Chapter

The Significance of Blockchain Governance in Agricultural Supply Networks

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Abstract

Firms in the agri-food sector have started implementing blockchain technology to both provide transparency over the supply chain transactions and to make trust attributes visible to consumers. Besides the well-known public blockchains such as Bitcoin and Ethereum, private- and consortium-type blockchain platforms exist. The latter ones are being operated in the agri-food ecosystem contributing to the vertically cooperated supply networks that are coordinated by a focal firm. Stakeholders' attitude and behavioral intentions toward the use of the blockchain technology impact their use behavior. The results show that permissioned blockchain governance mechanisms with consensus and incentives to motivate stakeholders are lacking in private and consortium blockchains. This study closes a research gap as understanding how the stakeholder management approach can compensate for the lack of consensus mechanisms can provide managerial guidance toward the development of an effective stakeholder management strategy, which eventually can be provided for a competitive advantage. As there is little research on the role of blockchain as a novel governance mechanism, this research will contribute to the scholarly discussion toward a common understanding.

Keywords: vertical coordination, blockchain, governance, stakeholder management, food industry

1. Introduction

Blockchain technology is a meta-technology that has the potential to change business models and supply chain networks (SCN) in the agri-food industry. Based on a distributed computing architecture, the blockchain protocol in its current form enables the provision of provenance information as well as tracking and tracing to support supply chain management. Recently its implementation in vertically cooperated food supply chains (FSC) has started. FSCs are typically managed centrally with a focal firm being responsible for the coordination of the network [1]. Sensitized by food poisoning cases, consumers nowadays require provenance information and transparency about the production of the food item [2]. Early adopters in the coffee industry are therefore building on blockchain technology (BCT) solutions to provide better visibility about the journey of the coffee product in their supply chain [3]. It has been demonstrated that the application of BCT to provide tracking, tracing and provenance information will result in increased consumer trust [4]. As a result, traceability of food products is becoming a competitive differentiator in the agri-food industry [5].

Since the first Bitcoin block has been minted in 2009 distributed ledger technologies (DLT) such as blockchain have gained rapid acceptance. Oftentimes DLT and BCT are used interchangeably. For purposes of this article, we will continue using the publicly used term "blockchain" respectively "BCT", although blockchain is a category of DLT. We will further use this term synonymously to describe a decentralized, public, and permissionless network. BCT has the potential to develop into a general-purpose technology with the outlook to fundamentally change the economy and society alike. Its decentralized and distributed digital ledger enables secure and trustful peer-to-peer transactions. It is the underlying technology for cryptocurrencies such as Bitcoin and also the basis for the tokenized economy, publicly referred to Web 3. Blockchain relies on the participation of many stakeholders in the decision-making process, in contrast to today's governance in hierarchical organized firms.

In general terms governance refers to the rules and processes of a control system that is used to manage and supervise how stakeholders interact within an organization, a firm, a state, or within an information technology (IT) based network. As such, governance can be seen as a form of regulation that supports the achievement of objectives [6]. The rules of governance coordinate decision-making processes between stakeholders. Governance systems provide for risk mitigation and are also implemented in digital ledger technologies such as BCT [7]. Blockchain as a software protocol enables a new governance infrastructure and its decentralized governance mechanisms involve multiple stakeholders rather than a single authority. Its governance is a self-regulating system that is based on a digital network. Until now, a generally accepted definition of blockchain governance has not yet been agreed upon. As in organizations and firms, decision-making and economic incentives are key attributes of BCT governance [7].

The purpose of decentralized peer-to-peer (P2P) networks is to eliminate the central decision-making authority. Rather than exercising authority by assignment, in decentralized networks authority is exercised by the engagement and experience of the stakeholders. Decisions are being coordinated through consensus mechanisms by the participating entities, by a single entity, or a set of a few entities that have been assigned to perform governance tasks. Consensus in broad terms is an agreement that is being made between various parties. The permissionless consensus mechanism in the cryptocurrency Bitcoin provides for verification of transactions stored in a block. As such, consensus is a confirmation on the status of the cryptocurrency network which leads to a subsequent update of all networked ledgers. Consensus mechanisms are therefore the foundation of the digital trust mechanism in BCT.

The type of governance exercised, and the associated consensus mechanism depend on the type of the blockchain technology platform type (BCTPT) with their varying coordination mechanisms [8]. Governance based on consensus mechanisms such as Proof-of-Work (POW) used with Bitcoin or with the current Ethereum platform[1] to validate transactions can be exercised on-chain (algorithmic, mathematical) or off-chain (human interaction, network policies). We will focus in this article on off-chain rather than on on-chain governance as the behavioral intentions, i.e., the perceived likelihood that supply chain stakeholders will exhibit a certain behavior, is key to our research.

[1] As the result of a governance decision Ethereum is currently in the process of swapping the Proof-of-Work consensus mechanism to the energy efficient Proof-of-Stake mechanism.

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The research is based on an exploratory case study of the premium coffee producer Solino Coffee based in Germany and Ethiopia. The case study has been selected by purpose due to its uniqueness and because it provides for insights about the influence of instrumental stakeholder management on technology adoption behavior. [2]

The aim of this research is twofold: first, we analyze how the stakeholder management approach impacts use behavior of stakeholders towards adoption of blockchain technology in the absence of permissioned consensus mechanisms in private and consortium BCTPT in vertically coordinated Food Supply Chain (FSC) networks. We want to gain an understanding, how the stakeholder management approach compensates for the lack of involvement in the consensus process. Second, we provide an analysis of the factors influencing blockchain technology adoption behavior of stakeholders in vertically coordinated FSC networks. The article is organized as follows: part 2 explains the research methodology we employed. In part 3 we elaborate on vertical coordination in the agri-food supply chain based on network theory. The theoretical foundation of the research is further built on instrumental stakeholder theory, as well as on technology adoption theory. Part 4 provides for a general blockchain technology overview and discusses the different blockchain technology platform types. Part 5 introduces governance in blockchain and refers to the different governance types that are being exercised. In the subsequent part 6 we introduce the model that determines the technology adoption behavior of stakeholders in the coffee supply chain. Part 7 describes the coffee supply chain case study our research is based on. With part 8 we provide a summary of the results and a discussion on our empirical findings. Eventually, we conclude the article with part 9 and provide guidance in terms of possible directions of future research. The objective is to investigate on the following research questions:

RQ 1: Which governance types apply to the different blockchain technology platforms?

RQ2: How is stakeholder engagement affected by governance mechanisms?

RQ3: How does the stakeholder management approach impact use behavior of stakeholders?

2. Methodology

The research methodology we followed is based on three pillars: an extensive literature review concerning BCT in vertically coordinated agri-food supply chains including network and technology adoption theory, a quantitative survey, and expert interviews. In addition, we have been, and we still are involved, in ongoing discussions with operators of BCT solutions. These operators have first practical experiences with the operationalization of BCT for the purpose of provision of tracking and tracing as well as of provenance information in agri-food SCNs. Based on the theories we have constructed a blockchain technology adoption model. Our proposed model combines principles of technology adoption, economics, and social psychology to investigate the behavioral intention of individual stakeholders in the coffee FSC towards BCT adoption.

Empirical data has been derived from an explorative case study of the premium coffee producer Solino Coffee based in Germany and Ethiopia which provides empirical insights into the applicability of the proposed model of technology

[2] The authors of the current paper contributed to the case study-based article "Nothing else matters: Blockchain technology adoption behavior of stakeholders in rural areas" which has been submitted in June 2021 [9].

adoption behavior. The production facility of Solino Coffee is located in the Ethiopian capital of Addis Abeba. As a few early adopters in the coffee industry have just implemented and operationalized BCT to enhance their supply chain, this is the earliest possible point in time to conduct research with the objective of obtaining meaningful results. Quantitative data has been collected through online interviews and qualitative data through expert interviews. Our online questionnaire methodologically follows the Reasoned Action Approach [10]. The questionnaire is based on five factors determining usage behavior and behavioral intention.

This case study has been selected by purpose due to its uniqueness and because it provides insights into the influencing factors of instrumental stakeholder management on technology adoption behavior.

3. Literature review

3.1 Attributes of agri-food supply chain networks

Food supply networks in the agri-food business are typically managed centrally with a focal firm being responsible for the decisions relating to the coordination of the network [11]. The networks have been classified as strategic networks where the focal firm is responsible for all attributes of the food item in the network [11]. Attributes of strategic networks are the hierarchical coordination through a focal firm, the intensity of relations, and the coordination mechanisms. Strategic networks are mainly organized in a pyramidal-hierarchical structure, in which a focal firm acts as the centralized decision-making authority which coordinates the network. The focal firm also sets the strategy and aligns the actions in the network [12]. Strategic networks are characterized as long-term relationships of power and trust through which organizations exchange influence and resources between at least two or more actors in the network. Furthermore, strategic networks can be seen as a construct of long-lasting inter-organizational links which have a strategic significance for the participating firms [13]. Gulati showed that coordination and cooperation are two important means for the management of vertical relationships [14].

3.2 Coordination mechanisms

Coordination can be understood as the alignment of actions to mutually achieve goals between intentionally chosen partners. Coordination problems arise if actors are not aware that their actions are interdependent or that there is uncertainty about others' rationality so that one does not know how others will act. Thus, problems of coordination are the result of the lack of shared and accurate knowledge about the decision rules that others are likely to use, and how one's actions are interdependent on those of the others [15]. There are formal (including programming, hierarchy, and feedback) and informal mechanisms (leadership, norms, culture, shared values and experience, trustworthiness, and a shared strategy) to overcome coordination problems [16]. Cooperation refers to the alignment of interests between the partners in which the intended scope of the relationship is laid out. Thus, problems of cooperation accrue from conflicts of interests because self-interested individuals optimize their benefits before they strive for collectively beneficial outcomes [13]. Formal mechanisms such as contracting, common ownership of assets, monitoring, sanctions, prospects of future interactions and informal mechanisms such as identification and embeddedness can be used to overcome the problem of motivation.

Coordination mechanisms in food supply chain management can be broadly divided into six groups: power, contractual relationships, information sharing, joint decision-making, collective learning, and building routines [17, 18]. In addition, Pietrwicz examined consensus building as well as coding and executing smart contracts as coordination mechanisms for online transactions [19]. Cooperation and coordination therefore need to be seen as two indispensable parts of the supply chain collaboration. For an efficient management of vertically cooperated FSC, it is necessary to manage both mechanisms simultaneously [1] where the key objective of the participating supply chain stakeholders is to provide the end customer with the products and services that are being demanded.

3.3 Blockchain as a trust technology

Vertical cooperation in the food industry is driven by trust attributes such as food quality, provenance, and safety [11]. In a pyramidal–hierarchic organization, decisions are made by the focal firm, which is responsible for the strategic direction of the SCN. According to Ketchen and Hult, intermediaries and agencies in supply networks increase the potential for abusing power and intentionally take advantage of the SCN, which is the result of a single decision authority [20]. According to Belaya and Hanf power can be used as an effective coordination mechanism in the FSC operating in centralized ecosystems. [21]. However, power could also be applied to the advantage of the network to solve issues and problems in supply networks [22]. The level of decision-making power applied to the supply network is critical for its efficiency, with a higher degree of control resulting in an increase in supply network value. It has also been proven to impact the management of highly interconnected networks, where the supply network performance suffers less with higher control applied [23]. A trust attribute of BCT is that blockchain is consensus safe as transactions can only be executed when the majority of participants verify them. Consensus is an agreement that is being made between various parties when participating entities reliably and efficiently verify transaction attributes [24]. The decentralization nature of a blockchain system impacts the level of control as well as the decision-making [24]. BCT is performing decision-making through consensus about the contents and validity of transactions as an aspect of coordination. In a decentralized network, decisions are made by the joint consensus of the participating entities. In public BCTPT decision-making is typically performed through mass consensus. In private BCTPT a single ruling entity performs the decisions alone; in consortium platform types authorized participants perform the decisions. As a result, based on the BCT platform, different consensus algorithms apply [8]. The founder of Ethereum blockchain, a public BCTPT provided a detailed explanation of the consensus algorithm: "*The purpose of a consensus algorithm, in general, is to allow for the secure updating of a state according to some specific state transition rules, where the right to perform the state transitions is distributed among some economic set. An economic set is a set of users which can be given the right to collectively perform transitions via some algorithm, and the important property that the economic set used for consensus needs to have is that it must be securely decentralized - meaning that no single actor, or colluding set of actors, can take up the majority of the set, even if the actor has a fairly large amount of capital and financial incentive.*" [25].

BCT is a trust technology through the application of its attributes of transparency, integrity of data, and immutability [26]. It enables the sharing of product trust attributes with consumers, making supply chain activities more transparent [3, 27]. BCT with its trust attributes consensus, immutability of data, cryptographic security, and transparency could create a new trust platform for business transactions as the application of disruptive technologies such as BCT to the agri-food supply chain management can increase trust by generating closer relationships between the firms [28].

3.4 Instrumental stakeholder theory

As part of his instrumental stakeholder theory Freeman defines a stakeholder as “any group or individual who can affect or is affected by the achievement of the organization’s objectives” [29]. Freeman views his theory to be used in the realm of management’s strategic decision making. The traditional instrumental stakeholder theory focusses specifically on independent, dyadic relationships whereas a newer strand argues that organizations are represented by a complex network of horizontal and vertical relationships [30, 31]. Following the instrumental stakeholder theory successful cooperation between management and stakeholders provides for a competitive advantage. Understanding the factors influencing behavioral intentions of stakeholders while using BCT can provide guidance as to what extent management can support and motivate stakeholders in using the technology, which eventually can provide for a more efficient use of the technology. This in turn could result in a distinct competitive advantage for the firm. When management introduces new technologies, they can be faced on one hand with the challenges that accompany the pure technical implementation but on the other hand more importantly they can be confronted with stakeholder resistance, unwanted attitudes towards usage, and potential anxiety of the users. The latter is the reason why we chose to analyze the behavioral intentions of stakeholders towards adopting and using BCT and putting this into perspective to the chosen stakeholder management approach, especially against the background of the novelty level of BCT. Employees in an organization can use their power and resist to changes through forms of behavior that do not support the objectives of the organization. It is therefore imperative that management must be aware of the stakeholders’ attitudes and behavioral intentions towards the usage of new technology. Lazzarini et al. show that the normative path of stakeholder theory can lead to a strong commitment of the organization in adhering to the strategies that have been set by management [32]. The normative view of stakeholder theory focusses on the state that should be achieved. Management and stakeholders therefore need to take each other’s objectives, motivations, intentional behaviors, and concerns into account to jointly strive for the envisioned economic rent of the firm. Consequently, management has to ensure that affected stakeholders accept and adopt the novel technology in order to achieve the expected economic rent. Stakeholder theory has been argued to be descriptive, which is the collaboration amongst stakeholders, instrumental, which assesses stakeholder management conduct and supply chain performance, and normative, which describes the attitudes of the firm towards its stakeholders. All three attributes support each other and are based on a normative foundation focusing on the value of economic fairness and corporate social responsibility (CSR) or on factors determining what an economy should represent [33]. To be economically successful and outperform their peers, firms should also enter into contractual agreements with their stakeholders following the instrumental stakeholder theory [34]. This coincides with the strategic value chain approach which views the value chain as a single solution improving the competitive position by putting the customer and their expectations first, to improve the overall chain performance [35]. Consequently, the development of close ties between the firm and its stakeholders has the potential to result in sustaining competitive advantage [36] As the actions of stakeholders in the supply chain affect the value of an asset, BCT must be accepted, adopted and used by users to gain productivity advantages [37] Stakeholders should have control over the asset e.g., over the BCT, to maximize their utility and satisfaction. Stakeholder theory asks managers to understand the needs, motivations, and interests of stakeholders and also factor in their experience and skills to increase the supply chain efficiency [38]. Stakeholder theory can be applied to IT projects and will be effective in that industry [39]. As blockchain is a software protocol that is being implemented with the IT infrastructure it can be viewed as an information technology asset [40].

3.5 Technology adoption

Technology adoption can be viewed from an organizational or an individual stakeholder level [41]. For the purpose of this article, we analyze user adoption from a blockchain user perspective and focus on these stakeholders that have been tasked by their principal to add data to the blockchain ledger. We utilize the Unified Theory of Acceptance and Use of Technology (UTAUT) which is amongst the three most common models to analyze technology adoption and use behavior of information technology [42]. UTAUT has been used in numerous studies to analyze and predict the acceptance and adoption of technologies predominately from the user perspective. It is based on four factors determining usage behavior and behavioral intention: performance expectancy (PE), which is the support of the technology for achieving the individual's objectives, effort expectancy (EE), which relates to the level of how easy an application is to be used, social influence (SI), which is the perceived influence of others to use the technology and facilitating conditions (FC), the support of the organization towards the individual using the technology. Complementing UTAUT, the Theory of Planned Behavior (TPB) predicts behavioral intent of individuals and the consequences of their behavior [43]. TPB has been built on three independent factors of intention, which are attitude (AT) towards the behavior and answering the question of whether the use of the technology will make a positive difference, subjective norm (SN), which investigates the perceived peer pressure to use a technology, and perceived behavioral control (PBC), which answers the question if the user has the appropriate tools to be successful. Those three independent factors of intention make up the believes of an individual which in turn drives their social behavior [43].

3.6 Trust as the Foundation of Economic Activity

While human trust is being exercised on the social and economic level, digital trust is being exercised on the crypto-technology level. The combination of both trust levels enables the development of novel business models. The increased demand in FSC transparency initiated a redesign of the food chain which is driven by trust attributes such as product quality and food safety [11]. Consumers are increasingly demanding a high level of product quality and safety and expect transparency about their food products, including information about provenance, suppliers, production, and transport conditions [2]. Trust has become a significant element of product quality and safety for which the focal firm is standing in with its brand to constantly ensure high standards. Consequently, agri-food firms need to provide food product related information with the objective to increase trust which could increase customer loyalty and which in turn offers the opportunity to convert one-time buyers to repeat buyers. Trust attributes in the FSC can be split into three categories: the metaphysical, chain transparency, and risk-related category [11] and can be used as a differentiator to enforce price premiums [44]. Examples for metaphysical, non-sensory credence attributes for the coffee industry are including but not limited to coffee completely produced at the place of origin [45] and coffee that has been hand-picked or hand-picked exclusively by women [46]. In our research we combine metaphysical and chain transparency trust attributes. Trust is also a central driver for achieving collaboration in vertical cooperation [46]. It is instrumental in managing the risk of cooperation problems in FSC [1]. In the FSC trust has the potential to reduce transaction costs while fostering cooperation [47]. Previous research has shown that trust has a positive effect on agricultural stakeholder's technology adoption efficiency [48].

4. Blockchain platform types

Blockchain is a decentralized and distributed digital ledger, enabling secure and trustful peer-to-peer transactions. It is the underlying technology for cryptocurrencies such as Bitcoin and also the basis for the tokenized economy, publicly referred to Web 3 [49]. The most prominent blockchains such as Bitcoin or Ethereum are public and permissionless.

BCT as it is being implemented today in agri-food supply networks can be viewed as an institutional technology as it is "a new institutional technology of governance that competes with other economic institutions of capitalism, namely firms, markets, networks, and even governments" [50]. BCT is revolutionizing governance and adhering to Williamson's New Institutional Economics theory, BCT is an institutional technology [51, 52]. This applies to blockchain in vertically cooperated supply networks where provenance and track and trace solutions dominate. Blockchain in permissionless public networks potentially develop further into a general-purpose technology (GPT) with the outlook to fundamentally change the economy and society alike creating a new type of economy [53–55] As the change in governance is key to our research, we will follow the institutional view of Davidson et al. and view BCT as an institutional technology utilizing aspects of the transaction cost theory.

4.1 Blockchain technology

Blockchain is based on the distributed ledger technology (DLT), a constantly synchronized ledger distributed across locations and entities. As it comprises of various existing technologies that are, intelligently combined, creating a new technology It can be viewed as a meta-technology [56]. In addition to DLT, certain blockchain solutions have been designed to set up rules for transactions enabling the development of decentralized applications, smart contracts, and digital autonomous organizations (DAO). Smart contracts are software programs that are based on BCT with rules for automatically executed transactions based on a set of predefined conditions that have to be met [57] whereas DAOs are a combination of several smart contracts executing on pre-determined business processes. Smart contracts in BCT can be seen as coordination mechanisms applying an institutional perspective over coordination [58]. A fungible token, the digital, alphanumerical representation of a physical asset such as a Bitcoin, is the simplest form of a smart contract. One of the key characteristics of blockchain is the decentralization of the network architecture enabling peer-to-peer transactions, which eliminates the need for a coordinating trusted entity. Trust is induced through the consensus algorithm, the ubiquitous visibility of transactions, the immutability of the data, and the anonymity of trading entities. The trust of the central authority is replaced by the consensus algorithm as transactions can only be executed when participants in the network approve them. The self-organizing peer-to-peer data-sharing technology operates without a central authority or intermediaries.

Although BCT is not managed by a central authority BCTPT exist that provide for a centralization of control [39]. Three different platforms exist today: the public, private and consortium BCTPT. They are predominantly differentiating through access rights and their rights to read from and write into the ledger. What all BCT platforms have in common is the distributed ledger technology, peer-to-peer transaction capability, as well as a generic consensus mechanism. However, different governance types apply to the BCTPT.

4.2 Public Blockchain platform

Decision-making in the way of verifying transactions in blockchain systems is performed through consensus. The consensus protocol ensures that participating entities agree on adding new transaction data to the blockchain replacing the central authority. In the public BCTPT consensus is typically achieved through the majority of the participating entities utilizing for example the Proof of Work (POW) or Proof of Stake (POS) consensus algorithm. The public network is open for participation to everyone and everyone has access and visibility to the transaction data in the ledger, can verify transaction blocks, and participate in the consensus process. Nodes can be added by anybody without the permission of a central authorizing entity as the only requirement is an internet connection and a computer platform. This type of BCTPT is called permissionless as no permission from an authority is needed to participate in the network. Transaction data, once verified, is secure and immutable.

Governance of public blockchains combines decision-making processes with incentives to secure the long-term operation of the network. In public networks, which operate the POW algorithm that is being used with Bitcoin, miners receive incentives for finding the nonce (number only used once). The prospect of the rewards drives miner's behavior to keep minting transaction blocks which are cryptographically hashed to ensure the immutability of the transaction data. The nonce is used to calculate a block hash that meets specific requirements. The first miner who finds the nonce resulting in a valid hash for the block, receives cryptocurrency as a reward. The validity is being confirmed by the participating entities operating blockchain nodes. The combination of technical as well as economic effects account for the proper functioning of the network. POW and POS are well known consensus algorithms that are being used in public BCTPT.

4.3 Private Blockchain platform

In a private BCTPT a single central authority is responsible for the decision-making process and is therefore performing the governance task of consensus building. A single ruling authority is coordinating the permissioned access and verification of transactions. Private BCTPT are mainly used in enterprise environments. There, the central authority approves the access of entities that are permitted to participate in the network. As the decisions are being made by a central authority network consensus remains in one hand. As a consequence, transactions are being verified much faster and transaction throughput can be much higher compared to public BCTPT.

4.4 Consortium Blockchain platform

The consortium BCTPT is also a permissioned technology such as the private type, as only authorized participants will be granted access to the network. In contrast to the private platform the network is being controlled by a group of entities having equal voting rights and jointly operating and maintaining network and system technology. In contrast to private BCTPT, delegated participants perform the decision-making process, authorized to perform consensus building. The system is decentralized, and its aim is rather collaboration than competition between the participating firms. Cost savings, accelerated learning, and sharing risks are the top benefits organizations expect from a certain consortium according to a recent research conducted by Deloitte [59]. PBFT (Practical Byzantine Fault Tolerance) and PoA (Proof of Authority) are examples of consensus algorithms executed in private and consortium BCTPT.

5. Decentralized network governance

Corporate governance is the factual and legal regulatory framework of firms to exercise good corporate management practice. It combines control and monitoring activities while striving for adhering to the economic and social objectives as well as the interests of their stakeholders [60]. In general terms governance refers to the rules and processes of a control system that is used to manage and supervise how stakeholders interact within an organization, a firm, a state, or within an IT-based network. As such, governance can be seen as a form of regulation that supports the achievement of objectives [6]. The rules of governance coordinate decision-making processes between stakeholders. Governance systems provide for risk mitigation and are also implemented in digital ledger technologies such as blockchain [13].

In contrast to the neo-classical approach, transaction cost economics (TCE) assumes that human beings are not capable of making perfectly rational and logical decisions [61], although this has been implicitly presumed in previous studies [62]. Human's decisions are limited by their cognitive abilities including but not limited to processing large amounts of data, their emotions, and the limited amount of time they have for making decisions without exploring all available alternatives or obtaining all relevant information which results in decision making based on incomplete information. Hence, humans are not able to make perfectly rational and logical decisions according to Herbert A. Simon's theory of bounded rationality [63]. As per TCE humans also act opportunistically, seeking to enforce their strategic objectives. Replacing human's limited decision-making capabilities by information technology solutions has the potential to impact bounded rationality and opportunism.

Entering into contractual agreements with other firms is associated with costs which are defined as transaction costs. Transaction costs, as result of the coordinating activities, can be ex-ante, which are costs associated with information gathering and searching for the right partner and cost of negotiation and entering into a contractual agreement or ex-post, which are costs associated with overseeing the transactions according to the agreement and applying the necessary measures if the transactions deviate from the contractually agreed framework. As transaction costs deriving from bounded rationality and opportunism of contracting parties diminishes the integrity of contracts, transactions should be organized so "as to economize on bounded rationality while simultaneously safeguarding them against the hazards of opportunism." [50]. To safeguard against the challenges of bounded rationality, opportunism and information asymmetry governance mechanisms are employed to maintain an orderly transaction process, reduce conflicts, mitigate problems to ensure profitable transactions.

Governance mechanisms can be described as reactions to incomplete knowledge, uncertainty, dependence, and opportunism between firms [51, 64]. From a

TCE perspective trust and incentive are governance mechanisms [65]. Trust should safeguard against the risk of opportunism to ensure efficient coordination of transactions [65], whereas incentives are governance and control mechanisms used to coordinate the interests between principals and agents while at the same time reducing agency-related challenges [65, 66]. Firms determine on the governance type to benefit from the gains of cooperation and coordination [64, 67].

Governance processes can also be executed in decentralized networks without the need of a trusted central authority [48]. This is the key concept of BCT. As a trusted entity is missing, the network has to ensure that decisions are being made in such a way that while performing transactions and transferring an asset it has to be prevented that a digital copy of the asset is being transferred multiple times which refers to solving the so-called double spending problem [68]. The economic problem of double-spending has been solved in decentralized networks with the implementation of multiple nodes carrying identical ledgers where consensus mechanisms such as POW or POS apply. Blockchain as a software protocol enables a new governance infrastructure and its decentralized governance mechanisms involve multiple stakeholders rather than a single authority. Blockchain governance is a self-regulating system that is based on a digital IT network. Research on blockchain governance is still scarce [69]. Until today, a generally accepted definition of blockchain governance has not yet been agreed upon.

Blockchain governance differs significantly from traditional corporate governance and can be seen as a new form of organizing collaboration between firms [70]. Lumineau et al. investigate blockchain governance from a meta-perspective and conclude that governance in blockchain can be viewed distinct from the traditional mechanisms of corporate both contractual and relational governance [68]. Contractual governance defines the control mechanisms and rules for enforcing legal contracts, relational governance addresses behaviors, the joint value system and prospects of future cooperation. The application of governance mechanisms for the verification of transactions is key to the operation to any blockchain network. Along the lines of Douma's definition that "Corporate Governance is the system by which business corporations are directed and controlled" [71], control in different BCTPT exercised through governance mechanisms is an aspect of the governance type. Where the intensity of control in vertical coordinated FSCs moves along a continuum ranging from spot market to vertical integration, the blockchain continuum ranges from no control in public BCTPT to single control in centralized systems. The control intensity in productive partnerships is beneficial to farmers and processing companies alike [72]. Farmers in FSCs benefit from a level of control that its being exercised through contractual agreements that amongst other benefits secure their income, enables production planning, and education [73]. We therefore hypothesize that control in blockchain governance can be described as blockchain governance continuum framework. The continuum suggests that the intensity of control exerted is developing from no control at public BCTPT to truly centralized implementations with sole control by a single authority. The continuum has been summarized in **Figure 1**.

Despite the decentralized character of public BCTPT certain consensus protocols such as POW in public networks support centralization efforts, as miners could agree and collaborate to achieve a 51% share of all mining activities. With his behavior, false transactions could be verified despite the fact that decentralized networks should be safeguarded from manipulation.

5.1 Trust through consensus

In the economy trust is needed to utilize assets such as gold, shares, or Fiat money as a store of value. Pass et al. define the store of value as any asset that can

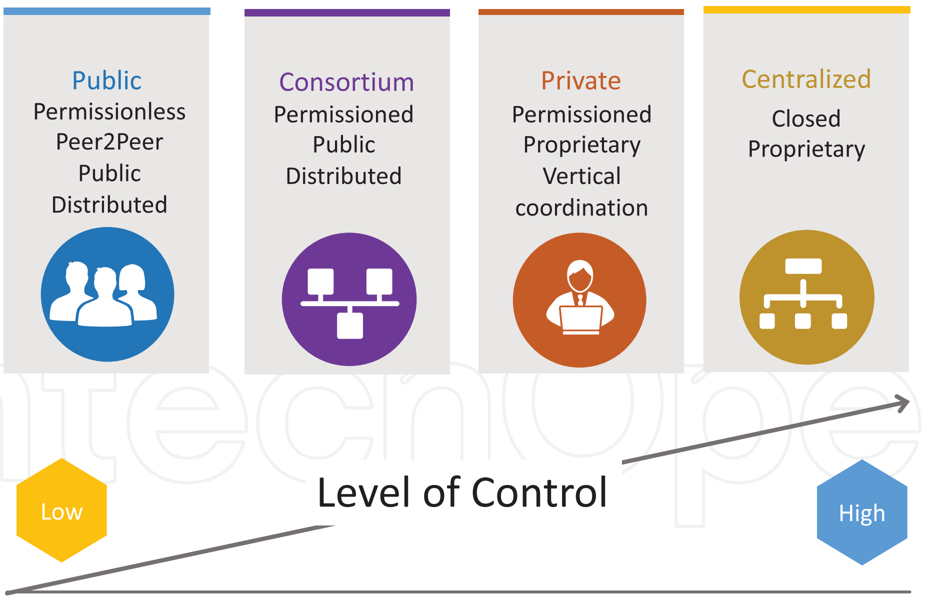

Figure 1.
Framework blockchain governance continuum.

be converted back money with a positive difference between purchase and sell price [73]. Using money for transactions is based on a consensus in its role as store of value. Trust in an asset such as Fiat money, which is the most common store of value, is generated by the issuing central authority, which is typically an assigned entity in the country that manages money supply.

A major security and trust factor in BCT is the process which adds transaction blocks to the blockchain. An algorithm ensures that the network consents on the chronologically sorted and constantly growing set of blocks. As part of this algorithm the specific consensus algorithm ensures that verification nodes agree on the validity of the block to be added. In a blockchain system transactions are being verified according to the governance type that has been chosen to operate the decentralized network. BCT establishes trust by using consensus mechanisms for decision-making. The consensus-based verification process establishes the trust in the transactions and the incentives drive the behaviors of the stakeholders.

The consensus mechanism in BCT is an integral part of its architecture and has been embedded as a separate layer in the layered blockchain architecture. A simplified overview of the BCT architecture layers is presented in **Figure 2**. Consensus acts as a confirmation on the status of the network which leads to a subsequent update of all networked ledgers. The consensus mechanism is therefore the foundation of the digital trust mechanism in BCT.

5.2 Consensus mechanisms in blockchain platforms

In our article we will analyze the governance types used by different BCTPTs and how the governance mechanisms affect coordination of the network. Decision-making and economic incentives are governance categories both, in organizations and firms as well as in BCT [13].

Public and permissionless blockchains operate under the governance type of public consensus as transactions can be verified by any participating node. The access to the network is permissionless which allows everyone with a computer and an internet connection to join the public network. The consensus algorithms such as POW or POS also operate permissionless. As such, the governance categories as decision-making and incentives through consensus are driving the behavior of stakeholders.

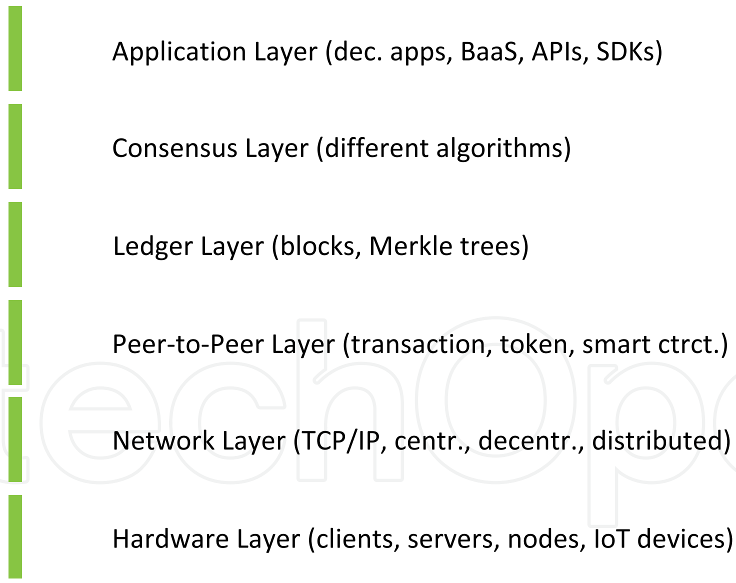

Figure 2.
Layered blockchain architecture.

In private BCTPTs the consensus is coordinated by a single central authority. The consensus algorithms deployed in those platforms therefore differ from those of public BCTPTs. Examples for consensus engines in private networks are Tendermint or Practical Byzantine Fault Tolerance (PBFT). They predominately ensure that transaction blocks are chronologically stored on each participating node. The governance type in private BCTPTs is reverted back to single management of transactions.

The governance type used with consortium BCTPTs differs slightly from that of private ones. The key difference is that the consensus is coordinated by a few, assigned entities who are authorized to perform governance related tasks. Same consensus engines are used as in private BCTPTs. As a result, different governance mechanisms apply for the three BCTPTs.

While public blockchains permit any entity to become stakeholder and participate in the network governance, permissioned blockchains such as private and consortium BCTPT are lacking the governance mechanism attributes of public consensus and incentive as either a single authority or a few pre-determined stakeholders are managing the consensus algorithms with permission. As a result, in private and consortium BCTPT the majority of the stakeholders are excluded from contributing to achieving consensus on transactions and on the state of the blockchain network. As a consequence, alternative governance mechanisms need to be applied in private and consortium BCTPT as consensus and incentive mechanisms are no longer available as governance attributes.

5.3 Off-chain vs. on-chain governance

As part of corporate governance, stakeholder management is being tasked to balance the different interests and motivations of stakeholders. The theory is based on the concept of a hierarchical organized enterprise. Although a blockchain network has different stakeholders the objective of blockchain governance is the same: to balance the interests of stakeholders. Katina et al. conclude that blockchain governance is based on three pillars which are direction, oversight and accountability where consistent decision-making is an attribute of direction, control of the system an attribute of oversight, and performance regarding the monitoring of resources and the system that of accountability [74]. The objectives of stakeholder management are similar in centrally coordinated and decentralized networks. However, different stakeholders are acting in both network types, further also depending on the chosen BCTPT. In selecting a blockchain governance type it is vital to analyze the various stakeholders involved in the network, the incentives that can be achieved, and the coordination of the stakeholders to conclude on valid transactions.

Blockchain stakeholders include but are not limited to contributors, steering board members, software developers, miners, platform operators, and users. Contributors are engaged in the funding of blockchain projects taking also a consultative role. Their incentive is the initial stake that they hold in the venture. Members of the steering board are consulting and collectively deciding on the future direction of the BCT. Their incentive is the potential gain of their stake in the network. Software developers are hardcoding rules for the BCT protocol. Other than a contractual relationship and potentially an early stake in the technology there is no incentive mechanism in place for them. While the consensus mechanism represents the DNA, miners represent the heart of the network. They ensure a constant flow of transactions that need to be verified. As incentive they receive either transaction fees or block rewards for hashing a transaction block. Node operators participate in the verification of transactions and benefit from the collectively gathered and distributed transaction fees. Platform operators are responsible for the provision of the IT infrastructure blockchain applications are running on and users are stakeholders that create transaction data and use the blockchain to achieve economic gains. Users pay for the transactions they initiate and for the use of the network service. Users are also adding data as agents of the principal that has tasked them to do so.

Decisions relating to transactions and to the operation of the network can take place off-chain on a social level where decisions impact the architecture, software code, processes, and consensus mechanisms in the blockchain as well as on-chain on a technical level where pre-coded algorithms that are implemented in the blockchain protocol perform tasks according to the predetermined rules. Both, the scientific and public literature describe on- and off-chain governance differently. As no common definition exists, we propose the following wording:

> *"Off-chain governance refers to the rules and decision-making processes, the communication between the involved stakeholders and the future development of the blockchain code. On-chain governance refers to the software-coded algorithmic enforcement of rules in the decentralized network concerning changes to the blockchain protocol, block verification, decision-making, and reward mechanisms."*

For the purpose of this research, we focus on off-chain governance mechanisms as the objective of the research is to analyze how, in the absence of mass consensus mechanisms, the consensus mechanism is being compensated for in private and consortium BCTPT through a stakeholder management approach.

6. Technology adoption research model

Coffee supply networks are strategic networks and both private and consortium BCTPT are supporting the supply chain management. Based on UTAUT and TPB we have constructed a model to analyze the intent of users in the coffee supply network towards BCT adoption to predict the individual behavior of the stakeholders. Our proposed model combines principles of technology adoption, economics, and social psychology to investigate the behavioral intention of individual stakeholders to adopt BCT.

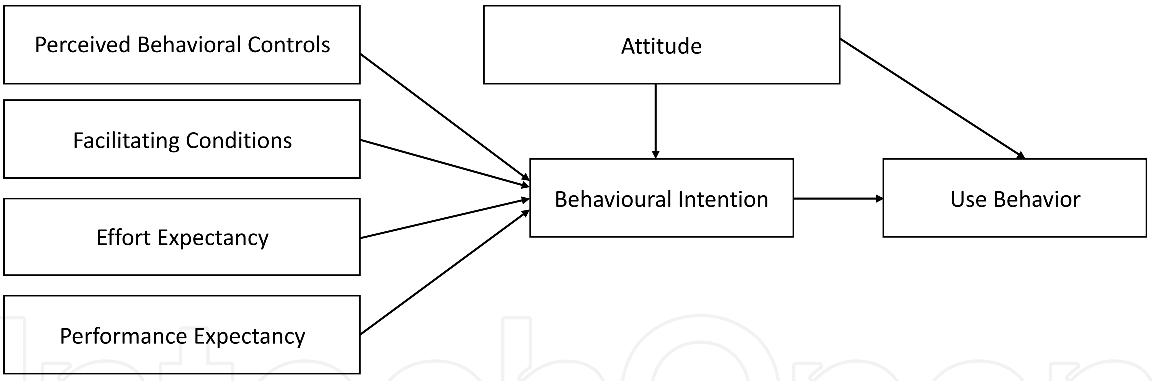

Figure 3.
Proposed theoretical blockchain technology adoption model (source: Authors, based on Ajzen, 1991 [41]).

UTAUT serves as a basis of the proposed model from which we selected the three appropriate parameters PE, EE, as well as FC, which have been supplemented by two additional parameters from PBT, namely AT and PBT. Not all parameters from UTAUT and TPB are applicable to the case study, and we argue why we exclude certain aspects. Theory on technology adoption suggests that older people and women are more sensitive towards social influences [41] and only in the early phase of technology usage as well as in mandatory settings there is significant evidence that the opinion of peers influence subjective norms as a determinant of behavioral intent [75]. There is also still a lack of understanding about the user acceptance or rejection of IT [76]. Consequently, we exclude the determinant subjective norm from TPB when building our proposed model. From UTAUT we excluded the parameter SI because according to Venkatesh it only fits a small target group and could potentially dilute the result [41]. The factor attitude is a key determinant of behavioral intentions and directly influences usage behavior [75]. Attitude plays a key role in the adoption of information technology. We propose the following model which should accurately predict FSC stakeholders blockchain technology adoption behavior (**Figure 3**).

7. Case study

Solino Coffee Products (Solino) is partnership under German law [44]. Coffee products are being produced completely in Ethiopia shifting major parts of value creation to the country of origin. Tasks include sourcing, roasting, packaging, labeling, and coordinating the transport to its German distributor. The business challenge was to provide trusted information about the coffee products in the supply chain in their quest to further increase customer loyalty as consumers are increasingly asking producers to make the supply chain processes more transparent to them; at present, this applies especially to the provenance information about the products sold. Solino is one of the first firms in the coffee industry that started their BCT implementation in 2018 while it is progressively adding more functionality to the supply chain. Every stakeholder of the Solino supply chain who adds data and value to the business process adds their data to the distributed ledger. In the case of coffee, smallholders, collectors, or cooperatives enter data about the date of harvest and where the coffee was harvested. Further information about the transfer of goods, roasting, and shipping are being recorded in the blockchain ledger. BCT provides benefits for both sides: Solino provides consumers with access to provenance information while the management of Solino is transparently monitoring their supply chain activities: from harvesting to roasting and shipping to Hamburg.

Solino has chosen a normative stakeholder management approach for their business operations in Ethiopia. The company and its stakeholders are jointly striving towards creating the majority of added value in the country where the raw material, the coffee cherries, originates. The interests of the stakeholders are dominating the business conduct rather than focusing on the economic rent of the firm. This approach emphasizes morals and ethical conduct while displaying a high degree of corporate social responsibility (CSR).

8. Results and discussion

We analyzed governance types and consensus mechanisms in public, private, and consortium BCTPT answering the first research question. It was demonstrated that public BCTPT permits any entity to participate in the network governance and transactions can be validated by every participating entity. Governance is exercised through public consensus mechanisms. Permissioned blockchains such as private and consortium BCTPT are managing the consensus algorithms with permission. The governance mechanism attributes of public consensus and incentive are not available for users of those BCTPT. As a result, in private and consortium BCTPT the majority of the stakeholders are excluded from contributing to the state of the blockchain network which answers the second research question. The corporate governance model applies to those BCTPTs.

Blockchain is a network developed and maintained by humans. Motivational psychology describes the two stimuli of humans' behavior which can either be extrinsic or intrinsic. Motivational psychology describes the two stimuli of humans' behavior which can either be extrinsic or intrinsic. In the absence of governance mechanisms extrinsic or intrinsic motivation factors need to be in place so that humans get incentivized to contribute to the operation of the network. Extrinsic motivation refers to the achievement of an objective that is driven by a reward despite the fact that the individual does not prefer to perform the action. It is therefore instrumental as the result is separated from the objective. Intrinsic motivation is stimulated from within the individual because the behavior exercised is naturally rewarding and satisfying.

Off-chain governance in private and consortium BCTPT is exercised through the stakeholder management approach. In order to understand how the stakeholder management approach impacts use behavior of stakeholders towards adoption of blockchain technology in the absence of permissioned consensus mechanisms we conducted on online-survey with blockchain users of Solino Coffee. In response to our third research question that asks for the factors that impact the adoption of blockchain technology by stakeholders in the coffee supply chain we developed a blockchain technology adoption model and interviewed stakeholders in the upstream coffee supply chain including coffee roasters, packing specialists, quality managers, as well as logistics managers. We addressed research questions of how these factors impact coffee supply chain performance by unveiling that normative stakeholder management obviously positively influences technology adoption behavior. Our findings further unveil that close ties between management and stakeholders positively influence behavioral intentions and subsequently the usage behavior of stakeholders towards blockchain technology adoption. Our findings suggest that the application of a normative stakeholder management approach coincides with strong positive behavioral intentions and strong positive usage behavior and ccompensates for the lack of consensus mechanisms in private and consortium BCTPTs. Our findings express a consistently high level of the attitude factor amongst stakeholders in the upstream portion of the supply chain towards adopting BCT. Stakeholders view the adoption of BCT as a critical success factor which affect them personally as the use of BCT will make a positive difference in their job and future career development. In addition, stakeholders strongly confirm through the PBC and FC factors that the enterprise is providing the appropriate IT tools to be successful. Stakeholders exercise a high belief in the technology to support them in achieving their individual job objectives. The results of the interviews also highlight the importance of EE which refers to the ease of use of the application that is driving the behavioral intention. AT and PBC are the strongest influencers of behavioral intentions which drive usage behavior. As per our model, attitude is directly impacting behavioral intentions as well as usage behavior which are key determinants of adopting IT technology. AT and PBC factors strongly impact BCT adoption behavior of stakeholders the agri-food supply chain. PE, EE, and FC conditions also impact the adoption but with a less strong characteristic. We also found that PE, EE, FC, PBC, and AT positively influence the usage of BCT in the coffee production process independent of age, gender, job function, and professional experience. We conclude that BCT adoption has a mediating role and is one of the key factors affecting supply chain performance.

We admit that the chosen research methodology has certain disadvantages including but not limited to the single case study, the data obtained through interviews and that the findings can only be applied to this specific case. As BCT is a novel technology, research on adoption of BCT by stakeholders in the supply chain has just provided some preliminary and limited research to date examining this topic. In order to overcome this shortfall, in addition to the case study we have conducted interviews with industry experts with experience in similar implementations with the objective to scale our single case study findings.

9. Conclusion

This article investigated how consensus mechanism is being compensated for in private and consortium BCTPT through a stakeholder management approach impacting stakeholder's use behavior towards the adoption of blockchain technology. The results show that permissioned blockchain governance mechanisms with stakeholder consensus and incentives implemented to motivate network stakeholders are lacking in private and consortium blockchains. The blockchain technology platform types are exercising different governance types with associated consensus algorithms.

We combined secondary and primary research to find evidence that the choice of a normative stakeholder management approach can replace the blockchain governance in private BCTPT, thus positively influencing the behavioral intentions of stakeholders and subsequently their usage behavior towards blockchain technology. It has been shown that the lack of blockchain governance in private BCTPT is compensated for by intrinsic motivational factors. This study closes a research gap as understanding how the stakeholder management approach can compensate for the lack of consensus mechanisms can provide managerial guidance towards the development of an effective stakeholder management strategy, which eventually can provide for a competitive advantage.

Considering that the research is based on a single use case, the individual circumstances need to be taking into account when applying the results to other supply chains. The decision on the most beneficial governance type needs to be carefully analyzed on a case-by-case basis.

We acknowledge that our study has some limitations as it is based on a case study which is subject to individual interpretation of the authors. We mitigated this shortfall by adding qualitative data about a similar case study. The blockchain technology has also just been operationalized in some coffee supply networks and this is the earliest possible time to obtain meaningful results derived from stakeholders of the blockchain supply chain. Our study also leads to future areas of blockchain governance research. Subsequent research needs to expand on the research object and include consortium BCTPT. Novel categories of potential blockchain governance mechanisms such governance tokens that represents decision-making capabilities referring to blockchain protocol implementations need to be included as well. Smart contracts have governance mechanisms hard coded in their application and automatic transactions play a key role in the future blockchain implementations. Special focus needs to be put on the role of fungible and non-fungible tokens. At the end, off-chain and on-chain governance mechanisms are originated by humans and it needs to be investigated how the application of Artificial Intelligence with its Deep Learning capabilities could impact on-chain governance.

Author contributions

Michael Paul Kramer developed the theoretical formalism and wrote the article. Linda Bitsch and Jon H. Hanf contributed to the design and implementation of the research, to the analysis of the results and provided feedback on the writing of the final version of the article. Jon H. Hanf also supervised the project. All authors have read and agreed to the published version of the manuscript.

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Conflicts of interest

The authors declare no conflict of interest.

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