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The implementation of blockchain within business supply chain management: an empirical exploration into the constructs that influence organisational intention to adopt blockchain against the background of trust and opportunism within supply chain networks

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Abstract

This study aims to explore which factors, and to what extent, influence the intention of business organisations to adopt blockchain within their supply chain management. This exploration will be conducted against the background of trust and opportunism within supply chain networks, as this dimension is often overlooked within both the Technology Acceptance Model and Unified Theory of Acceptance and Use of Technology. The contribution of this study is therefore twofold: it provides a framework of the most important factors that organisations need to assess vis-à-vis their receptivity for blockchain adoption, and this study simultaneously intends to address the existing research gap in terms of how the factors trust and opportunism within supply chain networks influence organisational indentation to blockchain adoption.

Next to the factors trust and opportunism, several influencing factors were identified and grouped into technological, environmental, and organisational factors. The method employed to determine the influences of the variables was partial least squares path modelling and the results revealed that the value drivers of blockchain, as well as its adoption barriers, and perceived ease of use significantly influence the perceived usefulness of blockchain. Furthermore, the facilitating conditions and competitive pressure directly significantly influence organisational intention to adopt blockchain. Lastly, whereas trust appeared to not have a significant influence on organisational intention to adopt blockchain, opportunism resulted to significantly positively affect organisational intention to adopt blockchain.

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1. The effect of the increasing demand for transparency and traceability in supply chains, and blockchain as one of the prominent coping technologies

"*From corned beef to fillet steak, every single piece of beef that M&S sells has two things in common – it can be traced back to the farm and animal it came from AND it is British" (Marks&Spencer, 2018).* This statement in the press release of Marks & Spencer's campaign 'We trace it, so you can trust it' highlights the contemporary increase in valuation of transparency and information relay that companies could provide concerning their products. According to the key findings of the Food Marketing Institute (2018, p. 2), 93% of the respondents in their survey conveyed that it's important that companies provide detailed food information regarding how the food is made and what its contents are. Furthermore 74% of the respondents express that they would switch brands if other brands provide more in-depth product information. Assuming that these percentages can be perceived to reflect the population as a whole, it becomes clear that companies shouldn't dismiss the opportunities and pitfalls that coincide with these new and disrupting insights about product transparency. The Food Marketing Institute (2018, p. 2) underlined the impact transparency can have from a business's point of view, as there is a direct connection between transparency and commercial benefits for brands plus it directly impacts consumer trust building and loyalty. Cole, Stevenson, and Aitken (2019, p. 469) argued that trust in products and brand is a key factor in a consumer's purchasing decision and thus emphasised the importance of ensuring end-to-end transparency and traceability in supply chains.

Several companies are now in the process of adopting and implementing different technologies that can provide visibility as well as increase efficiency of their supply chains (Sharma, Adhikary, & Borah, 2020, p. 444). Within this group of enabling technologies, blockchain is positioning itself as a prominent game changer to provide transparency and traceability (Carson, Romanelli, Walsh, & Zhumaev, 2018). Antonucci et al. (2019, p. 6129) essentially described blockchain as a database where records are distributed in the form of encrypted blocks. It can function as both a public and private ledger of all transactions or digital events that have taken place and shared among participating parties. All the transactions can be verified at any given time in the future; given its robust and decentralised functionality, blockchain is often employed in global financial systems. Blockchain can also be applied for contracting and operating processes, such as tracking of the global supply chain. Chang, Iakovou, and Shi (2020, p. 1) reinforced the versatile functionality of blockchain and argued that blockchain possesses the potential of transforming global supply chain management with a prediction that blockchain could be able to track approximately two trillion dollar worth of goods and services in their movement across the globe by 2023, and has the ability be a more than three trillion dollar business by 2030. Even nowadays business models in each sector are already being disrupted by a growing number of blockchain initiatives. Keeping this extrapolation in mind, companies need to be able to critically assess whether or not it is fruitful to implement blockchain and to what end it can provide strategic advantages in comparison to the traditional centralised databases that are used for supply chain management.

Granting that blockchain has been hailed by many different researchers as a promising emerging digital technology with multiple value drivers, they also outlined that blockchain still has to overcome multiple challenges and barriers. Next to the value drivers and adoption barriers, other factors, such as environmental factors and organisational factors, also influence the intention of organisations to adopt blockchain. Moreover, trust and opportunism within inter-organisational relationships can also influence organisation intention to adopt blockchain, but is often overlooked as an incentive for organisations to adopt blockchain; companies could benefit from adopting blockchain to enhance trust within their supply chain network, while also curbing any opportunistic behaviour. Several researchers, such as Queiroz and Fosso Wamba (2019), Kamble, Gunasekaran, and Arha (2019), and Wong, Leong, Hew, Tan, and Ooi (2020) have already applied the principles of the Technology Acceptance Model and the Unified Theory of Acceptance and Use of Technology to the organisational behavioural intention to adopt blockchain. This research will outline and discuss the results of these studies, and will try to approximate to relevance of the trust and opportunism dimension.

Against this background, this research will assimilate existing literature, and models on blockchain and technology adoption to uncover which factors influence the perceived usefulness of blockchain, and which factors directly influence organisational intention to adopt blockchain. Ultimately, the main analysis focusses on the extent in which the perceived usefulness of blockchain influences the behavioural intention of organisations to adopt blockchain. The assimilation will also include the trust and opportunism dimension within supply chain networks, as this dimension could be an important factor for many organisations that could affect their intention to adopt blockchain, as well as providing organisations with a stimulus to more positively or negatively assess the perceived usefulness of blockchain.

The research question that can derived from this posit is as follows:

To what extent does the perceived usefulness of blockchain influence organisational behavioural intention to adopt blockchain and what is the moderating effect of trust and opportunism within supply chain networks?

To answer the main research question and to guide the research itself, three sub questions are raised to fractionate the elements within the main research question. The first element contains the factors that influence the perceived usefulness of blockchain. The subquestion to delve into this element is:

What are the factors that influence the perceived usefulness of blockchain, and to what extent do these factors influence perceived usefulness?

The second subquestion addresses additional environmental and organisational factors that could affect a company's intention to adopt blockchain:

What are the environmental and organisational factors that influence the behavioural intention of organisations to adopt blockchain, and to what extent do these factors influence the behavioural intention of organisations to adopt blockchain?

The third and last subquestion is formulated to focus on the direct and moderating effect of trust and opportunism within supply chain networks:

To what extent does trust and opportunism in supply chain networks affect the behavioural intention of organisations to adopt blockchain, and to what extent does trust and opportunism within supply chain networks moderate the relationship between the perceived usefulness of blockchain and the behavioural intention of organisations to adopt blockchain?

In the next subheadings firstly blockchain as a technology will be discussed in terms of the current research outlook of blockchain, the history of blockchain, and blockchain's configuration and functionality. Subsequently blockchain's advantages and adoption barriers will be outlined, as well as the feasibility to adopt blockchain in supply chain management in comparison to traditional centralised databases. Thereafter the factors and theoretical models that will be incorporated in the research model of this research will be elaborated. Then the research model will be depicted with the proposed hypotheses, after which the methodology will be substantiated. After the methodology, the results of this research will be outlined and discussed. Lastly, the limitations of this research will be reviewed.

2. The disruptive technology that is blockchain

Blockchain is a contemporary technology that is based on the distributed digital implementation of transaction ledgers, and is therefore sometimes referred to as the 'Distributed Ledger Technology' (Biswas and Gupta (2019, p. 225). Blockchain has been identified by Panetta (2016) as one of the top ten strategic technology trends for companies, and further invigorated by Biswas and Gupta (2019, p. 225), who stated that blockchain could be the most disruptive innovation since the birth of the Internet. Blockchain has multiple applications in areas such as: securing contracts, creating e-health records, monetary remittances, academic credential systems, and tracking the origin and provenance of products (Beck, Avital, Rossi, & Thatcher, 2017, p. 381; Hald & Kinra, 2019, p. 376). Although organisations in both the public and private sphere could potentially benefit from blockchain, for example vis-à-vis their finance management and supply chain management, most managers are reserved and cautious (Hald & Kinra, 2019, p. 379). Hald and Kinra (2019, p. 379) argued that despite the overall realisation of the potential impact of blockchain, companies are hesitant to adopt and invest in blockchain applications due to the fact that there is no general consensus or leading example of the performance benefits and employee effects that blockchain generates. Hughes et al. (2019, p. 124) in extension, pointed out that organisations that have been early-adopters of blockchain are now biting the bullet as the technology is still at a very early stage of development, and hasn't been able to materialise significant commercial momentum. Bennett (2017) believed that because of this lack of momentum, an amount of otherwise feasible projects will ultimately flop.

Hald and Kinra (2019, p. 377) assumed that the reluctance of organisations adopting blockchain partly lies within the current available knowledge of blockchain. The current knowledge is dominated by a multitude of imprecise literature studies that only highlight the many promises of the new technology and its potential market disruption (Hald & Kinra, 2019, p. 377; Hughes et al., 2019, p. 114). According to Hald and Kinra (2019, p. 377), the theoretical and methodological approaches of these literature studies are impuissant and with low validity. Zoomed in on the specific adoption and application of blockchain in supply chain management, the literature is wanting as well. Hald and Kinra (2019, p. 377) commented that the literature on blockchain within supply chain management is in need of both a theoretical foundation and theoretical substance. Once the foundation is laid and supplemented with sufficient and comprehensive substance, the specific architectural properties and managerial implications can be conceptualised. This will sequentially contribute to a cleared and broader comprehension of the relationship between blockchain as a technology, managing blockchain, and blockchain's performance.

2.1 The history of blockchain

Biswas and Gupta (2019, p. 225) indicated that blockchain first appeared when Bitcoin was introduced; Bitcoin was invented by Satoshi Nakamoto, as pointed out by Hackius and Petersen (2017, p. 4), which is a pseudonym for a mysterious individual or group of persons who still remains unmasked to the general public. Richards (2019, pp. 161-164) discussed that Bitcoin was the first natural evolution of cryptocurrency, and the goal of Bitcoin was to speed up financial transactions at low processing costs. Herewith Bitcoin became the world's first decentralised digital currency in the context of a peer to peer electronic cash system (Biswas & Gupta, 2019, p. 225; Hughes et al., 2019, p. 115). Further delving into Bitcoin, Meiklejohn et al. (2013, p. 127) conceptualised Bitcoin as an independent online monetary system that combines some of the features of cash and existing online payment methods. In this system both payer and payee are not explicitly identified, transactions are cryptographically signed transfers of funds from one public key to another and are irreversible. Lastly, the Bitcoin system requires mediation from third parties that participate in the global peer-to-peer network to validate and certify all transactions.

Gurtu and Johny (2019, p. 882) simplified the usage of bitcoin: when a user wishes to participate in the bitcoin network, the user must download and subsequently install the bitcoin core client through which the user's computer is set up as in node in the network. Each computer that functions as a node becomes a terminological block into the public ledger, and a series of nodes ultimately form a blockchain (Gurtu & Johny, 2019, p. 882). Blockchain in this sense is an important part of the architectural configuration/structure of Bitcoin, and in the last decade blockchain was further transformed to presently incorporate a multitude of technologies (Richards, 2019, p. 162).

This transformation was elucidated by Richards (Richards, 2019, p. 162) via a timeline consisting of four blockchain generations. The first blockchain generation was constructed in 2009 to facilitate the formation and exchange of cryptocurrency, globally generating \$10–20 million in transaction payments and remittances. The second blockchain generation of 2010 focused on enhancing cryptocurrency, thus more cryptocurrencies emerged and in tandem companies started to realise that blockchain could be utilised beyond currency usage (Richards, 2019, p. 163). The third blockchain generation of 2012 put this realisation into practice, for example with the development of financial instruments in which a system of business logic and programs of blockchain were embedded; one of the most prominent programs of blockchain that came forth out of the third blockchain generation was smart contracts. The focal point of the fourth blockchain generation of 2017 was integrating blockchain into the Internet of Things; blockchain technologies furthermore serve as a 'proof of work' where miners as the largest computing group conduct the processing of data in exchange for cryptocurrency payments. Presently there are already initiatives for bringing the fifth blockchain generation into operation, but not much details and information is available regarding these initiatives.

2.2 The configuration and functionality of blockchain

DePatie (2016), and Petersson and Baur (2018, pp. 12-13) explained the configuration of blockchain in its simplest form with the example of a basic transaction between two persons. If person A wants to buy something from person B, firstly a block which represents the transaction is created within the blockchain system. Following the creation of the transaction block, it is transferred to every participant within the network of the blockchain system for verification. At that point the so called 'data miners' in the network compete to be the first to verify the transaction, and the first to successfully verify the transaction block gets rewarded with a digital payment; generally the reward is a very small Bitcoin payment (DePatie, 2016). Once the rest of the participants within the network have all verified the transaction block, the data will be date -and time stamped; if the transaction itself is preceded by congruent transactions, the transaction block is linked to previously verified blocks to form a chain of blocks that is commonly referred to as the blockchain. Once the block is verified in the network system, the transaction is concluded with person A receiving a proof of purchase and/or the bought item and person B receiving payment for said item. The properties of the blocks within the blockchain are thus configured to contain a header with a time-stamp, the transaction data, and a link to the previous block (Kamilaris, Fonts, & Prenafeta-Boldo, 2019, p. 640).

As specified by Manupati et al. (2019, p. 4), identification details to indicate an occurrence of a certain event are inserted into the timestamp and the cryptographic link between a block and the previous block is terminologised as a 'hash', making it practically impossible to alter the stored digital information. This reciprocity makes it easy to trace a transaction through the ledger's uniquely generated digital signature in the connected blocks (Manupati et al., 2019, p. 4). Lastly next to these safeguards there are several other types of data that can be enclosed within blocks on the blockchain with regards to products. Abeyratne and Monfared (2016, p. 6) mentioned that four additional data types can be collected: ownership data, location data, product specific data, and environmental impact data.

Allen, Berg, Davidson, Novak, and Potts (2019, p. 372) characterised blockchain as a combination of a number of existing technologies, such as asymmetric cryptography, peer-to-peer networking, and append-only databases. Blockchain, according to Hackius and Petersen (2017, p. 5) contains three basic properties: blockchain is decentralised, it is/can be verified, and it is immutable. Kamilaris et al. (2019, p. 640) stated that with the individual transaction data files of blockchain are managed through specific software platforms from which the data can be transmitted, processed, stored, and represented in human readable form. The property of a decentralised network is reflected by the design of blockchain in which participating members run the system, without relying on a central authority or centralised infrastructure that would normally establish trust in the traditional setting (Hackius & Petersen, 2017, p. 5). When a transaction is added to the ledger, this transaction is shared among all participants within the blockchain's peer-to-peer network, and all participants receive and get to keep their own local copy of the ledger encompassing all transactions. Pearson et al. (2019, p. 146) moreover remarked that new copies of the ledger are only available when a sufficient amount of system actors reach consensus that the data in the ledger is correct.

Although the decentralised characteristic is often stated and underlined by researchers, it has to be placed into perspective; Azzi, Chamoun, and Sokhn (2019, p. 584) stated that the blockchain network can either function as a permissionless network, or as a permissioned network. A permissionless blockchain network can be typified as an open distributed ledger where any participant can join the network and in which any two peers can conduct transactions without any authentication from the central agency (Azzi et al., 2019, p. 584; Sankar, Sindhu, & Sethumadhavan, 2017, p. 2). A permissioned blockchain network as the other type, is a closed/controlled distributed ledger where all participants are authenticated by a central authority that has to grant access to other participants to join the network. All participating identities are known to each other, and additionally the decision making and the validation process are the prerogative of the central authority (Sankar et al., 2017, p. 2). In this regard the decentralised nature of blockchain only de facto materialises in a permissionless network setting.

Blockchain's second property of verifiability comes to fruition in the transactions that are signed with a public-private-key cryptography by the individual members, before the transactions are shared with the rest of the network (Hackius & Petersen, 2017, p. 5). In this regard, only the rightful owner of the cryptographical key can initiate; the only downside is that individual members can remain anonymous, because the cryptographical keys are not linked to real-world human identities. Thirdly blockchain incorporates the property of immutability; blockchain is immutable though its consensus algorithm (Hackius & Petersen, 2017, p. 5). In this algorithm all members can verify the transactions within a block in the chain; the block will be added to the chain if consensus is reached that the transactions in the block are valid, and when the situation occurs that consensus is not attained, the block will be rejected. Users are therefore guaranteed to be able to operate with the highest degree of assurance that the data chain is unalterable and accurate (Abeyratne & Monfared, 2016, p. 3). Another advantage of blockchain in this regard according to Cole et al. (2019, p. 471), is that through the immutability of blockchain the provenance of assets is also ensured; users are able to locate products, see where the products have been, and what happened to the products throughout their lifetime

2.3 Blockchain's value drivers for supply chain management implementation

Hughes et al. (2019, p. 116) noted that the characteristics and inherent properties of blockchain create numerous potential applications beyond the domain of cryptocurrencies. Blockchain could potentially offer advantages over the current, more centralised methods and systems. Hughes et al. (2019, p. 116) summarised multiple application areas that have been explored by researchers, in which blockchain could provide benefits to users and contracting parties: smart contracts, digital payments, supply chain management, accounting and assurance, transport and logistics, and peer review and voting. Many of the conducted studies into blockchain's multiple application areas, indicate supply chain management (SCM) as one of the most receptive domains in which blockchain could leverage its advantages over traditional based approaches (Hughes et al., 2019, p. 116). Hald and Kinra (2019, p. 278) defined SCM as "*the systemic, strategic coordination of traditional business functions and the tactics across these functions within a particular company and across businesses within the supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole.*" Chang et al. (2020, p. 2083) presented several supply chain value drivers of blockchain that could improve the long-term performance of supply chains, such as traceability, dispute resolution, security, compliance, and trust. Many other authors have also highlighted a wide variety of value drivers of blockchain in terms of cost reductions, immutability, visibility, and improved demand forecasting to name a few. The most prominent and leading value drivers vis-à-vis supply chain management will be discussed in the following section.

2.3.1 Traceability

Chang et al. (2020, p. 2083) described supply chain traceability in terms of the ability of involved parties, such as business stakeholders, authorities, governmental agencies, and consumers, to manage and respond to risks in a responsive and documented way. Hald and Kinra (2019, p. 385) explained that a supply chain is by nature a distributed network of involved parties; activities and transactions that are conducted within supply chains can, at certain intervals, be dislocated across time and space. The ability to enhance supply chain transparency and traceability is thence a fundamental ambition of SCM, and often directly linked to the ability of improving overall supply chain performance. Azzi et al. (2019, p. 584) emphasised that a good supply chain traceability system therefore aims to minimise the production, as well as the distribution, of unsafe -or bad quality products by improving the labelling -and tracking systems. Chang et al. (2020, pp. 2083-2084) observed that traceability traditionally mainly focused on upstream supply networks, with the nucleus of tracking the source and origin of raw materials and components. However, in recent times the traceability range has expanded to include downstream supply networks as well; goods are traced along the multi-layer distribution networks all the way down to ultimately the end consumers. According to Dujak and Sajter (2019, p. 34), this expansion of the traceability range is in line with the increasing valuation of product traceability from customers. Information that is provided by companies as to where the product originated from, who made it, who transported it and how, and the real-time location of the product, is highly valued by customers and could very well present a true competitive advantage for the company that provides it.

Azzi et al. (2019, p. 584) doubted about the extent in which traditional centralised enterprise resource planning (ERP) technology used for supply chain management is becoming outdated, as ERP isn’t equipped to adapt to the ongoing supply chain revolution in terms of transparency, flexibility, data accessibility and advanced decision making. This supply chain revolution is driven by consumers, as well as governments and companies, that are increasingly demanding more traceability and transparency from brands, manufacturers, and producers throughout the entire supply chain (Chang et al., 2020, p. 2084). For many customers and buyers, the accessibility of reliable and efficient ways of validating product provenance and details of products and services are to a great extent still lacking in current supply chain constellations, due to the endemic lack of traceability and transparency. In this context businesses are becoming more aware of the urgency of supply chain transparency and traceability to ultimately be able to convey social, environmental, and sustainable credentials to customers (Chang et al., 2020, p. 2084).

To this end, as pointed out by Y. Wang, Singgih, Wang, and Rit (2019, p. 221), blockchains could create permanent shareable and actionable records of products' digital footprints from one end of the supply chain to the other, if it is combined with field-sensing technologies, such as the Radio-frequency identification (RFID) as an epitome example of an application within the Internet of Things. The improved product visibility through blockchain has the potential to enhance product traceability, product authenticity, and product legitimacy in many business sectors, such as the food, pharmaceutical, and luxury-item sector, and this improved product visibility could prove to be crucial for their supply chains (Y. Wang et al., 2019, p. 221). Chang et al. (2020, p. 2084) also shared this view, as blockchain and its associated tracking capabilities have the ability to provide a full audit trail of transaction data for every touchpoint within the supply chain and is able to add verifiable, transparent, and immutable records in the form of digital certificates to products’ provenance. Customers, governments, and other involved companies can thusly have access to information regarding the provenance of products, product authenticity, and product data. Simultaneously companies are better equipped to identify problems within their supply chains, and efficiently and accurately trace back the path of a product to its source when an incident such as a food contamination outbreak occurs (Chang et al., 2020, p. 2084).

2.3.2 Dispute resolution

Chang et al. (2020, p. 2084) stated that situations can arise in which an engaged participant of a company's supply chain fails to deliver required products on-time, or the engaged participant fails to deliver the agreed upon quantity, or complications bubble up due to products that are compromised en route. Given these possibilities, supply chain stakeholders should be able to quickly identify and analyse the situation. These issues often have a tendency to evolve in disputes that are generally settled by fines or compensations in the end. Chang et al. (2020, p. 2084) emphasised that these kinds of disputes typically are cumbersome and expensive for companies to contest, as auditing a products' track is error-prone and costly. Chang et al. (2020, p. 2084) indicated that the flaring up of these disputes have a twofold background: firstly ambiguities in contract clauses are common, and secondly there exists a degree of lacking accountability between involved parties.

Gupta (2017, pp. 25-26) and Chang et al. (2020, p. 2084) argued that blockchain could inherently make supply chain dispute resolution history, as blockchain is capable of recording data regarding asset provenance, ownership transfer, legalities and safety requirements in real-time. With the inclusion of smart contracts, in which predetermined business regulations within different possible frameworks are coded, compensations or fines can automatically be triggered at low procedural costs, for example in affairs where compliance with pre-set terms and regulations has been violated (Chang et al., 2020, p. 2084).

2.3.3 Cargo integrity and security

Chang et al. (2020, p. 2084) discussed that supply chain documentation, such as bills of lading, as well as policies of insurance and invoices, are imperative to ensure that buyers in the supply chain receive their payment and sellers receive genuine and uncompromised cargos. Hackius and Petersen (2017, p. 8) exemplified that the provenance of high-value items often relies on documentation in the form of paper certificates that can get easily lost or tampered with. Currently, when a diamond is traded, is it not straightforward to track down if the diamond's certificate is genuine or fake, ergo it is almost impossible to determine if the diamond was stolen or not. Unfortunately more danger lurks around the corner with global trade becoming increasingly reliant on IT, electronic trading platforms, and electronic documents, which could potentially severely disrupt supply chain operations; fraudsters can create fake product -or cargo documentation, hackers can launch cyber-attacks against companies, and employees of the company itself can commit malicious intra-company activities (Chang et al., 2020, pp. 2084-2085). Min (2019, p. 43) acknowledged these dangers, while commenting that despite countless efforts with means of antivirus -or malware software, password protection, and even threat alerts to deal with these threats, the risk of cybercrime has never been abated.

To counter these pernicious practices, blockchain offers security safeguarding between the cyber -and physical transportation of products while simultaneously ensuring the integrity of the chain-of-custody process (Chang et al., 2020, p. 2085). Gupta (2017, p. 7) mentioned that supply chain data can be dually secured through blockchain: firstly hackers can be kept at bay as the blockchain encryption is configured to thwart data tempering, as each data input must be verified and can't be altered later in the process. Secondly the ownership of cargo can be transferred digitally, while embedded with a unique identifier that is issued for each authorised participant in the supply chain network. In this sense cargo can only be received by legitimate recipients, thus foiling any possible irregular appropriation of cargo (Chang et al., 2020, p. 2085; Gupta, 2017, p. 22). Azzi et al. (2019, p. 585) also weighed in on the contribution of blockchain in terms of security, as blockchains' distributed ledger prevents hackers from taking advantage of a vulnerable point, because if one node fails, the remaining nodes will not be affected. By extension, when a data administrator is compromised, traditionally the whole system could be subject to tampering and falsifying information, but with blockchains' consensus mechanism these incidents are safeguarded.

2.3.4 Compliance

Chang et al. (2020, p. 2085) remarked that in the current global commerce, a vast number of requirements need to be monitored and adhered to. Requirements such as product safety, product integrity, technical regulations, social responsibility, and environmental responsibility are increasingly becoming an integral part of the supply chain and when companies fail to adhere to these compliance requirements, this could likely result in regulatory scrutiny or other negative impacts regarding an organisation's reputation and prestige (Chang et al., 2020, p. 2085). The fundamental cruxes of addressing current and emerging supply chain compliance, according to Chang et al. (2020, p. 2086), is the supply chain stakeholders' obtainment of valid compliance requirements information, and the effective and efficient coordination and communication of compliance requirements throughout the entire supply chain.

Chang et al. (2020, p. 2086) subsequently addressed how companies could utilise blockchain as a coping mechanism for these cruxes. Blockchain quintessentially provides involved supply chain parties real-time visibility into the supply chain, as well as the regulation of embedded contract conditions. Organisations can therefore coordinate operations to functionally work within the drawn compliance framework, and the stored data on the blockchain can readily be audited for verification.

2.3.5 Improved demand forecasting

Dujak and Sajter (2019, p. 36) argued that demand management is one of the most crucial elements within supply chain management. Besides a company's planning, coordinating, and integrating capabilities, it must possess the capability to manage demand, and it must also be able to influence the demand and supply to a certain extent; supply and demand should be adjusted within supply chains to ultimately maximise profits of the entire supply chain. Dujak and Sajter (2019, pp. 36-37) defined demand management as: *"the preparation of supply chain members for future events in the supply chain through coordinated efforts to forecast expected future demand, jointly influencing demand and accordingly creating their supply".* Layaq, Goudz, Noche, and Atif (2019, p. 55) explained that forecasting is always based on the available historical data which is used to forecast periods, and the accuracy of the forecast thus depends on the reliability of linking historical data with the most recent data.

Layaq et al. (2019, p. 55) pointed out that blockchain could improve demand forecasting, because blockchain can provide the most recent data together with secured historical data that goes all the way back to the first block within the blockchain. Additionally, blockchain presents the possibility for included supply chain participants to easily access all data on the blockchain; in this regard the planning process can be streamlined and made more accurate between all the participants within the supply chain.

2.3.6 Trust and stakeholder management

Chang et al. (2020, p. 2086) considered trust between supply chain stakeholders to be one of the most important factors in a committed and collaborative relation. Pournader, Shi, Seuring, and Koh (2020, p. 2071) emphasised that trust and trustworthiness within supply chains affect information sharing and forecasting accuracy. Matching supply and demand in supply chains is thusly subject to the degree of trust and trustworthiness. Helo and Hao (2019, p. 243) believed that in order to establish trust between participating parties and to realise a high level of transparency across the supply chain, companies should keep three things in mind. Firstly, it is important to optimize various flows of information, secondly a holistic view of all relevant activities should be created, and lastly the whole supply chain should be integrated through the adoption of advanced technologies. Chang et al. (2020, p. 2086) stated that currently supply chain stakeholders rely heavily on central intermediaries, such as banks or legal entities, to function as brokers of trust to ensure transactions are verified, recorded, and coordinated. Additionally, regulatory agencies like customs and other governmental regulators, are actors within the supply chain to safeguard regulatory compliance. Both intermediary parties and regulating parties add a degree of complexity within supply chains in terms of increased burden of proof, data transmittance, asymmetric trust, variability, and costs (Capell, 2018, p. 4; Chang et al., 2020, p. 2086).

Chang et al. (2020, p. 2086) explained that blockchain could tackle this increasing web of complexity through its modus operandi. At the heart of blockchain lie the date -and time stamped linked blocks of data that are accepted and verified through consensus of the blockchain participants. The data stored on the chain in this respect can’t be edited, altered or tampered with, as well as the certainty that supply chain stakeholders and other involved parties have the ability to access, verify, and audit the data at any stage. Product information, transactions information, and the credentials and reputation of involved supply chain parties is furthermore available in real time against low costs (Chang et al., 2020, p. 2086). In this way provenance of products can be accurately and forthcomingly be identified, whilst also accomplishing the nullification of existing asymmetric trust.

2.4 Barriers to blockchain implementation

Saberi, Kouhizadeh, Sarkis, and Shen (2019, p. 2124) expressed that if companies want to successfully implement blockchain technology, challenges and barriers that are to be managed, have to be identified. Together with their supply chain partners, companies should first and foremost understand these challenges and barriers to be able to incorporate them in the overall plan of adopting and implementing blockchain technology into their organisations. Gao, Hatcher, and Yu (2018, p. 8) added to this view, stating that despite increasing interest in blockchain's application possibilities, there still remain several key concerns towards wholesale organisational adoption of blockchain. Saberi et al. (2019, pp. 2124-2126) and Lohmer and Lasch (2020, pp. 8-11) showed, by reviewing relevant literature, that the barriers regarding the implementation of blockchain can be grouped into four main categories as shown in Figure 1 below: intra-organisational barriers, inter-organisational barriers, technology/system-related barriers, and external barriers. In the next section the most prominent and most often cited barriers within the literature will be discussed.

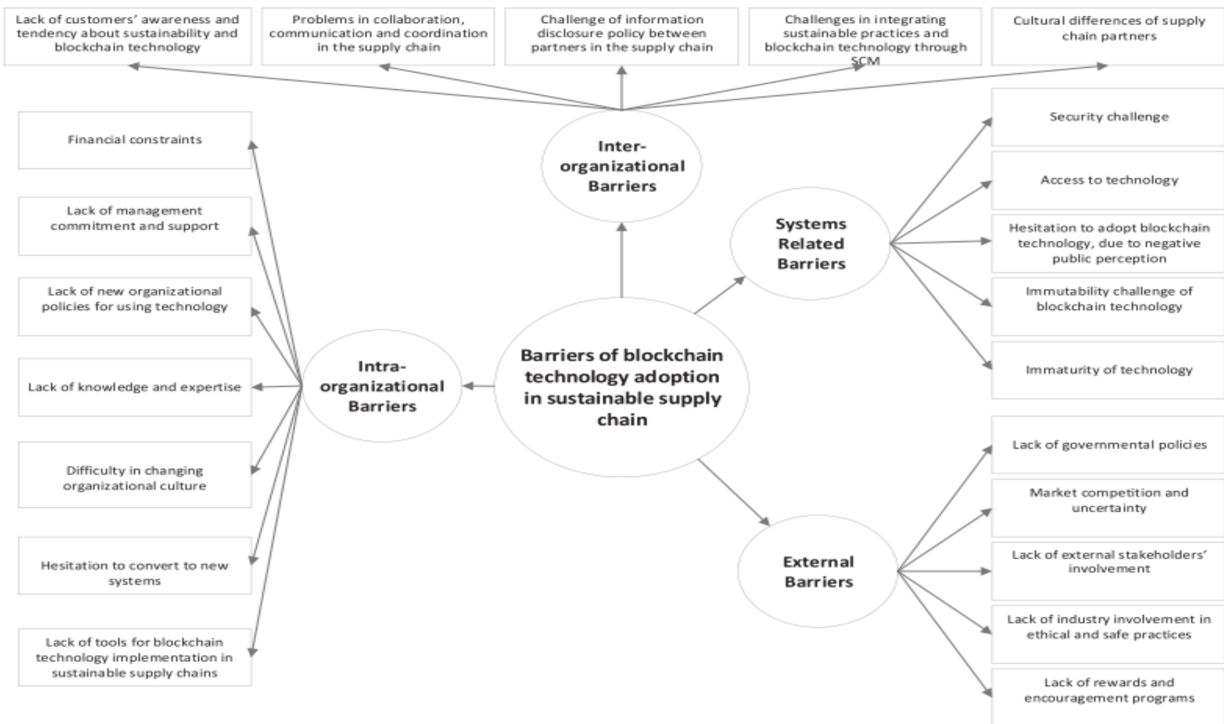

Figure 1: Barriers of blockchain technology adoption in supply chains (Saberi et al., 2019, p. 2124)

2.4.1 Intra-organisational barriers

Saberi et al. (2019, p. 2124) expressed that intra-organisational barriers relate to barriers that stem from internal activities of organisations. Multiple intra-organisational factors have to be taken into account regarding the intention of organisations to adopt blockchain within their supply chain management.

2.4.1.1 Lack of top management awareness

Firstly, a lack of top management awareness and commitment can pose a barrier to organisational intention of adopting blockchain. Saberi et al. (2019, p. 2124) claimed that top management support is an essential factor for implementing a supply chain practice, and in some instances top management fails to enter into a long-term commitment that is required for supporting and adopting a new technology. A lack of top management commitment poses a barrier for blockchain adoption, because the integrity of sustainable blockchain supply chain processes could be impeded, as well as resource allocations and financial decisions that would challenge the support that is needed for adopting and using blockchain (Fawcett Stanley, Ogden Jeffrey, Magnan Gregory, & Bixby Cooper, 2006, pp. 23-26; Saberi et al., 2019, p. 2124)

2.4.1.2 Lack of interoperability and integration problems

Interoperability and integration problems pose a noteworthy barrier, and solving these problems could be the key to widespread adoption of blockchain (Frizzo-Barker et al., 2020, p. 11). This barrier is not solely a part of the domain of intra-organisational barriers, but also of the inter-organisational domain as it affects both internal -and external data exchange. According to Astill et al. (2019, p. 245) interoperability is the ability of different systems, people, or entities to successfully work together in order to be able to exchange and share data in an accessible and presentable format for users of both interoperating systems. The interoperability and integration difficulties manifest themselves in two ways: data exchange between two different blockchain systems, and data exchange between a blockchain system and a legacy system. The first case of interoperability difficulties between two different blockchain systems, is the result of a growing rate of blockchain-based applications, leading to the creation of a large number of heterogeneous blockchain solutions (Casino, Dasaklis, & Patsakis, 2019, p. 71). This in turn harbors a large number of diverse blockchain implementations and features, which complicates making all the different blockchain systems compatible. Kurpjuweit, Schmidt, Klöckner, and Wagner (2019, p. 10) gave an example of this missing compatibility: multiple different blockchain systems contain a broad variety of blockchain protocols, and each blockchain system could potentially use different validation or consensus mechanisms, which could undermine the overall process of data exchange. Next to the interoperability between blockchain system, integrating blockchain into existing organisational IT-landscapes could be challenging. Kurpjuweit et al. (2019, p. 10) stressed that issues could arise when processes have to be established and/or aligned, as well as interfaces that have to be created to effectuate communication and data exchange between blockchain systems and internal legacy systems such as ERP or PLM. Upadhyay (2020, p. 3) expressed concern in regard to the current materialisation of fully functional blockchain systems, as there still exists a lack of clarity in the way blockchain interacts with legacy systems. The ultimate goal of free and seamless data exchange between blockchain systems and legacy systems is currently weighed down by organisations being in limbo in terms of restructuring systems, processes and legacy IT structures to facilitate free and seamless data exchange (Upadhyay, 2020, p. 3).

2.4.2 Inter-organisational barriers

Saberi et al. (2019, p. 2125) stated that inter-organisational barriers refer to barriers that could occur when aligning blockchain adoption between an organisation and its supply chain partners. The process of aligning technological adoption between partners within a supply chain relationship faces several challenges due to the nature of organisations themselves and the manner of information sharing. In addition to the earlier discussed interoperability barrier, both a lack of supply chain collaboration and a lack of standardisation pose inter-organisational barriers to blockchain adoption.

2.4.2.1 Lack of supply chain collaboration

Integrating blockchain in the supply chain as a technology is firstly subject to the willingness of supply chain partners to collaborate. As blockchain inherently provides information transparency and verifiability, supply chain partners are therefore committed to comply with open information sharing. The practice of open information sharing is not a thing all companies are enthusiastic about for a number of reasons, as information can be sensitive or be perceived as a competitive advantage (Fawcett Stanley, Wallin, Allred, &

Magnan, 2009, pp. 225-226; Saberi et al., 2019, p. 2125; Sayogo et al., 2015, p. 13). On that account Saberi et al. (2019, p. 2125) concluded that the reluctance of organisations to share information with their supply chain partners could ultimately hinder the advantages of adopting blockchain, and could even undermine the effectivity of implementing blockchain within a supply chain. In addition to organisations' reluctance for sharing information, a lack of privacy policies, or too many different privacy policies regarding the use and release of data and information could also affect supply chain collaboration. Furthermore, a lack of information sharing rules between organisations also holds sway over organisational willingness for supply chain collaboration.

2.4.2.2 Lack of standardisation

Another inter-organisational barrier blockchain faces, as well as posing an intra-organisational barrier, is the lack of standardisation. Sahebi, Masoomi, and Ghorbani (2020, p. 3) considered that blockchain coders and developers obtain a great amount of freedom through blockchain's decentralised nature, but due to the scarcity of standardisation of IT-departments, different blockchain platforms cannot convey and communicate well with each other without translation programs that recognise and facilitate this process. Thus the absence of standardisation will hinder participants on the blockchain to effectively and efficiently communicate and cooperate. Seebacher and Schüritz (2019, p. 8) expressed that industry –and data standards are imperative for ensuring data transferrals between organisations. Seebacher and Schüritz (2019, p. 8) emphasised that the current lack of a clear standardisation for blockchain is due to the fact that there is no single dominant blockchain platform in the first place, but a proliferation of several platforms and technologies.

2.4.3 Technology / System-related barriers

Saberi et al. (2019, p. 2126) cautioned that blockchain is regarded as an immature technology considering it is still in its early development stages. This is reflected by several concerns in terms of terms of scalability, transaction handling, data security, data manipulation, and privacy concerns. Gao et al. (2018, p. 8) revealed that all these concerns can be grouped into two primary themes that fall within the system-related barriers of blockchain adoption: security issues and performance issues. In the next section some of the more frequently discussed concerns of security issues and performance issues will be described.

2.4.3.1 Security issues

The first concern regarding the adoption of blockchain are security issues due to the nature of blockchain's overall configuration and mechanisms (Gao et al., 2018, pp. 8-9). There a different hostile threats that can pose severe security issues, for example Golosova and Romanovs (2018, p. 5) indicated that blockchains can be targeted by means of different threats: 51% attacks, double spending, Sybil's attacks, DDos's attacks, and cryptographical cracking. While all these threats are interesting to technically outline, this research will focus on the broader spectrum of majority and minority attacks. Majority and minority attacks will thus firstly be discussed, after which anonymity and privacy concerns will also be examined as leading security issues.

2.4.3.1.1 Majority and minority attacks

One of the factors that could lead to security incidents are attacks in the form of so-called hostile majority –and minority attacks (Gao et al., 2018, pp. 8-9). While blockchain is generally hailed for its immutability due to its consensus mechanism, the possibility exists that majority attacks, also called 51% attacks, can be executed when a participating party controls more than fifty percent of connected miners in the blockchain. In this possibility, erroneous blocks can be linked to the blockchain when the writing process of blocks is hijacked and subsequently verified by the party that controls more than fifty percent of the miners (Gao et al., 2018, p. 8). Yli-Huumo, Ko, Choi, Park, and Smolander (2016, p. 14) expressed that although the blockchain mechanism is invented with the assumption that the blockchain network is controlled by honest nodes, the marked-based centralisation of mining power in the hands of a few large mining pools gradually increases the risk of 51% attacks.

Another form of a majority attack can be found in the work of Barber, Boyen, Shi, and Uzun (2012, p. 405); these authors delved even further into the technical properties of blockchain regarding possible hostile attacks and warned about a 'history-revision' attack, which could be carried out when a hostile party musters a ludicrous amount of computational power. When such a ludicrous amount of computational power is mustered, the hostile party effectively controls some multiple of the computing capability of all normal nodes, which would allow them to create and publish an 'alternative history', leading to the discardment of the actual history of the blockchain in favour of the alternative history. Through the computational power, the alternative history becomes more authoritative than the actual history, thus de facto replacing it (Barber et al., 2012, p. 405). Although the required computational power is currently probably impossible to obtain, it is not unthinkable that this scenario can unfold in the near future if Moore's Law would be applied, as Moore's Law scilicet states that the number of transistors within an integrated circuit doubles approximately every two years, consequently increasing the amount of maximum computational power.

In addition to majority attacks, minority attacks could also pose a significant threat. Following Gao et al. (2018, pp. 8-9), a hostile party owning less than fifty percent of the total computational power still has the ability to be commit attacks. An example of this ability can be found in the context of a strategy called selfish mining. Gao et al. (2018, pp. 8-9) explained that selfish mining is the process in which a blockchain miner, who is in fact the monitory attacker, puts mined blocks in a private branch instead of broadcasting them as is expected of a miner. The miner/attacker can at a point in time when his/her private branch is longer than the actual public chain, reveal its private branch and in so doing, the actual public chain will be replaced by the longer private chain of the miner/attacker. This will effectuate the mining rewards, as the mining rewards for the attacker will increase while simultaneously negatively impacting the mining rewards for the miners from the original public chain (Gao et al., 2018, p. 9). Selfish mining could therefore lead to a snowball effect in which increasing numbers of miners switch to the dark side of mining, as they could be swayed by the acquisition of greater mining rewards through selfish mining, than from the honest mining in the public chains.

2.4.3.1.2 Anonymity and privacy

Blockchain provides the option for users that conduct transactions via blockchain to stay anonymous if they prefer it that way (Gao et al., 2018, p. 9). Biryukov, Khovratovich, and Pustogarov (2014, pp. 19-21) showed that despite this high degree of possible anonymity, there are still accessible and traceable breadcrumbs in the system that can be traced back to individual users thence risking revealing the identities and private information of users. An example of this risk is that transactions can be linked to IP addresses to reveal certain parts of user information, and incorporated applications from third parties enables the tracking of profiles, currencies, and data of users, which can ultimately be hacked and subverted (Biryukov et al., 2014, pp. 19-21; Gao et al., 2018, p. 9). Gao et al. (2018, p. 9) believed that there may not be a good solution currently available to fully secure trading platforms and connected third party software that manages identities and keys. With the implementation of blockchain, corporate management must carefully consider its options to prevent this kind of disclosure if a permissionless blockchain is used.

2.4.3.1.3 Data input

Saberi et al. (2019, p. 2126) pointed out that the immutability of information stored on the blockchain can pose an additional complication for organisations. As already elaborated, blockchain's immutability ensures that stored information within the blockchain cannot be altered or removed unless consensus is reached. The barrier this characteristic simultaneously constitutes, is that there still exists the possibility of erroneous data input into the blockchain. Even though key owners can correct the erroneous data and update the blockchain, once this erroneous data is on the blockchain, it will be permanently visible in the blockchain. Pournader et al. (2020, p. 2073) in extension mentioned that there are occasions when such corrections of erroneous data can come too late; if for instance a purchaser enters data that a certain product in their inventory is almost sold out, this could trigger blockchain's smart contract which will automatically assign a purchase order with the organisation's supplier or suppliers. In this case the purchase order has already been sent out before the erroneous data can be corrected, which can ultimately lead to order cancellation and other unpleasantries.

2.4.3.2 Performance issues

Gao et al. (2018, pp. 9-10) cautioned that in the context of InternetofThings, Big Data, and Cloud – and Edge Computing, the requirements of blockchain raises significant concerns resource wise. Due to blockchain's consensus mechanism a lot of resources are wasted which can be considered problematic, as blockchain's decentralised structure already trades compute power and resources in favour of latency gains.

2.4.3.2.1 Scalability

The first major factor that could undermine the performance of blockchain is scalability. Gao et al. (2018, p. 9) presented the inevitability that, because of the feature that the blockchain contains all the performed transactions over time, the size of the blockchain will continuously increase with every successive transaction. In the long run this will consequently increase the amount of data storage, which will inherently drive up the costs of data storage. The increased amount of data storage could also lead to reduced distribution –and transaction speed within the blockchain network.

Admittedly, there are already a number of solutions to address these scalability difficulties; companies can utilise two methods to counter the possible problems within the data storage dimension, namely storage optimisation and blockchain redesign. Through storage optimisation, occupied storage is released by the removal of old transactions records, or by allowing lightweight nodes to exist. With blockchain redesign, data blocks are decoupled into several smaller components with each having its own responsibility and execution for a specific function or purpose, such as maintaining transaction storage to balance data block sizes and certain security requirements (Gao et al., 2018, p. 9; Zheng, Xie, Dai, Chen, & Wang, 2018, pp. 366-367). Gao et al. (2018, p. 9) thought that, although these raised solutions could prove to be viable, significant work is still needed to develop a solution that tackles these scalability stumbling blocks.

2.4.3.2.2 Availability and applicability

The second major negative factor within the performance sphere is the availability and applicability of blockchain for users. The usage of blockchain as a distributed ledger technology relies heavily on factors that influence the availability and applicability of blockchain: the designated block-size of transmitted information, the network transmission speed, the underlying proof-of-work protocol, and the verification of miner information on every node (Biswas & Gupta, 2019, p. 227). Gao et al. (2018, p. 9) argued that these factors pose performance challenges, because transaction throughput and latency still remain an Achilles heel for blockchain systems, as they in general have trouble coping with increased transaction volumes. Nowadays the block size is limited to 1 megabyte per block, as the initial believe was that larger blocks could be technically challenging and could jeopardise the essence of decentralisation within the network (Biswas & Gupta, 2019, p. 227; Choi, Chung, Seyha, & Young, 2020, p. 5). Due to the limited block size, the number of transactions blockchains allow are relatively low compared with Visa and PayPal; blockchain throughput is now at 7 transactions per second, while Visa and PayPal process an average of 500 and 2000 transactions per second respectively (Biswas & Gupta, 2019, p. 227).

2.4.4 External barriers

Saberi et al. (2019, p. 2126) indicated that external barriers relate to barriers that stem from external stakeholders, such as industries, institutions, and governments. One of the external barriers is the current ambiguity -and lack of appropriate governmental regulations, laws, and policies surrounding the usage of blockchain. Janssen, Weerakkody, Ismagilova, Sivarajah, and Irani (2020, p. 304) explained that '*a technology, by definition, is not the subject of regulation, but it is rather the different uses of the technology itself which may call for regulatory constraints*'. Although it is evident that blockchain is a governance instrument in itself, it needs to be governed and regulated. Upadhyay (2020, p. 4) gave some examples of challenges that blockchain faces in this domain: the accountability related to responsibilities and terms of use for participants on the blockchain is still unclear, as well as there is not a clear ownership framework when automatic executions are carried out, also there exist unmanageable implications regarding compliance with legislation and regulation, and lastly there is no clarity who manages the safeguarding of cryptographic keys and what happens when cryptographic keys are lost or stolen. Biswas and Gupta (2019, p. 230) added that blockchains are exposed to regulatory and governance uncertainties, as there exists unclarity about taxations on the transactions, such as the sale of consumer products, across the countries wherein organisations operate blockchain. Irannezhad (2020, p. 303) considered blockchain as a global interconnected system, and according to her an important pitfall blockchain faces is the alignment of governments to force and control the regulations and legislations over a global system such as blockchain. More research is therefore required to examine the applicability of existing public regulatory frameworks, at both national, state and regional, as well as comparative international levels.

2.5 Feasibility of blockchain in comparison to centralised databases

Following the discussed configuration, key value drivers and key adoption barriers of blockchain, an overview of how blockchain differs from commonly used traditional centralised databases is essential to assess where and when blockchain can offer added value for organisations' supply chains in comparison to traditional centralised databases.

2.5.1 Blockchain compared with centralised databases in relation to writing entities

As already elaborated, blockchain can have either a permissionless or permissioned configuration. Wüst and Gervais (2018, p. 45) linked these two configurations of blockchain with the viability of implementing blockchain in the supply chain, in comparison to currently used centralised databases. Whereas a permissionless blockchain is substantially different from centralised databases, because any writer and reader can join the blockchain at any point in time, permissioned blockchains share particular similarities with centralised databases. For example, only an authorised set of entities is allowed to join the blockchain where they are granted writing and reading rights. For the comparison between permissionless blockchains, permissioned blockchains, and central databases, Wüst and Gervais (2018, p. 48) summarised several key properties of the three systems in Figure 2. These key system properties are: throughput, latency, number of readers, number of writers, number of untrusted writers, consensus mechanism, and if the system is centrally managed or not. Wüst and Gervais (2018, p. 46) concluded that centralised databases are generally better in terms of throughput and performance, and with a trusted third party being part of the system, there are no untrusted writers. When there are untrusted writers present within the system, blockchain systems can mitigate associated risks with its consensus mechanism. Wüst and Gervais (2018, p. 47) commented that there is trade-off between centralisation and throughput that should also be taken into account by companies; how well does a system scale to a large number of writers without mutual trust versus how many state changes/updates a system can handle in an amount of time respectively.

	Permissionless Blockchain	Permissioned Blockchain	Central Database
Throughput	Low	High	Very High
Latency	Slow	Medium	Fast
Number of readers	High	High	High
Number of writers	High	Low	High
Number of untrusted writers	High	Low	0
Consensus mechanism	Mainly PoW, some PoS	BFT protocols (e.g. PBFT [5])	None
Centrally managed	No	Yes	Yes

Figure 2: Contrast of properties between permissionless blockchains, permissioned blockchains, and central databases (Wüst and Gervais, 2018, p. 48)

Wüst and Gervais (2018, p. 47) used the key properties to construct a flowchart in Figure 3 that could be utilised as a guideline by companies to assess at first glance if incorporating blockchain can potentially add feasible value in their supply chain data system.

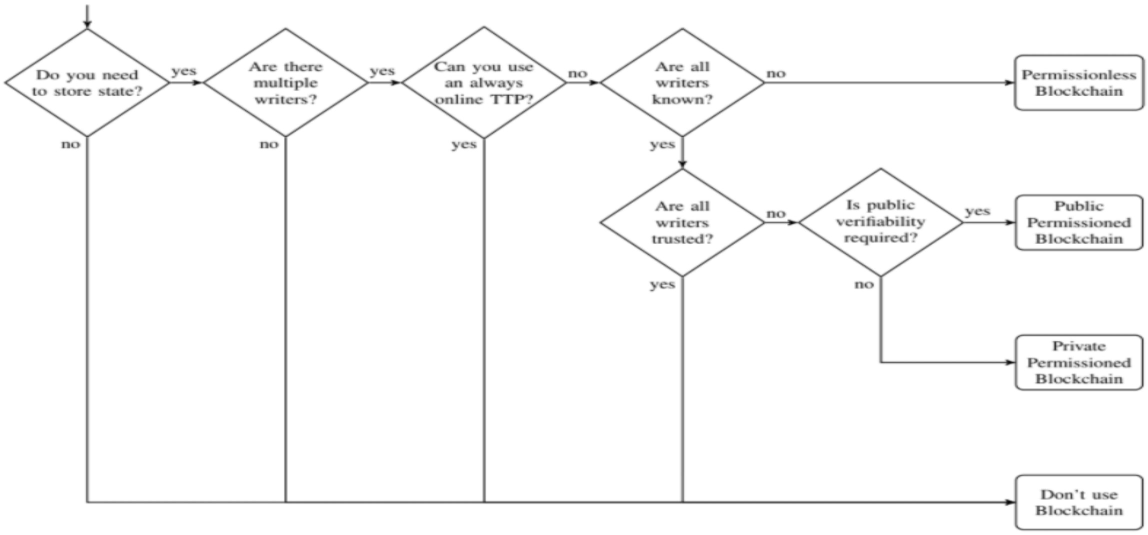

Figure 3: Flowchart to analyse whether blockchain is an appropriate technical solution to adopt (Wüst and Gervais, 2018, p. 47)

2.5.2 Comparative analysis of blockchain versus centralised databases on the basis of additional properties

Chowdhury, Colman, Kabir, Han, and Sarda (2018, pp. 1351-1352) also brought forth a comparative analysis of blockchain versus traditional centralised database systems, which is outlined in Figure 4. The basis of their comparative analysis are six properties: trust building, confidentiality of data, robustness/fault tolerance, performance, redundancy, and security. They have concluded that blockchain is a better data system solution if the properties of trust building, robustness, and provenance of data are being prioritised by an organisation. On the other hand, when a company prioritises confidentiality and system performance then the centralised database remains the better option.

Issue	BlockChain	Central Database	Advantage
Trust Building	Can operate without any trusted party	Need a central trusted party	Blockchain
Confidentiality of Data	(by default)All nodes have visibility of the data	It restricts access to authorized person	Database
Robustness/Fault Tolerance	Data is distributed among nodes	data is stored in central database	Blockchain
Performance	Takes time to reach consensus (e.g., 10 mins for Bitcoin)	Immediate execution/update	Database
Redundancy	(by default)Each participating node has the latest copy	Only the central party has copy	Blockchain
Security	(by default) Use cryptographic measures	uses traditional access control	Blockchain

Figure 4: Criteria for the comparison between blockchain and a central database (Chowdhury et al., 2018, p. 1352)

With their research Chowdhury et al. (2018, p. 1352) tried to draw attention to their notion of blockchain not being a general purpose technology. Blockchain could however prove useful in cases where supply chain collaboration must function with more than one administrative authority embedded, and where there is a trust deficit between participating parties. In supply chain management systems this described constellation is often customary, thus blockchain could definitely add value to an organisation's supply chain depending on the constellation.

2.6 Factors and theoretical models vis-a-vis individual/organisational adoption of innovations and technology

2.6.1 Queiroz and Wamba's altered technology adoption model: combining the technology acceptance model and the classical unified theory of acceptance and use of technology

Queiroz and Fosso Wamba (2019, p. 71) stated that the application of blockchain into supply chain management is still at its infancy stage; the majority of companies still haven't ventured beyond analyses for the adoption phase of blockchain. Queiroz and Fosso Wamba (2019, p. 73) built a model to understand the role of blockchain in the supply chain field, and tested it with India and the USA as sample countries. Their model was based on the works of Davis (1989, p. 332), Venkatesh, Thong, and Xu (2012, p. 160), and Venkatesh, Morris, Davis, and Davis (2003, p. 447) with the intended goal of assessing how individuals behave when confronted with the possibility of using a new technology. Queiroz and Fosso Wamba (2019, p. 77) showed that their model accounted for 63,9 and 69,2 percent of the variance in the intention to adopt blockchain for India and the USA respectively. An overview of the model is presented in Figure 5, with the factors performance expectancy, social influence, facilitating conditions, blockchain transparency, and trust of supply chain stakeholders as variables that potentially influence behavioural intention and behavioural expectation.

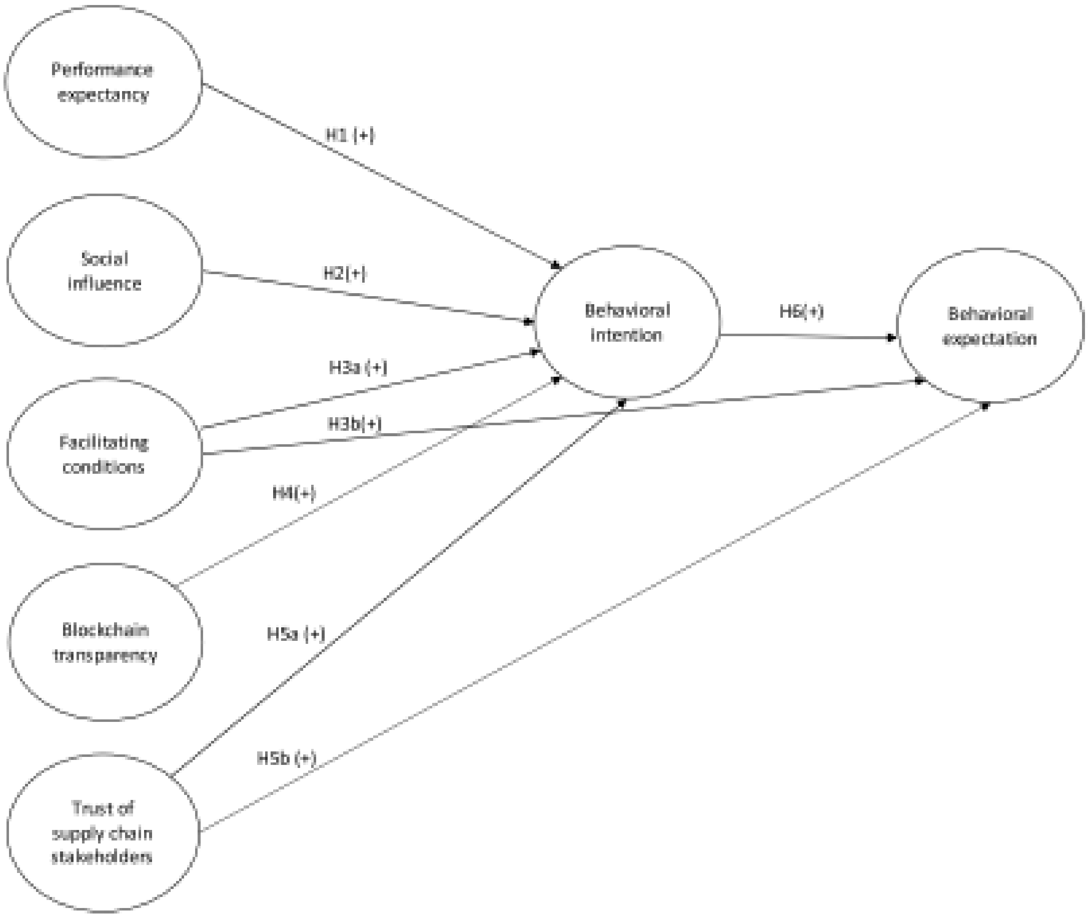

Figure 5: Constructs that influence the behavioural intention to adopt blockchain in the supply chain field (Queiroz & Fosso Wamba, 2019, p. 73)

2.6.1.1 Performance expectancy

Performance expectancy in the model of Queiroz and Fosso Wamba (2019, p. 73) is defined following the definition of Venkatesh et al. (2003, p. 447): *"the degree to which an individual believes that using the system will help him or her to attain gains in job performance"*. Applied to their own research, Queiroz and Fosso Wamba (2019, pp. 73-74) link performance expectancy to blockchain as the extent in which an employee perceives blockchain as a technology that could improve productivity and performance. Queiroz and Fosso Wamba (2019, p. 74) commented that prior literature reported that the intention of individuals to use and adopt a specific technology, significantly depends on performance expectancy: the motivation of an employee to accept and use a new technology depends on the perception of the employee as to scope of advantages that the technology could potentially provide. Within this context, the authors hypothesised that performance expectancy would positively affect the behavioural intention to adopt blockchain, which resulted to be significant for both the USA and India as sample countries (Queiroz & Fosso Wamba, 2019, p. 77).

2.6.1.2 Social influence

The concept social influence is also derived from Venkatesh et al. (2003, p. 451), and is described as *"the degree to which an individual perceives that important others believe he or she should use the new system"*. Queiroz and Fosso Wamba (2019, p. 74) link this concept to blockchain in the form of the extent to which an employee comprehends the relevance of why people, such as colleagues, friends, and family members believe they should use blockchain. For the integration of blockchain into supply chain management, collaboration between supply chain members is vital, and existing relationships within supply chain networks could create and reinforce influence on whether to adopt blockchain across the supply chain network. Queiroz and Fosso Wamba (2019, p. 74) therefore hypothesised that social influence positively affects the behavioural intention to adopt blockchain. The results of their study showed that social influence has a significant positive effect on the behavioural intention to adopt blockchain in the sample country India. The hypothesis was not supported for the USA, as the results showed a positive non-significant effect (Queiroz & Fosso Wamba, 2019, p. 77).

2.6.1.3 Facilitating conditions

Facilitating conditions has been conceptualised by Queiroz and Fosso Wamba (2019, p. 74) as the belief of an employee that his/her company possesses the organisational -and technical resources and infrastructure to support the use of blockchain. The adoption and effective use of blockchain largely depends on existing facilitators, such as computers, internet speed, data-infrastructure, and the receptivity of integrating blockchain with other systems. Francisco and Swanson (2018, p. 7) emphasised that the nature of blockchain and its application necessitates the availability of technical resources to enable usage. When an organisation lacks the appropriate resources, the use of blockchain will be negatively impacted, as employees will use systems that are supported within the organisation. Queiroz and Fosso Wamba (2019, p. 74) hypothesised that facilitating conditions firstly positively affect the behavioural intention to adopt blockchain, and secondly positively affect the behavioural expectation for blockchain adoption. For the USA sample both hypotheses were found to be significantly positive, but for the Indian sample both hypotheses were not supported (Queiroz & Fosso Wamba, 2019, p. 77). In the research of Wong, Tan, Lee, Ooi, and Sohal (2020, p. 2113) facilitating conditions were also significantly affecting the likeliness of organisations adopting blockchain within supply chain management.

2.6.1.4 Blockchain transparency

Morgan Tyler, Richey Jr Robert, and Ellinger Alexander (2018, p. 961) described supply chain transparency as the processes that *"involve reporting to and communicating with key stakeholders to provide traceability regarding the history of the product and visibility about current activities throughout the supply chain while also incorporating stakeholder feedback for supply chain improvement"*. In the context of blockchain adoption, Queiroz and Fosso Wamba (2019, p. 74) argued that blockchain transparency refers to the models through which an organisation communicates and reports supply chain actions to involved supply chain stakeholders throughout the supply chain network. In this sense, blockchain transparency can enhance the cooperation between the stakeholders in the supply chain network, and provide visibility of operations. Queiroz and Fosso Wamba (2019, p. 74) hypothesised that blockchain transparency positively affects the behavioural intention to adopt blockchain. Queiroz and Fosso Wamba (2019, p. 77) found that for both India and the USA, blockchain transparency had a non-significant effect on the behavioural intention to adopt blockchain.

2.6.1.5.1 Trust of supply chain stakeholders

Queiroz and Fosso Wamba (2019, p. 74) referred to trust of supply chain stakeholders as: *"the willingness that two or more organizations within the supply chain network are vulnerable to each other and uphold each other's expectations."* Supply chains are by nature complex constellations where stakeholders must cooperate with each other across the network. Relationships and communication are therefore of vital importance to organisations; supply chains can be characterised as inherently lacking information sharing and transparency amongst its stakeholders, which can critically affect supply chain operations and ultimately operational performance. Queiroz and Fosso Wamba (2019, p.

74) stated that previous studies indicated that the degree of trust between supply chain stakeholders could be improved by blockchain, leading to the following hypotheses: Trust between supply chain stakeholders positively affects behavioural intention to adopt blockchain and trust between supply chain stakeholders positively affects behavioural expectation for blockchain adoption. Queiroz and Fosso Wamba (2019, p. 77) that trust between supply chain stakeholders didn't significantly affect the behavioural intention to adopt blockchain, and that only in India trust between supply chain stakeholders positively affects behavioural expectation for blockchain adoption.

2.6.1.5.2 Supply chain stakeholders trust and its effect on continuance intention in blockchain-enabled supply chain applications

Fosso Wamba (2019, pp. 38-40) revisited the factor trust between supply chain stakeholders in relation to blockchain, the author in this endeavour developed an extended version of the expectation-confirmation model. The expectation-confirmation model was originally proposed by Bhattacherjee (2001, pp. 355-357) and was based upon the expectation-confirmation theory that was used to study consumer satisfaction, post-purchase behaviour, and service marketing in general. The expectation-confirmation model could ultimately be used to assess the cognitive beliefs that influence user's intentions to continue using information systems (Fosso Wamba, 2019, p. 39). Fosso Wamba (2019, p. 38) integrated the factor 'supply chain stakeholders trust' into the expectation-confirmation model, to be able to analyse users' continuance intention to use blockchain-enabled supply chain applications. Fosso Wamba (2019, p. 39) argued that trust amongst stakeholders within supply chains plays an important role in the adoption, use, and continued use of blockchain. To research if stakeholders trust critically influences the adoption, use, and continued use of blockchain, Fosso Wamba (2019, pp. 39-40) thus hypothesised that supply chain stakeholders trust has a significant positive effect on the user's intention to continue to use blockchain technologies-enabled supply chain applications. This hypothesis proved to be positively significant at the levels of 0.001 (Fosso Wamba, 2019, p. 41).

2.6.1.6 Behavioural intention and behavioural expectation

Queiroz and Fosso Wamba (2019, p. 75) indicated that, in relation to organisational adoption of blockchain, behavioural intention is the ability of an employee of a company to formulate a conscious plan to use blockchain and to subsequently perform a behaviour towards blockchain use. Sequently, as behavioural intention influences the use of blockchain as a technology, behavioural intention predicts behavioural expectation of blockchain use. Behavioural expectation is contextualised as the evaluation of the probability to perform future behaviour associated with the use of blockchain. Queiroz and Fosso Wamba (2019, p. 75) argued that intention precedes expectation, as behavioural expectation is reflected by the strength of the focal intention in comparison to other competing intentions that are also involved in the equation. The hypothesis thus raised was that behavioural intention positively affects behavioural expectation for blockchain adoption, and indeed intention proved to have a significant positive effect on expectation for both India and the USA (Queiroz & Fosso Wamba, 2019, p. 77).

2.6.2 Other variables found in research literature that could influence organisational intention to adopt blockchain

While the research model of Queiroz and Wamba (2019) is quite comprehensive, other studies have incorporated additional variables that could potentially influence the intention to use blockchain. Given the described functionality, advantages, and barriers of blockchain, this research will incorporate additional supplementary variables that fit within the context of factors that could influence an organisation's intention to adopt blockchain.

2.6.2.1 Perceived ease of use and perceived usefulness

Kamble et al. (2019, pp. 2015-2016) claimed that perceived ease of usage is an essential forecaster of technology adoption; numerous authors researched and supported this claim with usage intention being significantly influenced by perceived ease of use. Kamble et al. (2019, p. 2015) described perceived ease of use as: *"the degree to which a person believes that using a particular system would be free of effort"*. Employees show rather more inclination to use a system that is easily accessible and utilisable, than a system that requires high competency. Kamble et al. (2019, p. 2016) linked perceived ease of use, as an influencing variable, to perceived usefulness of blockchain in their research; perceived usefulness in this regard corresponds with the factor 'performance expectancy' in the research of Queiroz and Fosso Wamba (2019, p. 73). Next to perceived usefulness, perceived ease of use is also directly linked to someone's attitude towards using blockchain, which led to Kamble et al. (2019, p. 2016) raising two hypotheses: perceived ease of use positively affects perceived usefulness of blockchain, and perceived ease of use positively affects attitudes towards using the blockchain. The results of the research of (Kamble et al., 2019, p. 2023) showed that perceived ease of use indeed significant positively affects perceived usefulness of blockchain, but the hypothesis that perceived ease of use positively affects attitudes towards using the blockchain was rejected. This research will therefore only incorporate perceived ease of use as an influencing variable for the perceived usefulness of blockchain, and discard the link between perceived ease of use and attitude towards blockchain use.

2.6.2.2 Relative advantage

Y.-M. Wang, Wang, and Yang (2010, p. 803) considered relative advantage as an important factor that could affect the adoption of innovations and technologies. Relative advantage can be defined as the degree to which an innovation is perceived to provide greater organisational benefits than the idea it supersedes or the status quo; the degree is often expressed in terms of economic profitability, social profitability, or other profitable ways, depending on the nature of the innovation that to a great extent determines the type of advantage the adopter wants to effectuate (Rogers, 1983, p. 213; Y.-M. Wang et al., 2010, p. 807). Y.-M. Wang et al. (2010, p. 807) summed this prospect of profitability up with the statement that companies which perceive higher relative advantages of a specific technology, are more likely to adopt that technology. According to Wong, Leong, et al. (2020, p. 3), relative advantage has been an fundamental factor in the adoption of technologies with the adoption of interbank mobile payments and business intelligence systems. Wong, Leong, et al. (2020, pp. 11-12) showed in their research that relative advantage is indeed a significant exogenous construct that influences the behavioural intention of adopting an innovation or technology; in the case of their research the specific technology was the adoption of blockchain in operations and supply chain management of Malaysian SME’s.

2.6.2.3 Knowledge sharing

Fosso Wamba, Queiroz, and Trinchera (2020, p. 4) identified and hypothesised that knowledge sharing positively impacts the adoption of blockchain. Knowledge sharing can be defined as the process through which one unit within –or across organisational boundaries, is affected by the experience of another; this can be through social interactions involving exchange of ideas and experiences, or other mechanisms in the form of personnel movement, training, technology transfer, and alliance engagement (Argote, Ingram, Levine, & Moreland, 2000, p. 3; Lin, 2017, p. 703). The necessity for innovation is often an essential driver for organisations to engage and improve knowledge sharing, and within the blockchain-integration context, knowledge sharing is primarily undertaken by firms with their supply chain members (Fosso Wamba et al., 2020, p. 4). This outlook resulted in Fosso Wamba et al. (2020, pp. 6-7) assuming that knowledge sharing, in terms of technologies and skills, between organisations in the same supply chain is fundamental for the adoption of blockchain; with their conducted research they ultimately concluded that knowledge sharing significantly positively impacts the adoption of blockchain.

2.6.2.4 Trading partner pressure

Besides knowledge sharing, another factor that influences the adoption of blockchain was investigated within the same research of Fosso Wamba et al. (2020, p. 4), namely trading partner pressure. Trading partner pressure can occur within a trading partner relationship between two or more organisations, where one organisation enacts power over the other(s). Alsaad, Mohamad, and Ismail (2014, pp. 518-519) described that when a dominant actor within a supply chain wants to invest in new innovations/technologies, the benefit of these new innovations/technologies can occasionally only be exploited with the collaboration and cooperation of the trading partners of the dominant actor. For that reason, dominant actors exercise their power capabilities to influence and coerce trading partners to co-operate with the desired technology adoption.

Supply chain constellations where trading partner pressure could come to pass are, for example supply chains in which one strong actor has inter-organisational relationships with weaker partners, or when a powerful actor generates a large portion of a firm’s sales or profits (Alsaad et al., 2014, p. 518; Y.-M. Wang et al., 2010, p. 808). The significant influence of trading partner pressure on the adoption of innovations and technologies was already reinforced by the research of Y.-M. Wang et al. (2010, p. 813) and Low, Chen, and Wu (2011, p. 1019) regarding the adoption of Radio-frequency Identification (RFID) and Cloud Computing respectively. Given the outlined context of trading partner pressure and the adoption of blockchain, Fosso Wamba et al. (2020, p. 4) hypothesised that pressure from trading partners has a positive significant effect on blockchain adoption, and this hypothesis proved to be significant in their research.

2.6.2.5 Competitive pressure

Sin et al. (2016, p. 437) defined competitive pressure as the extent of which a competitive atmosphere is present within a particular industry. Cruz-Jesus, Pinheiro, and Oliveira (2019, pp. 5-6) added to this definition, that in regard to the context of the adoption of innovative technologies, competitive pressure corresponds to the degree of pressure felt by organisations vis-à-vis their competitors within the same industry. Competitive pressure not only refers to competitors, but in a broader sense also refers to the desire of companies to gain a competitive advantage when faced pressure from new business model developments and industry standards (Shi & Yan, 2016, p. 4; Wong, Leong, et al., 2020, p. 4). Zhu, Kraemer, and Xu (2003, p. 256) commented that in the innovation adoption literature, many researchers recognised competitive pressure as an important adoption driver, and Sin et al. (2016, p. 437) furthermore remarked that the majority of empirical studies into competitive pressure proved that higher innovative adoption is connected with higher competitive pressure. An example of innovation adoption vis-à-vis competitive pressure can be found in the research of Zhu et al. (2003, p. 256), where the researchers expected that there is a positive association between competitive pressure and innovation adoption, specifically the adoption of E-business. They thusly hypothesised that firms facing higher levels of competitive pressure are more likely to adopt e-business, which proved to be statistically significant (Zhu et al., 2003, p. 264). Research results of Sin et al. (2016, pp. 440-441), Shi and Yan (2016, p. 9), and Wong, Leong, et al. (2020, p. 11) also showed statistically significant relationships between competitive pressure and the adoption of E-commerce amongst SME’s in Northern state of Malaysia, competitive pressure and RFID adoption in China, and competitive pressure and the intention to adopt blockchain in operations and supply chain management among Malaysian SME’s respectively.

2.7 Blockchain as a tool to enhance trust and curb opportunism within supply chain networks

Müller, Ostern, and Rosemann (2020, p. 3) observed that in recent years the progressing digitalisation and internationalisation within the domain of supply chain management has caused a shift towards increasing collaboration in business processes between organisations. With multiple collaborators in these inter-organisational business processes, uncertainty has been increasing as well. The counteragent for uncertainty is trust, and due to the trust-intensive nature of collaborative business processes, trust is a critical success factor of inter-organisational relationships. Seppänen, Blomqvist, and Sundqvist (2007, p. 249) argued that a firm's ability to establish inter-organisational relationships has become a key source of knowledge-based competitiveness and a dynamic capability, and trust therein is crucial to facilitate open communication, information sharing, conflict management, predictability, and strategic flexibility.

Cheng and Sheu (2012, pp. 565-566) expressed that inter-organisational relationships are *"arenas for potential opportunistic behaviour by partners with different sets of goals, and the inherent temporalities of alliances play significant roles in partner opportunism"*. A high level of perceived opportunistic behaviour within an inter-organisational relationship in this regard leads to less favourable relationship outcomes. Seppänen et al. (2007, p. 249) mentioned that a certain threshold of trust is therefore needed within inter-organisational relationships for the evolvement of cooperation, and to reach this threshold of trust, organisations can implement different tools. Müller et al. (2020, p. 3) remarked that several studies have identified blockchain as such a tool to enhance trust in collaborative business processes. Before getting into details regarding blockchain as a trust enhancing tool, firstly the concepts of trust and opportunism will be discussed, as well as their effectuation on organisational business processes.

2.7.1 Trust within inter-organisational relationships

Singh and Teng (2016, p. 291) stated that trust is a cognitive construct and a key factor within inter-organisational relationships. The overall definition of trust can be grasped by a person's confidence or predictability in his/her expectation about another person's behaviour, while simultaneously relying on the belief that the other person makes good-faith efforts to behave according to commitments and doesn't take advantage of a situation or person when the opportunity arises (Singh & Teng, 2016, p. 291). Within supply chain management at the inter-organisational level, trust thus reflects the extent as to which a focal organisation places trust in a partner organisation within its supply chain to act with good-faith behaviour and doesn't operate with opportunistic intent. Dyer and Chu (2003, p. 58) added to this conceptualisation of trust that trust is de facto micro-level phenomenon and thus has its conceptual basis in individuals opposed to organisations as an entity. In this sense one individual can place trust in another individual or a group of individuals within another organisation.

Lado, Dant, and Tekleab (2008, p. 404) argued that followers of the Relational Exchange Theory view trust as a catalyst to the formation and maintenance of value enhancing inter-organisational relationships, and high levels of trust might foster organisations to identify and bond with each other, which in turn could lead to a greater level of commitment within the exchange relationship. Lado et al. (2008, p. 405) also viewed the downside of inter-organisational relationships with a trust deficit, which are characterised by shallow interdependence. This shallow interdependence is shaped by organisations trying to reduce their risk of dependence and a great focus on developing mechanisms to efficiently coordinate the execution of tasks within their mutual operations. As mentioned, trust between supply chain partners is essential for a successful inter-organisational relationship, but several perils could arise that have the potential to underlie the demise of these relationships (Singh & Teng, 2016, p. 291). Singh and Teng (2016, p. 291) named information sharing reluctance, dominance issues, clash of personalities, incompatibility of organisational cultures and values, inadequate communication, and betrayal as some of the prime reasons that could undermine and sour inter-organisational relationships.

Delbufalo (2012, pp. 385-388) reviewed the influence of inter-organisational trust on three different organisational outcomes: direct economic outcomes, indirect outcomes, and relational outcomes. According to Delbufalo (2012, p. 386), there are several central direct economic outcomes that are influenced by inter-organisational trust; fulfilment of the goal of a competitive price, timeliness of delivery and high quality supply is positively impacted by trust, as well as a positive support for the link between trust and operational - and task performance in terms of efficiency, productivity, cycle time reduction, and strategic flexibility. Financial performance, measured by sales growth, cash flows, return on investment, purchasing cost reduction, and lowered transaction costs, is also positively affected by trust. Indirect outcomes that are positively affected by trust relate to the actions of an partner organisation in respect of investing in relation specific assets, supplier integration, joint action, joint problem-solving, cooperation, and information sharing (Delbufalo, 2012, p. 386). Lastly multiple relational outcomes have been related to inter-organisational trust. Under the overarching umbrella of positive trading partner orientation and behaviour, trust has shown to increase the loyalty of a partner and its support for change (Delbufalo, 2012, p. 387). Subsequently, trust positively increases affective partner commitment while on the other hand decreasing calculative commitment. Trust also has a positive effect on satisfaction and relationalism, which are strong factors that contribute to the overall fulfilment of the inter-organisational relationship (Delbufalo, 2012, pp. 387-388).

2.7.2 Opportunism within inter-organisational relationships

Within inter-organisational relationships, the risk of opportunism is regularly seen as an inherent feature of this kind of relationships, and a large part of research literature has been dedicated to the transactional cost analysis of opportunism and how the risk of opportunism between trading partners creates trading difficulties (Lumineau & Quélin, 2012, p. 55; Wathne & Heide, 2000, p. 36). Within transaction cost theory literature the definition of opportunism is self-interest seeking with guile (Wathne & Heide, 2000, p. 38; Williamson, 1975, p. 6). Opportunism is set apart from the standard economic assumption of self-interest-seeking behaviour because of the notion of guile (Wathne & Heide, 2000, p. 38). Guile is described by Williamson (1985, p. 47) as *"lying, stealing, cheating, and calculated efforts to mislead, distort, disguise, obfuscate, or otherwise confuse."* Jap and Anderson (2003, p. 1686) added that opportunism also involves elements, such as distorting information, which includes overt behaviours like the already mentioned lying, cheating and stealing, but also more subtle behaviour, for example misrepresenting information by not fully disclosing. Furthermore, opportunism also entails reneging on explicit or implicit commitments, and failing to fulfil promises and obligations that were agreed upon. Besides the different forms of opportunism, opportunism can also be divided into ex ante opportunism and ex post opportunism, and active and passive opportunism. (Jap & Anderson, 2003, p. 1686) explained that ex ante opportunism is when either party in an exchange engages in opportunism before the organisations transact with each other, and ex post opportunism is when either party in an exchange engages in opportunism after the transactions is underway. Wathne and Heide (2000, pp. 39-40) and Seggie, Griffith, and Jap (2013, pp. 73-74) pointed out that there are two general categories of opportunistic behaviours, namely active and passive; active opportunism applies when an organisation actively engages in opportunistic actions, while passive opportunism applies when an organisation, for its own benefit, deliberately chooses to refrain from taking particular actions, such as evading obligations previously agreed on or refuses to adapt to new circumstances.

Wathne and Heide (2000, p. 36) emphasised that if the risk of opportunism in inter-organisational relationships is sufficiently high, the relationship could prove to be a costly expense post, as resources have to be allocated for control and monitor purposes that could otherwise have been deployed for more productive purposes. Lado et al. (2008, p. 404) also weighed in regarding the increased costs associated with opportunism. In terms of ex ante opportunism, organisations will have higher transaction costs as they initiate and write extensive contingent-claims contracts to curb opportunistic behaviour of their exchange partner. Ex post opportunism also imposes additional transaction costs, because organisations will have to monitor, modify, and enforce the terms of the exchange contract. Next to increasing costs, opportunism also forms an obstacle for organisations to foster confidence in partner cooperation and could even escalate into inter-organisational conflicts that erode the foundation of the collaboration (Luo, 2006, p. 125). Luo (2006, p. 125) added that opportunism increases the degree of coordination uncertainty between trading partners, because the benefit of joint pay-off highly depends on the extent to which organisations can create synergies with each other. Lastly, Luo (2006, pp. 125-126) reasoned that when the development of reciprocity and repeated commitment, which are essential for generating joint pay-offs for long term economic exchanges, are hampered by opportunism, it becomes difficult for organisations to sustain economic exchanges for a long period of time due to moral hazard and adjoined uncertainty about individual and joint pay-offs.

2.7.3 Blockchain as a tool to enhance trust and curb opportunism within inter-organisational relationships

The research of Müller et al. (2020, p. 4) aimed to close the literature gap regarding how blockchain can improve trust-intensive collaborative business processes, by describing how blockchain's trust enhancing capabilities can be utilised to mitigate trust concerns within collaborative business processes. To describe the trust-enhancing capabilities of a given technology, Müller et al. (2020, pp. 6-7) developed a taxonomy of trust patterns which they divided in five dimensions: Trust-Enhancing Method, Uncertainty Root, Trust Concern, Process Component, and Limitations. Firstly, the Trust-Enhancing dimension represents the approach of the technology to increase the trustworthiness of a collaborative business process, which can be by reducing uncertainty, reducing process vulnerabilities, or by building confidence (Müller et al., 2020, p. 6). Secondly, the Uncertainty Root dimension represents the possible origination of the uncertainty, which could be found in the data, the organisation in charge of a part of the process, a specific resource of an organisation, an activity in itself, or a combination of these sources. Thirdly, Müller et al. (2020, pp. 6-7) raised the Trust Concern dimension to pinpoint the specific trust concern of uncertainty. A specific trust concern could be a concern regarding integrity, confidentiality, availability, non-repudiation, or performance. Fourthly, the Process Component dimension describes in which elements of the collaborative business process the trust concern is relevant (Müller et al., 2020, p. 7). Trust patterns regarding the mitigation of uncertainty are often centre around atomic process elements, whereas trust patterns that are aimed at reducing vulnerability and building confidence, are mostly centred around sub-processes or the process as a whole. Lastly, Müller et al. (2020, p. 7) outlined that the limits and trade-offs of the trust pattern are described within the Limitations dimension. Table 1 provides an overview of these five dimensions applied to the trust-enhancing capabilities of blockchain.

Pattern name (section)	Trust-enhancing method	Uncertainty root	Trust concern	Process component	Limitations
Hash storage (Sect. 4.1)	Reduce uncertainty	Data	Integrity	Data object	Data processing outside scope
Transparent event log (Sect. 4.2)	Reduce uncertainty	Organization	Non-repudiation	Event	Initial event submission must be ensured
Blockchain BP engine (Sect. 4.3)	Reduce uncertainty	Resource, activity, organization	Integrity	Gateway, sequence flow, message flow	Time-based logic
Smart contract activities (Sect. 4.4)	Reduce uncertainty	Activity	Integrity, availability	Activity	Oracle, privacy
Blockchain-based reputation system (Sect. 4.5)	Build confidence	Organization	Integrity	Any	Reputation system attacks
Decentralization (Sect. 4.6)	Build confidence	Organization	Integrity	Any	Incentives

Table 1: Blockchain based trust patterns (Müller et al., 2020, p. 9)

2.7.3.1 Blockchain's hash storage

The first trust enhancing capability of blockchain is rooted in the storage of data hashes within the blockchain. Müller et al. (2020, p. 9) explained that in collaborative business processes, the integrity of shared data is a crucial trust concern, because when data gets altered or manipulated, this could lead to anomalies and malicious behaviour. For trading partners it is often difficult to verify data integrity, thus data integrity becomes an uncertainty where organisations have to trust their trading partners with the provided data. Blockchain's stored data hashes can mitigate this uncertainty, as data hashes are tamper-proof and at any point in time can be viewed and verified by every organisation participating on the blockchain.

2.7.3.2 Blockchain's transparant event log

Müller et al. (2020, p. 10) noted that non-repudiation of event occurrences is a common trust distress within inter-organisational business processes. For example, when incidents such as a failure during an activity execution occurs during the inter-organisational collaboration, it is vital that organisations can't deny or falsify the occurrence of such an event to avoid compensation claims. In this sense the organisation would in terms of trust-aware business processes otherwise cause a trust concern regarding the non-repudiation of that event occurrence. To avoid non-repudiation, blockchain can be utilised as it constitutes an immutable decentralised event log of all data and occurrences. Müller et al. (2020, pp. 10-11) explained that when all the data related to event occurrences gets hashed and submitted with a transaction to blockchain's ledger, through which ultimately the integrity of the event can be insured by relevant stakeholders if needed.

2.7.3.3 Blockchain-based business process engine

Müller et al. (2020, p. 11) elaborated that for the successful execution of a part of a business process, organisations have to ensure the correct control flow between sub-processes and activities of participating organisations and within the organisations themselves. To this end business process engines, that traditionally have a centralised background, are regularly used within inter-organisational relationships. The centralisation aspect of these business process engines implicitly causes process flow integrity uncertainty, as privy organisations will have to trust that the party that manages the business process engine acts as intended and without malice. In this regard, blockchain has the capability to store business process models in smart contracts, so that all participating organisations have access to the smart contract and can verify the correctness of the model at any given moment. A smart contract is also in itself a process execution engine, and new instances of business processes can be developed as new smart contracts with encoded process flows in line with the business logic of that particular contract.

2.7.3.4 Smart contract activities

Next to the process flow of inter-organisational processes, organisational activities within the overall inter-organisational relationship are also a cause of uncertainty. Müller et al. (2020, p. 12) pointed out that different collaborating organisations are responsible for certain activities, and the execution of these activities are a ‘black box’ for the other organisations in terms of visibility and verifiability. This ‘black box’ is due to the reason that organisations can’t verify the correct execution of other organisation’s activities, as well as not being able to trace the availability and allocation of resources that other organisations use for executing their activities. Blockchain can mitigate this activity uncertainty, as it provides a highly available and transparent computing environment. While the earlier mentioned smart contracts within the blockchain based process engine focuses on the correct orchestration of the process as a whole, smart contracts can also be applied to encode the business logic of an activity. In this sense, smart contract activities have the capability to focus on executing a specific activity, thus validating the integrity and providing traceability for participating organisations.

2.7.3.5 Blockchain-based reputation systems

Müller et al. (2020, p. 13) mentioned that reputation systems are currently a way to track down the trustworthiness of other organisations, and can therefore be seen as an approach to build inter-organisational confidence. In the reputation system the reputation claims are stored and traditionally managed by a central single authority. The centralised nature of the reputation system solicits other organisations to trust the central authority to handle the reputation data with integrity and not to manipulate it. This constellation poses an uncertainty for organisations, which would not have been the case if blockchain were to be used. Blockchain can, given the reputation data, be leveraged to implement fully decentralised reputation systems where organisations won’t have to put their trust in a central authority, as every participant on the blockchain has access to data regarding reputation statements.

3. Conceptual research model and hypotheses

In the theoretical review, multiple factors that could influence organisational intention to adopt blockchain were identified and discussed. Based on the theoretical review, these factors will be used as independent variables to construct hypotheses to ultimately examine the underlying relationships between these independent variables and organisational intention to adopt blockchain as the dependent variable. In this part the hypotheses will be briefly discussed, as the reasoning for the inclusion of these specific factors has already been given by examining the results of studies conducted by other authors. Following the hypotheses, the derived research model will be displayed to provide a clear and accessible overview.

3.1 Hypotheses

In line with the described factors derived from the research of various authors that influence the intention of an organisation to adopt a technology, sometimes further specialised into blockchain, linkages between these factors and organisational intention to adopt blockchain were hypothesised. The main link that this study tries to unveil, is to what extent the perceived usefulness of blockchain influences organisational intention to adopt blockchain. Other links include the dimension of trust and opportunism within supply chain networks, and other relevant environmental and organisational factors. To this end, the posited hypotheses can be clustered into four main groups: technological factors, environmental factors, organisational factors, and the factors trust and opportunism within supply chain networks.

3.1.1 Technological factors

The first group consist of four factors that influence the perceived usefulness of blockchain, which in turn influences organisational intention to adopt blockchain. From the literature it became evident that blockchain provides advantages for supply chain management in the form of value drivers, but blockchain also has some inherent adoption barriers that could influence how organisations perceive the usefulness of blockchain. It is likely that organisations that can benefit from blockchain's outlined value drivers, are more inclined to perceive blockchain as a useful technology, opposed to organisations that reckon that blockchain doesn't provide any additional value. The same principle can be applied to the adoption barriers, as organisations that identify blockchain's adoption barriers to be too impactful in a negative manner, thus diminishing their perceived usefulness of blockchain. In the other way around where organisations reckon that the adoption barriers of blockchain are not insurmountable, the perceived usefulness of blockchain is less likely to be depreciated. Therefore, hypotheses 1a and 1b are formulated as follows:

H1a: *The value drivers of blockchain positively affect the perceived usefulness of blockchain*

H1b: *The adoption barriers of blockchain negatively affect the perceived usefulness of blockchain*

Next to value drivers and adoption factors, the perceived ease of using blockchain technology is also an inherent characteristic that could influence how a person factors the perceived usefulness of blockchain. If blockchain is easy to use, this could positively influence the perceived usefulness of blockchain, as well as the other way around if an individual reckons that blockchain is difficult to use. Therefore, hypotheses 1c is formulated as follows:

H1c: *The perceived ease of blockchain use positively affects the perceived usefulness of blockchain*

Given these technological factors, organisations can assess to what extent they perceive blockchain as a useful technology within supply chain management. Although each of the technological factors will most likely have different weighing impact for individual organisations, they all indirectly affect the intention of organisations to adopt blockchain or refrain from adopting it. Combining the three technological factors gives organisations a framework as to how blockchain is perceived to be useful in terms of data sharing capabilities and performance capabilities. Organisations that perceive blockchain to be useful in this setting could have positive inclinations to the intention of adopting blockchain. Therefore, hypothesis 1d is formulated as follows:

H1d: *The perceived usefulness of blockchain positively influences organisational intention to adopt blockchain*

3.1.2 Environmental factors

The second group of factors that influence organisational intention to adopt blockchain falls within the domain of environmental factors. In the literature various environmental factors were examined by researchers, and from the perspective of technology adoption, social influence/subjective norms, trading partner pressure, and competitive pressure are prominent and significant factors. Therefore, hypotheses 3a, 3b, and 3c are included as follows:

H2a: *Social influence/subjective norms positively affect organisational intention to use blockchain*

H2b: *Trading partner pressure positively influences organisational intention to adopt blockchain*

H2c: *Competitive pressure positively influences organisational intention to adopt blockchain*

3.1.3 Organisational factors

The third group of factors that influence organisational intention to adopt blockchain consist of two organisational factors; the first factor is facilitating conditions, which refers to the interplay between the available in-house resources, such as expertise and knowledge, and the belief of an employee that his/her company possesses the organisational -and technical resources and infrastructure to support the use of blockchain. Employees of organisations that have sufficient facilitating conditions at their disposal are more likely to be receptive to blockchain adoption, than employees of organisations that lack the appropriate facilitating conditions. Additionally, knowledge sharing between organisations is also identified by researchers as a significant prerequisite for blockchain adoption, as organisation are likely more open to adopting blockchain if they already have a preference to share knowledge in terms of technological know-how and market knowledge. Therefore, hypotheses 4a and 4b are formulated as follows:

H3a: *The facilitating conditions within an organisation positively affect organisational intention to adopt blockchain*

H3b: Knowledge sharing between partners within the supply chain positively affects organisational intention to adopt blockchain.

3.1.4 Trust and opportunism within supply chain networks

The fourth and last group of factors that could have an effect on blockchain adoption fall within the dimension of trust and opportunism within supply chain networks. Referring to the research of Wüst and Gervais (2018, p. 47), Chowdhury et al. (2018, p. 1352), and Müller et al. (2020, p. 9), blockchain could prove to be a useful tool for organisations that operate in supply chain networks wherein the data system writers are unknown and/or untrustworthy. Also organisations that don't want to trust and rely on third parties for data transferrals and auditing could potentially benefit from blockchain. Lastly, blockchain can be utilised as a tool to enhance the building of confidence within supply chain networks, as well as reducing uncertainty and curbing potential opportunistic behaviour. In this sense the adoption of blockchain is influenced by the degree of trust and opportunism that exists or is perceived to exist within an organisation's supply chain network. Moreover, it could be expected that trust and opportunism not only directly influences the behavioural intention to adopt blockchain, but also moderates the relationship between blockchain's perceived usefulness and organisational intention to adopt blockchain. The reasoning behind this moderating effect is that blockchain's inherent characteristics and functionality position it as an advantageous tool for the supply chain management of organisations that reside in supply chain networks where there exists a high degree of trust issues and/or opportunistic behaviour. Organisations in this constellation would perceive blockchain as more useful than organisations that blindly trust their supply chain partners. Therefore, the hypotheses that comprise the trust and opportunism dimension are:

H4a: *Trust between supply chain trading partners within the supply chain network negatively affects organisational intention to adopt blockchain*

H4b: *Opportunistic behaviour within the supply chain network positively influences organisational intention to adopt blockchain*

H4c: *Trust between supply chain trading partners negatively moderates the relationship between the perceived usefulness of blockchain and organisational intention to adopt blockchain*

H4d: *Opportunistic behaviour within the supply chain network positively moderates the relationship between the perceived usefulness of blockchain and organisational intention to adopt blockchain*

3.2.1 Research model

Based on the previously established hypotheses, the research model that is depicted below was derived.

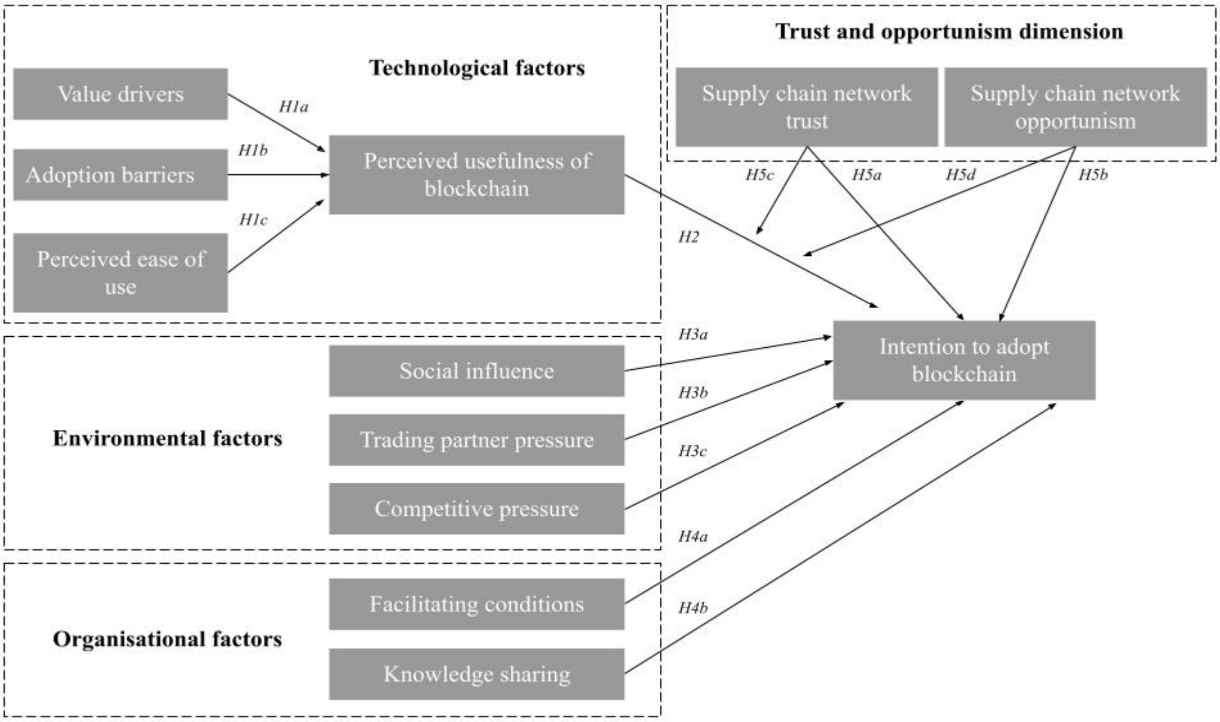

Figure 6: Research Model

3.2.2 Additional sub-grouped research model

In addition to testing the research model in figure 6, several other analyses were conducted to assess the significance of the proposed relationships. One of these other analyses was conducted on the basis of subgrouping the indicators of the value drivers and adoption barriers. In figure 7 an overview of the corresponding subgrouped research model is presented, which will be further discussed in section 5.2.

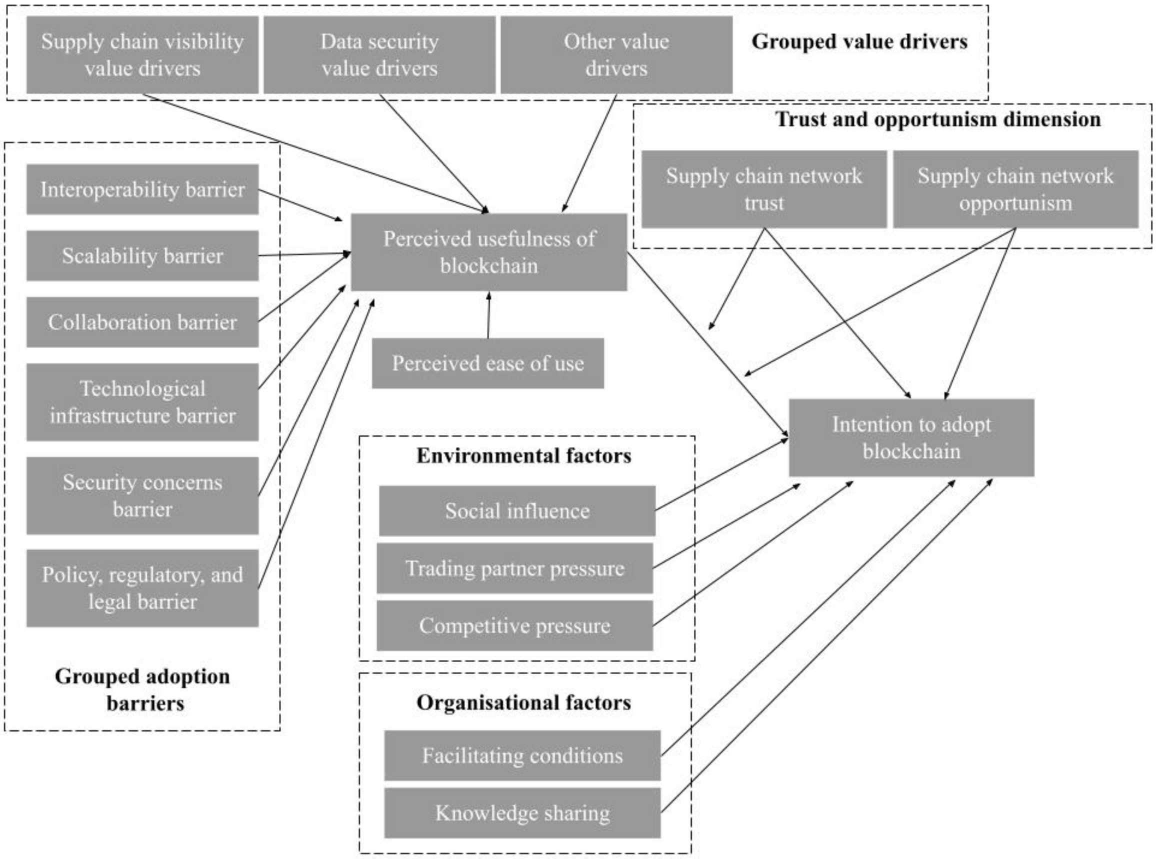

Figure 7: Sub-grouped research model

4. Methodology

This chapter entails the methodological approach to answer the main research question and associated subquestions. The first part of this chapter outlines the research design, followed by the sampling and the measurement of the variables. Lastly the data quality in terms of data reliability and validity is discussed.

4.1 Research design

To answer the research question and associated subquestions, this research has examined the relationship between different dependent –and independent variables. The main dependent variable is organisational intention to adopt blockchain and the independent variables that influence the main variable consist of perceived usefulness of blockchain, social influence, trading partner pressure, competitive pressure, facilitating conditions, and knowledge sharing. Perceived usefulness in turn is influenced by the value drivers, adoption barriers, and perceived ease of use. Supply chain network opportunism and supply chain network trust was tested as both directly affecting variables for organisational intention to adopt blockchain, as well as moderating variables for the relationship between perceived usefulness of blockchain and organisational intention to adopt blockchain. Additional control variables were also added to account for non-spuriousness. Given this exploratory nature of potential underlying relationships between the stated variables, this research followed a descriptive quantitative research design. On the basis of adduced theories and models, surveys were constructed to collect data and to ultimately unravel these underlying relationships. For this reason the research is deductive, as it aims to test relationships based on existing and supported theories and models. The data was collected at a certain point in time from many individuals within different organisations, so the type of study that fitted this most optimally is that of the cross-sectional study.

4.2 Sampling

This research focussed on the target population of individuals employed within Dutch organisations, without making any distinctions between large enterprises and SME's. From the literature it became evident that blockchain could affect and be implemented in a large variety of industries, so no exceptions were made in regard to the inclusion of different industries within the Netherlands. The only prerequisite the respondents within their respective organisations had to meet was that their organisations must have a supply chain in which they conduct supply chain operations with at least one supply chain partner. Additionally, the respondents' job activities must coincide with the management of the supply chains of their companies. Against this background, individuals were approached through LinkedIn, Chamber of Commerce registers, and additional fora to fill in the online survey. The approached individuals may or may not have had sufficient knowledge about blockchain, but they were ought to be in a position to value and assess if their organisations could intent to adopt blockchain, given their experience of supply chain operations, facets of the industry their organisation operates in, and the provided line of questioning about blockchain. To smoothen the transition into the questions within the survey, an instructional video of what blockchain is and how it works was added to the survey. To safeguard privacy and confidential information of respondents, the dataset was configured to anonymise the data immediately upon the completion of the survey.

4.2.1 Population characteristics distribution

The largest part of the respondents was approached via LinkedIn; 450 invitations were send out, of which 55 individuals accepted the invitation which corresponds with an invite acceptance rate of approximately 12%. As not all respondents conveyed that they filled in the survey, an educated guess would be that 40 to 45 individuals actually completed the survey which would roughly translate to a response rate between 9% and 10%. The remainder of the completed surveys came from individuals approached via the Chamber of Commerce and online fora, totalling N=72 respondents. Within the data of these 72 respondents, there were no missing values. The following tables give an overview of the distribution of the respondents' characteristics.

The statistics from table 2 show the distribution of gender within the respondent characteristics. The reason for the rather large discrepancy can partly be found in the fact that the search terms, for example, 'supply chain manager', 'supply chain analyst', and 'supply chain specialist' entered into LinkedIn predominantly led to male search results.

	Frequency	Percentage
Male	69	95,80%
Female	3	4,20%

Table 2: Gender distribution of the respondents

The statistics from table 3 show the distribution of age, working years of the respondents, and the respondents' understanding of blockchain. Most respondents were still in the process of learning about blockchain with a percentage of 65.3%, and 18.1% respondents had no prior understanding of blockchain. Next, there are some organisations that already commenced with blockchain testing -and implementing processes, totalling 16.6% of the respondents.

	Minimum	Maximum	Mean	Std. Deviation
Age of respondent	25	63	42,18	10,43
Tenure of respondent in company	1	34	9,08	7,88
Respondent's understanding of blockchain	1	5	1,96	1,54

Table 3: Characteristics of respondents

4.2.2 Company characteristics distribution

The distribution of the characteristics of the respondents' companies, in terms of company age, number of employees, and market competitiveness, can be viewed in table 4 below. Only 11% of the respondents expressed that they perceive their market as very low or low in terms of competitiveness, whereas 89% of the respondents expressed that their market has an average, high, or very high degree of competitiveness.

	Minimum	Maximum	Mean	Std. Deviation
Age of company in years	4	141	57,36	36,51
Number of employees of company	2	80000	5701,18	17898,877
Competitiveness of market	1	5	3,65	0,96

Table 4: Characteristics of respondents' companies

The distribution of the company branches is displayed in table 5. From a total of 18 branches as indicated by the Chamber of Commerce, almost 60% of the companies operate in either the automotive trade, wholesale and retail branch, the industry branch, or the construction, installation and infrastructure branch.

	Frequency	Percent
Automotive trade, wholesale, and retail	21	29,2%
Industry	14	19,4%
Construction, installation and infrastructure	7	9,7%
Agricultural sector	5	6,9%
Healthcare and social services	5	6,9%
ICT, media and communication	5	6,9%
Business services	4	5,6%
Advice and consultancy	3	4,2%
Energy	2	2,8%
Food service industry	2	2,8%
Real Estate	2	2,8%
Education and training	1	1,4%
Financial services	1	1,4%

Table 5: Branch distribution

4.3 Measurement

As stated, this research aimed to explore the relationship between the perceived usefulness of blockchain and other factors, and organisational intention to adopt blockchain against the background of opportunism and trust within supply chain networks. To this end surveys were send out to measure these relationships on the basis of multiple theoretical survey constructs and items. These theoretical survey constructs and items have already been used by different researchers, such as Fosso Wamba et al. (2020), Low et al. (2011), Queiroz and Fosso Wamba (2019), Fosso Wamba (2019), and Hsing Wu, Kao, and Lin (2013) within the 'Technology Adoption Model' and 'Unified Theory of Acceptance and Use of Technology' framework. The survey items of this research contain a 5-point Likert scale that respondents filled in, ranging between the number 1 if they highly disagreed and the number 5 if they highly agreed. In Appendix A an overview is presented of the indicators and constructs, with their respective Cronbach's Alpha, Composite Reliability, and Average Variance Extracted scores, as presented in the researches of the corresponding authors. In Appendix B the conversion to the Dutch questionnaire used for this research is presented.

4.4 Data quality

The data gathered via the survey was analysed with the program SmartPLS. For the overall model a reflective measurement was applied, but regarding the constructs value drivers and adoption barriers, a formative measurement was eventually used. This means that these indicators for these two constructs are excluded from the reliability and validity tests, because they are formative indicators and therefore have weights instead of loadings, thus the reliability and validity thresholds don't apply anymore. This research intended to obtain a stable estimation, thus the algorithm needed to converge before reaching the maximum number of 300 iterations. SmartPLS will stop the estimation when either the stop criterion of the algorithm has been reached, or the maximum number of 300 iterations has been reached. For the dataset of this research, SmartPLS carried out 9 iterations, which means that a stable estimation was obtained. To further assess the consistency and accuracy of the measurement of this research, the reliability and validity of the research data will be discussed.

4.4.1 Data reliability

Firstly, the details for the indicator reliability can be found in Appendix C. This table shows all outer loadings, where a score of at least 0.7 per item is preferred, but a score of 0.4 is acceptable for this research as it is an exploratory research. All items within competitive pressure, ease of use, facilitating conditions, intention to adopt blockchain, knowledge sharing, perceived usefulness, social influence, trading partner pressure', and trust in supply chain network have scores above the preferred 0.4. A score of 0.399 or below is reached for one indicator within the group of opportunism in supply chain network. This means that this construct is paired with an unreliable indicator. Another reliability criterion is the internal consistency reliability and traditionally Cronbach's Alpha is as measurement. The general rule of thumb is that a score of 0.7 and above is sufficient; table 7 shows the results for the Cronbach's Alpha criterion with all items scoring above 0.7, so this criterion has been met. Whereas Cronbach's Alpha is often considered to be a conservative measurement, Composite Reliability has been suggested as a worthy replacement. Different thresholds are suggested for Composite Reliability, with 0.6 or above being a common acceptable score. As can be viewed in table 6, all composite reliability scores are at least 0.8 or higher. Some items even have a score of 0.9, which all in all indicates that the constructs have a high internal consistency reliability and consequently this means that the constructs are adequately measured.

	Cronbach's Alpha	Composite Reliability	Average Variance Extracted (AVE)
Competitive pressure	0.865	0.908	0.711
Facilitating conditions	0.846	0.897	0.686
Knowledge sharing	0.860	0.904	0.703
Opportunism in supply chain network	0.759	0.827	0.494
Organisational intention to adopt blockchain	0.925	0.941	0.729
Perceived ease of use	0.823	0.881	0.649
Perceived usefulness	0.841	0.888	0.615
Social influence	0.895	0.935	0.826
Trading partner pressure	0.909	0.943	0.847
Trust in supply chain network	0.893	0.916	0.647

Table 6: Cronbach's Alpha, Composite Reliability, and Average Variance Extracted

4.4.2 Data validity

Moving from reliability to validity, criteria in the form of convergent validity and discriminant validity have to be tested as well to assess the accuracy of the measurement. Starting with the convergent validity, which according to Krabbe (2017, p. 118) tests "*how closely the new scale is related to other variables and other measures of the same construct*". In this sense the constructs should correlate with related variables, and to check the convergent validity, SmartPLS provides the option to evaluate each latent variable's Average Variance Extracted. An acceptable threshold for the Average Variance Extracted is 0.5; table 7 shows that all items have a score higher than 0.5, with the exception of opportunism in supply chain network. This unsatisfying score is addressed in section 4.4.3. Equally important is the discriminant validity, which entails that constructs shouldn't correlate with dissimilar, unrelated variables ((Krabbe, 2017, p. 118). Discriminant validity can be tested via the Heterotrait-Monotrait Ratio of Correlations (HTMT); the HTMT measures the similarity between latent variables. Henseler, Ringle, and Sarstedt (2015, p. 121) discussed that 0.85 and 0.90 are often used as an absolute thresholds for HTMT values, and this research discriminant validity will be regarded as established when the HTMT values are below 0.85. The HTMT values for this research are presented in table 7: all values are below the threshold of 0.85 and therefore discriminant validity has been established in the model.

	1	2	3	4	5	6	7	8	9	10
1. Competitive pressure										
2. Facilitating conditions	0.730									
3. Knowledge sharing	0.740	0.803								
4. Opportunism in supply chain network	0.421	0.328	0.323							
5. Organisational intention to adopt blockchain	0.786	0.811	0.755	0.459						
6. Perceived ease of use	0.419	0.305	0.352	0.289	0.379					
7. Perceived usefulness	0.529	0.514	0.527	0.517	0.608	0.624				
8. Social influence	0.758	0.744	0.786	0.417	0.710	0.505	0.549			
9. Trading partner pressure	0.760	0.578	0.743	0.309	0.659	0.551	0.449	0.668		
10. Trust in supply chain network	0.369	0.335	0.320	0.592	0.360	0.145	0.166	0.374	0.397	

Table 7: Heterotrait-Monotrait Ratio of Correlations (HTMT) values

4.4.3 Addressing indicator reliability and average variance extracted issues

As mentioned, the construct opportunism in supply chain network has some problems with its indicator reliability and average variance extracted. As can be seen in Appendix D, the second indicator of the construct opportunism in supply chain has troublesome correlation loadings. Deleting this indicator provides a better outlook, as can be viewed in Appendix E. Referring back to the indicator reliability and average variance extracted, Appendix F and G show that deleting the second indicator produces an average value extracted value of 0.52, which is above the acceptable 0.4 threshold and thusly the convergent validity condition has been met. The indicator reliability condition is still not met for the third indicator of opportunism in supply chain network, as is falls just short of the 0.4 threshold with a score of 0.39. Given that the convergent validity condition has now been met for the construct opportunism in supply chain network, the second indicator will be cut from this research.

5. Results

5.1.1 Constructed model

Via SmartPLS the model was constructed, as can be viewed in Appendix H. All constructs with their respective indicators are present, plus the moderating interaction effect of both trust in supply chain network and opportunism in supply chain network on the relationship between perceived usefulness and organisational intention to adopt blockchain.

5.1.2 Results of the model

The structured equation modelling results of this model, which can be viewed in Appendix I, show some interesting outcomes. First off, the constructs value drivers, adoption barriers, and perceived ease of use explain the variance in perceived usefulness for 58%. The variance in the construct organisational intention to adopt blockchain is for 72,3% accounted for by the constructs perceived usefulness, social influence, trading partner pressure, competitive pressure, facilitating conditions, knowledge sharing, trust in supply chain network, and opportunism in supply chain network, which is a relatively high effect size. Furthermore, the inner model suggests that the construct facilitating conditions (β = 0.319) had the strongest effect on organisational intention to adopt blockchain, followed by competitive pressure (β = 0.222) and opportunism in supply chain network (β = 0.154). The constructs perceived usefulness of blockchain (β = 0.046) and social influence (β = -0.059) both had the weakest effects on organisational intention to adopt blockchain.

5.1.3 Significance of the relationships between the variables

To check if the path coefficients are significant, SmartPLS provides the bootstrapping tool to calculate the T-statistics and P-values. In table 8 an overview of the bootstrapping output is provided. Given the small sample of this research, the significance level is set to 10%, so P-values of 0.10 and below are statistically significant. A total of 13 path coefficients are presented in this research, of which 6 are significant. Firstly, the adoption barriers of blockchain significantly negatively (β = -0.442; α < 0.01) affect the perceived usefulness of blockchain. Secondly, the value drivers of blockchain significantly positively influence (β = 0.322; α < 0.01) the perceived usefulness of blockchain. Thirdly, perceived ease of use significantly positively (β = 0.148; α < 0.05) influences the perceived usefulness of blockchain. Fourthly, facilitating conditions significantly positively (β = 0.319; α < 0.01) affect organisational intention to adopt blockchain. Fifthly, opportunism in the supply chain network significantly positively (β = 0.154; α < 0.05) affects organisational intention to adopt blockchain. Lastly, competitive pressure significantly positively (β = 0.222; α < 0.05) influences organisational intention to adopt blockchain.

	Original Sample	Sample Mean	Std. Dev.	T-Statistics	P-Values
Adoption barriers -> Perceived usefulness	-0.442	-0.505	0.103	4.272	0.000
Competitive pressure -> Organisational intention to adopt blockchain	0.222	0.212	0.114	1.950	0.026
Facilitating conditions -> Organisational intention to adopt blockchain	0.319	0.330	0.107	2.997	0.001
Knowledge sharing -> Organisational intention to adopt blockchain	0.124	0.098	0.119	1.043	0.148
Moderating Effect Opportunism in supply chain network -> Organisational intention to adopt blockchain	-0.146	-0.064	0.166	0.884	0.188
Moderating Effect Trust in supply chain network -> Organisational intention to adopt blockchain	-0.141	-0.080	0.162	0.873	0.191
Opportunism in supply chain network -> Organisational intention to adopt blockchain	0.154	0.142	0.093	1.655	0.049
Perceived ease of use -> Perceived usefulness	0.148	0.132	0.083	1.775	0.038
Perceived usefulness -> Organisational intention to adopt blockchain	0.046	0.064	0.099	0.467	0.320
Social influence -> Organisational intention to adopt blockchain	-0.059	-0.046	0.121	0.486	0.313
Trading partner pressure -> Organisational intention to adopt blockchain	0.109	0.092	0.106	1.021	0.154
Trust in supply chain network -> Organisational intention to adopt blockchain	-0.059	-0.048	0.101	0.580	0.281
Value drivers -> Perceived usefulness	0.322	0.325	0.096	3.347	0.000

Table 8: Bootstrapping output of the model

5.1.4 Model with path coefficients and significances

To conclude this part of the statistical analysis, figure 8 provides a final display of the overall research model with its significant relationships.

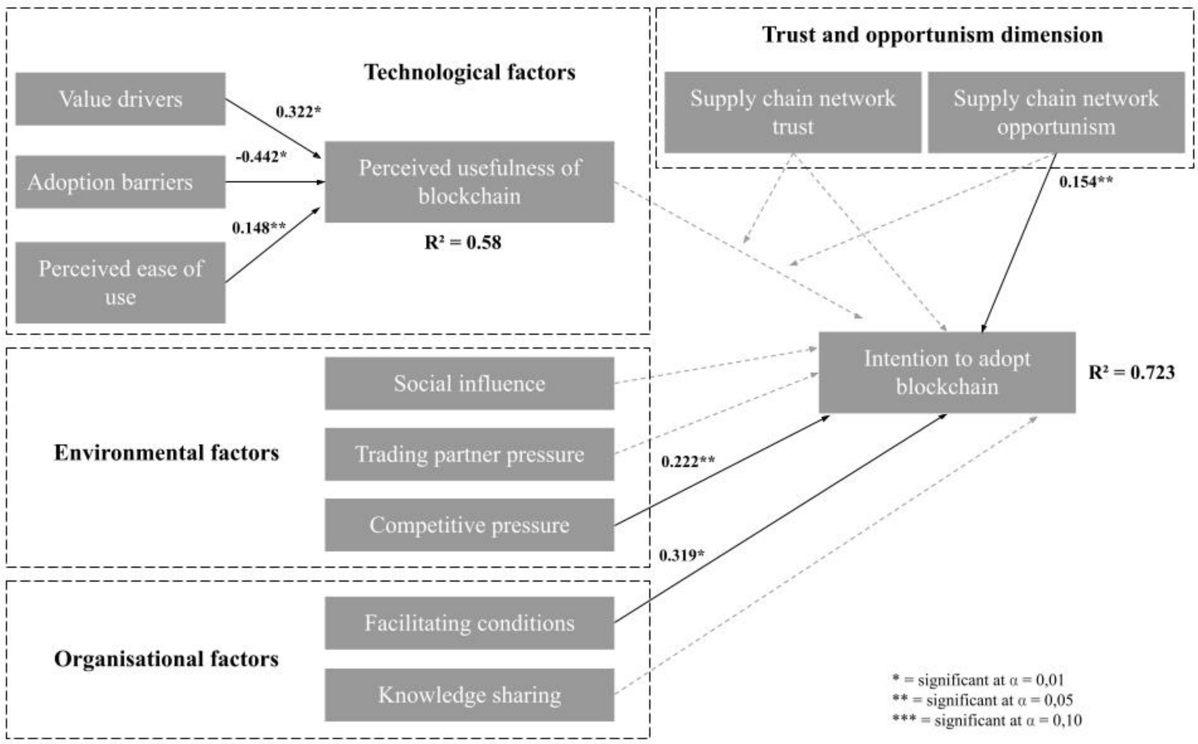

Figure 8: Research model with significances

5.2 Additional statistical analyses

Next to the analyses of the results regarding the initial research model, other analyses have been conducted to assess if there are any additional significances to be detected. In the first extra analysis, the indicators within the constructs value drivers and adoption barriers were grouped into coherent subparts. For the value drivers, three groups were created: supply chain visibility value drivers, (data) security value drivers, and other value drivers. For the adoption barriers, six groups were created: interoperability barrier, scalability barrier, collaboration barrier, technological infrastructure barrier, security concerns barrier, and policy, regulatory and legal barrier. The constructed model, T-statistics, and P-values of this new analysis can be viewed in Appendix J and K. The results show that both competitive pressure, facilitating conditions, and opportunism in supply chain network remain significant, and that not all value drivers and adoption barriers are significant. Regarding the value drivers, both the security -and other value drivers are significant, and regarding the adoption barriers, only the interoperability barrier is significant.

Another approach was to test if the constructs that were set up to influence perceived usefulness of blockchain, namely the value drivers, adoption barriers, and perceived ease of use, could significantly influence the intention to adopt blockchain directly next to their relationship with perceived usefulness. Appendix L provides the bootstrapping output of this setup and the results show that opportunism in supply chain network loses its significance, but two new significances are obtained. As well as the already established significant negative influence the adoption barriers have on the perceived usefulness, in this setting adoption barriers also directly, significantly and negatively affect organisational intention to adopt blockchain with a significance level of < 0.01. The second relationship that became significant, was the positive relationship between the construct knowledge sharing and organisational intention to adopt blockchain with a significance level of < 0.10.

Subsequently, in the other setup the value drivers, adoption barriers, and perceived ease of use were separated from perceived usefulness to assess the extent in which each construct individually affects organisational intention to adopt blockchain. In Appendix M the results reveal that multiple relationships lose their significance. Just like the previous setup, the adoption barriers still directly, significantly and negatively influence organisational intention to adopt blockchain, but facilitating conditions is no longer significant in relation to organisational intention to adopt blockchain. Furthermore, the value drivers and perceived ease of use don't significantly affect organisational intention to adopt blockchain.

Although even more statistical tests with other diverse relationships and construct divisions could be conducted, the last additional analysis in this research has focussed on dividing the construct opportunism in supply chain network into a lower half and a higher half. The reasoning behind this division is that it could be worthwhile to look at the relationships between the variables when there only is a high degree of opportunism. In relation to the overall research model, a high degree of opportunism should increase both the perceived usefulness of blockchain, as well as the intention to adopt it. SPSS output showed that the median of the construct opportunism in supply chain network was 2.75, which thusly indicates that half of the observations lays under the value of 2.75 and the other half above it. In this setup, the indicators relating to the construct opportunism in supply chain network now only had values of 2.75 and above; Appendix N reveals the output of this setup: there are no significant relationships other than the already established ones.

6. Discussion

In this section the key findings of this research are discussed. Firstly, an elaboration and reflection vis-à-vis the proposed hypotheses is given, followed by the answers of the research questions. A practical overview of the hypotheses is given below in table 9.

Hypothesis	Relationship	Proposed Relationship	Observed Relationship	Result
H1a	Value drivers → Perceived usefulness	Positve	Positive	Supported
H1b	Adoption barriers → Perceived usefulness	Negative	Negative	Supported
H1c	Perceived ease of use → Perceived usefulness	Positve	Positive	Supported
H1d	Perceived usefulness → Intention to adopt	Positve	Positive	Rejected
H2a	Social influence → Intention to adopt	Positve	Negative	Rejected
H2b	Trading partner pressure → Intention to adopt	Positve	Positive	Rejected
H2c	Competitive pressure → Intention to adopt	Positve	Positive	Supported
H3a	Facilitating conditions → Intention to adopt	Positve	Positive	Supported
H3b	Knowledge sharing → Intention to adopt	Positve	Positive	Rejected
H4a	Trust → Intention to adopt	Negative	Negative	Rejected
H4b	Opportunism → Intention to adopt	Positve	Positive	Supported
H4c	Trust → Perceived usefulness-Intention to adopt	Negative	Negative	Rejected
H4d	Opportunism → Perceived usefulness-Intention to adopt	Positve	Negative	Rejected

Table 9: Summary of hypotheses testing results

6.1 Key findings

To test the extent to which the organisational behavioural intention to adopt blockchain is influenced by multiple factors, 13 hypotheses were posited and grouped into 4 cohorts with corresponding proposed relationships. The first hypotheses cohort centred around the technological factors, with the three variables value drivers, adoption barriers, and perceived ease of use influencing the variable perceived usefulness of blockchain. The observed relationship matched the proposed relationship, but as mentioned in the data quality section, both the value drivers as the adoption barriers harboured some inherent reliability issues. The possible cause for these issues are discussed in the limitations section, but again it is advisable to be cautious to take the results and the outward relationships of these two variables at face value. The value drivers and adoption barriers proved to be statistically significant, thus respectively positively and negatively influencing the perceived usefulness of blockchain, which in essence makes sense as the value drivers and their possibilities for supply chain management increase the perceived usefulness of blockchain and the adoption barriers decrease the perceived usefulness of blockchain. Perceived ease of use also showed a significant relationship with the perceived usefulness of blockchain when the second indicator of opportunism in supply chain network was deleted. The significant effect of perceived ease of use on perceived usefulness of blockchain corresponds with the research of Kamble et al. (2019, p. 2023), thusly invigorating the assumption that when a person believes that using blockchain is free of effort, they are more inclined to blockchain adoption. The first technological hypotheses cohort also revolved around the main research question: the extent to which the perceived usefulness of blockchain influences organisational intention to adopt blockchain. Although the proposed positive effect of the perceived usefulness of blockchain was indeed observed as being positive as well, unfortunately the effect itself proved to be statistically insignificant. In the study of Kamble et al. (2019, p. 16), the effect of the construct perceived usefulness of blockchain on organisational intention to adopt blockchain was statistically significant within a technology adoption setting. A possibility for the discrepancy between the results of the research of Kamble et. al (2019) and this research could be that the respondents of the former had a better understanding of blockchain and its usefulness. As 83,4% of the respondents of this research indicated that they had either no prior knowledge of blockchain or are still in the process of learning about blockchain, it could be that the interplay of this indication with answering the rather abstract survey indicators for the variable perceived usefulness of blockchain, in the form of ‘performance’, ‘productivity’, and ‘effectiveness’, manifested into an incongruity.

The second hypotheses cohort explored if the environmental factors, that were brought forward within the technology adopting models and its variants, have an impact on the intention to adopt blockchain. The results showed that only competitive pressure has a significant effect on the organisational intention to adopt blockchain, which is conform the research of Zhu et al. (2003, p. 256), as companies that are facing high levels of competitive pressure are more likely to adopt blockchain. Results also revealed that the relation of both social influence and trading partner pressure with organisational intention to adopt blockchain was insignificant, consequently the results for social influence contradict the research results regarding the sample pool of India of Queiroz and Fosso Wamba (2019, p. 77), but simultaneously coinciding with their sample pool of the USA. In the research of Fosso Wamba et al. (2020, p. 7) a significant effect was found for trading partner pressure, which differs from the insignificant results of this research. This statistical insignificance of both social influence and trading partner pressure vis-á-vis the significant competitive pressure could be rationalised by the nature of these variables. Whereas competitive pressure is relatively imperative and coercive for an organisation, for example with regards to safeguarding business operations, social influence and trading partner pressure has a more of advisory and lenient nature. Another contributing component could be that a lot of organisations still haven't delved into blockchain, so they aren't in a position to make recommendations or put pressure on other people and/or organisations.

The third hypotheses cohort included the organisational factors derived from the technology adoption models. The results of the analysis have shown a positive significant effect for the relationship between the facilitating conditions of an organisation and organisational intention to adopt blockchain, but the relationship between the factor knowledge sharing and organisational intention to adopt blockchain lacks statistical significance in the first wave of statistical tests. The support that the results show for the significant relationship between facilitating conditions and organisational intention to adopt blockchain means that organisations that have the right -and adequate resources, knowledge, and expertise for the adoption of blockchain are more inclined to actually adopt blockchain than organisations that lack one or more of these facilitating aspects. This result resonates with the research of Wong, Tan, et al. (2020, p. 2113) in which the facilitating conditions were also found to be significant. Regarding the effect of knowledge sharing on organisational intention to adopt blockchain, it appears that a significant effect was not found. This indicates that an organisation's inclination to share know-how, knowledge, and innovations with their supply chain partners has no significant impact on the intention to adopt blockchain. These result contradict the research results of Fosso Wamba et al. (2020, p. 7), in which they found a significant positive relationship between knowledge sharing and blockchain adoption.

The fourth and last cohort of hypotheses focussed on the trust and opportunism dimension within supply chain networks. This dimension's nucleus was formed by the relationship between trust and opportunism within the supply chain networks of organisations, and the intention of organisations to adopt blockchain. Additionally, the moderating effect that trust and opportunism within the supply chain networks of organisations could have on the perceived usefulness of blockchain was also tested. Only one of these four relationships resulted in a significant effect, with opportunism within supply chain networks significantly positively influencing organisational intention to adopt blockchain. This significance can be explained well by the fact that blockchain is in essence a useful tool to keep opportunistic behaviour in check, thus organisational that perceive a high degree of opportunistic behaviour tend to respond positively to the intention of adopting blockchain. Opportunism in supply chain networks on the other hand, as well as trust in supply chain networks, didn't have a significant moderating effect on the relationship between the perceived usefulness of blockchain and the intention of organisations to adopt blockchain. A possible reason for this insignificance could be that the constructs trust and opportunism didn't connect appropriately to the relationship between the perceived usefulness of blockchain and organisational intention to adopt blockchain. The indicators of perceived usefulness measured certain supply chain management aspects, such as performance, productivity, and effectiveness, and it could be assumed that the trust and opportunism constructs are unrelated to this measurement.

Trust in supply chain networks proved to be insignificant on both accounts. The proposed negative effect of trust in supply chain network on the relationship between perceived usefulness of blockchain and organisational intention to adopt blockchain, and on organisational intention to adopt blockchain as a variable itself, was ultimately observed as well. The reasoning behind the negative effect of trust thusly proved to be sensible and rational, as organisations that have a high degree of trust vis-à-vis their supply chain partners don't necessarily need to adopt blockchain in this respect. Unfortunately, the influencing effect of trust proved to be insignificant, this could be attributed to the indicators of the construct itself. The indicators that were used in this research were adopted from the research of Singh and Teng (2016, p. 298), who used these indicators and the construct trust to uncover what relationship trust had regarding transaction costs, relational governance, and performance. The research of Singh and Teng didn't have technology adoption as the focal point of their research, so it could be that these indicators of trust and the variable trust itself didn't appropriately assimilate into the model of this research.

Taking all the information from the hypotheses into account to answer the main research question and subsequent subquestion, several conclusions can be made. Firstly, regarding the following subquestion: *What are the factors that influence the perceived usefulness of blockchain, and to what extent do these factors influence perceived usefulness?* The research results have shown that the perceived usefulness is significantly influenced by the value drivers of blockchain, and the adoption barriers of blockchain. The value drivers of blockchain have a moderate positive effect on blockchain's perceived usefulness, and the adoption barriers of blockchain have a moderate negative effect on the perceived usefulness of blockchain.

Regarding the second subquestion: *What are the environmental and organisational factors that influence the behavioural intention of organisations to adopt blockchain, and to what extent do these factors influence the behavioural intention of organisations to adopt blockchain?*, this research has identified several environmental and organisational factors, of which competitive pressure has a moderate positive effect on organisational behavioural intention to adopt blockchain and facilitating conditions has a relatively weak positive effect on organisational behavioural intention to adopt blockchain.

The third subquestion was: *To what extent does trust and opportunism in supply chain networks affect the behavioural intention of organisations to adopt blockchain, and to what extent does trust and opportunism within supply chain networks moderate the relationship between the perceived usefulness of blockchain and the behavioural intention of organisations to adopt blockchain?*, and the answer is that the only significant effect on organisational intention to adopt blockchain is from the variable opportunism in supply chain networks, which has a relatively weak influence. The results show that there was no moderating effect present from the trust and opportunism dimension.

The main research question has been formulated as follows:

To what extent does the perceived usefulness of blockchain influence organisational behavioural intention to adopt blockchain and what is the moderating effect of trust and opportunism within supply chain networks?

The answer to the main research question is that perceived usefulness doesn't significantly influence organisational behavioural intention to adopt blockchain, and while opportunism in supply chain networks has a weak significant influence on organisational behavioural intention to adopt blockchain, there is no moderating effect of trust and opportunism within supply chain networks vis-à-vis organisational behavioural intention to adopt blockchain.

6.2 Academic implications

This study has, in the footsteps of several other studies, tried to enrich the current state of blockchain research with empirical evidence. Through the theoretical lens of both the Technology Adoption Model and Unified Theory of Acceptance and Use of Technology frameworks, this study has made an effort to contribute and expand the literature on blockchain adoption for supply chain management. A common and practical grouping of factors that influence the intention to adopt blockchain revolved around the factors referring to the technology itself in terms of performance and use, environmental factors, and organisational factors. Also a common approach was to only include SME's and their intention to adopt blockchain. This research applied a combination of the Technology Adoption Model and the Unified Theory of Acceptance and Use of Technology, which was based on prior research results that indicated several factors that significantly influence organisational intention to adopt blockchain, combined with a broader organisational scope that also included large companies. Next to this more extensive research scope, this research provided an additional dimension, namely the trust and opportunism dimension. The factor opportunism in supply chain network proved to be a significant influencing factor for organisational intention to adopt blockchain. This significance therefore indicates that organisations are more receptive to adopt blockchain if they perceive that their supply chain network acts opportunistically. Paired with an overall explained variance of the variable organisational intention to adopt blockchain of 72,3%, the inclusion of the trust and opportunism dimension into the research model has been fruitful.

6.3 Managerial implications

This research provides managers with a couple of starting points to assess the usefulness of adopting blockchain for supply chain management purposes, as well as that this research provides managers with an outlook of the current progress of blockchain adoption. Firstly, this research identified multiple value driving factors from which supply chain management could benefit. Managers should keep in mind that the value drivers of blockchain have a significant impact on the perceived usefulness of blockchain, but they should also be able to determine for themselves and their organisation which value drivers could potentially benefit supply chain management, as not all the supply chain management activities are evenly receptive for every value driver.

The results showed that the adoption barriers have a significant negative relationship with both the perceived usefulness of blockchain and organisational intention to adopt blockchain, thus the respondents have identified that they think that the adoption barriers currently complicate the potential adoption of blockchain. The additional analysis in which the indicators of the adoption barriers were grouped, indicated that the interoperability barrier was in fact significant. Regarding this significance, managers that are planning to adopt blockchain now or in the future are therefore advised to look into the compatibility of blockchain with internal and external data systems. Although this identification of adoption barriers is a contemporary reflection of blockchain, future improvements of blockchain itself and changes in the external environment that influences blockchain could very well reduce or even remove several of the outlined adoption barriers. Managers are therefore advised to monitor the developments surrounding blockchain to be able to ultimately seize a favourable entry point if they want to adopt blockchain. The identified adoption barriers in this research could in this sense serve as a reference point for managers due to their significance, if managers want to assess the different barriers that could have an impact on business operations when adopting blockchain.

Another implication that managers should keep in mind is that their company needs to be adequately equipped to facilitate the adoption of blockchain. The outcome of this research revealed that organisations that have adequate facilitating conditions are more inclined to adopt blockchain within the foreseeable future, which simultaneously points out that organisations should not underestimate the weight of the whole blockchain adoption process itself, let alone the continuous maintenance of all blockchain connected activities. This research also pointed out that there already are multiple organisations that have sufficient facilitating conditions to test and implement blockchain. Managers should keep in mind that besides following blockchain developments, they have to keep a close eye on blockchain adoption developments. The possibility exists that within a few years an increasing amount of organisations will start to adopt blockchain or already have implemented blockchain, and therefore managers could be forced to adopt blockchain as well from a competitive point of view. They should make sure that they have deployed the right preparations regarding the facilitating conditions of their company for the whole blockchain adoption process. This reasoning is further invigorated by the significance of the variable competitive pressure, which showed that organisations are already looking into adopting blockchain as their competitors are also exploring blockchain to gain a possible competitive advantage.

Lastly, this research has revealed that organisations perceiving a high degree of opportunistic behaviour in their supply chain network are more inclined to adopt blockchain than organisations that perceive a low degree of opportunism vis-à-vis their supply chain partners. For managers this means that, as the respondents of this research have indicated, blockchain could indeed prove to be a viable and useful tool to address opportunism in supply chain networks. Even if managers perceive a low degree of opportunism, the reality could always be different. In both constellations blockchain could be utilised by organisations to ensure untampered data input, provide secure data transferral, and create more supply chain visibility.

7. Limitations

As became evident in the data quality section, this research has several limitations regarding the collection of data and the data itself. This last section addresses these limitations and provides various indications for future research.

Starting with the first limitation of this research: the sample size was rather small. Only a total of 72 respondents participated in the surveys, which obviously impairs and distorts data output in terms of reliability, validity, significance, and furthermore, it decreases generalisability. Generalisability of this research is further complicated by the fact that 95,8% of the respondents was male and the three branches of the automotive trade, wholesale and retail, industry, and construction, installation and infrastructure accounted for almost 60% of the total branch diversity. Future research should therefore be focussing on expanding the respondent pool, as well as trying to include more female individuals that are involved within supply chain management, and working towards gathering a more diversified branch representation. Given, not all branches could profit equally from the possible adoption of blockchain, as some organisations' business operations lend themselves better for blockchain's application, but at least an attempt should be made to include more organisations from other branches.

Another sample size limitation was that this research only focussed on Dutch organisations. Although organisations from all possible sizes were included, this research only outlined organisational intention to adopt blockchain from the overall technological level of the Netherlands. Other researchers, such as Wong, Leong, et al. (2020, p. 15), also mentioned that a cross-country study could be considered as future research to account for different technological levels between countries, as some countries are more technologically developed than others, which could ultimately affect organisational intention to adopt blockchain. The generalisability could also be improved in this sense, as different technological advancements on country level are included as a variable.

As already stated in the data quality section, this research had problems with indicator reliability and convergent validity. While this problem can partly be attributed to the small sample size, the other part could be because of the indicators of the constructs. Apparently some of these indicators are not adequate enough to be paired with their respective constructs. This inadequacy could be rooted in the description of the survey items, as some were described rather vague, some rather too broad, and also some were too detailed. Future research could try to rewrite these items, or search for new or similar indicators that fit the Technology Adoption Model and Unified Theory of Acceptance and Use of Technology framework.

Another limitation of this research is the rather limited knowledge and experience of the respondents with blockchain. By extension, it could be that they weren't able to grasp the whole concept blockchain entailed, which could have had an impact on how they estimated the perceived usefulness of blockchain, as well as some of the other influencing factors. Wong, Tan, et al. (2020, p. 2114) indicated that they faced the same limitation, as their respondents also showed low familiarity with blockchain. One option for future research could be to only include blockchain experts, and an alternative could be to undertake a longitudinal study in which participants are selected that have no knowledge of blockchain. The observation is then repeated once or twice, with between observations the setting that the respondents have time to get acquainted with blockchain, or are even provided the possibility to work with blockchain regarding the execution of supply chain activities. It would then be interesting to see if their survey response would change over the course of the study.

The selection of constructs also proves to be a limitation of this research. From the Technology Acceptance Model and Unified Theory of Acceptance and Use of Technology several constructs were adopted into this research, such as facilitating conditions, social influence, and perceived usefulness. Altogether the constructs form a comprehensive model, but as became obvious in the research of Queiroz and Fosso Wamba (2019, p. 78) as well, the number of total constructs is perhaps too limited to explain blockchain adoption within the context of supply chain management. Future research could consider extending the research model of this study by including even more constructs. Another coherent limitation is the measurement level of the constructs. While some constructs are measured on an individual level, the actual behavioural intention to adopt blockchain is measured on organisational level. A possibility for future research is to only include respondents that have the authority to make decisions regarding the adoption of blockchain into their organisation; in this sense the measurement can be conducted for the individual level alone.

The last limitation relates to the constructs trust and opportunism.
It isn't farfetched to raise the notion that with a larger sample size and perhaps some

modifications in the relationships between the trust and opportunism dimension and the other variables, more significant relationships with an emphasis on the variable trust, could be established. A side note regarding this implication is that the trust and opportunism dimension ideally lends itself in relation to the adoption of blockchain. The application of the trust and opportunism dimension could be less useful when the adoption of other technologies is researched, as blockchain can be utilised to actively responds to the trust and opportunism that is present in supply chain networks. It would make sense to only apply the trust and opportunism when researching technologies that have similar trust enhancing and opportunism curbing capabilities. Regardless, trust appeared to be an insignificant construct; this insignificance could be due to the indicators of trust vis-à-vis the indicators of opportunism, as they appear to be very similar and in some instances the indicators of opportunism even overlap with the indicators of trust. One could argue that with the included indicators of opportunism in this research, a high degree of opportunism is equivalent to a low degree of trust. In this sense the significance of opportunism could have overruled any significant effect of trust. Future research could therefore opt to add some of the indicators of opportunism to the construct trust and then only use trust as a construct to assess inter-organisational relationships.

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9. Appendix

Appendix A: Complete codebook of this study

Intro of survey:	General info: Since we will present the findings .				
Technological (TECH) section					
Intro of section	Introduction: The following questions relate to t .				
	Value drivers of blockchain			Missing (CA), Missing (CR), Missing (AVE)	
	I believe that blockchain could provide supply chain advantages for my organisation in terms of...				
TECH_value_drivers_011_01		...transparancy	Shoaib, M., Lim Ming, K., &	-	standard likkert: 1= I fully disagre
TECH_value_drivers_011_02		...traceability	Shoaib, M., Lim Ming, K., &	-	standard likkert: 1= I fully disagre
TECH_value_drivers_011_03		...security	Shoaib, M., Lim Ming, K., &	-	standard likkert: 1= I fully disagre
TECH_value_drivers_011_04		...disintermediation	Shoaib, M., Lim Ming, K., &	-	standard likkert: 1= I fully disagre
TECH_value_drivers_011_05		...immutability and encryption	Shoaib, M., Lim Ming, K., &	-	standard likkert: 1= I fully disagre
TECH_value_drivers_011_06		...automation	Shoaib, M., Lim Ming, K., &	-	standard likkert: 1= I fully disagre
TECH_value_drivers_011_07		...cost reductions	Shoaib, M., Lim Ming, K., &	-	standard likkert: 1= I fully disagre
TECH_value_drivers_011_08		...creating a trustless environment	Shoaib, M., Lim Ming, K., &	-	standard likkert: 1= I fully disagre
	Adoption barriers of blockchain				
	In terms of interoperability, I believe that blockchain...			0.630 (CA), 0.823 (CR), 0.699 (AVE)	
TECH_adoption_barriers_012_01		...is compatible with our or our supply chain partners' information systems	Choi, D., Chung, C. Y., Seyha	-	standard likkert: 1= I fully disagre
TECH_adoption_barriers_012_02		...is compatible with our operations or business process	Choi, D., Chung, C. Y., Seyha	-	standard likkert: 1= I fully disagre
TECH_adoption_barriers_012_03	In terms of scalability, I believe that...	...the overall speed of a blockchain transaction (7 transactions per second) is adequate	Choi, D., Chung, C. Y., Seyha	0.694 (CA), 0.803 (CR), 0.577 (AVE)	standard likkert: 1= I fully disagre
TECH_adoption_barriers_012_04		...the overall block size (1 Megabyte) is decent for practical use	Choi, D., Chung, C. Y., Seyha	-	standard likkert: 1= I fully disagre
TECH_adoption_barriers_012_05	In terms of supply chain collaboration efforts, I believe that...	...collaborating with supply chain partners to allow for blockchain adoption will be daunting	Choi, D., Chung, C. Y., Seyha	0.714 (CA), 0.852 (CR), 0.743 (AVE)	standard likkert: 1= I fully disagre
TECH_adoption_barriers_012_06		...collaborating with supply chain partners to allow for blockchain adoption will require too much time and effort	Choi, D., Chung, C. Y., Seyha	-	standard likkert: 1= I fully disagre
TECH_adoption_barriers_012_07	In terms of the contraints of technological infrastructure, I believe	...the current technological structure is not adequate for blockchain	Choi, D., Chung, C. Y., Seyha	0.778 (CA), 0.842 (CR), 0.639 (AVE)	standard likkert: 1= I fully disagre
TECH_adoption_barriers_012_08		...the current Internet service is not efficient enough for blockchain	Choi, D., Chung, C. Y., Seyha	-	standard likkert: 1= I fully disagre
TECH_adoption_barriers_012_09		...there is not sufficient access to blockchain technology	Choi, D., Chung, C. Y., Seyha	-	standard likkert: 1= I fully disagre
TECH_adoption_barriers_012_10	With regard to blockchain's security concerns...	...I feel secure in providing sensitive information related to the company (e.g., transaction data) when working with blockchain platforms	Choi, D., Chung, C. Y., Seyha	0.758 (CA), 0.832 (CR), 0.623 (AVE)	standard likkert: 1= I fully disagre
TECH_adoption_barriers_012_11		...I feel that blockchain is a safe platform for operating business with sensitive information overall	Choi, D., Chung, C. Y., Seyha	-	standard likkert: 1= I fully disagre
TECH_adoption_barriers_012_12	With regard to constraints on existing government support, regulations and legal frameworks related to blockchain, I think that...	...the government has not introduced relevant policies to boost blockchain technology adoption	Choi, D., Chung, C. Y., Seyha	Government support: 0.738 (CA), 0.822 (CR), 0.607 (AVE) / Regulation and legal frameworks: 0.715 (CA), 0.813 (CR), 0.592 (AVE)	standard likkert: 1= I fully disagre
TECH_adoption_barriers_012_13		...the regulatory body is not yet well-established to deal with blockchain issues	Choi, D., Chung, C. Y., Seyha	-	standard likkert: 1= I fully disagre
TECH_adoption_barriers_012_14		...legal structures do not satisfactorily protect users from problems on blockchain platforms	Choi, D., Chung, C. Y., Seyha	-	standard likkert: 1= I fully disagre

		Perceived ease of using blockchain			Missing (CA), 0.955 (CR), 0.841 (AVE)		
		I feel...					
	TECH_perceived_ease_013_01		...the features of blockchain will be easy to use	Kamble, S., Gunasekaran, A	-	standard likkert: 1= I fully disagre	.
	TECH_perceived_ease_013_02		...blockchain will be more easy to use compared to the conventional practices of managing supply chain	Kamble, S., Gunasekaran, A	-	standard likkert: 1= I fully disagre	.
	TECH_perceived_ease_013_03	I think...	...blockchain is clear and understandable	Kamble, S., Gunasekaran, A	-	standard likkert: 1= I fully disagre	.
	TECH_perceived_ease_013_04		...it will be easy for me to remember and perform tasks using blockchain	Kamble, S., Gunasekaran, A	-	standard likkert: 1= I fully disagre	.
	Perceived usefulness (PUSE) section						
Intro of section		The following questions relate to your/your orga	.				
		Perceived usefulness of blockchain			Missing (CA), 0.915 (CR), 0.729 (AVE)		
		Using blockchain...					
	PUSE_021_01		...will help minimise my transaction delays	Kamble, S., Gunasekaran, A	-	standard likkert: 1= I fully disagre	.
	PUSE_021_02		... would improve supply chain performance	Kamble, S., Gunasekaran, A	-	standard likkert: 1= I fully disagre	.
	PUSE_021_03		...would improve supply chain productivity	Kamble, S., Gunasekaran, A	-	standard likkert: 1= I fully disagre	.
	PUSE_021_04		...would improve supply chain effectiveness	Kamble, S., Gunasekaran, A	-	standard likkert: 1= I fully disagre	.
	PUSE_021_05		...would make it easier to share data	Shrestha, A. K., & Vassileva	-	standard likkert: 1= I fully disagre	.
Additional factor / not used for hypothesis testing		**Relative advantage**			0.971 (CA), 0.978 (CR), 0.899(AVE)		
		Blockchain...					
	Relative_advantage_022_01		...can quickly complete the firm's operations	Wong, L.-W., Leong, L.-Y., H	-	standard likkert: 1= I fully disagre	.
	Relative_advantage_022_02		...can enhance the efficiency of operations and supply chain management	Wong, L.-W., Leong, L.-Y., H	-	standard likkert: 1= I fully disagre	.
	Relative_advantage_022_03		...can increase firm's profits	Wong, L.-W., Leong, L.-Y., H	-	standard likkert: 1= I fully disagre	.
	Relative_advantage_022_04		...is helpful for operations and supply chain management	Wong, L.-W., Leong, L.-Y., H	-	standard likkert: 1= I fully disagre	.
	Relative_advantage_022_05		...is convenient for me to manage operations and supply chain	Wong, L.-W., Leong, L.-Y., H	-	standard likkert: 1= I fully disagre	.
	Environment (ENVR) section						
Intro of section		The following questions relate to the environme	.				
		Social Influence			India = 0.837; USA = 0.893 (CA), India = 0.891; USA = 0.926 (CR), India = 0.671; USA = 0.757 (AVE)		
	ENVR_social_infl_031_01	Most of my colleagues and SC partners...	...believe using blockchain is a wise decision	Kamble, S., Gunasekaran, A	-	standard likkert: 1= I fully disagre	.
	ENVR_social_infl_031_02	People who...	...influence my behavior think that I should use blockchain	Queiroz, M. M., & Fosso Wa	-	standard likkert: 1= I fully disagre	.
	ENVR_social_infl_031_03		...are important to me think that I should use blockchain	Queiroz, M. M., & Fosso Wa	-	standard likkert: 1= I fully disagre	.
		Trading partner pressure			0.880 (CA), 0.882 (CR), 0.715 (AVE)		CA/CR/AVE from Fosso Wamba
		The major trading partners of my company...					
	ENVR_trade_partner_pres_032_01		...encouraged implementation of blockchain	Wang, Y.-M., Wang, Y.-S., &	-	standard likkert: 1= I fully disagre	.
	ENVR_trade_partner_pres_032_02		...recommended implementation of blockchain	Wang, Y.-M., Wang, Y.-S., &	-	standard likkert: 1= I fully disagre	.
	ENVR_trade_partner_pres_032_03		...requested implementation of blockchain	Wang, Y.-M., Wang, Y.-S., &	-	standard likkert: 1= I fully disagre	.
		Competetive pressure			0.955 (CA), 0.966 (CR), 0.849 (AVE)		
		I personally / My organisation...					
	ENVR_comp_pres_033_01		...believes that we may lose customers if we do not use blockchain	Wong, L.-W., Leong, L.-Y., H	-	standard likkert: 1= I fully disagre	.
	ENVR_comp_pres_033_02		...believes that using blockchain to gain competitiveness is important when making strategic decisions	Wong, L.-W., Leong, L.-Y., H	-	standard likkert: 1= I fully disagre	.
	ENVR_comp_pres_033_03		...believes that other organisations in our industry have recently begun to explore blockchain	Wong, L.-W., Leong, L.-Y., H	-	standard likkert: 1= I fully disagre	.
	ENVR_comp_pres_033_04	Competitive pressures...	...force my organisation to look into blockchain	Wong, L.-W., Leong, L.-Y., H	-	standard likkert: 1= I fully disagre	.

(Inter-) Organisational (ORG) Section					
Intro of section	The following questions relate to organisational				
	Facilitating conditions of organisation			0.949 (ρA), 0.948 (CR), 0.819 (AVE)	
	My organisation has...				
ORG_facilitating_conditions_041_01		...the right resources for blockchain	Wong, L.-W., Tan, G. W.-H.,	-	standard likkert: 1= I fully disagre
ORG_facilitating_conditions_041_02		...the expertise for blockchain in case technical assistance is required	Wong, L.-W., Tan, G. W.-H.,	-	standard likkert: 1= I fully disagre
ORG_facilitating_conditions_041_03		...the knowledge necessary for operating blockchain	Wong, L.-W., Tan, G. W.-H.,	-	standard likkert: 1= I fully disagre
ORG_facilitating_conditions_041_04	Blockchain...	...is compatible with other systems I use	Queiroz, M. M., & Fosso Wa	-	standard likkert: 1= I fully disagre
	Knowledge sharing between partners within the supply chain			0.882 (CA), 0.883 (CR), 0.653 (AVE)	
	Your organisation...				
ORG_knowledge_sharing_042_01		...prefers to share know-how, innovations and blockchain-enabled supply chain knowledge with supply chain partners	Fosso Wamba, S., Queiroz,	-	standard likkert: 1= I fully disagre
ORG_knowledge_sharing_042_02		...prefers to share relevant market knowledge and blockchain-enabled supply chain knowledge with supply chain partners	Fosso Wamba, S., Queiroz,	-	standard likkert: 1= I fully disagre
ORG_knowledge_sharing_042_03		...openly shares knowledge on blockchain-enabled supply chain applications with your supply chain partners	Fosso Wamba, S., Queiroz,	-	standard likkert: 1= I fully disagre
ORG_knowledge_sharing_042_04		...and supply chain partners share knowledge on blockchain-enabled supply chain applications that help in the establishment of business plannin	Fosso Wamba, S., Queiroz,	-	standard likkert: 1= I fully disagre
Supply chain trust and opportunism (TROP) section					
Intro of section	The following questions relate to the dimension				
	Trust within the supply chain			Missing (CA), 0.98 (CR), 0.87 (AVE)	
	I believe that my organisation's supply chain partner(s)...			-	
TROP_trust_051_01		...are dependable	Singh, A., & Teng, J. T. C. (20	-	standard likkert: 1= I fully disagre
TROP_trust_051_02		...meet their negotiated obligations to my organisation	Singh, A., & Teng, J. T. C. (20	-	standard likkert: 1= I fully disagre
TROP_trust_051_03		...are reliable	Singh, A., & Teng, J. T. C. (20	-	standard likkert: 1= I fully disagre
TROP_trust_051_04		...keep the spirit of an agreement	Singh, A., & Teng, J. T. C. (20	-	standard likkert: 1= I fully disagre
TROP_trust_051_05	I believe that the employees of supply chain partners...	...keep their promises	Singh, A., & Teng, J. T. C. (20	-	standard likkert: 1= I fully disagre
TROP_trust_051_06		...honor the commitments made in our dealings	Singh, A., & Teng, J. T. C. (20	-	standard likkert: 1= I fully disagre
	Opportunism within the supply chain			0.90 (CA), Missing (CR), Missing (AVE)	
	I believe that one or more of my organisation's supply chain partner(s)...				
TROP_opportunism_052_01		...exaggerate their needs in order to get what they want	Lado, A. A., Dant, R. R., & Te	-	standard likkert: 1= I fully disagre
TROP_opportunism_052_02		...are not always sincere if that helps to promote their own objectives	Lado, A. A., Dant, R. R., & Te	-	standard likkert: 1= I fully disagre
TROP_opportunism_052_03		...alter facts in order to meet their own goals and objectives	Lado, A. A., Dant, R. R., & Te	-	standard likkert: 1= I fully disagre
TROP_opportunism_052_04		...do not negotiate from a good faith bargaining perspective	Lado, A. A., Dant, R. R., & Te	-	standard likkert: 1= I fully disagre
TROP_opportunism_052_05		...breaches formal or informal agreements to benefit themselves	Lado, A. A., Dant, R. R., & Te	-	standard likkert: 1= I fully disagre
Behavioral intention (BINT) section					
Intro of section	The following questions relate to your/your orga				
	Behavioral intention to adopt blockchain			India = 0.840; USA = 0.921 (CA), India = 0.904; USA = 0.950 (CR), India = 0.758; USA = 0.863 (AVE)	
	I...				
BINT_061_01		...intend to use blockchain in the following months	Queiroz, M. M., & Fosso Wa	-	standard likkert: 1= I fully disagre
BINT_061_02		...predict that I would use blockchain in the following months	Queiroz, M. M., & Fosso Wa	-	standard likkert: 1= I fully disagre
BINT_061_03		...plan to use blockchain in the following months	Queiroz, M. M., & Fosso Wa	-	standard likkert: 1= I fully disagre
BINT_061_04		...plan to use blockchain within the next 5 years	Selfmade		
BINT_061_05		...plan to use blockchain within the next 10 years	Selfmade		
BINT_061_06		...expect I will use blockchain or a similar type of system for supply chain operations/management	Kamble, S., Gunasekaran, A	-	standard likkert: 1= I fully disagre

Demographics (DEM) section

	Control Variables				
DEM_variable_071_01	Gender		Wong, L.-W., Leong, L.-Y., H-		1 = Male; 2 = Female; 3 = Other
DEM_variable_071_02	Age	Years	Wong, L.-W., Leong, L.-Y., H-		1 = below 25; 2 = 25 - 34; 3 = 35 - 44
DEM_variable_071_03	Number of years with the organisation	Years	Wong, L.-W., Leong, L.-Y., H-		1= Less than 1; 2= 1 Between 1 and
DEM_variable_071_04	Which of the following best describe your present level of understanding on blockchain technology?		Wong, L.-W., Leong, L.-Y., H-		1 = Learning the technology; 2 = Te
DEM_variable_071_05	Age of firm	Years	Wong, L.-W., Leong, L.-Y., H-		1 = Less than 5; 2 = Between 5 and
DEM_variable_071_06	Numbers of employees within your organisation		Wong, L.-W., Leong, L.-Y., H-		1 = Less than 50; 2 = Between 50 ar
DEM_variable_071_07	In which branch does your organisation operate?		Selfmade	-	1 = Advice & Consultancy etc. etc.
DEM_variable_071_08	How would you rate the overall competitiveness within your market(s)		Selfmade	-	standard likkert: 1= Very low comp

Appendix B: Questionnaire in Dutch

Master Thesis Business Administration Survey B.H.S.P van Haren Final

Q1 Beste Heer/Mevrouw,

Hartelijk dank voor uw tijd en interesse voor dit onderzoek.

In dit onderzoek wordt er gekeken naar verschillende factoren die een prominente rol kunnen spelen als het gaat om de organisationele adoptie van blockchain tegen de achtergrond van vertrouwen en opportunisme in supply chain netwerken.

Voor het invullen van de vragenlijst is het geen vereiste dat u gedetailleerde kennis omtrent blockchain heeft, aangezien er een beroep wordt gedaan op uw kennis en werkervaring met betrekking tot supply chains. Het invullen van deze vragenlijst zal ongeveer 9 minuten duren.

Deelname aan dit onderzoek is geheel vrijwillig. U kunt op elk moment besluiten om te stoppen met deze vragenlijst, zonder hiervoor een reden te hoeven geven.

Alle persoonlijke data die wordt verzameld zal worden geanonimiseerd en daarmee zal de data niet teruggeleid kunnen worden tot individuen/bedrijven. De geanonimiseerde resultaten kunnen worden gebruikt voor wetenschappelijke publicaties.

Heeft u vragen over dit onderzoek, dan kunt u contact opnemen met Bryan van Haren (b.h.s.p.vanharen@student.utwente.nl) Master Student aan de Universiteit van Twente.

Q2 Mocht u niet bekend zijn met blockchain of uw geheugen willen opfrissen, dan kunt u hieronder een video bekijken waarin wordt uitgelegd wat blockchain is en hoe blockchain werkt.

Q3 Kunt u op basis van uw kennis en werkervaring aangeven in welke mate blockchain supply chain voordelen voor uw bedrijf zou kunnen opleveren met betrekking tot de onderstaande waardecreërende drijfveren die vanuit de wetenschappelijke literatuur zijn geïdentificeerd?

	Helemaal mee oneens (1)	Oneens (2)	Neutraal (3)	Eens (4)	Helemaal mee eens (5)
Transparantie (1)	o	o	o	o	o
Traceerbaarheid (2)	o	o	o	o	o
Veiligheid (3)	o	o	o	o	o
Desintermediatie (minder/geen tussenkomst van derde partijen) (4)	o	o	o	o	o

Onveranderbaarheid van data en versleuteling (5) o o o
o o

Automatisering (6) o o o o o

Kostenbesparingen (7) o o o o o

Het creëren van een betrouwbare omgeving (8) o o o
o o

Q4 Kunt u op basis van uw kennis en werkervaring aangeven in welke mate u denkt dat de volgende stellingen met betrekking tot de geïdentificeerde adoptiebarrières van blockchain van toepassing zijn op uw bedrijf?

Helemaal mee oneens (1) Oneens (2) Neutraal (3) Eens (4) Helemaal mee eens (5)

Betreffende de interoperabiliteit, ben ik van mening dat... ...blockchain niet verenigbaar is met onze eigen data systemen en/of die van onze supply chain partners. (1) o
o o o o

...blockchain niet verenigbaar is met onze bedrijfsactiviteiten en bedrijfsprocessen. (2) o
o o o o

Betreffende de schaalbaarheid van blockchain, ben ik van mening ik dat... ...de algehele snelheid van een blockchain transactie (7 transacties per seconde) niet adequaat is. (3) o
o o o o

...de algehele blokgrootte (1 Megabyte) niet degelijk is voor praktisch gebruik. (4) o
o o o o

Betreffende de collaboratieve supply chain inspanningen, ben ik van mening dat... ...de samenwerking met onze supply chain partner(s) om blockchain adoptie mogelijk te maken een ontmoedigend vooruitzicht is. (5) o o o o
o

...de samenwerking met onze supply chain partner(s) om blockchain adoptie mogelijk te maken teveel tijd en moeite in beslag zal nemen. (6) o o o
o o

Betreffende de beperkingen van de technologische infrastructuur, ben ik van mening dat... ...de huidige technologische structuur niet adequaat is voor blockchain. (7) o
o o o o

...de huidige internet service niet efficiënt genoeg is voor blockchain. (8) o o
o o o

...de toegang tot blockchain niet toereikend is. (9) o o o
o o

Betreffende blockchain's veiligheidsrisico's, ben ik van mening dat... ...ik me niet veilig voel als het gaat om het verstrekken van gevoelige bedrijfsinformatie wanneer met blockchain platformen wordt gewerkt. (10) o o o o o

...blockchain geen veilig platform is als het gaat om de algehele overdracht van gevoelige informatie. (11) o o o o o

Betreffende de beperkingen van de bestaande overheidsondersteuning, regelgeving en de wettelijke inkadering ten opzicht van blockchain, denk ik dat... ...de overheid nog geen relevant beleid heeft geïntroduceerd om blockchain adoptie te stimuleren. (12) o o o o o

...regelgevende instanties nog niet dermate erkend zijn om zich te mengen in blockchain gerelateerde problematiek/vraagstukken. (13) o o o o o

...de juridische structuren de blockchain gebruikers niet naar behoren beschermen als het gaat om problemen op blockchain platformen. (14) o o o o o

Q5 Kunt u op basis van uw kennis en werkervaring aangeven hoe u blockchain zou beoordelen met betrekking tot de gebruiksvriendelijkheid?

Helemaal mee oneens (1) Oneens (2) Neutraal (3) Eens (4) Helemaal mee eens (5)

Ik ben van mening dat... ...de functies van blockchain gemakkelijk te gebruiken zullen zijn. (1) o o o o o

...blockchain gemakkelijker te gebruiken zal zijn in vergelijking tot de conventionele praktijken van supply chain beheer. (2) o o o o o

...blockchain duidelijk en begrijpelijk is. (3) o o o o o

...het gemakkelijk voor me zal zijn om taken te onthouden en uit te voeren door het gebruik van blockchain. (4) o o o o o

Q6 Gegeven de waardecreërende drijfveren, adoptie barrières, en gebruiksvriendelijkheid van blockchain, zou u aan kunnen geven in welke mate u blockchain als bruikbaar/nuttig voor supply chains ervaart/inschat aan de hand van de volgende stellingen?

Helemaal mee oneens (1) Oneens (2) Neutraal (3) Eens (4) Helemaal mee eens (5)

Door blockchain te gebruiken... ...zouden transactie vertragingen geminimaliseerd kunnen worden. (1) o o o o o

...zou onze supply chain prestatie verbeterd kunnen worden. (2) o o o o o

...zou onze supply chain productiviteit verbeterd kunnen worden. (3) o o o o o

...zou onze supply chain effectiviteit verbeterd kunnen worden. (4) o o o o o

...zou het gemakkelijker worden om data te delen. (5) o o o o o

Q7 Kunt u op basis van uw kennis en werkervaring aangeven in welke mate u denkt dat blockchain beter is uitgerust voor supply chain management doeleinden in vergelijking met traditionele supply chain datasystemen?

Helemaal mee oneens (1) Oneens (2) Neutraal (3) Eens (4) Helemaal mee eens (5)

Blockchain is beter in staat om bedrijfsactiviteiten te completeren. (1) o o o o o

Blockchain levert meer efficiëntie op met betrekking tot bedrijfsactiviteiten en supply chain management (2) o o o o o

Blockchain kan het bedrijfsresultaat sneller verhogen. (3) o o o o o

Blockchain is nuttiger voor supply chain operaties en supply chain management. (4) o o o o o

Blockchain is handiger om operaties en de supply chain te beheren. (5) o o o o o

Q8 Naast factoren die vanuit een technologisch perspectief zijn opgeworpen, zijn er ook omgevingsfactoren die organisationele adoptie van blockchain kunnen beïnvloeden. Kunt u om te beginnen in onderstaande stellingen aangeven in hoeverre sociale invloed de mogelijke adoptie van blockchain in uw bedrijf beïnvloedt?

Helemaal mee oneens (1) Oneens (2) Neutraal (3) Eens (4) Helemaal mee eens (5)

Mijn collega's en/of supply chain partners zijn van mening dat het gebruiken van blockchain een verstandige keuze is. (1) o o o o o

Mensen die enigszins invloed hebben/kunnen uitoefenen op mijn gedragswijze, zijn van mening dat ik blockchain zou moeten gebruiken. (2) o o o o o

Mensen die belangrijk voor mij zijn en/of die hoog in mijn aanzien staan, zijn van mening dat ik blokchain zou moeten gebruiken. (3) o o o o o

Q9 Kunt u vervolgens aangegeven in hoeverre druk vanuit uw handelspartner(s) de mogelijke adoptie van blockchain in uw bedrijf beïnvloedt?

Helemaal mee oneens (1) Oneens (2) Neutraal (3) Eens (4) Helemaal mee eens (5)

De belangrijkste handelspartners in de supply chain van mijn bedrijf... ...moedigen de implementatie van blockchain aan. (1) o o o o o

...bevelen de implementatie van blockchain aan. (2) o o o o o

...verzoeken mij/ons om blockchain te implementeren. (3) o o o o o

Q10 Kunt u aangeven in hoeverre competitieve druk de mogelijke adoptie van blockchain in uw bedrijf beïnvloedt?

Helemaal mee oneens (1) Oneens (2) Neutraal (3) Eens (4) Helemaal mee eens (5)

Ik/Mijn bedrijf is van mening dat... ...we klanten kunnen verliezen als we geen gebruik maken van blockchain. (1) o o o o o

...het gebruik van blockchain om ons concurrentievermogen te vergroten belangrijk is ten tijde van het nemen van strategische beslissingen (2) o o o o o

...andere organisaties in onze branche onlangs zijn begonnen met het verkennen van blockchain. (3) o o o o o

Concurrentiële druk dwingt mijn bedrijf om blockchain te onderzoeken. (4) o o o o o

Q11 Kunt u op basis van uw kennis en werkervaring aangeven in hoeverre de faciliterende condities binnen uw bedrijf de adoptie van blockchain waarborgen?

Helemaal mee oneens (1) Oneens (2) Neutraal (3) Eens (4) Helemaal mee eens (5)

Mijn bedrijf heeft... ...de juiste middelen beschikbaar om blockchain te implementeren. (1) o o o o o

...de expertise voor blockchain in het geval dat technische assistentie benodigd is. (2) o o o o o

...de benodigde kennis voor het gebruik van blockchain. (3) o o o o o

Blockchain is verenigbaar met andere systemen die binnen mijn bedrijf worden gebruikt. (4) o o o o o

Q12 Kunt u op basis van uw kennis en werkervaring aangeven in welke mate uw bedrijf de mogelijkheid tot het delen van kennis met uw supply chain partner(s) aangrijpt met betrekking tot blockchain?

Helemaal mee oneens (1) Oneens (2) Neutraal (3) Eens (4) Helemaal mee eens (5)

Mijn bedrijf prefereert het delen van vakkennis, innovaties, en blockchain gebaseerde supply chain kennis met onze supply chain partner(s). (1) o o o o o

Mijn bedrijf prefereert het delen van relevante marktkennis en blockchain gebaseerde supply chain kennis met onze supply chain partner(s). (2) o o o o o

Mijn bedrijf deelt openlijk kennis over blockchain gebaseerde supply chain applicaties met onze supply chain partner(s). (3) o o o o o

Mijn bedrijf en onze supply chain partner(s) delen kennis over bockchain gebaseerde supply chain applicaties die helpen met het opzetten van bedrijfsplanning. (4) o o o o o

Q13 De laatste twee factoren die dit onderzoek includeert zijn de aanwezigheid van vertrouwen en opportunisme binnen supply chain netwerken. Kunt u op basis van uw kennis en werkervaring in de volgende stellingen aangeven in hoeverre u vertrouwen legt in het supply chain netwerk van uw bedrijf?

	Helemaal mee oneens (1)	Oneens (2)	Neutraal (3)	Eens (4)	Helemaal mee eens (5)
Ik ben van mening dat de supply chain partners van mijn bedrijf... ...geloofwaardig zijn. (1)	o	o	o	o	o
...voldoen aan de onderhandelde verplichtingen jegens mijn bedrijf. (2)	o	o	o	o	o
...betrouwbaar zijn. (3)	o	o	o	o	o
...zich houden aan de geest van een afgesloten overeenkomst. (4)	o	o	o	o	o
Ik ben van mening dat de werknemers van de supply chain partners van mijn bedrijf... ...zich houden aan hun beloften. (5)	o	o	o	o	o
...de onderling afgesloten verplichtingen nakomen. (6)	o	o	o	o	o

Q14 Kunt u op basis van uw kennis en werkervaring in onderstaande stellingen aangeven in hoeverre u opportunistisch gedrag in uw supply chain netwerk bemerkt?

	Helemaal mee oneens (1)	Oneens (2)	Neutraal (3)	Eens (4)	Helemaal mee eens (5)
Ik ben van mening dat één of meerdere van de supply chain partners van mijn bedrijf... ...hun behoeften overdrijven om te krijgen wat ze willen (1)	o	o	o	o	o
...niet altijd oprecht zijn als dit bevorderlijk is voor hun eigen doeleinden. (2)	o	o	o	o	o
...gegevens/feiten veranderen om zo hun eigen doelen en doelstellingen te bevorderen. (3)	o	o	o	o	o
...niet handelen vanuit een ter goeder trouw onderhandelingsperspectief. (4)	o	o	o	o	o
...formele en/of informele overeenkomsten schenden om zichzelf te bevoordelen. (5)	o	o	o	o	o

Q15 Kunt u aangeven in hoeverre u/uw bedrijf voornemens is om blockchain te adopteren?

Helemaal mee oneens (1) Oneens (2) Neutraal (3) Eens (4) Helemaal mee eens (5)

Ik/mijn bedrijf heeft het voornemen om in de komende maanden blockchain te gebruiken. (1) o o o o o

Ik voorspel dat ik/mijn bedrijf in de komende maanden blockchain zal gebruiken. (2) o o o o o

Ik/mijn bedrijf is van plan om in de komende maanden blockchain te gebruiken. (3) o o o o o

Ik/mijn bedrijf is van plan om binnen nu en 5 jaar blockchain te gebruiken (4) o o o o o

Ik/mijn bedrijf is van plan om binnen nu en 10 jaar blockchain te gebruiken (6) o o o o o

Ik verwacht dat ik/mijn bedrijf blockchain of een gelijkwaardig type datasysteem zal gebruiken voor supply chain operaties en/of management. (7) o o o o o

Q16 Tot slot enkele vragen met betrekking tot uzelf en uw bedrijf.

Q17 Wat is uw geslacht?

o Man (1)

o Vrouw (2)

o Anders (3)

Q18 Wat is uw leeftijd?

0 10 20 30 40 50 60 70 80 90 100

Jaren ()

Q19 Hoelang werkt u al voor uw bedrijf?

0 10 20 30 40 50 60 70 80 90 100

Jaren ()

Q20 Wat is de leeftijd van uw bedrijf?

____

Q21 Hoeveel personen werken er binnen uw bedrijf?

____

Q22 Kunt u, op basis van de door de KvK aangemerkte branches, aangeven tot welke branche uw bedrijf behoort?

o Advies en consultancy (1)

o Agrosector (2)

o Bouw, installatie en infrastructuur (3)

o Cultuur en sport (4)

o Delfstoffen (5)

o Energie (6)

o Financiële dienstverlening (7)

o Gezondheidszorg en maatschappelijke dienstverlening (8)

o Autohandel, groothandel en detailhandel (9)

o Horeca (10)

o ICT, media en communicatie (11)

o Industrie (12)

o Onderwijs en training (13)

o Onroerend goed (14)

o Persoonlijke dienstverlening en not-for-profit (15)

o Vervoer, post en opslag (16)

o Water en afval (17)

o Zakelijke dienstverlening (18)

Q23 Hoe zou u de competitiviteit van uw markt classificeren?

- o Zeer lage competitiviteit (1)
- o Lage competitiviteit (2)
- o Gemiddelde competitiviteit (3)
- o Hoge competitiviteit (4)
- o Zeer hoge competitiviteit (5)

Q24 Welke van de volgende niveaus komt bij benadering het beste overeen met uw huidige begrip en kennis van blockchain technologie?

- o Aan het leren over blockchain (1)
- o Blockchain aan het testen (2)
- o Blockchain aan het implementeren (3)
- o Blockchain aan het gebruiken (4)
- o Geen voorkennis over blockchain (5)

Q25 Kunt u tot slot aangeven of u genoeg kennis had om alle vragen in de vragenlijst te kunnen beantwoorden?

- o Helemaal mee eens (1)
- o Eens (4)
- o Neutraal (5)
- o Oneens (6)
- o Helemaal mee oneens (7)

Q26 Heeft u nog extra opmerkingen met betrekking tot deze vragenlijst, dan kunt u dat hieronder aangeven.

____

Q27 Mocht u geïnteresseerd zijn in de resultaten van dit onderzoek, dan kunt u uw emailadres hieronder achterlaten.

____

Appendix C: Indicator reliability loadings

Latent Variable	Indicators	Loadings	Indicator reliability
Competitive Pressure	Comp_pres_1	0.839	0.70
	Comp_pres_2	0.876	0.77
	Comp_pres_3	0.811	0.66
	Comp_pres_4	0.846	0.72
Ease of use	Ease_use_1	0.742	0.55
	Ease_use_2	0.819	0.67
	Ease_use_3	0.832	0.69
	Ease_use_4	0.827	0.68
Facilitating conditions	Fac_con_1	0.739	0.55
	Fac_con_2	0.846	0.72
	Fac_con_3	0.898	0.81
	Fac_con_4	0.821	0.67
Intention to	Int_adop_1	0.908	0.82
adopt blockchain	Int_adop_2	0.898	0.81
	Int_adop_3	0.895	0.80
	Int_adop_4	0.858	0.74
	Int_adop_5	0.767	0.59
	Int_adop_6	0.784	0.61
Knoweldge sharing	Know_shar_1	0.824	0.68
	Know_shar_2	0.815	0.66
	Know_shar_3	0.894	0.80
	Know_shar_4	0.818	0.67
Opportunism in	Opport_1	0.645	0.42
supply chain network	Opport_2	0.752	0.57
	Opport_3	0.590	0.35
	Opport_4	0.846	0.72
	Opport_5	0.650	0.42
Perceived usefulness	Per_useful_1	0.751	0.56
	Per_useful_2	0.845	0.71
	Per_useful_3	0.711	0.51
	Per_useful_4	0.872	0.76
	Per_useful_5	0.727	0.53
Social influence	Soc_infl_1	0.903	0.82
	Soc_infl_2	0.905	0.82
	Soc_infl_3	0.919	0.85
Trading partner pressure	Trad_pres_1	0.921	0.85
	Trad_pres_2	0.955	0.91
	Trad_pres_3	0.883	0.78
Trust in supply	Trust_1	0.758	0.57
chain network	Trust_2	0.859	0.74
	Trust_3	0.856	0.73
	Trust_4	0.832	0.69
	Trust_5	0.715	0.51
	Trust_6	0.795	0.63

Appendix D: Rotated component matrix

Rotated Component Matrix[a]

	Component							
	1	2	3	4	5	6	7	8
Opport_1	-0,051	0,469	-0,438	0,363	-0,147	-0,088	0,044	0,145
Opport_2	-0,245	0,383	-0,406	0,251	-0,278	-0,186	0,100	-0,048
Opport_3	-0,230	0,771	0,102	0,153	0,031	-0,089	-0,128	-0,060
Opport_4	-0,342	0,471	-0,228	-0,066	0,031	-0,523	0,297	-0,082
Opport_5	-0,212	0,794	-0,022	-0,094	0,023	-0,102	0,079	-0,129
Trust_1	0,752	-0,138	0,107	0,083	-0,092	0,144	-0,288	0,100
Trust_2	0,787	-0,209	-0,049	0,179	0,104	0,082	0,167	-0,134
Trust_3	0,871	0,081	-0,002	0,053	-0,016	0,150	0,058	-0,110
Trust_4	0,742	-0,361	0,258	0,041	0,074	-0,114	-0,046	0,126
Trust_5	0,790	-0,059	0,138	-0,084	-0,247	-0,076	0,053	0,078
Trust_6	0,721	-0,368	0,020	0,010	0,135	0,068	0,207	-0,181
Adop_bar_1	0,055	-0,138	0,158	0,006	0,159	0,826	0,179	0,213
Adop_bar_2	-0,010	-0,024	0,616	0,196	-0,012	0,462	0,217	-0,191
Adop_bar_3	0,034	-0,583	-0,156	0,476	-0,034	-0,014	0,160	0,058
Adop_bar_4	0,151	-0,425	-0,060	0,339	0,187	-0,128	0,575	-0,153
Adop_bar_5	0,036	0,057	0,179	0,017	-0,030	0,272	0,829	0,278
Adop_bar_6	0,189	-0,046	-0,091	0,195	0,439	0,448	0,421	-0,054
Adop_bar_7	-0,043	-0,008	-0,044	0,139	0,873	0,125	0,020	0,024
Adop_bar_8	-0,150	0,043	0,237	-0,079	0,682	-0,033	0,065	0,508
Adop_bar_9	-0,029	-0,180	-0,057	0,150	0,126	0,185	0,111	0,867
Adop_bar_10	0,087	0,111	0,827	0,064	0,051	-0,073	-0,035	0,165
Adop_bar_11	0,164	0,021	0,834	0,033	-0,069	0,152	0,054	-0,064
Adop_bar_12	0,153	-0,011	0,128	0,881	0,028	0,088	0,068	-0,178
Adop_bar_13	0,107	0,056	-0,026	0,869	0,091	0,095	-0,028	0,224
Adop_bar_14	-0,173	-0,103	0,357	0,529	0,162	-0,112	0,223	0,302

Appendix E: New rotated component matrix with the removal of the indicator Opport_2

Rotated Component Matrix[a]

	Component							
	1	2	3	4	5	6	7	8
Opport_1	-0,065	0,443	0,395	-0,442	-0,142	-0,117	0,054	0,125
Opport_3	-0,239	0,765	0,186	0,097	0,031	-0,110	-0,108	-0,067
Opport_4	-0,349	0,434	-0,052	-0,218	0,042	-0,557	0,277	-0,090
Opport_5	-0,220	0,788	-0,060	-0,029	0,022	-0,134	0,101	-0,135
Trust_1	0,755	-0,126	0,072	0,111	-0,078	0,168	-0,293	0,097
Trust_2	0,787	-0,209	0,181	-0,057	0,100	0,075	0,165	-0,136
Trust_3	0,869	0,094	0,071	-0,018	-0,026	0,142	0,075	-0,113
Trust_4	0,749	-0,358	0,019	0,264	0,077	-0,093	-0,067	0,134
Trust_5	0,792	-0,054	-0,083	0,135	-0,246	-0,071	0,049	0,074
Trust_6	0,725	-0,363	0,003	0,013	0,129	0,068	0,200	-0,176
Adop_bar_1	0,059	-0,124	-0,003	0,154	0,176	0,825	0,212	0,207
Adop_bar_2	-0,007	-0,021	0,192	0,613	-0,003	0,457	0,237	-0,193
Adop_bar_3	0,034	-0,624	0,442	-0,130	0,006	-0,010	0,114	0,041
Adop_bar_4	0,152	-0,468	0,319	-0,046	0,207	-0,151	0,539	-0,162
Adop_bar_5	0,036	0,039	0,030	0,167	-0,030	0,229	0,852	0,265
Adop_bar_6	0,188	-0,056	0,196	-0,094	0,449	0,420	0,435	-0,060
Adop_bar_7	-0,040	-0,019	0,119	-0,029	0,895	0,121	0,004	0,031
Adop_bar_8	-0,144	0,051	-0,084	0,234	0,674	-0,033	0,066	0,521
Adop_bar_9	-0,027	-0,178	0,152	-0,066	0,118	0,187	0,124	0,863
Adop_bar_10	0,093	0,107	0,047	0,841	0,072	-0,060	-0,047	0,166
Adop_bar_11	0,170	0,031	0,027	0,833	-0,060	0,160	0,058	-0,064
Adop_bar_12	0,148	-0,050	0,876	0,139	0,038	0,080	0,064	-0,183
Adop_bar_13	0,099	0,034	0,885	-0,034	0,075	0,087	-0,012	0,223
Adop_bar_14	-0,171	-0,121	0,528	0,352	0,135	-0,115	0,231	0,316

Appendix F: New indicator reliability loading for opportunism in supply chain network

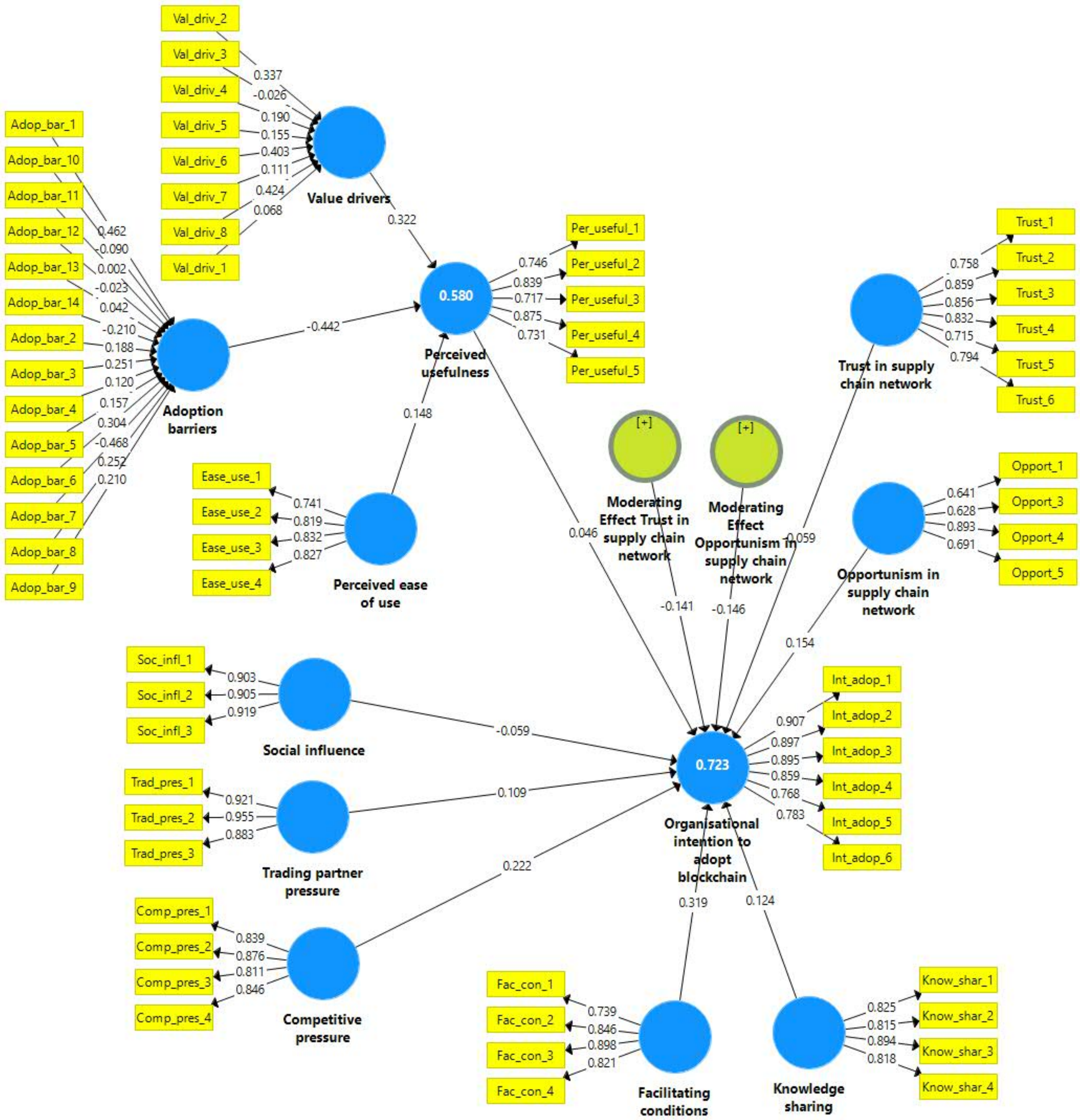
Latent Variable	Indicators	Loadings	Indicator reliability
Opportunism in supply chain network	Opport_1	0.641	0.41
	Opport_3	0.628	0.39
	Opport_4	0.893	0.79
	Opport_5	0.691	0.48

Appendix G: New Cronbach's Alpha, Composite Reliability, and Variance Extracted of opportunism in supply chain network

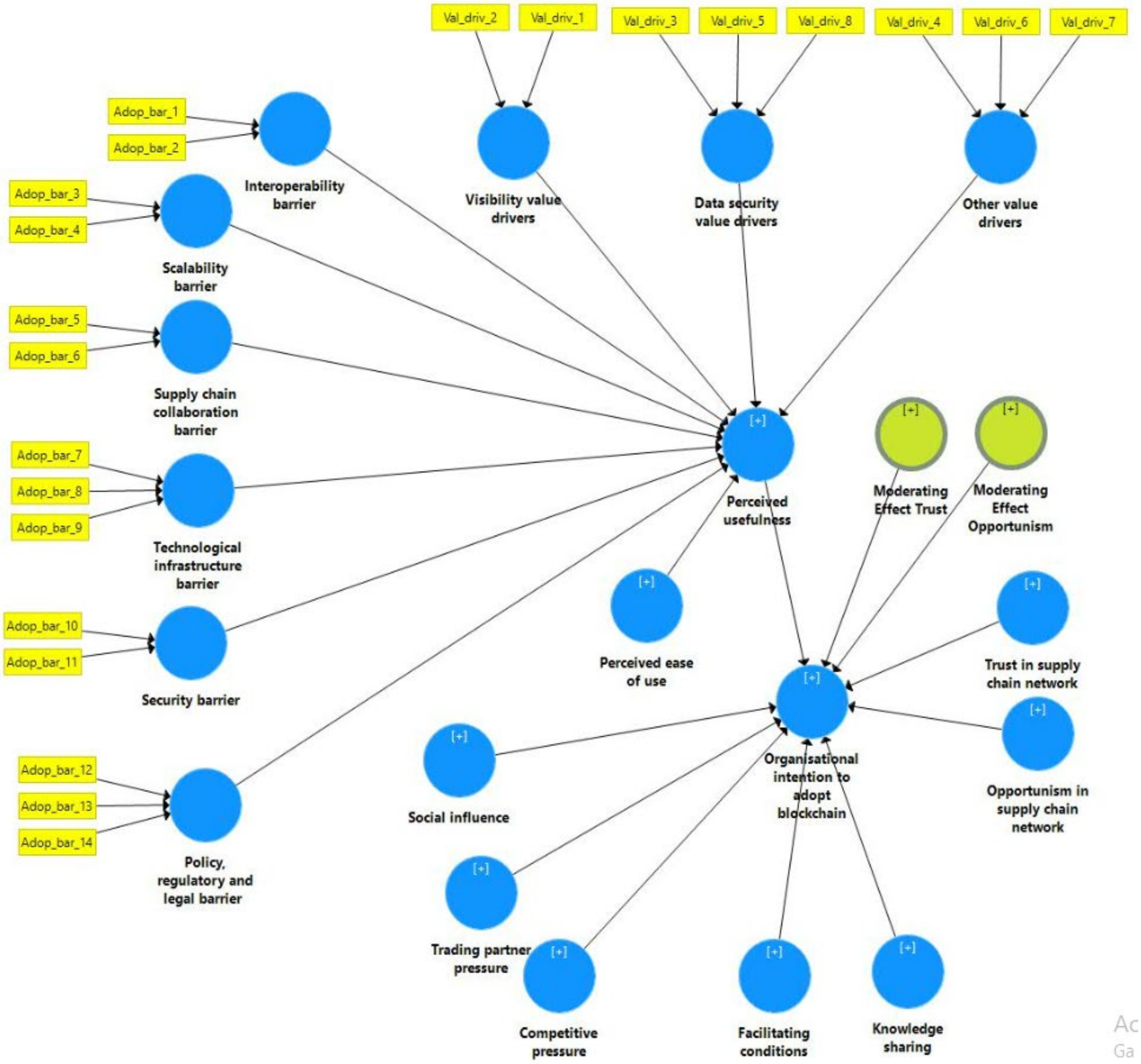
	Cronbach's Alpha	Composite Reliability	AVE
Opportunism in supply chain network	0.721	0.809	0.520

Appendix H: Constructed PLS Model

Appendix I: Structured equation modelling results



Appendix J: PLS model with grouped indicators for the constructs value drivers and adoption barriers



Appendix K: Bootstrapping output of grouped indicators of value drivers and adoption barriers

	Original Sample	Sample Mean	Std. Dev.	T-Statistics	P-Values
Competitive pressure_ -> Organisational intention to adopt blockchain_	0.214	0.198	0.113	1.902	0.057
Data security value drivers -> Perceived usefulness	0.267	0.244	0.136	1.961	0.050
Facilitating conditions_ -> Organisational intention to adopt blockchain_	0.325	0.334	0.111	2.925	0.003
Interoperability barrier_ -> Perceived usefulness	-0.350	-0.320	0.104	3.362	0.001
Knowledge sharing -> Organisational intention to adopt blockchain_	0.111	0.103	0.134	0.830	0.407
Moderating Effect Opportunism -> Organisational intention to adopt blockchain_	-0.034	-0.027	0.095	0.360	0.719
Moderating Effect Trust_ -> Organisational intention to adopt blockchain_	-0.063	-0.085	0.081	0.779	0.436
Opportunism in supply chain network__ -> Organisational intention to adopt blockchain_	0.160	0.159	0.095	1.679	0.093
Other value drivers_ -> Perceived usefulness	0.277	0.259	0.109	2.544	0.011
Perceived ease of use -> Perceived usefulness	0.194	0.215	0.133	1.459	0.145
Perceived usefulness -> Organisational intention to adopt blockchain_	0.116	0.135	0.113	1.022	0.307
Policy, regulatory and legal barrier -> Perceived usefulness	0.046	0.028	0.142	0.324	0.746
Scalability barrier -> Perceived usefulness	0.090	0.085	0.121	0.745	0.456
Security barrier_ -> Perceived usefulness	0.184	0.154	0.132	1.401	0.161
Social influence_ -> Organisational intention to adopt blockchain_	0.009	0.007	0.121	0.074	0.941
Supply chain collaboration barrier -> Perceived usefulness	-0.152	-0.128	0.113	1.342	0.180
Technological infrastructure barrier -> Perceived usefulness	-0.001	-0.038	0.122	0.009	0.993
Trading partner pressure -> Organisational intention to adopt blockchain_	0.129	0.132	0.105	1.224	0.221
Trust in supply chain network -> Organisational intention to adopt blockchain_	-0.039	-0.041	0.096	0.403	0.687
Visibility value drivers -> Perceived usefulness	0.080	0.090	0.108	0.745	0.456

Appendix L: Bootstrapping output of technological factors also influencing organisational intention to adopt blockchain

	Original Sample	Sample Mean	Std. Dev.	T-Statistics	P-Values
Adoption barriers -> Organisational intention to adopt blockchain_	-0.298	-0.357	0.128	2.328	0.010
Adoption barriers -> Perceived usefulness	-0.387	-0.416	0.114	3.405	0.000
Competitive pressure_ -> Organisational intention to adopt blockchain_	0.183	0.167	0.112	1.629	0.052
Facilitating conditions_ -> Organisational intention to adopt blockchain_	0.169	0.161	0.125	1.357	0.088
Knowledge sharing -> Organisational intention to adopt blockchain_	0.171	0.155	0.119	1.438	0.075
Moderating Effect Opportunism -> Organisational intention to adopt blockchain_	-0.062	-0.032	0.103	0.603	0.273
Moderating Effect Trust in supply chain network_ -> Organisational intention to adopt blocl	-0.130	-0.094	0.158	0.826	0.205
Opportunism in supply chain network_ -> Organisational intention to adopt blockchain_	0.098	0.092	0.095	1.032	0.151
Perceived ease of use -> Organisational intention to adopt blockchain_	-0.094	-0.075	0.117	0.807	0.210
Perceived ease of use -> Perceived usefulness	0.164	0.169	0.103	1.591	0.056
Perceived usefulness -> Organisational intention to adopt blockchain_	0.022	-0.023	0.119	0.181	0.428
Social influence_ -> Organisational intention to adopt blockchain_	-0.020	-0.021	0.128	0.155	0.438
Trading partner pressure -> Organisational intention to adopt blockchain_	0.110	0.083	0.121	0.909	0.182
Trust in supply chain network -> Organisational intention to adopt blockchain_	-0.057	-0.053	0.092	0.618	0.269
Value drivers_ -> Organisational intention to adopt blockchain_	0.037	0.047	0.111	0.332	0.370
Value drivers_ -> Perceived usefulness	0.337	0.334	0.130	2.594	0.005

Appendix: M: Bootstrapping output of technological factors separated from each other and thusly only directly influencing organisational intention to adopt blockchain

	Original Sample	Sample Mean	Std. Dev.	T-Statistics	P-Values
Adoption barriers -> Organisational intention to adopt blockchain_	-0.363	-0.424	0.112	3.232	0.001
Competitive pressure_ -> Organisational intention to adopt blockchain_	0.163	0.140	0.095	1.717	0.043
Facilitating conditions_ -> Organisational intention to adopt blockchain_	0.146	0.132	0.120	1.218	0.112
Knowledge sharing -> Organisational intention to adopt blockchain_	0.199	0.183	0.102	1.949	0.026
Moderating Effect Opportunism -> Organisational intention to adopt blockchain_	-0.052	-0.032	0.091	0.569	0.285
Moderating Effect Trust in supply chain network_ -> Organisational intention to adopt blocl	-0.104	-0.074	0.130	0.802	0.212
Opportunism in supply chain network_ -> Organisational intention to adopt blockchain_	0.067	0.053	0.084	0.799	0.212
Perceived ease of use -> Organisational intention to adopt blockchain_	-0.077	-0.066	0.105	0.733	0.232
Perceived usefulness -> Organisational intention to adopt blockchain_	0.073	0.057	0.094	0.780	0.218
Social influence_ -> Organisational intention to adopt blockchain_	-0.089	-0.091	0.110	0.810	0.209
Trading partner pressure -> Organisational intention to adopt blockchain_	0.106	0.085	0.104	1.017	0.155
Trust in supply chain network -> Organisational intention to adopt blockchain_	-0.064	-0.053	0.083	0.772	0.220
Value drivers_ -> Organisational intention to adopt blockchain_	0.061	0.083	0.087	0.696	0.243

Appendix N: Bootstrapping output of the model with the construct opportunism in supply chain set to only include indicator values above 2.75

	Original Sample	Sample Mean	Std. Dev.	T-Statistics	P-Values
Adoption barriers -> Perceived usefulness	-0.442	-0.505	0.100	4.441	0.000
Competitive pressure_ -> Organisational intention to adopt blockchain_	0.219	0.214	0.113	1.937	0.026
Facilitating conditions_ -> Organisational intention to adopt blockchain_	0.310	0.321	0.112	2.757	0.003
Knowledge sharing -> Organisational intention to adopt blockchain_	0.107	0.084	0.127	0.839	0.201
Moderating Effect Opportunism -> Organisational intention to adopt blockchain_	-0.062	-0.023	0.096	0.640	0.261
Moderating Effect Trust in supply chain network_ -> Organisational intention to adopt blocl	-0.119	-0.077	0.171	0.695	0.244
Opportunism in supply chain network_ -> Organisational intention to adopt blockchain_	0.159	0.150	0.093	1.719	0.043
Perceived ease of use -> Perceived usefulness	0.148	0.131	0.082	1.790	0.037
Perceived usefulness -> Organisational intention to adopt blockchain_	0.088	0.093	0.098	0.897	0.185
Social influence_ -> Organisational intention to adopt blockchain_	-0.007	-0.009	0.120	0.057	0.477
Trading partner pressure -> Organisational intention to adopt blockchain_	0.131	0.121	0.104	1.267	0.103
Trust in supply chain network -> Organisational intention to adopt blockchain_	-0.049	-0.040	0.097	0.502	0.308
Value drivers_ -> Perceived usefulness	0.322	0.327	0.096	3.353	0.000