 ideas related to digital supply chain integration. Focus group activities are summarized in Table 1.

Data collection activity	Focus group members	Objective	Main results
FG1 2014	18	Requirements for integration	DSC integration requirements
FG2 2014	18	System functionalities	DSC system functionalities
FG3 2016	31	Blockchain ideas based on functionalities	Blockchain ideas for DSC integration

Table 1. Data collection during focus groups (2014–2016)

The data were collected during the focus group workshops by using an internet-based tool that combines anonymity of respondents, interactivity participation and structured processes to organize data collection. This tool was used for idea generation by focus group participants. For the second round, the focus group prioritized the ideas on a Likert scale ranging from 1 to 7. This type of group communication process is effective in allowing a group of individuals as a whole, to deal with a complex problem as discussed in Delphi method literature [37], [38], [39], [40], [41]. This method provides insights for future-oriented research design. During the three focus group meetings, data related to digital supply chain integration included 41 ideas on prioritized requirements, 49 on system functionalities and current readiness and 85 ideas on how blockchain technology might support B2B transaction integration.

To translate integration needs to system functionalities, we used the quality function deployment (QFD) method, which is widely used for expert analysis of new product and service development. QFD is an analytical tool to convert high-level business objectives ("what" the business needs) into functionalities ("how" the business is to deliver those "whats") [42]. QFD uses a 1, 3, 9 scale for assessing the connection between whats and hows, where 1 implies a low relationship and 9 denotes a very high relationship.

To increase the validity and reliability of the study, we used triangulation [43, 44] to assess research qualification, participant relevance, participant engagement in the field and collaboration in pursuit of common interests and goals.

4. Research result

DSC integration design should take account of the current requirements of different business stakeholders and related system functionalities. The option of using new technologies like blockchain should be mapped to the same architecture framework. The literature reports very few methods for designing and analyzing large business networks or digital business ecosystems. For that reason, we used the DBE framework [46], based on the Zachman Enterprise Architecture presented in Figure 1.

Blockchain design principles that can be placed as horizontal layers in the DBE framework were introduced by Tabscott [1]. Based on the interviews with blockchain technology experts and on the literature review, functionalities could be summarized as four vertical activities within the DBE framework: 1) transaction data; 2) processing ledger or smart contract; 3) storing blocks to peer-to-peer networks; and 4) managing blocks by mining experts. Blockchain design principles and functionalities are illustrated in Figure 1.

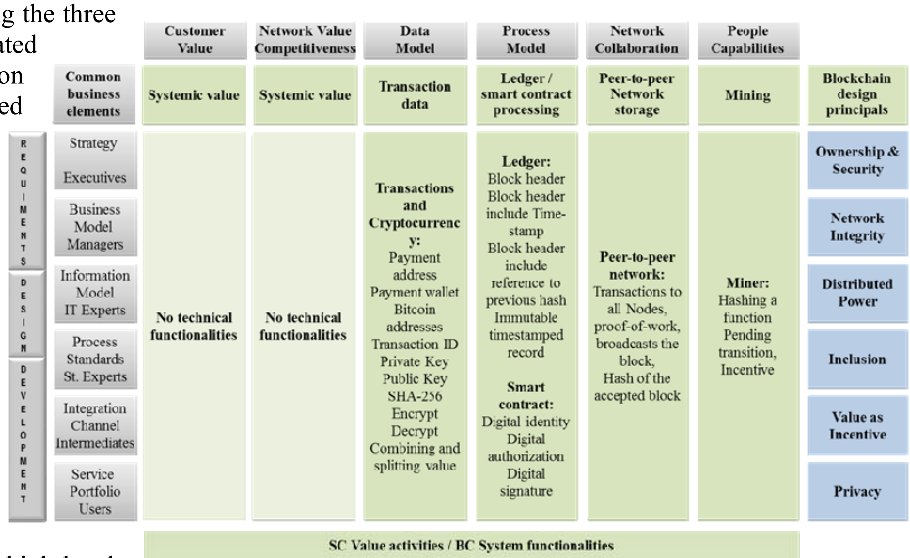

Figure 1. Blockchain design principles and functionalities in the DBE framework.

This framework builds the architecture for DSC integration in multi-stakeholder environments. By designing supply chain integration and blockchain integration within the same structure, we can explore system functionalities and supply chain business managers' ideas for a more meaningful understanding of supply chain integration.

In the first phase, to understand the current stage of supply chain integration, we arranged a focus group meeting with 18 highly experienced business managers. During the session, we first asked the participants to list their ideas about the requirements for supply chain integration, which yielded 41 specific requirements. These requirements were then prioritized by participants on a 7-point Likert scale. In the second phase, participants generated ideas about how these supply chain requirements should inform the design of system functionalities. These functionalities were also prioritized by participants as illustrated in Table 2.

The business managers were then asked to assess their own company's current readiness for integration, and how blockchain technology could support integration. Using the QFD method, the correlations between supply chain functionalities "Whats" in vertical axis and blockchain functionalities "Hows" in horizontal axis were assessed with 9,3,1 scale (1 = Low, 3 = Medium, 9= High correlation).

Analyzing and combining the results of supply chain and blockchain functionalities into the same scale, we were able to illustrate the current gap between perceived importance of supply chain integration and supply chain and blockchain readiness, as illustrated in Figure 2 by the 20 most important functionalities.

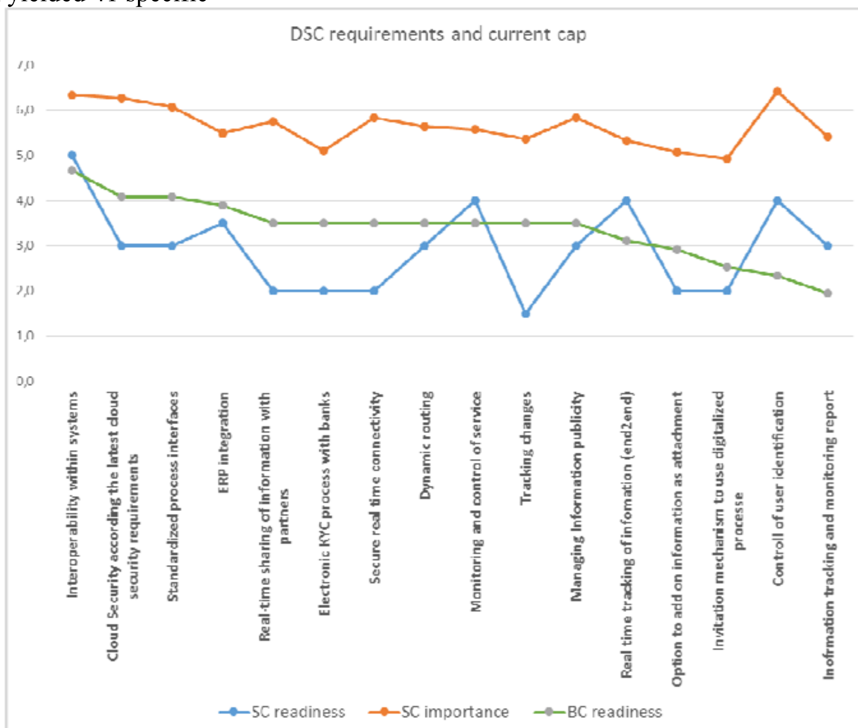

Figure 2. Perceived importance of DSC integration and current supply chain and blockchain readiness.

Fuctionalities	SC functionalities: SC importance	SC readiness	Values of BC functionalities: 1. Transaction	2. Ledger	3. Smart Contract	4. Hash	BC integration: Total QFD value	BC readiness
Interoperability within systems	6,3	5,0	3	9	9	3	24	4,7
Cloud Security according the latest cloud security requirements	6,3	3,0	3	9	9		21	4,1
Standardized process interfaces	6,1	3,0		9	9	3	21	4,1
ERP integration	5,5	3,5	1	9	9	1	20	3,9
Real-time sharing of information with partners	5,8	2,0		9	9		18	3,5
Electronic KYC process with banks	5,1	2,0	9	9			18	3,5
Secure real time connectivity	5,8	2,0		9	9		18	3,5
Dynamic routing	5,6	3,0		9	9		18	3,5
Monitoring and control of service	5,6	4,0		9	9		18	3,5
Tracking changes	5,4	1,5		9	9		18	3,5
Managing Information publicity	5,8	3,0		9	9		18	3,5
Real time tracking of infomation (end2end)	5,3	4,0	1	3	9	3	16	3,1
Option to add on information as attachment	5,1	2,0	3	9	3		15	2,9
Invitation mechanism to use digitalized processe	4,9	2,0		3	9	1	13	2,5
Controll of user identification	6,4	4,0	3		9		12	2,3
Inofrmation tracking and monitoring report	5,4	3,0	1	9			10	1,9
Raw score			134,5	694,7	688,8	63,64		
Relative Weight			9 %	44 %	44 %	4 %		

Table 2. Examples of metrics of sc-importance, sc-readiness and QFD valuation of blockchain readiness

Utilizing the QFD method for analysis of the total effect of blockchain functionalities produced interesting results as shown in Figure 3. Blockchain process functionalities were seen to support good integration for ledger (44%) and smart contract (44%) but less so for transactions (9%) and hash (4%). This can be explained by the fact that blockchain supports data integration but does not offer a data model to solve end-to-end integration of supply chain systems, and DSC integration requires a standardized data model. Interestingly, there were no ideas at this point concerning remittance by cryptocurrency. Hash functionality by blockchain network experts was seen as the key activity for tracking blocks but more as an integral part of blockchain functionality than for supply chain integration.

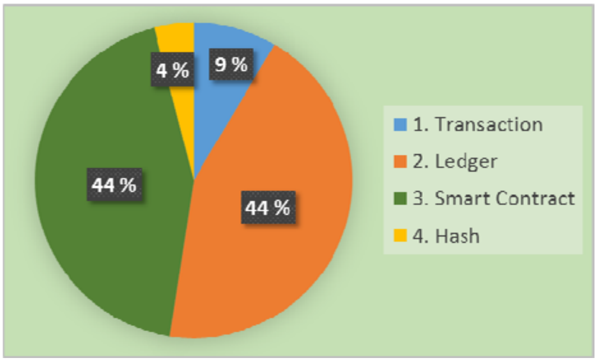

Figure 3. Blockchain functionality results from QFD analysis.

In the final stage of the study, we collected ideas for blockchain utilization. At this 2016 session, 31 participants from different organizations generated ideas about how blockchain could be used for DSC integration, yielding 85 valid ideas.

These were linked to blockchain functionalities, and QFD was then used to identify which BC functionalities related to each idea. The prioritized illustration is shown in Figure 4.

In general, blockchain system security and privacy by digital signature was a high priority. Contracting was also seen as an important new functionality. From a business perspective by the focus group, the blockchain is seen as a service for delivering both business transactions and IoT transactions. However, the fundamental issue of a supply chain data model for integration needs to be adjusted in common ground.

The views of DSC stakeholders can be summarized as follows. Big organizations often use ERP systems as a private cloud. Suppliers are often SMEs, and they are now beginning to use cost-effective cloud services. For intermediates, blockchain technology offers a public cloud model that can improve current business but also enables new agile start-ups to enter the market. Combining the long-term results of the study, if a data model could be agreed and adjusted for both B2B transactions and M2M IoT transactions, the above combination of cloud integrations can build this disruptive technology into a DSC.

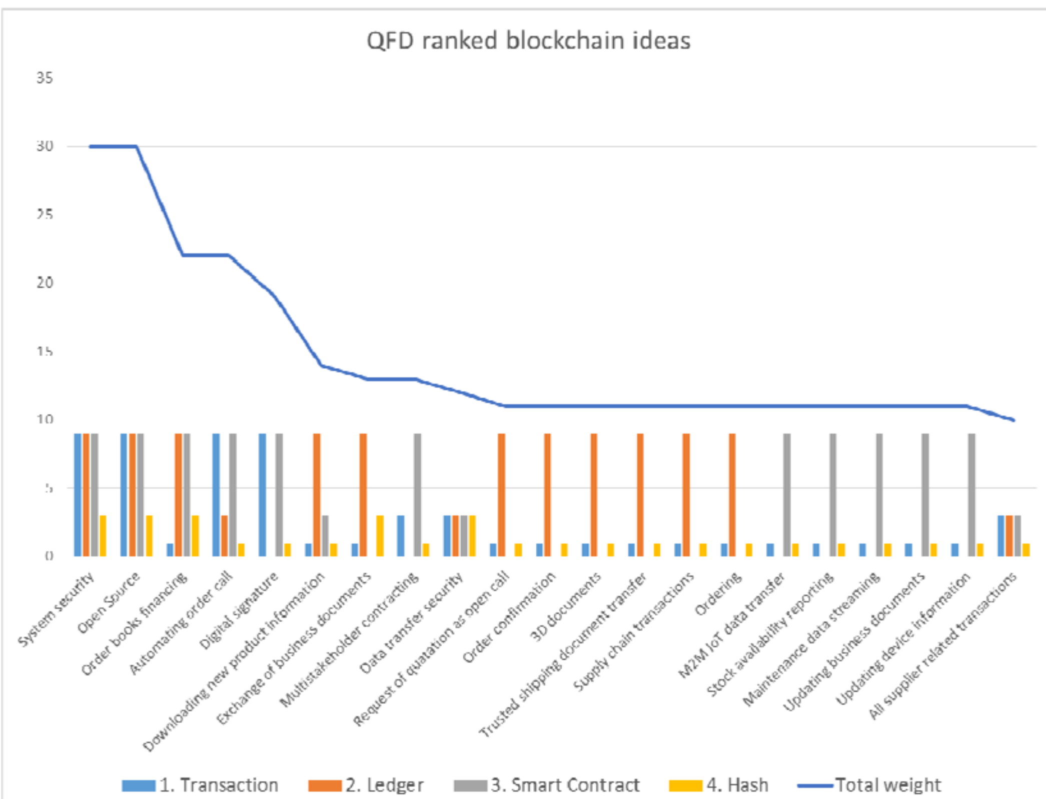

Figure 4. Blockchain ideas for supply chain integration from QFD analysis.

5. Discussion and Conclusions

For a number of industry sectors (retail, auto, electronic, aviation, chemical), digitalization of supply networks has been an important issue for more than two decades, but this concern is not shared across other industries. The aim of this study was to establish how B2B DSC integration can be accelerated. To this end, experienced business managers from 30 companies were asked to generate requirements and functionalities for business process integration, as well as ideas about how blockchain technology could accelerate that integration.

By analysing the business requirements and the current readiness of integration there seemed to be a significant gap in many functionalities. This was an interesting finding, as intermediates (EDI operators) including banks (SWIFT operators) have been operating and collaborating in this area over two decades, but services still lack some fundamental functionalities (e.g., standards, timestamping of transactions, monitoring and tracking of information flows and secure end-to-end delivery of information). An analysis showed many of these missing functionalities to be embedded in blockchain technology. From an academic perspective, many-to-many integration models like private cloud (ERP/Hub companies), public cloud (ERP/SME) and public cloud (Intermediate/Blockchain) are the most cost-effective integration models. This supports the theory of transaction cost economics, in which companies make “buy” decisions and outsource operations to the market [27]. The open source blockchain technology seems to offer functionalities beyond those of current legacy technologies; additionally, this technology offers data security and cost-effective transmission of transactions in peer-to-peer networks with no central system. In this way, blockchain technology simplifies B2B integration and enables micro level IoT integration.

In our review of the rapidly developing blockchain technology as a new document exchange solution, we found that its ledger, security and smart contract platforms, as well as software connectors, offer tools to build a cost-effective and flexible DSC network. In this context, we considered trade finance, as we believe that DSC transactions may occasionally require financing services that need to be integrated to the DSC network. Blockchain technology appears a good fit for such integration.

The participating business managers generated many ideas for integration supported by blockchain technology. The blockchain ledger and smart contracting for processing the transaction were seen as the most valuable functionalities (88%). Time stamping functionality, which is mostly missing from intermediate services, seems a very promising blockchain functionality for integrating (B2B) business and (M2M) IoT transactions. Data-encrypting private and public keys enable secure data transfer and digital signatures for smart contracting. However, DSC integration requires standards for system interoperability, which blockchain technology itself does not offer.

In conclusion, this case study was able to elicit new knowledge for accelerating digital supply chain integration, informed by experienced business managers operating in a global trade environment. However, one limitation of the study is that the participating companies represented a mainly Finnish supply chain. Interesting directions for future research include cloud applications that can accelerate and simplify DSC integration.

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