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Block Chain as an Enabler of Supply Chain Trust: The Role of Transparency, Traceability and Information Flow

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BLOCK CHAIN AS AN ENABLER OF SUPPLY CHAIN TRUST: THE ROLE OF TRANSPARENCY, TRACEABILITY AND INFORMATION FLOW

Research full-length paper

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Abstract

The purpose of this study is to examine the role of transparency, traceability and information flow on the relationship between block chain characteristics and supply chain trust. Non-probability sampling technique with a convenience method is used to collect qualitative data from 10 different organizations from various industries. Findings illustrate that the blockchain characteristics of verifiability and immutability are related to the transparency characteristics of the supply chain. Although traceability within the supply chain (especially intr-aorganizational traceability) is reached by other technologies besides blockchain, Transparency and traceability are connected. Both transparency and traceability lead to supply chain trust. The path through which blockchain technologies enable supply chain trust is identified. Traceability is the main feature through which both verifiability and immutability characteristics affect supply chain trust between supply chain partners. Additionally the type of information flow required for this path is defined.

1. Introduction

In 2008, the block chain technology was introduced through the Bitcoin currency; since then, the technology has gained prominence among researchers and users. The features provided by the block chain technology have been unfolding and researchers have been tempted to explore broader applications of the technology outside the finance industry, including the supply chain. According to industry experts, the block chain technology is expected to transform the supply chain through the disruption of the entire supply chain processes (Dickson, 2016). Many studies have focused on the applications of block chain technology within the supply chain. These studies tried to identify uses of blockchain technology to minimize products counterfeit (Biswas, Muthukkumarasamy & Tan, 2017), maintain food safety (Bailey, Bush, Miller & Kochen, 2016), ensure that all actors maintain the agreed upon data and links within the supply chain (Kumar, Hallqvist & Ekwall, 2017), and to ease and support the process of product recall in case of emergencies (Kumar, Heustis & Graham, 2015). According to Francisco & Swanson (2018), trust is necessary for any supply chain to function effectively due to the essential information interdependencies between the involved organizations. However, in recent years, global supply chains across numerous industries have experienced the issue of trust deterioration (Guenther, 2020). To address this concern, many companies started adopting supply chain trust enabler technologies such as the block chain (Sneader & Sternfels, 2020). The fact that blockchain could enhance trust within the supply chain lies within its capability to enhance transparency, traceability and information flow throughout the supply chain (Yavaprachas, Pournader &Seuring, 2022).

1.1. Research gap

Academic literature addressed this topic through initiating inquiries on whether or not block chain could impact trust within the supply chain. However, there is no consensus on how trust is built with the help of block chain technology (Yavaprachas, Pournader &Seuring, 2022). This study aims to fill this gap by investigating the paths connecting block chain characteristics with supply chain trust. The role of transparency, traceability and information flow will be observed within these paths. The answers to the following research questions are attempted:

RQ1- How do characteristics of block chain affect supply chain trust?

RQ1a- What role does transparency play within the relationship between block chain characteristics and supply chain trust?

RQ1b- What role does traceability play within the relationship between block chain characteristics and supply chain trust?

RQ2- What is the type of information required to ensure transparency and traceability?

2. Literature review

In this section the main definitions, characteristics and previous studies related to block chain technology, supply chain trust, traceability, and transparency and information flow are introduced.

2.1. Block chain as an enabling mechanism

Block chain is a public permissioned distributed ledger system maintaining the integrity of transaction data (Yli-Huumo et al., 2016). The block chain is so-called decentralized because the network is entirely run by its members, there is no central authority to rely on or to manage the network or to establish trust (Hackius et al., 2017). According to Britchenko et al. (2018), each member is responsible for storing his own transaction histories and other members can either accept or reject them. The dis-intermediated nature of the block chain allows for a direct exchange between different entities that may or may not know or trust each other without a third party that observes the transactions (Di Ciccio et al., 2018). Despite the absence of intermediaries during runtime, block chain-based systems always rely on the correctness of predefined rules, and thus it is crucial to ensure they are secure, reliable and accurate

(Wattenhofer, 2016). The whole blockchain network guarantees the integrity of the data shared, without an intermediary (Michelman, 2017).

The most important characteristics of the block chain technology are decentralization, verifiability and immutability. According to Hackius et al. (2017), the verifiability of the block chain comes from the members' signature of transactions using public-private-key cryptography before sharing them with the network. As well as the consensus algorithm, this allows members to add one or more transactions to the chain after being verified and validated by all members of the network. The block chain is also characterized as immutable due to the use of cryptographic methods (Pilkington, 2016); transactions can neither be changed nor counterfeited without the members' validation (Britchenko et al., 2018). Therefore, a block chain is a complete and immutable history of network activities, which are shared among all nodes of a distributed network (Abeyratne et al., 2016). Accordingly, the block chain technology allows the resolution of conflicting data by providing a transparent, valid and irreversible record of transactions (Mengelkamp et al., 2018).

2.2. Effect of block chain on supply chain trust

The block chain technology only allows mutually accepted parties from the network to engage in transactions at specific points of interaction (Francisco et al., 2018). The technology seeks to ensure a secure system while protecting user safety and privacy (Yan et al., 2014). Privacy gives the user or block chain participant the option to determine whether certain information about the entity should be disclosed or not. If yes, when and to whom it should be released (Yan & Holtmanns, 2008). Moreover, the longer a blockchain is, the stronger and more trustworthy it is; with a long chain, modifications to previous blocks become very complicated to execute (Treiblmaier, 2018). Smith & Dhillon (2019) discuss three key mechanisms for building trusting relationships: formal, informal and technology. Each of these mechanisms affects relationships differently. The formal mechanism uses measures such as contracts to legally obligate two or more parties to perform a set of mutually beneficial actions. These contracts provide a degree of trust between the parties because as long as the benefits outweigh the drawbacks from the contract, each party will perform his agreed upon duties. Informal mechanisms are enhanced by individual relationships developed between individuals taking part of the formal agreement. In such case, the stronger the relationship, the greater level of trust generated and accordingly the least opportunism (Bloom & Hinrichs, 2011). Finally, the technology trust mechanism is when technology acts as a trust-building tool (Korpela, Hallikas & Dahlberg, 2017). Technology can be used to provide greater security, increased record keeping, reduced inefficiencies, and as a result more trust in the supply chain.

2.3. Effect of block chain on supply chain transparency

Lamming, Caldwell, Harrison & Phillips (2001) consider transparency as an element of supply relations, rather than a property of the system, among others such as agreed procedures, equity sharing, joint-patents, long-term acquaintance, etc. Furthermore, Awaysheh & Klassen (2010) identify transparency as the extent to which information is readily available for exchange between companies involved in the supply network as well as outside observers and stakeholders. As per Pilkington (2016), the technology promises transparency throughout the network allowing every member of the network to access the same data providing a single point of truth. As opposed to a fully private system, a fully transparent system allows anyone to see any piece of information (Wüst et al., 2018) and stake holders to see further along on the organization's supply chain (Carter & Rogers, 2008). In a transparent supply chain, all participants of the system will have access to entire events history, all transfers, agreements and records are always available to all participants of the system (Britchenko et al., 2018). The events history include information about supplier names, sustainability conditions at suppliers, and buyers' purchasing practices (Egels-Zandén, Hulthén & Wulff, 2015). Additionally, as per Agrawal, Sharma & Kumar (2018), the network would allow and encourage on demand and effective information sharing.

2.4. Effect of block chain on Supply chain traceability

Folinas et al. (2006) pointed out that the efficiency of a traceability system depends on its ability to track and trace each digital unit to enable real time monitoring from primary production until final delivery to the consumer. Research has shown many traceability frameworks using the blockchain technology to minimize products counterfeit (Biswas, Muthukkumarasamy & Tan, 2017), maintain food safety (Bailey, Bush, Miller & Kochen, 2016), ensure that all actors maintain the agreed upon data and links within the supply chain (Kumar, Hallqvist & Ekwall, 2017), and to ease and support the process of product recall in case of emergencies (Kumar, Heustis & Graham, 2015). All the presented frameworks tackled block chain from a technical perspective; and therefore, focused on the implementation and functioning of the technology.

2.5. Block chain and information flow

Petersen et al. (2018) illustrates the supply chain with three flows: a downstream material flow linking the various entities through different modes of transport, followed by an upstream financial flow and a two-way information flow (Figure 1). Moreover Petersen et al. (2018) consider the information flow a core resource to the chain as it enhances supply chain optimization (Petersen et al., 2018). Conferring Christopher (2011), the flow of information is a core resource in supply chain management since; the downstream flow helps in the planning and synchronization of activities, whereas the upstream flow helps in the fulfilment of customers' needs. Thus, the up-to-date information flow is essential to enable transparency throughout the supply chain. Folinas et al. (2006) introduce a generic framework of traceability data management guiding all entities involved. The main objective of this framework is to establish an environment that supports information flow transparency and efficient decision making. The framework consists of the four following stages:

Step 1: Identification and classification

Traceability data is distinguished between static (referring to product features that cannot change) and dynamic (referring to dynamic features that change over time while the product moves along the supply chain). Traceability data is then classified into mandatory or optional (table 1): mandatory data shall be collected, archived and communicated between all members of the supply chain; while optional data are useful to be collected and shared but not essential for the efficient operation of a traceability system.

Data Classification	Requirements	
Mandatory	Lot number Product ID Product Description	Supplier ID Quantity Unit of measure Buyer ID
Optional	Buyer's name Contact Information Country of origin Date of pack Logistics service provider ID	Trade unit Transportation vehicle ID Supplier name Receipt data Dispatching date

Table 1: Folinas et al. (2006) classification of mandatory and optional data

Step 2: Transformation and modelling

The main objective of this stage is to model the previously extracted and transformed data to allow their uniform management and utilization through common business vocabularies that describe the structure and the semantics of the traceability data (Folinas et al., 2003). These vocabularies will allow users to document all these data in a unified format that will act as a standard. This standard will benefit the use, exchange and presentation of information in order to support the traceability process.

Step 3: Processing

In this phase, data is processed according to requirements set by the final users in order to be converted into expedient knowledge. The main objective is to integrate process and organize information in combination with the experience of the final users.

Step 4: Presentation of traceability data.

In this final stage, the internet is used as the distribution channel for the presentation of traceability data and knowledge dissemination in a user-friendly manner. For an integrated traceability system to be successful it must be able to archive and communicate information regarding product quality, origin and consumer safety. The most important features of an integrated traceability system are adequate filtering of information, information extraction from databases that already exist, harmonization with international codification standards and harmonization with internet standards and up to date technologies.

3. Proposed conceptual framework

It is indeed a fact that Block chain technology could have a positive effect on supply chain trust, but the mechanism of this effect is quite unknown until now. This study proposes the below framework as a conceptual framework to identify how the three characteristics of block chain technology affect transparency, traceability and trust.

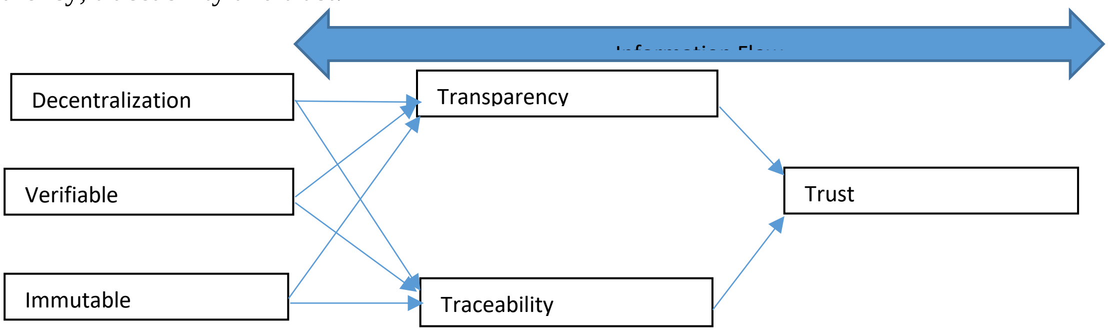

Figure 1: Conceptual Framework

As for the Information flow construct, the information types selected by Folinas et al. (2006) in the division of mandatory and optional data, can be classified into two categories: "Supplier Information" and "Product Information & Specifications". Table 2 shows the classification of mandatory and optional data into the fore-mentioned categories.

Information Category	Information Type	Requirements	
Supplier Information	Mandatory	Supplier ID Buyer ID	
	Optional	Buyer's Name Contact Information	Supplier Name
Product Information & Specifications	Mandatory	Lot Number Product ID	Product Description Quantity Unit of Measure
	Optional	Country of Origin Date of Pack Logistics Service Provider Trade Unit	Transportation Vehicle ID Receipt date Dispatching Date

Table 2: Folinas et al. (2006) Data Classified by Data Type

4. METHODOLOGY

The qualitative approach seeks to achieve in-depth understanding of situations and phenomena occurring in the social world. Consequently, when in data collection, qualitative research seeks realistic data obtained through interviews, focus groups, observations, etc. (Bauer et al., 2010). Under the qualitative research umbrella, there are several means to collect data such as archives, interviews, questionnaires, and observations (Meyer, 2001). In this research the primary research instrument is semi-structured interviews. In order to maintain the reliability of the instrument, the design was inspired by exploring the effects of the blockchain technology in supply chain and logistics.

This research adopts a non-probability sampling technique with a convenience method as it is the most appropriate for exploratory research, where the researcher is seeking guidance (Bauer et al., 2010), convenience sampling is the most common technique when the purpose of the study is mainly to explore and understand a phenomenon (Yan et al., 2014). The criteria for including supply chain management companies in this research sample is as follows:

Companies representing multiple industries to show a diversity of perspectives to supply chain trust and block chain technology benefits

Well-established companies with mature supply chain activities and participants

Middle-managers from supply chain and operations departments who deal on a regular basis with suppliers

5. RESULTS

The data was collected from organizations operating in Egypt (local and multinational companies). In this section the demographics, validity and reliability as well as the results of the analysis is explored.

5.1. Demographics

Figure 2, below, shows the classification of the companies. The majority of the companies included in the sample are multinational companies as their supply chain activities are more structured and mature.

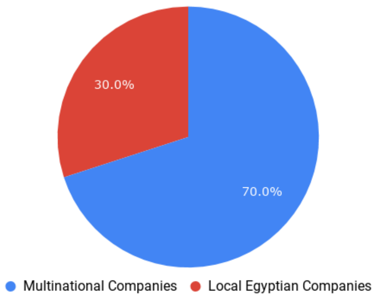

Figure 2: Classification of Companies by Type

The data was collected from 10 different organizations from different industries. The involved industries are presented below (figure 3). The involvement of many industries provides beneficial insight on the various supply chain activities and the measures taken by each company. Additionally, the size of the organization provides insights on the amount of supply chain transactions conducted by the organizations on a daily basis; figure 4 shows the classification of organizations based on their sizes. The researcher was aiming to interview middle managers but according to the organization’s structure the titles may vary, also not all managers were open to interviews.

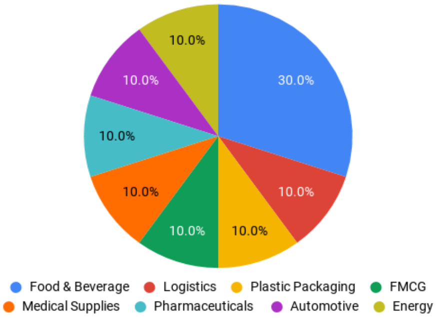

Figure 3: Classification of Companies by Industry

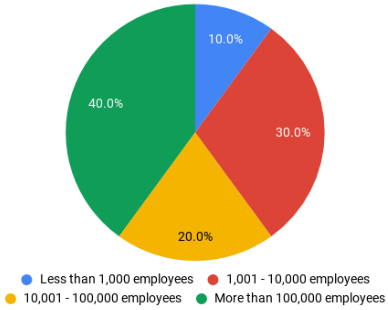

Figure 4: Classification of Companies by Size

5.2. Validity and reliability of data

In the first step of qualitative data analysis, data reduction, the researcher performs a process of coding, selection, and categorization of data (Sekaran & Bougie, 2013; Ghauri et al., 2002). The process of coding uses words, sentences, paragraphs, and themes. Through identifying themes, specific ideas or issues appear (Sekaran & Bougie, 2013). The second step of qualitative data analysis is data display; which refers to the way the researcher chooses to present the reduced data in an organized and condensed manner through graphs, matrix, and charts that would help in the understanding of patterns later on (Sekaran & Bougie, 2013). Finally, the researcher would draw conclusions from the reduced data displayed; such conclusions would be answers to research questions (Sekaran & Bougie, 2013). The software NVIVO was used as the qualitative data analysis tool to conduct the coding, selection and categorization of data in a clear and effective manner.

5.3. Data analysis

Transparency

Interviewees were asked to explain their perception of supply chain transparency. Most interviewees perceive transparency as the openness of allied partners through information sharing and disclosure of issues and concerns about the supply chain. All interviewees agreed that transparency is the sharing of information through clear and honest communication of accurate information. They all expect a minimum acceptable level of information sharing to allow the smooth flow of operations, the sharing of best practices and ideas. Another perception of transparency is the alignment of organizations with their suppliers and customers. Meaning that, supply chain participants become so connected that they openly share their best practices, insights, and future plans. The majority of interviewees found that trust and transparency are directly related. Since transparency encourages effective communication and thus information sharing. Extensive information sharing provides supply chain visibility, which allows them to understand the causes of problems and easily solve them. Therefore, transparency enhances trust and yields to an extended support system ensuring successful present and future relationships. Internally, organizations are confident in the degree of transparency. For instance, well-established companies rely on SAP or Oracle software to actively store, communicate and retrieve information internally; and only give specific employees access to classified information. Whereas, external transparency seems more challenging as supply chain actors consider total transparency and openness as a threat to their operations. Organizations fear the consequences of complete openness on competition and the contamination of the overall system. Here the verifiability and immutability characteristics play an important role to make sure that information is secured. However, multinational organizations have shown a higher degree of transparency as they believe in the partners' selection process and thus the entire operations' environment.

Traceability

In the differentiation between transparency and traceability, most of the interviewees were able to point out that transparency is the day-to-day information sharing, whereas traceability is the ability to retrieve information long after operations are executed. It was found that few organizations consider traceability as a tracking tool or system. It enables the organization to have a clear view of the flow of information and consequently trace a product throughout its production cycle. Moreover, traceability gives organizations access to product information even after operations have ended. Therefore, the ability to get back to any information required whenever needed. Consequently, transparency and traceability are inter-related. Without transparency traceability will not be possible, just as traceability is based on the retrieval of previously shared information through transparency. Most of the organizations are confident about their internal traceability procedures. They can trace back the whole production processes, from the receipt of raw materials to the shipment of finished goods. To enable traceability, some companies keep a sample from each batch, with identification information. Thus, in case of product deficiencies or recall, the company can trace the product to its source and investigate the saved sample to specify the exact issue encountered. The detailed documentation of the process allows the linking of the reported deficiencies to one or more of the 4Ms (Man, Machine, Material or Method).

On the other hand, external traceability is more challenging. In the upstream supply chain, most organizations can only trace back to one supplier. Whereas in the downstream, organizations have an increased level of traceability especially if the downstream participant is a critical partner. To ensure overall traceability, organization identified two sets of measures: internal based on the company's identification and recording systems and external where the company relies on its suppliers and partners. Externally, organizations rely on their supply chain partners to ensure traceability. This is expected through ongoing communication, an acceptable level of transparency, and the – partial – visibility of the work processes. Internally, organizations agreed on the coding or identification of each product – from raw materials to products, equipment, etc. – linked either automatically or manually to the company system. Some organizations keep records manually, through ID numbers and batch numbers in Excel Sheets or simple ledgers. Others use more advanced tracking systems that sometimes include warehouse management systems. The choice of the traceability technology is strongly affected by the Egyptian market's culture (see figure 5). A company may be using the most advanced traceability technologies internally, but unable to communicate them to other supply chain partners. Accordingly, many of the organizations use ID numbers for external identification of their products and barcodes internally. Others rely on manual traceability techniques in Egypt, while globally the company uses barcodes.

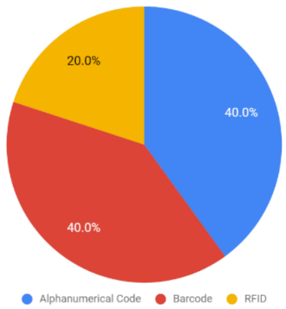

Figure 5: Distribution of traceability technologies across organizations

In some other cases, the nature of the product does not allow the use of advanced technologies. For instance, in pharmaceutical and energy industries, materials – mainly chemicals – are identified through ID numbers. Moreover, in medical supplies companies, the use of radio frequency is harmful to the product itself; therefore, companies can only use barcodes. After IDs come barcoding systems. Most companies agreed that this is the most common internally implemented traceability technology currently in Egypt. Especially, since companies who deal directly with distributors and retailers are required to add barcodes to their finished goods. Moreover, only some of the companies are actively using RFID tags and/or guns mainly to track the internal movements of products as well as a warehouse management tool.

Information Management for Supply Chain Management

An important aspect of the supply chain operations is the organizations' process of managing and handling information. Based on the data collection, the information flowing can be divided into three categories: confidential information, information for sharing, and information for operational activities (table 3).

Confidential Information	Technical and tactical information consisting the companies' core competitive advantages
Information for Sharing	Information shared with partners for an overall successful supply chain performance
Information for Operational Activities	Information necessary for any organization to efficiently perform its operational activities

Table 3: *Description of Information Categories*

Confidential Information

All organizations agree, unanimously, that most of the information can and must be shared, except tactical and technical information. As they have the potential of exposing the core competencies of an organization which certainly negatively affects the market environment and points of strength of each organization. The majority consider tactical information to be mainly financial. Thus, companies withhold information about the costs of production, the actual volumes of production, the actual sales and revenues figures; the overall profitability of the company. On the other hand, technical information are concerned with the operations and procedures held internally. In general, technical information are related to the know-how the organization has built over the years, the product's bill of materials (the exact amount of each material or component used), and the internal operations and procedures (the way operations are executed). Moreover, for companies in FMCGs and F&B industries, technical information includes the trade secrets and recipes of the products.

Information for Sharing

After internal operations are executed, the organization must transfer some information along with the product to the following downstream partner; manufacturer, distributor/retailer, or customer. All types of downstream partners require a brief about the product and its specifications, the materials used, the health and safety certificates associated with the product, the volumes available (available stock or stocks-in-transit), the minimum order quantity, the delivery and lead time, the storage conditions, and the bank details. As well as the SOP, safety and quality assurance measures, and warehousing rules. Some organizations also share the products' certificate of analysis. Furthermore, most of the companies agreed that they prefer to partially share their strategies and future plans with upstream partners as well as downstream ones to remain aligned and thus maintain a successful performance.

Information for Operations

All organizations agreed on four types of data necessary for operations: supplier information, product or material specifications, certificates, and SOP (Standard Operating Procedures), presented in table 4. Naturally, all organizations must have a clear profile of the supply partners. This profile must cover a brief about the supplier, the supplier history, sales volume, customer satisfaction level, bank details, and the contacts of the key people responsible for the operations at the supplier's company. Additionally, information about the supplier's service level must be communicated, they give the organization a clear picture of what should be expected from that supplier. This information includes the supplier's capacity (to make sure the supplier has the production capabilities to fulfill the required order volumes), the minimum order quantity (each supplier sets a minimum quantity for orders usually based on cost calculations), the response time, and the lead time for orders' delivery (the expected time between making the order and receiving it). Afterwards, all organizations agreed it is crucial to gather information about the product offered, along with its specifications. These specifications are linked to the product's ID and must include the quantity received, all the materials included in the product, and the expiry date (if applicable). The product specifications allow the organization to determine whether the used materials are accepted or not, and their compliance with quality assurance measures. The approval of the used materials is partially based on the certificates presented by the supplier. These certificates vary depending of the type of product or material the supplier is providing. The last and most crucial set of information imperative to operations are the Standard Operating Procedures (SOP) of a product or material. The SOPs are detailed step-by-step instructions issued by the supplier to help the organization carry out operational activities efficiently. The SOPs include the product's technical data sheet, quality training, safety training, and necessary production and storage conditions.

Information Category	Information Type	Requirements	
Supplier Information	Mandatory	Supplier ID Bank details Contact people	Minimum order quantity Response time Lead time
	Optional	Brief about supplier Supplier history Capacity	Sales volume Customer satisfaction level Service level
Product Information & Specifications	Mandatory	Product ID Quantity	Materials Expiry date
	Optional	Sampling	
Certificates	Mandatory	Quality assurance Safety assurance	Governmental institutions registration
Standard Operating Procedures	Mandatory	Technical data sheet Quality training	Production conditions Warehousing and storage conditions Safety training

Table 4: Gathered Information Classified per Category and Type

6. DISCUSSION

A revised framework (Figure 6) is introduced as a result of the above results. The revised framework proposes that the characteristics of verifiability ad immutability relate to the transparency of information within the supply chain. Also traceability and transparency are related constructs. Both traceability and transparency are prerequisites to trust.

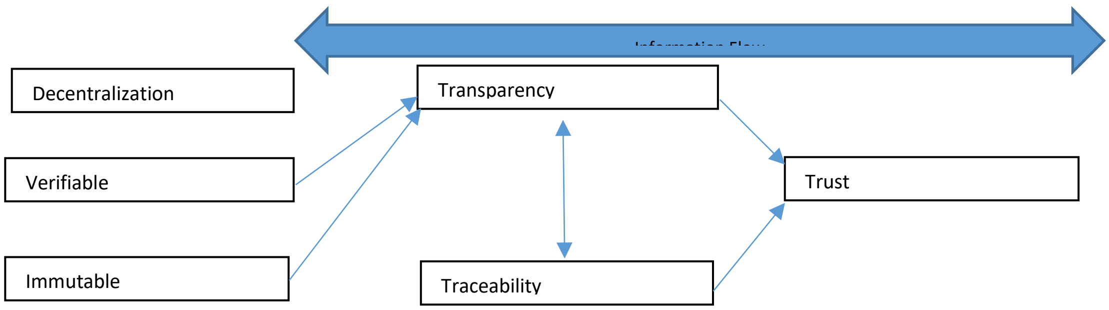

Figure 6: Revised Conceptual Framework

All organizations agreed that they share product-related information to only one partner downstream and another upstream. The downstream communicated information includes, but not limited to, a brief about the product and its specifications, the materials used, the health and safety certificates associated with the product, the volumes available (available stock or stocks-in-transit), the minimum order quantity, the delivery and lead time, the storage conditions, and the bank details. Whereas the upstream communicated information includes the organization's internal policies and industry insights to strengthen the relationship with suppliers and improve the flow of operations. In addition to that, most companies prefer to partially share their strategies, future plans, and operational issues with upstream and downstream partners to remain aligned and thus maintain a successful performance (Figure 7).

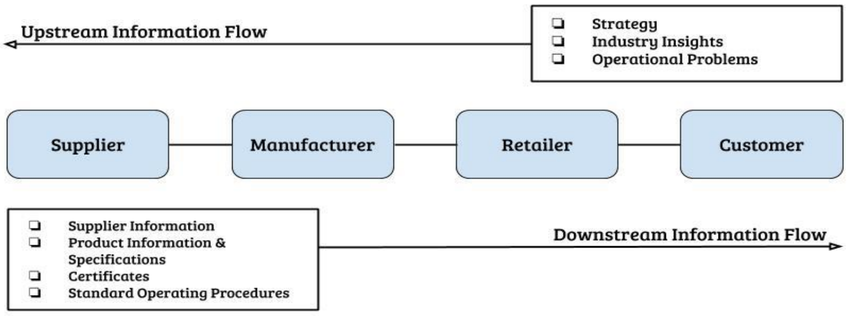

Figure 7: Upstream & Downstream Flows of Information Across the Supply Chain

All organizations agreed on four categories of information necessary for transparency and traceability and hence trust: supplier information, product or material specifications, certificates, and SOP (Standard Operating Procedures). Table 5 shows all the required information for each of the categories, combined with the data suggested by Folinas et al. (2006) in table 1.

Information Category	Information Type	Requirements	
Supplier Information	Mandatory	Supplier ID Buyer ID Bank details Contact people	Minimum order quantity Response time Lead time
	Optional	Buyer’s name Supplier name Contact information Brief about supplier Supplier history	Sales volume Customer satisfaction level Service level Capacity
Product Information & Specifications	Mandatory	Lot number Product ID Product description	Quantity Unit of measure Materials Expiry date
	Optional	Sampling Country of origin Date of pack Logistics service provider ID	Trade unit Transportation vehicle ID Receipt date Dispatching date
Certificates	Mandatory	Quality assurance Safety assurance	Governmental institutions registration
Standard Operating Procedures	Mandatory	Technical data sheet Quality training Safety training	Production conditions Warehousing and storage conditions

Table 5: Revised gathered information classified per category and type

6.1. Managerial implications

From the side of the blockchain providers, the most important characteristics required for attaining supply chain traceability and hence traceability is revealed. Blockchain adopters require the technology to be verifiable and immutable hence, these two characteristics should be dealt with caution. Furthermore, Blockchain providers could use these characteristics for marketing purposes in persuading adopters to use the technology especially if the objective is enabling trust between supply chain partners. From the blockchain adopters, the type of information required for one tier upstream and downstream supply chain partners trust enabled by adoption of blockchain technologies is revealed. Early adopters of this technology should make sure that the mandatory information is at least available to a one tier upstream and downstream supply chain partner. Table 5 provides a roadmap to all the required type of information which should be available before adopting blockchain for increasing trust.

6.2. Theoretical implications

The most important characteristics enabling supply chain trust through transparency are identified. The paths between both verifiability, immutability and supply chain trust is defined and highlighted. The role of transparency is defined to be a mediator between both blockchain characteristics (verifiability and immutability)and supply chain trust. Mandatory and optional information types are defined for enabling blockchain technology to affect trust through transparency.

6.3. LIMITATIONS AND FUTURE RESEARCH

The limitations encountered in this study is mainly related to the early development stage of blockchain-enabled supply chains, especially in Egypt which might lead to biased information compared to other organizations working in different countries. Furthermore, future research may focus on specific industries in critical need for supply chain trust solutions and the potential of the adoption of the technology in Egypt.

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