The impact of blockchain technology on the tea supply chain and its sustainable performance

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Abstract

Blockchain technology (BCT) has recently attracted interest from academics and practitioners. However, little is known about the benefits and impact of BCT on the tea supply chain and its sustainable performance. To bridge this gap, this study extends the resource-based view (RBV) and network theory (NT) by integrating BCT into the tea supply chain. We develop a conceptual model of a BCT-driven tea supply chain, which we analyse using a partial least squares regression-based structural equation modelling method with data collected from 305 experts in India. The findings show that the use of BCT has a significant positive effect on the tea supply chain; in particular, transparency and reliability are shown as the sustainable performance parameters. The implementation of BCT is a progressive paradigm shift that encourages actors to change their attitudes and become more competent in the tea sector. This study is the first report on integrating BCT into supply chains, contributing to the scant literature on this subject. Furthermore, our conceptual framework could help develop a more sustainable supply chain for the global tea industry.

Keywords: Blockchain technology, tea supply chain, resource-based view, network theory, sustainable performance.

1. Introduction

Supply chains have traditionally used centralised management systems, such as enterprise resource planning systems, to handle their information flow (Majeed & Rupasinghe, 2017). Errors, hacking, and corruption are all risks with centralised systems (Chopra & Meindl, 2014). These concerns can be resolved using blockchain technology (BCT). A blockchain is a distributed database of immutable digital records maintained by a network of nodes, which are not owned by any single individual (Yoffie & Woo, 2017). Immutability in the context of the blockchain refers to the fact that once something has been entered into the blockchain, it cannot be changed. Because the blockchain is a linked list with information and a hash pointer to the previous block, it forms a chain. This technique is what makes blockchains so precise and innovative (Larios-Hernández, 2017; Islam et al., 2021). Cryptographic concepts are used to protect and connect each of these data blocks. The method has the advantage of making it extremely difficult to modify data after it has been registered in a blockchain. The entire process of validating transactions and adding blocks is distributed, so that no central control authority exists (Venkatesh et al., 2020). In addition, BCT has advanced procedures to counter cheating (e.g., double-spending). Proof-of-work is a fraud-prevention tool of BCT that ensures security; this mechanism makes it difficult to tamper with blocks. Because of this security measure, independent data processors cannot mislead the system about a transaction (Nakamoto, 2008). Blockchains also use a peer-to-peer network that anyone could join, rather than relying on a central authority to manage the chain. When a user joins this network, they receive a complete copy of the blockchain. When someone creates a new block, it is distributed along the whole network (Johnson, 2017). To ensure that the block has not been tampered with, all nodes (users) in the block must verify it. When everything is confirmed, each node adds this block to the network's ledger (Pan et al., 2016). By this point, they have reached an agreement on which blocks are genuine and which are not. The consensus is produced by all the network's nodes (users), which ensures traceability among the nodes (Breidbach & Tana, 2021).

In a globalised market, supply chain managers and participants often aspire to create a more efficient and responsive global supply chain. Due to its unique characteristics of immutability, data integrity, provenance, and conclusiveness, many companies aspire to incorporate BCT into their business models (Centobelli et al., 2021). BCT can help improve trust within the supply chain network (Yeoh, 2017). It can also help deliver services and products on time, since it also includes global-level transactions, process disintermediation, and decentralisation among various players (Park et al., 2020). Therefore, BCT can minimise uncertainties in supply and demand to increase supply chain efficiency (Marsal-Llacuna, 2018). BCT adoption can also boost knowledge among stakeholders in the supply chain (Tsolakis et al., 2020). The applications of blockchain in the supply chain are varied: it can be used to classify the players carrying out any action, and it allows the results and efficiency of the supply chain processes to be measured effectively (Lee & Pilkington, 2017). Once the information for input monitoring is in a blockchain ledger, it is immutable. Each function in the chain can be monitored, such as the origin of the raw material, the production, shipments, their progress, and the deliveries along the way (Acquaye et al., 2014). The supply chain includes several different governance policies for each stakeholder (Pereira et al., 2019). It is hard to follow one specific organisation's policy consistently. The challenge for governance is to create consensus on a particular transaction by building trust between the different parties in the supply chain network. Doing so significantly increases traceability and transparency (Aung & Chang, 2014), ensuring the genuineness and legality of the product (Singh & Teng, 2016).

An examination of the extant literature shows that studies on BCT have focused on technology acceptance. Studies on the impacts of BCTs on supply chain sustainability are underrepresented (Pólvora et al., 2020). This paper aims to narrow the knowledge gap by developing a system architecture that integrates BCT to improve traceability in sustainable performance of supply chains (Kimani et al., 2020). For example, there is a dearth of theory-driven investigations in the context of BCT, and no one has attempted to measure the effect of BTC on sustainable performance. The organic tea supply chain (OTSC) is considered as a case in this study (Yin, 2014). The OTSC is chosen for the following reasons. First, it has a composite value chain comprising small-scale tea growers and tea plucking labourers on the lower end; large plantations, tea processing factories, and brokers on the middle end; and brands in the upper end (Biggs et al., 2018). Furthermore, an entire supply chain of transport, distributors, and retailers exists to deliver this vital product to consumers worldwide (Kadavil, 2005). Second, only tea leaves from certified-organic tea gardens are selected for this supply chain. Tea growers must have a licence for their organic tea garden to gain a premium edge. To obtain a licence, they must pay considerable registration fees every year, including an application fee, a site inspection fee, and an annual certification fee (Paul & Sandeep, 2021). Often, domestic and foreign certifications are not mutually recognised, and organic tea gardens have to apply for two different certificates to sell their organic tea in both domestic and foreign markets. Therefore, transparency and traceability are fundamental challenges in this supply chain process (Hm et al., 2017). Third, the organic tea industry can be modernised through changes in the operation process to improve transparency and overall managerial excellence. Possible improvements include quality improvement, cost-effectiveness, supply chain optimisation, and new export market identification (Roy, 2011). BCT adoption is one of the most promising solutions for optimising supply chains (Francisco et al., 2018; Venkatesh et al., 2020). Forth, very little research is being done to resolve the issues related to the traditional tea supply chain (Wijesinha & Hirimuthugodage, 1999; Kustanti & Widiyanti, 2007; Mansingh & Johnson, 2012; Biggs et al., 2018; Lowe et al., 2020). In particular, no prior research has considered an implementation of BCT in the OTSC.

This study investigates the impact of BCT on the sustainable performance of the OTSC in the Indian tea industry. Structural equation modelling (SEM) is used to test non-observable and observable BCT-driven OTSC constructs. BCT primarily addresses questions about how to restructure the OTSC to improve sustainability (Casado-Vara et al., 2018), while questions about what is required to maintain such systems are addressed using the theories of the resource-based view (RBV) (Yang & Lirn, 2017) and network theory (NT) (Treiblmaier, 2018). We consider two research questions: 1) What characteristics of BCT can influence the OTSC integration? 2) How can the BCT improve the OTSC's sustainable performance? We take the following steps to answer the research questions. (i) We undertake a comprehensive literature review of prior research related to BCT and supply chains. (ii) We adopt a mixed-method approach: we use focus group discussions and interviews for qualitative data collection, and questionnaire survey for quantitative data collection. (iii) Finally, we propose and empirically test research hypotheses for conceptualising a BCT-driven OTSC process.

The key contributions of the study are fourfold. 1) A significant contribution is demonstrating how adopting BCT can improve transparency and reliability, and thereby improve the supply chain performance. 2) This study extends RBV and NT by adapting BCT to the supply chain sustainable performance context, thus adding to the relatively scant literature. 3) The study responds to the call for more research on BCT-driven supply chain management in various fields. 4) The main contribution of this work is the BCT-driven OTSC model, which is applicable in various other supply chain contexts. Therefore, the target audience of this paper is professionals involved in various supply chains, as well as researchers in the supply chain field.

The article is structured as follows. The literature review is presented in the second section. The third section addresses the role of BCT in the OTSC process, and the fourth section presents the development of research models and hypotheses. The methodology is discussed in the fifth section. The sixth section provides the data analysis and results. The seventh section is the discussion, and the eighth section contains the conclusions, implications, limitations, and future research directions.

2. Literature review

2.1. Transparency and reliability in the supply chain

Supply chain transparency and reliability require knowledge of the identity, location, and status of supply chain transiting entities, captured in timely event messages, along with the scheduled and actual dates/times for these events (Francis, 2008). Traditional centralisation of the supply chains has restricted the opportunities for some stakeholders by generating knowledge asymmetry (Treiblmaier, 2018), usually favouring larger organisations or organisations implementing IT systems. This reduces the efficiency of efficiency of the supply chain (Michalski et al., 2018). Effective supply chains allow managers to process the enormous amount of information needed to make decisions (Williams et al., 2013). Therefore, supply chain professionals consider transparency and reliability (Kaipia & Hartiala, 2006) to significantly improve inter-company cooperation, facilitating convergence between levels, up to and including the client (Schoenherr & Swink, 2012), improving confidence (Johnson et al., 2013), and increasing productivity (Bartlett et al., 2007). Transparency and reliability thus promote supply chain intervention (Delen et al., 2009) and influence decision-making (Christopher & Lee, 2004).

Digital transparency increased in the early 2000s to include additional functions such as product and distribution management by enterprise resource planning (ERP) (G. Parry & Graves, 2008), enterprise resource management, and customer resource management (Chuang & Shaw, 2008; Lambert & Schwieterman, 2012). The relationship between physical objects and the digital world is essential for the use of advance technologies. Because of their low cost and simplicity, barcodes have become popular (Apiyo & Kiarie, 2018). Radio frequency identification (RFID) tagging of products, while more expensive, can also provide organisations with real-time data at the individual product item level (Wang et al., 2017).

The transparency of the movement of materials between all supply chain members has improved, and as has information exchange (Fawcett et al., 2012; Pereira et al., 2019). The Internet of Things has been conceived to link devices, as technology has evolved sufficiently to allow greater transparency of processes along the entire supply chain, reducing human error (Majeed & Rupasinghe, 2017; Parry et al., 2016). There is a demand for technologies that allow stakeholders to see the complexities of supply chain processes, rather than merely tracing where and when a process took place; this suggests that supply chains are increasingly embracing reliability. Since the most challenging aspects of the OTSC are the raw materials used (sourcing organic tea leaves), the processes used, and the individuals involved (tea growers, made-tea manufacturers, made-tea brokers, branding companies, exporters, etc.) (Gold et al., 2015), visibility is more helpful than traceability. In a traceable supply chain, administrators are still unable to see what is done, by whom it is done, and what the implications are at each node (Abeyratne & Monfared, 2016). Traceability does not offer managers actionable knowledge (Parry et al., 2016). Therefore, to create a fairer, healthier, and more sustainable supply chain for every stockholder, including workers, farmers, and the environment transparency is needed. BCT can provide transparency for OTSC.

2.2. The resource-based view (RBV) and network theory (NT) in the context of supply chains

The RBV (Porter, 1980) postulates only a subset of an organisation's resources produces a competitive advantage, and an even smaller subset leads in the long term to excellent performance. Only a few papers have applied RBV to the field of supply chains, and information about the usefulness of this theory and closely related principles (such as the resource–advantage theory) for supply chains is scarce. More recent studies have explored topics such as the effect on capacity utilisation of the organisation's resources and capabilities; the role of business knowledge in creating an advantageous position for transport providers; the achievement of closed-loop supply chain designs; and the antecedents of supply chain information integration (Yang & Lirn, 2017).

NT attempts to understand inter-organisational interaction complexities by concentrating on personal relationships between the parties and building mutual trust through cooperative relationships and exchange processes (Treiblmaier, 2018). Organisations have to create relationships to access external resources. They generate large-scale networks, which are both stable and evolving. Two forms of interaction help secure ties within the business network: exchange processes (social, business, and information) and adaptation processes (products, output, and routines). Many supply chain topics have integrated important aspects of NT, including the development of joint venture formations, network centrality antecedents in an environmental supply chain initiative, the operation of strategic networks and alliances, and the comparison of networked and non-networked software industry companies (Carnovale et al., 2014; Wichmann et al., 2015).

Thus, when it comes to understanding and investigating real-world supply chain phenomena, the theories offer different kinds of insight. Combining them for methodological plurality allows for a more detailed investigation of this multifaceted research subject than would be possible with a single theory (Halldorsson et al., 2015).

2.3. Blockchain technology in the context of supply chains

The BCT is a digital decentralised distributed ledger in which transactions are registered in chronological order to provide transparent and immutable information (Lansiti et al., 2017; Islam et al., 2020). In a globalised market, supply chain managers often aspire to create a more efficient and responsive global supply chain by organising all supply chain participants using a new technology such as BCT. Adopting BCT could boost the flow of knowledge among stakeholders in the supply chain. This would minimise uncertainties in supply and demand, boosting supply chain efficiency. Each supply chain member's role is critical in integrating the supply chain with BCT (Shen et al., 2018; Centobelli et al., 2020). A combination of the supply chain and BCT optimises supply chain activities, allowing knowledge exchange among the stakeholders. Sharing of transactional and strategic information strengthens supply chain processes (Kopyto et al. 2020).

In a blockchain, the entire process of validating transactions and adding blocks is entirely distributed, so that no central control authority exists. BCT uses advanced procedures to counter cheating (e.g., double-spending); hence, it is also claimed that the BCT leads to trustless consensus (Venkatesh et al., 2020).

Due to its unique characteristics of immutability, data integrity, provenance, finality, and the distributed ledger, many companies aspire to incorporate BCT into their current business model. Because of its exceptional properties (such as trustless, immutable, and decentralized), BCT-based bitcoin is commonly accepted in financial transactions (White et al., 2020). In the supply chain, BCT could be used to eradicate fraud and ensure productive transactions (Lansiti et al., 2017; Su et al., 2020). By reducing the need for a third party, BCT helps carry out quick transactions involving information, products, and money at reduced transaction costs. That contributes to improving trust within the supply chain network. Through BCT, funds can also be moved from payer to payee anywhere in the world without a banking system (Yeoh, 2017; White et al., 2020).

In the supply chain, a BCT can be used to classify the players carrying out any action. The BCT allows the results and efficiency of the supply chain processes to be measured validly and effectively. Once the information for input monitoring is in a blockchain ledger, it is immutable. Each process in the chain can be monitored, including the origin of the raw material, the production, shipments, their progress, and the deliveries along the way (Acquaye et al., 2014; Schlecht et al., 2021).

Despite the growing interest in supply chain sustainability research (Neri et al., 2021) and in attempts to implement blockchains in operation (Pólvora et al., 2020), the understanding of BCT applications in supply chain sustainability remains limited. First, studies on BCT have largely focused on acceptance from a technology perspective, leaving out other aspects of the sustainable performance of the supply chain. Second, none of the research has focused on the OTSC or on the implementation of blockchain technology in it.

This study intends to bridge the research gap by creating a system architecture incorporating BCT for greater supply chain traceability and sustainability. The research makes significant contributions by introducing BCT into the sustainable performance of the supply chain, with the OTSC in mind.

3. The proposed blockchain-driven organic tea supply chain model

The complexity and risk of the OTSC require quick responses. Blockchains could be well suited to providing the necessary transparency (Ringsberg, 2014). The growing customer demand for origin product information is a key driver of blockchain use to ensure the reliability of organic supply chains (Casado-Vara et al., 2018).

Consumers are now deeply involved in food and beverage processing (Duffy et al., 2005). Agriculture adulteration is a major source of concern because organic cultivation is not entirely transparent to consumers. Furthermore, tracking all activities within this supply chain is challenging, as global OTSCs are dynamic and include a wide range of stakeholders, each of whom plays a unique role in the production and supply of organic tea. The OTSC is becoming more complex over time, and the importance of transparency and reliability in organic tea production is increasing. A general diagram of how a traditional OTSC could be transformed into a blockchain-driven OTSC is shown in Figure 1.

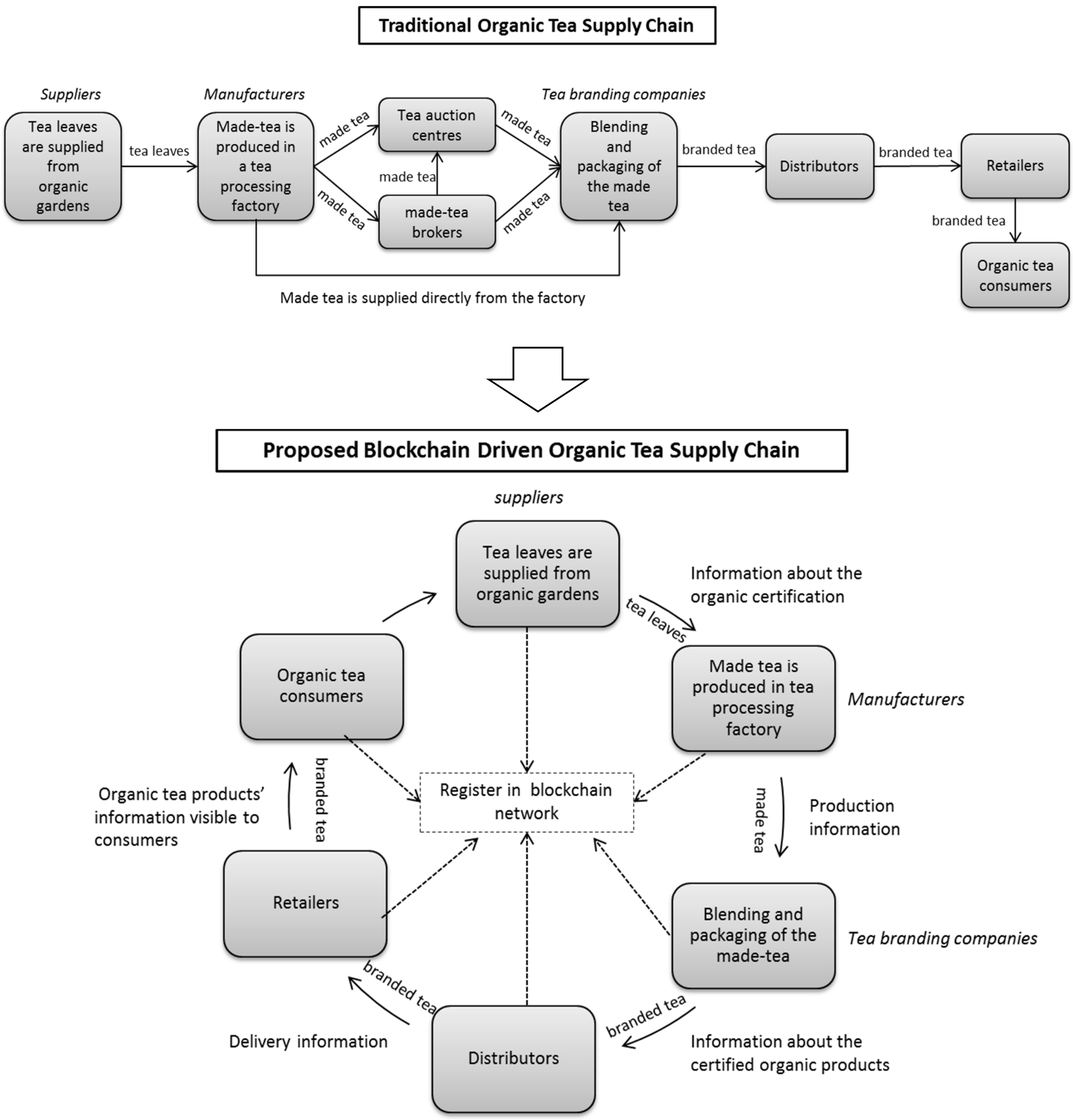

Figure 1: The traditional OTSC vs. a hypothetical BCT-driven OTSC model

In a blockchain-driven OTSC, each product would have a digital blockchain presence, and the product profile would be directly accessible to all local stakeholders (Figure 1). Security measures can be taken so that only individuals with the correct digital keys can access a product, restricting access. A wide range of information can be collected, including the product status, the product type, and the standards to be implemented for an organic product. An information tag attached to a product acts as an identifier, linking the physical product to its virtual identity in the blockchain. Before a product is transferred (or sold) to another player, all players can sign a digital contract to authenticate the exchange. They must afterwards conform to the smart contract requirements. If both parties fulfil the contractual responsibilities and processes, transaction information is updated in the blockchain ledger. When a modification is initiated, the BCT-integrated device automatically updates the data transaction records (Abeyratne & Monfared, 2016).

Critical product information can be supplied and highlighted by the blockchain technology. In the case of organic tea, the area of the tea producing region, the tea variety, its quality, quantity, status/location (where it is currently), and ownership are all included in the information (who deals with the distribution network at any given stage). In this way, the blockchain eliminates the need for a trustworthy central organisation to operate and maintain the system. It enables consumers to inspect the uninterrupted chain of custody and transactions, from raw materials (green tea leaves picked from the organic gardens) to final products (certified organic tea). As transactions occur, they are recorded in ledgers using different aspects of blockchain information with verifiable updates.

The transparency and reliability of blockchains can help transfer materials and information across the supply chain more efficiently, using automated governance criteria. Their widespread adoption could lead to a broad shift from an economy of durable manufacturing, commodities, and products to an economy of knowledge and customisation. Customers could also monitor certain aspects of specific products (certified organic tea, in our case), which would improve their confidence in the products (Kopyto et al., 2020; Schlecht et al., 2021).

Smart contracts can help record the interactions between the stakeholders involved in the system as written rules stored in the blockchain. Smart contracts affect the exchange of network data between participants in the supply chain and ensure the continuous improvement of the processes (Kumar et al., 2020). For instance, certifiers and standards bodies can digitally view participant profiles and check the authenticity of their organic tea. Beyond product distribution and governance issues, this kind of framework and knowledge has enormous potential (Tsolakis et al., 2020) for OTSC design with real-time consequences.

Blockchain-based procedures are still open to interpretation and adaptation in the supply chain context (Marsal-Llacuna, 2018). In particular, blockchain-driven supply chain networks may require a closed, private, authorised blockchain with a large but restricted number of players, unlike the bitcoin blockchain (Breidbach & Tana, 2021) and other blockchain-based financial applications (Shah & Murthi, 2020; Balasubramanian et al., 2021), which may be open to the public. However, a more public set of relationships may also be viable (de Villiers et al., 2020; Park et al., 2020). The privacy standard should be set up early in the process (Kimani et al., 2020).

4. Research framework and hypothesis development

The RBV focuses on market gaps and discusses internal competencies that help businesses achieve strategic advantages, while NT addresses dyadic relationships and the networks in which they are embedded. The RBV helps achieve competitive advantage by allocating resources, while NT (Treiblmaier, 2018) allows the pledged blockchain to establish ‘trustless trust’ (Werbach, 2018) – commodity trust and quality business relationships. In this study, structural equation modelling (SEM) and analysis of moment structures (AMOS) approaches were used to develop the computational power to elucidate an appropriate relationship among the identified latent variables (Figure 2).

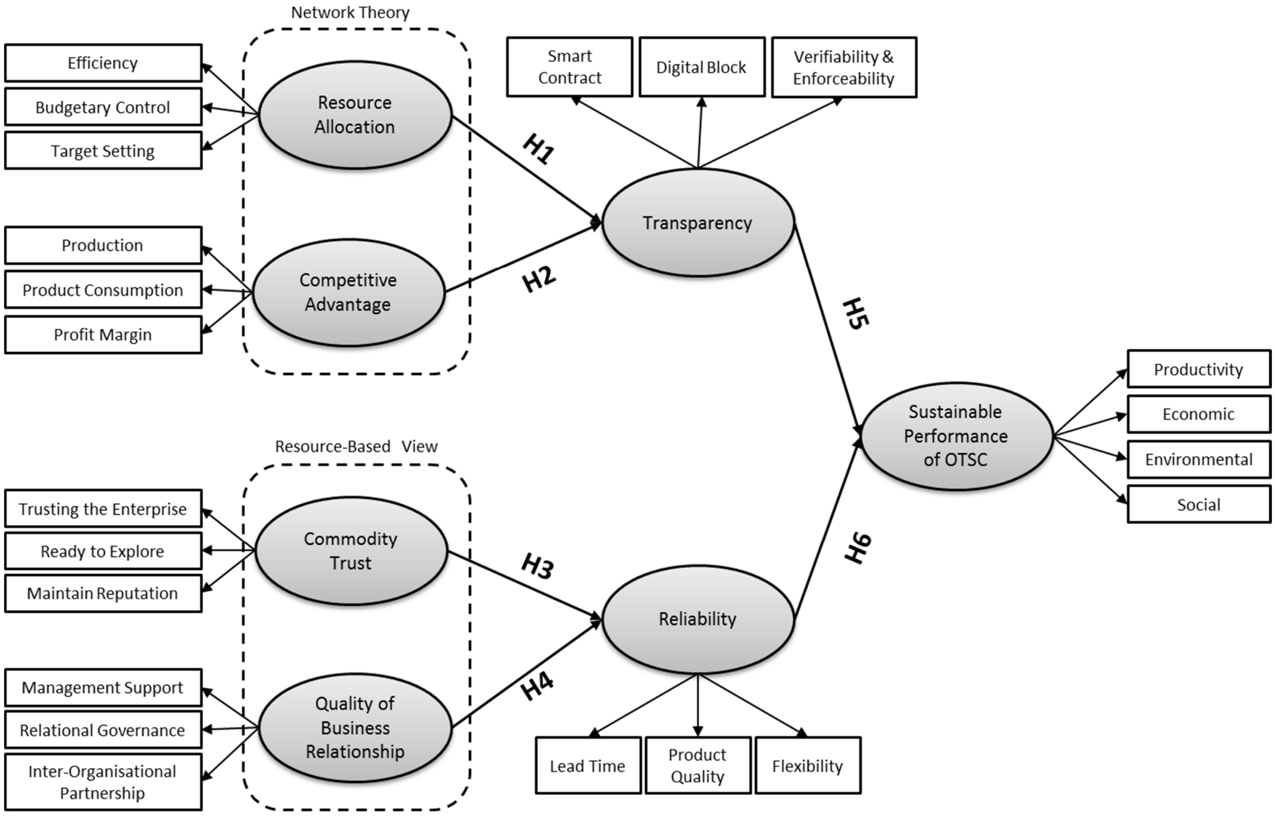

Figure 2: Research framework for a BCT-driven sustainable OTSC

(i) Resource allocation (RA)

Resource allocation is a particular challenge, especially in tea supply chain systems, which are complicated and unpredictable (Paulraj et al., 2008). Several resource allocation methods (Sharahi & Khalili-Damghani, 2019) and goal-setting applications have been described in the supply-chain literature in recent years. The use of blockchain-based resources can help plan schedules and trade-offs between inputs/outputs consisting of a series of production options, which increases the transparency of the OTSC. In the real world, budget and target spending is usually accompanied by uncertainty in the allocation of capital. The allocation model was developed by combining the efficiency invariant of Cooka and Kressbc (1999) with Beasley's unique allocation principle. The new resource allocation and target-setting model focuses on minimising the gross deviation of ideal solutions. Furthermore, it minimises the overall deviation of the ideal solution (Amirteimoori & Tabar, 2010), which increases the transparency of the supply chain (Astill et al., 2019). Therefore, we make the following hypothesis:

H1: The use of a BCT-driven framework increases the resource allocation that is positively related to the transparency of the OTSC

(ii) Competitive advantage (CA)

Organic tea manufacturing is an industry with fragmented supply chains and few standardised connections with business partners (Paul & Mondal, 2021). BCT can increase supply chain efficiency (Musigmann et al., 2020), which is crucial for gaining a competitive advantage. The competitiveness of the organic tea sector is closely related to sustainable production (Neri et al., 2021) and resource efficiency in the supply chain (Frohlich & Westbrook, 2001). The society's awareness of environmental damage and of the importance of environmental conservation is steadily growing. Environmental impact mitigation must be considered an efficiency measure for organic tea cultivation, alongside cost control, network management, maximisation of benefits, strategic planning, and value-added services. Adopting transparency as a priority may help the OTSC access new markets or persuade buyers to change or raise their purchasing standards, creating opportunities for competitive advantage (Ramirez et al., 2019). Thus, BCT can offer the OTSC a competitive advantage (Olatunji et al., 2019) that improves transparency (Ghode et al., 2020) by offering a revolutionary solution to determining the origin of the commodity (i.e., specifying the tea-growing region: Darjeeling green tea, Assam orthodox tea, Shizuoka black tea, etc). Thus, we propose the following hypothesis:

H2: The use of a BCT-driven framework increases the competitive advantage, which is positively related to transparency of the OTSC.

(iii) Commodity trust (CT)

Trust is defined as a psychological condition characterised by the willingness to tolerate vulnerability in exchange for favourable expectations about another's intentions or actions (Fawcett et al., 2012). Commodity trust is a multi-faceted concept. It can exist in one dimension between commodities and persons; inside a single organisation; and between organisations (Tadesse & Kassie, 2017). Trust decreases the perceived level of risk in a scenario, rather than the actual risk (Jena et al., 2018). Within an organisation, commodity trust may be actively controlled. Because active management develops processes and structures, commodity trust can also be managed by this method (Balasubramanian et al., 2021). Commodity trust in supply chains is focused mainly on product awareness, proof of trust (Ryciuk, 2017), and the trustee's attributes, such as product efficiency or performance. The OTSC cannot be developed or sustained without trust in organic goods, and the provision of trust is at the heart of BCT innovation. A dynamic model of a BCT system establishes a trust mechanism to improve OTSC cooperation, innovation, and organisational ability. Customers always want to know where and how products are manufactured and stored. Blockchain trials in supply chains have contributed to increasing reliability (Caridi et al., 2013). Thus, by exhibiting qualities such as authenticity, precision, honesty, serviceability, promise-keeping, and behaviour consistent with demands, the BCT-driven OTSC can ensure commodity trust (Stanley et al., 2012), increasing the reliability of the chain. Accordingly, we propose the following hypothesis:

H3: The use of a BCT-driven framework increases the commodity trust, which is positively related to the reliability of the OTSC

(iv) Quality of the business relationship (QBR)

The quality of the business relationship (QBR) is described as a cognitive assessment of many aspects of inter-firm connections that OTSC providers establish and manage with their worldwide clientele (Lo et al., 2018). Relationship quality and total purchasing intention are both influenced by reliability. Numerous studies have been undertaken using a range of corporate situations to conceptualise the intrinsic nature of the QBR (Martha & Lisa, 1993). Although many findings from this research demonstrate the QBR’s academic and practical relevance, it is still unclear what influences the QBR, and, as a result, this subject continues to draw scholarly and executive attention (Younis et al., 2020). Consistency of inter-organisational relationships is crucial to achieving OTSC reliability (i.e., relationship quality) (Kim et al., 2006). The integration of the upstream OTSC is affected by the relationship’s continuity (top management assistance and relational governance). Supplier production fully mediates the link between top management support and upstream OTSC, as well as some of the interactions between downstream and upstream OTSC (Kaipia & Hartiala, 2006). BCT provides the upstream reliability that customers demand from the OTSC; for example, by logging data on whether specific organic tea types have been produced authentically, or whether tea leaves are picked from the organic gardens of the correct region (Francisco & Swanson, 2018). Transactions of the blockchain system are continuously checked, approved, and stored in digital blocks linked to the OTSC. Hence, we make the following hypothesis:

H4: The use of a BCT-driven framework increases the quality of business relationships that are positively related to the reliability of the OTSC

(v) Transparency (TR)

Transparency depends on many elements of an effective OTSC, including the source of raw materials (organic tea leaves), cost (organic cultivation, made-tea production, and blending and packaging), inventory management, and physical logistics (Kwon & Kim, 2018; Sunny et al., 2020). Effective use, and, crucially, knowledge sharing with suppliers (Kaipia & Hartiala, 2006) can provide advantages, including the reactivity of the OTSC stakeholders (Kim et al., 2006), improved measurements and key metric design (Caridi et al., 2013), improved efficiency, improved customer support, and overall better business performance (Frohlich & Westbrook, 2001). Anyone with access to the system can see every transaction and its accompanying value. In a blockchain, each node, or user, is identified by a 30-plus-character alphanumeric address (Murck, 2017). Users have the option of remaining anonymous or revealing their identity to everyone else. Transactions take place between addresses in the blockchain. In BCT, the digital block forms a chain that allows authentication of resources and ensures information transparency (Venkatesh et al., 2020). Verifiability and enforceability are also improved through blockchain deployment to monitor sustainable OTSC performance. The BCT supports smart contract governance, encouraging OTSC stakeholders to simplify their credential contracts and procedures. Therefore, the blockchain's transparency helps stakeholders access accurate and reliable information, while reducing the number of inaccurate data (McConaghy et al., 2017; Saaty & Ergu, 2015). This improves the sustainable performance of the OTSC. Therefore, we propose the following hypothesis:

H5: The transparency of the supply chain is positively related to the sustainable performance of the OTSC

(vi) Reliability (RE)

The supply chain system's reliability depends on its structure and consistency (Zhang et al., 2020). The efficiency of the supply chain operation affects the possibility of meeting the end customer's requirements within lead time, volume, and quality. The blockchain's fundamental properties include reliability and transparency, pseudonymity, and irreversible non-reputability (Centobelli et al., 2020). These qualities lead to higher-level derived concepts with significant management implications, such as secure authentication, trust, confidentiality, privacy, compliance, quality, consent, reliability, originality, and accountability, all of which might have important consequences for the OTSC (Sidorov et al., 2019). In BCT, all transactions are time-stamped and cannot be changed once registered, protecting the OTSC operations from tampering and fraud (Lee & Pilkington, 2017). Thus, BCT ensures immutability for all the transactions. The BCT decreases lead time and improves flexibility, boosting the reliability of the OTSC system. Furthermore, BCT is transforming relationships between organic tea consumers, organic made-tea manufacturers (tea processing factories) (Carnovale & Yeniyurt, 2014), and organic branded-tea producers (tea companies), as well as relationships between organisations. The origin of the organic tea can be verified without third-party certification, as all transactions reported are time-stamped and tamper-proof. The blockchain, therefore, forms a reliable network for all OTSC stakeholders, and helps increase the sustainable performance of the OTSC. Thus, we make the following hypothesis:

H6: Reliability of the supply chain is positively related to the sustainable performance of the OTSC

(vii) Sustainable performance of the OTSC (SPOTSC)

The BCT's benefits are primarily due to the technology's decentralised, consensus-based acceptance mechanism, which contributes to performance management through the simultaneous immutability and transparency of vital OTSC processes (Bastian & Zentes, 2013; Kshetri, 2018). BCT can also increase the organisational stability of the OTSC (Khan et al., 2018), and support market success based on an organisation's defined objectives. Furthermore, BCT can support governments through successful resource conservation policies in a sustainable environment (Venkatesh et al., 2020). By improving capacity and minimising uncertainty and risks, BCT promotes OTSC sustainability (Saberi et al., 2019). BCT capabilities can assist with routine processes and procedures, reduce lead and cycle time, optimise production, and allow mass customisation. BCT processing increases the agility and resiliency of OTSCs (Cicculo et al., 2018). BCT allows the organic supply chain to be optimised through improved data quality management and automated data acquisition (Song et al., 2017; Treiblmaier, 2018). Thus, BCT positively influences four types of OTSC sustainability: productivity, economic, environmental, and social sustainability (Song et al., 2017). Nevertheless, the use of BCT for sustainable OTSC can be challenging, especially in developing economies.

5. Research methodology

This study has used a mixed research method, combining qualitative and quantitative data, to assess the impact of blockchain technology on OTSC process integration. The research method consists of five stages, which are shown in Figure 3.

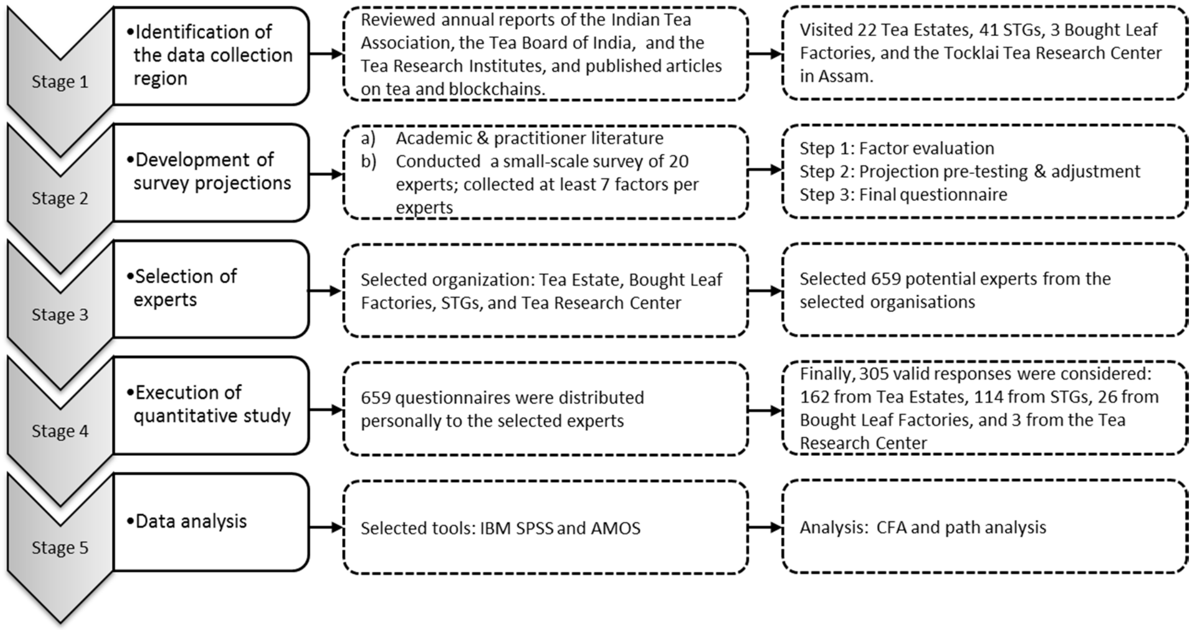

Figure 3: The stages of research process

5.1. Data collection site

The data were collected from the north-eastern Indian state of Assam (Table 1). Assam tea is famous for its texture, flavour, aroma, and colour (Sarma, 2011). The study is based on a three-year in-depth field survey of the Assam tea industry (Appendix-1). The world's largest tea plantation is found in the foothills of the Eastern Himalayas, in the Brahmaputra Valley (Roy, 2011). Assam produces 52 per cent of India's tea (Tea Board of India, 2015) and about 1/6 of the world's tea (Tea Board of India, 2017). Assam tea accounts for around 50 per cent of the foreign exchange earned by India's tea industry (Groosman, 2011). The total number of tea gardens in Assam is around 41,000, covering 307,080 hectares (Paul & Mondal, 2019). This large quantity of tea gardens and factories means that the state was the most suitable area for carrying out the proposed research.

Table 1: List of the field visits

Research Fields	Name
Tea Research Institute in Jorhat, Assam	Tocklai Tea Research Institute
6 tea estates in Dibrugarh, Assam	Desam Tea Estate, Langharjan Tea Estate, Naharkatia Tea Estate, Nadua Tea Estate, Thanai Tea Estate, Dikom Tea Estate
5 tea estates in Sivasagar, Assam	Ajoy Chetia T.E, Duwari Tea Estate, Azim Tea Estate, Humali Tea Estate, Surab Tea Estate
9 tea estates in Sivasagar, Assam	Hunwal Tea Estate, Lakhibari Tea Estate, Kolony Tea Estate, Praphat Tea Estate, Kharjan Tea Estates, Bagrodia Tea Estate, Towkok Tea Estate, Banwaripur Tea Estate, Gatoonga Tea Estate

2 tea estates in Golaghat, Assam	Hathikuli Tea Estate, Aalmat Tea Estate
3 bought-leaf factories in Jorhat, Assam	Deha Tea Factory, Dhanshree Tea Factory, Titabar Tea Factory
41 Small Tea Gardens (STGs) in four districts of Assam	11 STGs in Dibrugarh, 9 STGs in Sivasagar, 18 STGs in Jorhat, and 3 STGs in Golaghat
A tea auction centre in West Bengal, India	Kolkata Tea Auction Centre

5.2. Development of survey projections

The research is based on a three-year detailed study in Assam. The development and design of questions and projections are central to ensuring the value, validity, and reliability of studies (Mitchell, 1996). A comprehensive and well-established multi-stage method was therefore selected to generate concise and thought-provoking projections. The illustration of the projection design process is shown in Stage 2 of Figure 3.

To identify critical factors concerning the future of BCT in supply chains, relevant journal and conference articles (Kopyto et al., 2020; Musigmann et al., 2020; Tsolakis et al., 2020) and online forum posts were screened. A small-scale survey was conducted among OTSC experts and academics to identify additional factors and reconstruct the selection process, ensuring that all relevant concerns were identified for projection development.

Scientists from the Tocklai Tea Research Institute and academics who have published relevant articles on BCT were invited to participate in a small-scale survey. Experts were asked about the future of the OTSC and the impact of BCT in the OTSC. The survey continued until responses became repetitive and there were diminishing returns of new elements. To ensure that the projections were applicable to aspects of BCT beyond the technical features, the multilevel perspective of Geels (2004) on technology transformation was also used to include aspects of society, nature, economy, accepted practices, and strategy.

Finally, as suggested by Warth et al. (2013), five academics and four OTSC experts with significant conceptual and subject-specific expertise in this field pre-tested the questionnaire, which verified the predictions for accuracy, clarity, reasonableness, and conceptual adequacy to ensure the validity of identity and content. Their suggestions resulted in minor modifications to the wording and structure of the questionnaire. The final collection contained 22 projections regarding the impact of BCT on OTSC.

5.3. Selection of experts

The reliability of the results of the survey depends heavily on the choice of panellists. To achieve a high degree of heterogeneity and reduce the cognitive biases of different participants, such as framing bias, anchoring bias, desirability bias, and the bandwagon effect, the expert panel was chosen systematically. Heterogeneity was achieved through the participation of experts from various domains, such as logistics, information technology, small tea gardens, tea estates, and bought-leaf factories, and through the inclusion of designated experts from academia, the Tea Research Institute, the Tea Auction Centre, and the Tea Board of India. In total, 659 experts (including tea-estate managers; employees of the tea estates and bought-leaf factories; owners of small tea gardens; and scientists from the Tocklai Tea Research Institute) with experience related to the research area were asked to participate in the panel of experts. To ensure that only experts were included in the panel, only participants with genuinely expert knowledge of the tea supply chain were selected. The participants were fully informed about the study's context before the survey, and were assured that their private information would not be shared.

The Mann–Whitney U-Test was used to check for potential non-response bias. In this phase, estimates of early and late respondents were compared, as it can be presumed that late respondents show the characteristics of non-respondents (Wagner & Kemmerling, 2010). However, there were no significant differences ($p < 0.05$), and no non-response bias could be found by comparing the differences in response to all 22 projections.

5.4. Execution of the quantitative study

A questionnaire-survey methodology was used in this research, where the quantitative analysis of the panellists' evaluations was carried out. Prior appointments had been made to increase the response rate. 659 questionnaires were distributed personally to the selected experts. Each expert was asked to rate the projections based on a metric scale of 0–100 per cent, depending on their estimated likelihood of occurrence. They were also asked to rate the projections' impact on the OTSC and their desirability on a 5-point Likert scale. In addition, respondents had a chance to add qualitative justifications for their quantitative estimates provided. After discarding incomplete replies, 305 valid responses were used for analysis.

5.5. Data analysis

The data were analysed through IBM SPSS and AMOS using a two-step methodology. First, a confirmatory factor analysis (CFA) was carried out to determine the measures' reliability and validity. Subsequently, structural paths were analysed to evaluate the hypotheses. The use of structural equation modelling (SEM) as a data-analysis tool was justified on the grounds that these experiments tested hypotheses based on a clear theoretical context, based on Hew et al. (2019). The data collected also meet the multivariate criteria for SEM analysis: they are normally distributed and have no problems with multicollinearity (Kock & Lynn, 2012). Due to the self-reported nature of the data, common method bias (CMB) may be a concern (Podsakoff et al., 2012); it was tested for using a single-factor Harman test.

6. Results

Structural equation modelling (SEM), a convenient statistical tool, was used to evaluate the measurement and structural models concurrently. We ran factor the analysis, multiple regression analysis, and hypothesis testing at the same time. The collected data were analysed and interpreted in a two-stage process, using both a measurement model and a structural model.

6.1. Multicollinearity

Data on the occurrence of multicollinearity effects was tested before the CFA. We evaluated inflation variance factors and tolerances. The results show that variance factor values were below 10 and that tolerances were above 0.10, confirming the absence of multicollinearity, as in previous studies (T. S. Hew & Kadir, 2016).

6.2. Common method bias

Since the data for all the variables were collected using the same tool, there is a possibility of common method bias. Harman's single-factor test (Harman, 1976) was used to check for this problem in our dataset, as in previous studies (Talwar et al., 2020). We found that 48.97 per cent of the total variance was explained by a single factor, which is less than 50 per cent.

6.3. The measurement model validity

The CFA was performed to assess the validity and reliability of the measures. The data collected from different respondents were checked for normality. Skewness was within the ±3 range, and for all variables observed, kurtosis was within ±10 (R.B. Kline, 2011). The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy (0.948) indicates a high-shared variance and a relatively low uniqueness invariance. Bartlett's test of sphericity was strongly validated (chi-square = 4026.275, df = 231) (Cooper & Schindler, 1998). The sample size adequacy confirms that this dataset is suitable for factor analysis.

The Cronbach alpha coefficient was considered appropriate for all constructs, as alpha > 0.7 (Nunnally & Bernstein, 1994). This means that the internal consistency of the instruments used was adequate. To confirm the existence of particular patterns of relationships between observable variables and factors, confirmatory factor analysis (CFA) was used. The results show that the goodness-of-fit indices were adequate ($\chi 2/df = 1.379$, RMSEA = 0.035, CFI = 0.982, TLI = 0.978, IFI = 0.982, NFI = 0.937). For each construct, the minimum number of items should have been three, and all calculated standard factor loading was above 0.70. The average variance extracted (AVE) exceeded the recommended level of 0.5 for all constructs, indicating strong convergent validity. Also, each construct's composite reliability (CR) was above 0.70 (Table 2) (Hair et al., 2016).

Table 2: Results of confirmatory factor analysis

Items	Skewness	Kurtosis	Factor loading	Constructs	α*	AVE	CR
RA1	−3.037	9.957	0.778	Resource allocation (RA)	0.807	0.605	0.705
RA2	−2.961	8.711	0.830				
RA3	−2.709	7.302	0.686				
CA1	−2.519	6.091	0.852	Competitive advantage (CA)	0.897	0.746	0.898
CA2	−2.900	9.408	0.872				
CA3	−2.518	6.456	0.867				
CT1	−2.100	4.872	0.729	Commodity trust (CT)	0.795	0.565	0.796
CT2	−1.744	3.728	0.774				
CT3	−1.860	3.832	0.752				
QBR1	−2.509	6.974	0.730	Quality of business relationship (QBR)	0.764	0.525	0.768
QBR2	−2.538	8.003	0.729				
QBR3	−1.964	4.094	0.714				
TR1	−2.809	9.222	0.769	Transparency (TR)	0.808	0.591	0.812
TR2	−2.194	5.682	0.762				
TR3	−2.147	5.169	0.775				
RE1	−1.750	4.094	0.799	Reliability (RE)	0.829	0.619	0.830
RE2	−1.825	3.905	0.772				
RE3	−1.602	2.704	0.790				
SPOTSC1	−1.851	3.591	0.706	Sustainable performance of OTSC (SPOTSC)	0.862	0.617	0.865
SPOTSC2	−2.206	5.053	0.851				
SPOTSC3	−1.911	3.553	0.799				
SPOTSC4	−2.182	4.963	0.780				

α* = Cronbach's Coefficient α

6.4. Structural equation modelling results

The study tested the proposed hypotheses after analysing the validity of the theoretical model's measurement scales. The structural model was evaluated using analysis of moment structures (AMOS). The maximum probability estimator was used to estimate the standardised regression weight and the probability values that indicate the significant path. First the structural model was validated, and then the relationships between variables were analysed using structural equation modelling (SEM).

As shown in Figure 4, the proposed BCT-driven OTSC model improved the sustainable performance of OTSC (SPOTSC), with TR and RE playing a crucial role. The data imply that the SPOTSC cannot be isolated from RA, CA, CT, and QBR. The framework positions the role of BTC in such a way that it links the TR and RE in the newly-formed OTSC framework. An integrated description of the core components of the OTSC processes within a BCT was adapted from the recent literature and from the analytical work of the various supply chains. The results demonstrate the positive impact of blockchains on the supply chain of organic tea. The study's findings have significant impact for policymakers and stakeholders involved in defining BCTs' behavioural patterns in the context of the OTSC. We conclude that integrating BCT into the OTSC process improves sustainable performance.

The model was checked to verify the relations between the different parameters. The modelling of the structural equation of this study was based on covariance. Figure 4 presents the outcomes of the structural model path analysis done in this study. The findings from the structural model are shown in Table 4.

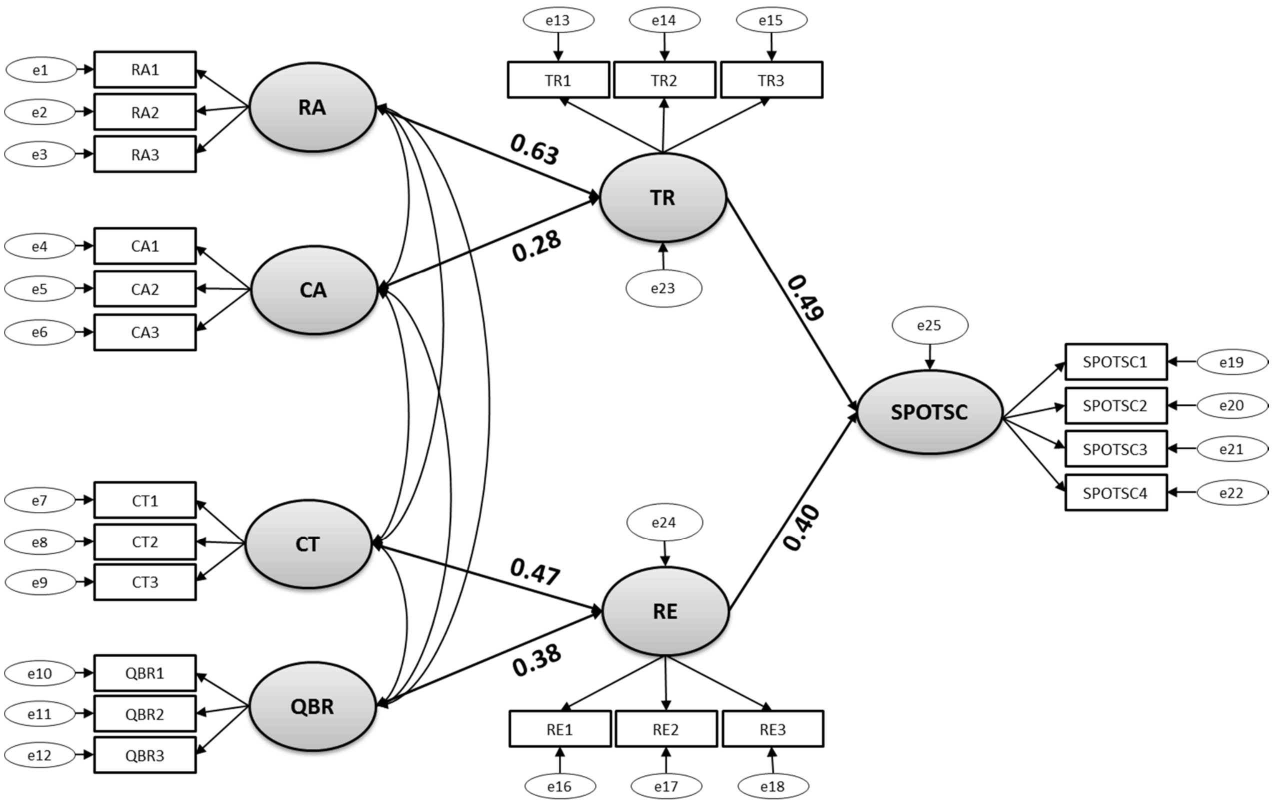

Figure 4: The structural equation model of a BCT-driven OTSC

6.4.1. *Evaluating the goodness - of - fit criteria*

Comparative fit index (CFI) points to a good fit value of 0.974 when the required value is matched with a goodness-of-fit index (GFI) of 0.923. It is marginally smaller than the recommended value of 0.90. The root mean square approximation error (RMSEA) is 0.041, which indicates good data accuracy and good fit. The measured value of Chi-square/degrees of freedom (CMIN/DF) is 1.511, indicating strong model fit. The values of Goodness-of-fit index (AGFI) (0.902), Tucker Lewis index (TLI) (0.970), Incremental fit index (IFI) (0.974), Parsimonious normed fit index (PNFI) (0.791), and Parsimonious goodness-of-fit index (PGFI) (0.719) show that the proposed model is statistically acceptable, as the resulting parameters are above or very close to the recommended range of values for good fit (Table 3).

Table 3: Goodness-of-fit indices of structural model testing using AMOS

Good-of-fit index statistics	Abbreviation	Recommended range of values for a good fit	Resultant value
Absolute Fit Measure			
Chi-square test	χ^2	p > 0.05 (Marsh & Hocevar, 1985)	297.723
Degrees of freedom	df	df > 0 (Bentler, 1990)	197
Chi-square/degrees of freedom	χ^2/df	χ^2/df < 3 (Marsh & Hocevar, 1985)	1.511
Goodness-of-fit index	GFI	GFI ≥ 0.90 (Chau, 1997)	0.923
Adjusted goodness-of-fit index	AGFI	AGFI ≥ 0.90 (Chau, 1997)	0.902
Root mean square error of approximation	RMSEA	RMSEA < 0.08 (Byrne, 2013)	0.041
Increment fit measure			
Tucker Lewis index	TLI	TLI ≥ 0.95 (Rex B Kline, 2016)	0.970
Normed fit index	NFI	NFI ≥ 0.95 (Hooper et al., 2008)	0.928
Comparative fit index	CFI	CFI ≥ 0.90 (Segars & Grover, 1993)	0.974
Relative fit index	RFI	RFI > 0.90 (Hooper et al., 2008)	0.916
Incremental fit index	IFI	IFI > 0.90 (Hooper et al., 2008)	0.974
Parsimonious fit measure			
Parsimonious normed fit index	PNFI	PNFI > 0.50 (Hooper et al., 2008)	0.791
Parsimonious goodness-of-fit index	PGFI	PGFI > 0.50 (Hooper et al., 2008)	0.719

6.4.2. *Path analysis*

This method helps to evaluate the relationship between the key factors that influence the BCT-driven OTSC. We used SEM to test six hypotheses to evaluate the impact of RA, CA, CT, QBR, TR, RE, and SPOTSC. Table 4 summarises the significance of the structural relationships (t-values) and the coefficients of the path. In the structural model, the correlations between the constructs were all significant.

Hypothesis 1 predicts that resource allocation (RA) has a positive impact on transparency (TR) for the sustainable performance of the OTSC. The standardised coefficients (β) of resource allocation and transparency are 0.636, and the t-value is 6.456, $p < 0.01$, indicating statistical insignificance. The results support this hypothesis.

Hypothesis 2 proposes that competitive advantage (CA) has a positive impact on transparency (TR) for the sustainable performance of the OTSC. The standardised coefficients (β) of competitive advantage and transparency are 0.291, and the t-value is 3.417, $p < 0.01$, indicating statistical insignificance. The results validate this hypothesis.

Hypothesis 3 suggests that commodity trust (CT) has a positive impact on reliability (RE) for the sustainable performance of the OTSC. The standardised coefficients (β) of commodity trust and reliability are 0.469, and the t-value is 4.227, $p < 0.01$, indicating statistical insignificance. The results confirm this hypothesis.

Hypothesis 4 proposes that quality of the business relationship (QBR) has a positive impact on reliability (RE) for the sustainable performance of the OTSC. The standardised coefficients (β) of quality of the business relationship and reliability are 0.383, and the t-value is 3.488, $p < 0.01$, indicating statistical insignificance. The results support this hypothesis.

Hypothesis 5 predicts that transparency (TR) has a positive impact on the sustainable performance of the OTSC (SPOTSC). The standardised coefficients (β) of transparency and sustainable performance of the OTSC are 0.843, and the t-value is 6.114, $p < 0.01$, indicating statistical insignificance. The results support this hypothesis.

Hypothesis 6 suggests that reliability (RE) has a positive impact on the sustainable performance of the OTSC (SPOTSC). The standardised coefficients (β) of reliability and sustainable performance of the OTSC are 0.402, and the t-value is 5.283, $p < 0.01$, indicating statistical insignificance. The results support this hypothesis.

These results validate hypotheses H1–H6 of this study. Therefore, the influence of BTC on the OTSC is positive.

Table 4: Path coefficient estimates

Hypothesis	Structural equations	Coefficients (β)	t-value	p-value	Result
H1	RA → TR	0.636	6.456	***	Supported

H2	CA → TR	0.291	3.417	***	Supported
H3	CT → RE	0.469	4.227	***	Supported
H4	QBR → RE	0.383	3.488	***	Supported
H5	TR → SPOTSC	0.843	6.114	***	Supported
H6	RE → SPOTSC	0.402	5.283	***	Supported

Notes: *** Significance level: $p < 0.01$

7. Discussion and conclusions

The study results support H1–H6, revealing that resource allocation, competitive advantage, commodity trust, and quality of the business relationship values have significant positive associations with transparency and reliability values, which also have positive associations with the sustainable performance of a BCT-driven OTSC.

With globalisation, OTSC management has become an incredibly complicated job. Neither consumers nor tea branding companies have full transparency and reliability for all the components in the chain. Since products travel through multiple regions, it is not easy to track every channel through which they pass. Because of this lack of transparency and reliability, tea companies have no way of identifying inefficient intermediaries that hamper customer satisfaction and inflate consumer prices. On the other hand, maintaining good relationships with suppliers involved in the network is crucial for handling the OTSC. While this is a smaller issue for domestic players, it is a crucial component of global supply chain network management. When they are globalised, with a broader number of suppliers, companies need to maintain the trust of their suppliers and clients, while at the same time they have no control over them. As a result, companies cannot effectively manage their own business, as they are dependent on suppliers to deliver products. It is therefore crucial for businesses to weed out unreliable suppliers.

BCT is a distributed ledger that operates on the principles of game theory, peer-to-peer technology, and cryptography. Its decentralisation is the ideal solution to the transparency issue. For instance, in the BCT-driven OTSC, companies can record information about the tea's cultivation area, organic garden certificates, made-tea production details, branding, current product location, price, and date, as well as other relevant organic tea information. This information, shared via the public ledger, can inform all stakeholders on both the status of the transit and the origin of the items.

Once the information is recorded in a block in the chain, the immutability feature ensures that it cannot be tampered with without altering the subsequent blocks and without the consensus of most users in the network. The security level that the blockchain allows owing to its immutable nature ensures that the recorded information cannot be altered. In the case of the OTSC, the availability of trustworthy shared records ensures that stakeholders can maintain trust among themselves.

The following are undoubtedly significant advantages of the BCT-driven OTSC: streamlined business processes; improved supply chain visibility; improved channel material traceability; a competitive edge; reduced communication errors and improved collaboration between parties; improved trust and transparency between business parties; prevention of theft and piracy; and increased customer satisfaction. Therefore, it is evident that the adoption of a blockchain can provide the OTSC with numerous advantages that can help businesses to remain relevant in the market.

Although BCT has immense potential in OTSC management, one of the key challenges in a BCT-driven OTSC is the balance between data disclosure and confidentiality: collaboration versus competition. To protect confidential data, supply chain stakeholders need to avoid transparency (Wang et al., 2019). Confidentiality of sensitive data should be protected in the made-tea manufacturing factories and blending units. However, transparency is central to marketing and branding in this industry, so BCT poses a significant challenge when balancing transparency and data confidentiality (Queiroz & FossoWamba, 2019).

In the supply chain, the implementation of BCT is a progressive paradigm shift that encourages players to change their attitudes and become more competent (Queiroz & FossoWamba, 2019). Despite the known barriers (Yadav et al., 2020), the adoption of BCT in OTSC is underway. The adoption behaviour (Muhammad et al., 2021) of all OTSC stakeholders will improve over time, and trust will grow among them. This study shows that the chosen parameters, such as transparency and reliability, contribute to the sustainable performance of the BCT-driven OTSC. However, it should be remembered that the problems faced in developing countries vary with their technological innovation rate (Soni et al., 2021).

7.1. Theoretical implications

The four vital theoretical contributions of this work are as follows. The main contribution is the BTC-driven OTSC model. This model is also applicable in various other contexts, such as the Agro supply chain, the green supply chain, and the beverage supply chain. The model suggests that the adoption of BCT in the supply chain can help increase transparency and reliability, which positively affect the supply chain's sustainable performance.

Second, this study responds to the call for more research on BTC in the context of supply chains. In the current literature, blockchain studies have focused mainly on implementing the technology, while ignoring other dimensions of the supply chain's sustainable performance. Notably, considering the active use of BTC in the context of banking and cryptocurrencies and its limited use in the general supply chain, no analytical research has established or analysed the sustainable performance associated with the OTSC.

This study paves the way for future researchers to extend the use of BCT to other services in the supply chain domain, such as online purchase and logistics management.

Third, from a conceptual point of view, this study's exploratory mixed-method approach to extending existing theories (RBV and NT) to the supply chain model promotes the use of BTC to adapt existing theories to new contexts. The proposed model could enable future researchers to adapt similar theories to the contexts of other product networks and services, especially in the supply chain field.

Fourth, the research provides information about the Indian tea supply chain and the importance of BCT adoption for the OTSC in the Indian context. It is essential for researchers to understand the behaviour of the OTSC, as India represents a large segment of tea customers worldwide. This contribution is critical because prior studies have pointed out geographical disparities in the supply chain, underscoring the need for studies that focus on diverse geographies and cultures.

7.2. Practical implications

Organic tea growers and producers are interested in encouraging the general public to consume organic tea from an authentic source. The industry can benefit from restructuring the OTSC by adopting BTC. There are three key messages.

First, given that transparency and reliability are the main drivers of sustainable performance, BCT can increase the OTSC's customer base by promoting the organic tea brand to the existing tea consumers. Moreover, the use of BCT can lead to continuous quality care improvements, which will attract and retain consumers and ultimately increase the supply chain's customer base and reduce redundancies.

Second, this study has shown that sustainable performance, measured in terms of transparency and reliability, improves the OTSC process. Operators in the BCT-driven OTSC should therefore work on ways to accelerate organic-tea supply and to control supply-related information.

Third, this study is the first formal study focusing on the OTSC. It will help organic tea growers and manufacturers to identify the key strategies for responsible practices and to find opportunities to increase this supply chain's sustainable performance. An additional strength of the study is its focus on the cryptocurrency supply chain, which extends from traditional labourers to high-end consumers.

7.3. Conclusion, limitations, and future research

This study contributes to the research on BTC in the context of the OTSC to improve the OTSC's sustainable performance. This research is essential from the supply chain sector's perspective, since scholars have argued that it is critical to understand various aspects of stockholders' engagement during the organic product supply. We have found that the BTC can play a vital role in the supply chain. The empirical investigation justifies the adoption of the BTC by the various stakeholders.

Despite its significant achievements, this study has some limitations that should be noted.

First, the study included 41 small tea gardens, 22 tea estates from 4 separate tea-developing districts of Assam, and a tea research institute. Correspondingly, questionnaires were administered to 305 respondents through a survey. Comprehensive sample data would have made the resulting model more accurate.

Second, in certain instances, an inappropriate understanding of the roles and responsibilities of tea supply chain participants may have resulted in respondents' insufficient replies, and some assumptions made during the development of the BCT-driven OTSC model may have harmed its diversity.

Third, this study has used a cross-sectional method, so it depends on self-reported data collected at one point in time. This increases the probability of biased findings. In the future, researchers could use other research designs, such as longitudinal and experimental studies, to overcome this limitation and confirm our results.

There are many promising pathways for future research. First, it would be productive to discuss how BCT impacts social sustainability issues, especially the legal and ethical implications of its adoption in the OTSC. Second, to provide strategic insight into the implementation dynamics, we recommend a comparative analysis of BCT enablers and obstacles in different cultures and differently-sized tea-manufacturing factories. Third, in future experiments, investigating non-linear relationships using instruments such as artificial neural networks may be considered.

References

Abeyratne, S. A., & Monfared, R. P. (2016). Blockchain ready manufacturing supply chain using distributed ledger. *International Journal of Research in Engineering and Technology, 5*(9), 1–10.

Acquaye, A., Genovese, A., Barrett, J., & Lenny Koh, S. C. (2014). Benchmarking carbon emissions performance in supply chains. *Supply Chain Management: An International Journal*, *19*(3), 306–

321.
Amirteimoori, A., & Tabar, M. M. (2010). Resource allocation and target setting in data envelopment analysis. *Expert Systems with Applications*, *37*(4), 3036–3039.
Apiyo, R. O., & Kiarie, D. (2018). Role of ICT tools in supply chain performance. *International Journal of Supply Chain Management*, *3*(1), 17–26.
Astill, J., Dara, R. A., Campbell, M., Farber, M., Fraser, E. D. G., Sharif, S., & Yada, R. Y. (2019). Trends in Food Science & Technology Transparency in food supply chains : A review of enabling technology solutions. *Trends in Food Science & Technology Journal*, *91*(July), 240–247. https://doi.org/10.1016/j.tifs.2019.07.024
Aung, M. M., & Chang, Y. S. (2014). Traceability in a food supply chain: Safety and quality perspectives. *Food Control*, *39*, 172–184.
Balasubramanian, S., Shukla, V., Sethi, J. S., Islam, N., & Saloum, R. (2021). A readiness assessment framework for Blockchain adoption: A healthcare case study. *Technological Forecasting and Social Change*, *165*, 120536. https://doi.org/10.1016/j.techfore.2020.120536
Bartlett, P. A., Julien, D. M., & Baines, T. S. (2007). Improving supply chain performance through improved visibility. *The International Journal of Logistics Management*, *18*(2), 294–313.
Bastian, J., & Zentes, J. (2013). Supply chain transparency as a key prerequisite for sustainable agri-food supply chain management. *The International Review of Retail, Distribution and Consumer Research*, *23*(5), 553–570.
Bentler, P. (1990). Comparative Fit Indices in Structural Models Permalink. *Psychological Bulletin*, *107*(2), 238–246.
Biggs, E. M., Gupta, N., Saikia, S., & Duncan, J. (2018). Tea production characteristics of tea growers (plantations and smallholdings) and livelihood dimensions of tea workers in Assam, India. *Environmental Science & Policy Data in Brief*, *Submitted*, 1379–1387. https://doi.org/10.1016/j.dib.2018.02.056
Breidbach, C. F., & Tana, S. (2021). Betting on Bitcoin: How social collectives shape cryptocurrency markets. *Journal of Business Research*, *122*, 311–320. https://doi.org/10.1016/j.jbusres.2020.09.017
Byrne, B. M. (2013). *Structural Equation Modeling With EQS*. Routledge. https://doi.org/10.4324/9780203726532
Caridi, M., Perego, A., & Tumino, A. (2013). Measuring supply chain visibility in the apparel industry. *Benchmarking: An International Journal*, *20*(1), 25–44.
Carnovale, S., & Yeniyurt, S. (2014). The role of ego networks in manufacturing joint venture formations. *Journal of Supply Chain Management*, *50*(2), 1–17.
Casado-Vara, R., Prieto, J., La Prieta, F., & Corchado, J. M. (2018). How blockchain improves the supply chain: case study alimentary supply chain. *Procedia Computer Science*, *134*, 393–398.
Centobelli, P., Cerchione, R., Esposito, E., & Oropallo, E. (2021). Surfing blockchain wave, or drowning? Shaping the future of distributed ledgers and decentralized technologies. *Technological Forecasting and Social Change*, *165*, 120463. https://doi.org/10.1016/j.techfore.2020.120463
Centobelli, P., Cerchione, R., Esposito, E., Oropallo, E., Ghode, D. J., Jain, R., … Yadav, V. (2020). Architecture to Enhance Transparency in Supply Chain Management using Blockchain Technology. *Procedia Manufacturing*, *51*, 1614–1620. https://doi.org/10.1016/j.promfg.2020.10.225
Chau, P. Y. K. (1997). Reexamining a model for evaluating information center success using a structural equation modeling approach. *Decision Sciences*, *28*(2), 309–334. https://doi.org/10.1111/j.1540-5915.1997.tb01313.x
Chopra, S., & Meindl, P. (2014). *SUPPLY CHAIN MANAGEMENT Strategy, Planning, and Operation*. *Igarss 2014*. https://doi.org/10.1007/s13398-014-0173-7.2
Christopher, M., & Lee, H. (2004). Mitigating supply chain risk through improved confidence. *International Journal of Physical Distribution & Logistics Management*, *34*(5), 388–396.
Chuang, M. L., & Shaw, W. H. (2008). An empirical study of enterprise resource management systems implementation: from ERP to RFID. *Business Process Management Journal*, *14*(5), 675–693.
Ciccullo, F., Pero, M., Caridi, M., Gosling, J., & Purvis, L. (2018). Integrating the environmental and

social sustainability pillars into the lean and agile supply chain management paradigms: a literature review and future research directions. *Journal of Cleaner Production*, *172*, 2336–2350.
Cooka, W. D., & Kressbc, M. (1999). Characterizing an equitable allocation of shared costs: A DEA approach. *European Journal of Operational Research*, *199*(3), 652–661.
Cooper, D. R., & Schindler, P. S. (1998). *Business research methods*. Irwin/McGraw-Hill. Retrieved from https://books.google.com.ng/books/about/Business_Research_Methods.html?id=Toe-QgAACAAJ&redir_esc=y
de Villiers, C., Kuruppu, S., & Dissanayake, D. (2020). A (new) role for business – Promoting the United Nations' Sustainable Development Goals through the internet-of-things and blockchain technology. *Journal of Business Research*. https://doi.org/10.1016/j.jbusres.2020.11.066
Duffy, R., Fearne, A., & Healing, V. (2005). Reconnection in the UK food chain. *British Food Journal*, *107*(1), 17–33.
Fawcett, S. E., Jones, S. L., & Fawcett, A. M. (2012). Supply chain trust: The catalyst for collaborative innovation. *Business Horizons*, *55*(2), 163–178. https://doi.org/10.1016/j.bushor.2011.11.004
Francis, V. (2008). Supply chain visibility: lost in translation? Supply chain management. *Supply Chain Management: An International Journal*, *13*(3), 180–184.
Francisco, K., & Swanson, D. (2018). The supply chain has no clothes: technology adoption of blockchain for supply chain transparency. *Logistics*, *2*(1), 2–13.
Frohlich, M. T., & Westbrook, R. (2001). Arcs of integration: an international study of supply chain strategies. *Journal of Operations Management, 19*(2), 185–200.
Geels, F. W. (2004). From sectoral systems of innovation to socio-technical systems. *Res. Policy*, *33*(6–7), 897–920.
Gold, S., Trautrims, A., & Trodd, Z. (2015). Modern slavery challenges to supply chain management. *Supply Chain Management: An International Journal*, *20*(5), 485–494.
Groosman, M. (2011). *Tea : sector overview*. *IDH – the sustainable trade initiative*. Retrieved from http://www.bibalex.org/Search4Dev/files/432041/460374.pdf
Hair, J., Anderson, R., Black, B., & Barry, B. (2016). *Multivariate Data Analysis - Joseph Hair, Rolph Anderson, Bill Black, Barry Babin - Google Books* (7th ed.). Pearson Education. Retrieved from https://books.google.com.ng/books?id=LKOSAgAAQBAJ&dq=Hair+et+al.,+2010&hl=en&sa=X&ved=0ahUKEwjcwZDhwKnmAhX0snEKHeXCBToQ6wEIKDAA
Halldorsson, A., Hsuan, J., & Kotzab, H. (2015). Complementary theories to supply chain management revisited – from borrowing theories to theorizing. *Supply Chain Management: An International Journal*, *20*(6), 574–586.
Harman, H. H. (1976). *Modern factor analysis*. *the University of Chicago press* (Third Edit). Chicago & Lndon.
Hew, J.-J., Leong, L.-Y., Tan, G. W.-H., Ooi, K.-B., & Lee, V.-H. (2019). The age of mobile social commerce: An Artificial Neural Network analysis on its resistances. *Technological Forecasting and Social Change*, *144*, 311–324.
Hew, T. S., & Kadir, S. L. S. A. (2016). Predicting instructional effectiveness of cloudbased virtual learning environment. *Industrial Management and Data Systems, 116*(8), 1557–1584.
Hm, U., Narayan, S., Kumar, P., & Nabi, A. (2017). Export of organic products : Opportunities and challenges. *Journal of Pharmacognosy and Phytochemistry*, *6*(6), 1084–1088.
Hooper, D., Coughlan, J., Mullen, M. R., Mullen, J., Hooper, D., Coughlan, J., & Mullen, M. R. (2008). Structural Equation Modelling : Guidelines for Determining Model Fit Structural equation modelling : guidelines for determining model fit. *Dublin Institute of Technology ARROW @ DIT*, *6*(1), 53–60. Retrieved from www.ejbrm.com
Islam, N., Marinakis, Y., Olson, S., White, R. & Walsh, S. (2021). Is Blockchain mining profitable in the long run?. *IEEE Transactions on Engineering Management.*
J.-Sharahi, S., & Khalili-Damghani, K. (2019). Fuzzy type-II De-Novo programming for resource allocation and target setting in network data envelopment analysis: A natural gas supply chain. *Expert Systems with Applications*, *117*, 312–329. https://doi.org/10.1016/j.eswa.2018.09.046

Jena, L. K., Pradhan, S., & Panigrahy, N. P. (2018). Pursuit of organisational trust: Role of employee engagement, psychological well-being and transformational leadership. *Asia Pacific Management Review*, *22*(3), 227–234.

Johnson, A. (2017). An Introduction to Blockchain. *Darden Business Publishing*, 1–15.

Johnson, N., Elliott, D., & Drake, P. (2013). Exploring the role of social capital in facilitating supply chain resilience. *Supply Chain Management: An International Journal*, *18*(3), 324–336.

Kadavil, S. M. (2005). *Indian Tea Research*. Retrieved from https://www.somo.nl/wp-content/uploads/2007/01/Indian-Tea-Research.pdf

Kaipia, R., & Hartiala, H. (2006). Information-sharing in supply chains – five proposals on how to proceed. *The International Journal of Logistics Management*, *17*(3), 377–393.

Khan, M., Hussain, M., Papastathopoulos, A., & Manikas, I. (2018). Trust, information sharing and uncertainty: An empirical investigation into their impact on sustainability in service supply chains in the United Arab Emirates. *Sustainable Development*, *26*(6), 870–878.

Kim, D., Cavusgil, S. T., & Calantone, R. J. (2006). Information system innovations and supply chain management: channel relationships and firm performance. *Journal of the Academy of Marketing Science*, *34*(1), 40–54.

Kimani, D., Adams, K., Attah-Boakye, R., Ullah, S., Frecknall-Hughes, J., & Kim, J. (2020). Blockchain, business and the fourth industrial revolution: Whence, whither, wherefore and how? *Technological Forecasting and Social Change*, *161*, 120254. https://doi.org/10.1016/j.techfore.2020.120254

Kline, R. . (2011). *Principles and practice of structural equation modeling, 3rd ed. - PsycNET*.

Kline, R. B. (2016). *Principles and Practice of Structural Equation Modeling, Fourth Edition - Rex B. Kline - Google Books* (fourth Edition). New York: The Guilford Press. Retrieved from https://books.google.com.ng/books?id=Q61ECgAAQBAJ&printsec=frontcover&dq=TLI+%3E%3D0.95+Kline,+2005+structural+equation+modeling&hl=en&sa=X&ved=0ahUKEwjEpuH32avmAhXagVwKHSY2CtoQ6AEIKDAA#v=onepage&q&f=false

Kock, N., & Lynn, G. (2012). Lateral collinearity and misleading results in variance-based SEM: an illustration and recommendations. *Journal of the Association for Information Systems*, *13*(7), 546–580.

Kopyto, M., Lechler, S., von der Gracht, H. A., & Hartmann, E. (2020). Potentials of blockchain technology in supply chain management: Long-term judgments of an international expert panel. *Technological Forecasting and Social Change*, *161*, 120330. https://doi.org/10.1016/j.techfore.2020.120330

Kshetri, N. (2018). Blockchain's roles in meeting key supply chain management objectives. *International Journal of Information Management*, *39*, 80–89.

Kumar, V., Ramachandran, D., & Kumar, B. (2020). Influence of new-age technologies on marketing: A research agenda. *Journal of Business Research*, *125*, 864–877. https://doi.org/10.1016/j.jbusres.2020.01.007

Kustanti, V. R., & Widiyanti, T. (2007). *RESEARCH ON SUPPLY CHAIN IN THE TEA SECTOR IN INDONESIA*.

Kwon, I.-W., & Kim, S.-H. (2018). Framework for successful supply chain implementation in healthcare area from provider's perspective. *Asia Pacific Journal of Innovation and Entrepreneurship*, *12*(2), 135–145.

Lambert, D. M., & Schwieterman, M. A. (2012). Supplier relationship management as a macro business process. *Supply Chain Management: An International Journal*, *17*(3), 337–352.

Lansiti, M., Lakhani, K. R., Iansiti, M., & Lakhani, R. K. (2017). The truth about blockchain. *Harvard Business Review*, (January-February), 1–14.

Larios-Hernández, G. J. (2017). Blockchain entrepreneurship opportunity in the practices of the unbanked. *Business Horizons*, *60*(6), 865–874. https://doi.org/10.1016/j.bushor.2017.07.012

Lee, J. H., & Pilkington, M. (2017). How the blockchain revolution will reshape the consumer electronics industry [future directions]. *IEEE Consumer Electronics Magazine*, *6*(3), 19–23.

Lo, S. M., Zhang, S., Wang, Z., & Zhao, X. (2018). The impact of relationship quality and supplier

development on green supply chain integration: A mediation and moderation analysis. *Journal of Cleaner Production*, *202*, 524–535. https://doi.org/10.1016/j.jclepro.2018.08.175
Lowe, B. H., Oglethorpe, D. R., & Choudhary, S. (2020). Comparing the economic value of virtual water with volumetric and stress-weighted approaches: A case for the tea supply chain. *Ecological Economics*, *172*(September 2018), 106572. https://doi.org/10.1016/j.ecolecon.2019.106572
Majeed, M. A. A., & Rupasinghe, T. D. (2017). Internet of things (IoT) embedded future supply chains for industry 4.0: an assessment from an ERP-based fashion apparel and footwear industry. *International Journal of Supply Chain Management*, *6*(1), 25–40.
Mansingh, P., & Johnson, L. T. (2012). *COMPARATIVE ANALYSIS OF EXISTING MODELS OF SMALL TEA GROWERS IN TEA VALUE CHAIN IN THE NILGIRIS*.
Marsal-Llacuna, M. L. (2018). Future living framework: Is blockchain the next enabling network? *Technological Forecasting and Social Change*, *128*, 226–234. https://doi.org/10.1016/j.techfore.2017.12.005
Marsh, H. W., & Hocevar, D. (1985). Application of Confirmatory Factor Analysis to the Study of Self-Concept. First- and Higher Order Factor Models and Their Invariance Across Groups. *Psychological Bulletin*, *97*(3), 562–582. https://doi.org/10.1037/0033-2909.97.3.562
Martha, C., & Lisa, E. (1993). Characteristics of Supply Chain Management and the Implications for Purchasing and Logistics Strategy. *The International Journal of Logistics Management*, *4*(2), 13–24.
McConaghy, M., McMullen, G., Parry, G., McConaghy, T., & Holtzman, D. (2017). Visibility and digital art: blockchain as an ownership layer on the internet. *Strategic Change*, *26*(5), 461–470.
Michalski, M., Montes-Botella, J. L., & Narasimhan, R. (2018). The impact of asymmetry on performance in different collaboration and integration environments in supply chain management. *Supply Chain Management: An International Journal*, *23*(1), 33–49.
Mitchell, V. (1996). Assessing the reliability and validity of questionnaires: an empirical example. *J. Appl. Manag. Stud*, *5*(2), 199–208.
Muhammad, S. S., Dey, B. L., Kamal, M. M., & Alwi, S. F. S. (2021). Consumer engagement with social media platforms: a study of the influence of attitudinal components on cutting edge technology adaptation behaviour. *Computers in Human Behavior*, *121*, 106802.
Murck, P. (2017). Who Controls the Bloclchain? *Harvard Business Review*.
Musigmann, B., Von Der Gracht, H., & Hartmann, E. (2020). Blockchain Technology in Logistics and Supply Chain Management - A Bibliometric Literature Review from 2016 to January 2020. *IEEE Transactions on Engineering Management*, *67*(4), 988–1007. https://doi.org/10.1109/TEM.2020.2980733
Nakamoto, S. (2008). *Bitcoin: A Peer-to-Peer Electronic Cash System*. Retrieved from www.bitcoin.org
Neri, A., Cagno, E., Lepri, M., & Trianni, A. (2021). A triple bottom line balanced set of key performance indicators to measure the sustainability performance of industrial supply chains. *Sustainable Production and Consumption*, *26*, 648–691. https://doi.org/10.1016/j.spc.2020.12.018
Nunnally, J. C., & Bernstein, I. H. (1994). *Psychometric theory*. McGraw-Hill. Retrieved from https://books.google.com.ng/books?id=r0fuAAAAMAAJ&q=inauthor:%22Jum+C.+Nunnally%22&dq=inauthor:%22Jum+C.+Nunnally%22&hl=en&sa=X&ved=0ahUKEwiej5-xwKnmAhWXFMAKHfhoAccQ6wEIKjAA
Olatunji, O. O., Ayo, O. O., Akinlabi, S., Ishola, F., Madushele, N., & Adedeji, P. A. (2019). Competitive advantage of carbon efficient supply chain in manufacturing industry. *Journal of Cleaner Production*, *238*. https://doi.org/10.1016/j.jclepro.2019.117937
Pan, M., Xin, P., Xu, X., This, B. F., & Publishing, I. (2016). Block Chain: A New Solution for Supply Integrity. *IVEY Publishing*, 1–8.
Park, G., Shin, S. R., & Choy, M. (2020). Early mover (dis)advantages and knowledge spillover effects on blockchain startups' funding and innovation performance. *Journal of Business Research*, *109*, 64–75. https://doi.org/10.1016/j.jbusres.2019.11.068
Parry, G. C., Brax, S. A., Maull, R. S., & Ng, I. C. L. (2016). Operationalising IoT for reverse supply: the development of use-visibility measures. *Supply Chain Management: An International Journal*,

21(2), 228–244.
Parry, G., & Graves, A. (2008). The importance of knowledge management for ERP systems. *International Journal of Logistics Research andApplications*, *11*(2), 427–441.
Paul, T., & Mondal, S. (2019). A strategic analysis of tea leaves supply chain before manufacturing – a case in Assam. *Benchmarking: An International Journal*, *26*(1), 246–270. https://doi.org/10.1108/BIJ-01-2018-0007
Paul, T., & Mondal, S. (2021). Classification of Indian Tea Supply Chain - in Context of Assam. *International Journal of Process Management and Benchmarking*, *11*(2), 220–253. https://doi.org/10.1504/IJPMB.2020.10018901
Paul, T., & Sandeep, M. (2021). The Impact of Organic Transformation: Strategies and Innovative Ideas towards Profitability - A case of Hathikuli Tea Estate. *International Journal of Strategic Change Management*. https://doi.org/10.1504/IJSCM.2019.10025807
Paulraj, A., Lado, A. A., & Chen, I. J. (2008). Inter-organizational communication as a relational competency: Antecedents and performance outcomes in collaborative buyer-supplier relationships. *Journal of Operations Management*, *26*(1), 45–64. https://doi.org/10.1016/j.jom.2007.04.001
Pereira, J., Tavalaei, M. M., & Ozalp, H. (2019). Blockchain-based platforms: Decentralized infrastructures and its boundary conditions. *Technological Forecasting and Social Change*, *146*, 94–102. https://doi.org/10.1016/j.techfore.2019.04.030
Podsakoff, P. M., MacKenzie, S. B., & Podsakoff, N. P. (2012). Sources of method bias in social science research and recommendations on how to control it. *Annual Review of Psychology*, *63*, 539–569.
Pólvora, A., Nascimento, S., Lourenço, J. S., & Scapolo, F. (2020). Blockchain for industrial transformations: A forward-looking approach with multi-stakeholder engagement for policy advice. *Technological Forecasting and Social Change*, *157*, 120091. https://doi.org/10.1016/j.techfore.2020.120091
Porter, M. E. (1980). *Competitive Strategy: Techniques for Analyzing Industries and Competitors*. New York: Free Press.
Queiroz, M. M., & FossoWamba, F. S. (2019). Blockchain adoption challenges in supply chain: an empirical investigation of the main drivers in India and the USA. *International Journal of Information Management*, *46*, 70–82.
Ramirez, S. Q., Sánchez, B. M., Jimenez, S. C., Castañeda, W. R., & Ramirez, D. G. (2019). Avocado and Coffee Supply Chains Specialization in Colombia. *Procedia Computer Science*, *158*, 573–581. https://doi.org/10.1016/j.procs.2019.09.091
Ringsberg, H. (2014). Perspectives on food traceability: a systematic literature review. *Supply Chain Management: An International Journal*, *19*(5/6), 558–576.
Roy, S. (2011). Historical Review of Growth of Tea Industries in India : A Study of Assam Tea. In *International Conference on Social Science and Humanity* (Vol. 5, pp. 166–170). Singapore: IACSIT Press. Retrieved from http://www.ipedr.com/vol5/no1/35-H00082.pdf
Ryciuk, U. (2017). Identification of Factors Related to Trust Formation in Construction Supply Chains. *Procedia Engineering*, *182*, 627–634. https://doi.org/10.1016/j.proeng.2017.03.168
Saaty, T. L., & Ergu, D. (2015). When is a Decision-Making method trustworthy? Criteria for evaluating Multi-Criteria Decision-Making methods. *International Journal of Information Technology&Decision Making*, *14*(6), 1171–1187.
Saberi, S., Kouhizadeh, M., Sarkis, J., & Shen, L. (2019). Blockchain technology and its relationships to sustainable supply chain management. *International Journal of Production Research*, *57*(7), 2117–2135.
Sarma, G. (2011). A Historical Background of Tea in Assam. *Pratidhwani the Echo*, *1*(IV), 123–131.
Schlecht, L., Schneider, S., & Buchwald, A. (2021). The prospective value creation potential of Blockchain in business models: A delphi study. *Technological Forecasting and Social Change*, *166*, 120601. https://doi.org/10.1016/j.techfore.2021.120601
Schoenherr, T., & Swink, M. (2012). Revisiting the arcs of integration: cross-validations and extensions. *Journal of Operations Management*, *30*(1/2), 99–115.

Segars, A. H., & Grover, V. (1993). Re-examining perceived ease of use and usefulness: A confirmatory factor analysis. *MIS Quarterly: Management Information Systems*, *17*(4), 517–525. https://doi.org/10.2307/249590

Shah, D., & Murthi, B. P. S. (2020). Marketing in a data-driven digital world: Implications for the role and scope of marketing. *Journal of Business Research*, *125*, 772–779. https://doi.org/10.1016/j.jbusres.2020.06.062

Shen, B., Choi, T. M., & Minner, S. (2018). A review on supply chain contracting with information considerations: information updating and information asymmetry. *International Journal of Production Research*, *7543*, 1–39.

Sidorov, M., Ong, M. T., Sridharan, R. V., Nakamura, J., Ohmura, R., & Khor, J. H. (2019). Ultralightweight mutual authentication RFID protocol for blockchain enabled supply chains. *IEEE Access*, *7*, 7273–7285. https://doi.org/10.1109/ACCESS.2018.2890389

Singh, A., & Teng, J. T. C. (2016). Enhancing supply chain outcomes through information technology and trust. *Computers in Human Behavior*, *54*, 290–300.

Song, Y., Cai, J., & Feng, T. (2017). The influence of green supply chain integration on firm performance: A contingency and configuration perspective. *Sustainability*, *9*, 763–780.

Soni, G., Mangla, S. K., Singh, P., Dey, B. L., & Dora, M. (2021). Technological interventions in social business: Mapping current research and establishing future research agenda. *Technological Forecasting and Social Change*, *169*, 120818.

Su, C. W., Qin, M., Tao, R., & Umar, M. (2020). Financial implications of fourth industrial revolution: Can bitcoin improve prospects of energy investment? *Technological Forecasting and Social Change*, *158*, 120178. https://doi.org/10.1016/j.techfore.2020.120178

Sunny, J., Undralla, N., & Pillai, V. M. (2020). Supply chain transparency through blockchain-based traceability: An overview with demonstration. *Computers & Industrial Engineering*, 106895.

Tadesse, G., & Kassie, G. T. (2017). Measuring trust and commitment in collective actions Evidence from farmers' marketing organizations in rural Ethiopia. *International Journal of Social Economics*, *44*(7), 980–996. https://doi.org/10.1108/IJSE-09-2015-0253

Talwar, S., Dhir, A., Kaur, P., & Mäntymäki, M. (2020). Barriers toward purchasing from online travel agencies. *International Journal of Hospitality Management*, *89*, 102593.

Tea Board of India. (2015). *Tea Area and Production 2015_16*. Kolkata.

Tea Board of India. (2017). *Global tea statistics* (Vol. 295). Kolkata. Retrieved from http://www.teaboard.gov.in/pdf/Global_tea_statistics_pdf4619.pdf

Treiblmaier, H. (2018). The impact of the blockchain on the supply chain: a theory-based research framework and a call for action. *Supply Chain Management: An International Journal*, *23*(6), 545–559. https://doi.org/10.1108/SCM-01-2018-0029

Tsolakis, N., Niedenzu, D., Simonetto, M., Dora, M., & Kumar, M. (2020). Supply network design to address United Nations Sustainable Development Goals: A case study of blockchain implementation in Thai fish industry. *Journal of Business Research*. https://doi.org/10.1016/j.jbusres.2020.08.003

Venkatesh, V. G., Kang, K., Wang, B., Zhong, R. Y., & Zhang, A. (2020). System architecture for blockchain based transparency of supply chain social sustainability. *Robotics and Computer-Integrated Manufacturing*, *63*(March 2019), 101896. https://doi.org/10.1016/j.rcim.2019.101896

Wagner, S. M., & Kemmerling, R. (2010). Handling nonresponse in logistics research. *Journal Business Logistic*, *31*(2), 357–381.

Wang, Y., Han, J. H., & Beynon-Davies, P. (2019). Understanding blockchain technology for future supply chains: a systematic literature review and research agenda. *Supply Chain Management*, *24*(1), 62–84.

Wang, Z., Hu, H., & Zhou, W. (2017). RFID enabled knowledge-based precast construction supply chain. *Computer-Aided Civil and Infrastructure Engineering*, *32*(6), 499–514.

Warth, J., Von der Gracht, H. A., & Darkow, I. L. (2013). A dissent-based approach for multi-stakeholder scenario development - The future of electric drive vehicles. *Technological Forecasting and Social Change*, *80*(4), 566–583. https://doi.org/10.1016/j.techfore.2012.04.005

Werbach, K. (2018). Trust, but verify: why the Blockchain needs the law. *Berkeley Technology Law Journal*. Retrieved from www.techpolicy.com/Articles/T/Trust,-But-Verify-Why-the-%0ABlockchain-Needs-the-La.aspx

White, R., Marinakis, Y., Islam, N., & Walsh, S. (2020). Is Bitcoin a currency, a technology-based product, or something else? *Technological Forecasting and Social Change*, *151*, 119877. https://doi.org/10.1016/j.techfore.2019.119877

Wichmann, B. K., Carter, C. R., & Kaufmann, L. (2015). How to become Central in an informal social network: an investigation of the antecedents to network centrality in an environmental SCM initiative. *Journal of Business Logistics*, *36*(1), 102–119.

Wijesinha, A., & Hirimuthugodage, D. (1999). Promoting Regional Value Chains in Tea in South Asia: Case of Sri Lankan Tea Sector. *Journal of Plantation Managment*, *15*(2).

Williams, B. D., Roh, J., Tokar, T., & Swink, M. (2013). Leveraging supply chain visibility for responsiveness: the moderating role of internal integration. *Journal of Operations Management*, *31*(7/8), 543–554.

Yadav, V. S., Singh, A. R., Raut, R. D., & Govindarajan, U. H. (2020). Blockchain technology adoption barriers in the Indian agricultural supply chain: an integrated approach. *Resources, Conservation and Recycling*, *161*, 104877.

Yang, C.-S., & Lirn, T.-C. (2017). Revisiting the Resource- Based view on logistics performance in the shipping industry. *International Journal of Physical Distribution & Logistics Management*, *47*(9), 884–905.

Yeoh, P. (2017). Regulatory issues in blockchain technology. *Journal of Financial Regulation and Compliance*, *25*(2), 196–208.

Yin, R. . (2014). *Case Study Research Design and Methods*. Thousand Oaks , CA: Sage.

Yoffie, D. B., & Woo, A. K. (2017). Note on Blockchain and Bitcoin. *Harvard Business School*, *November*, 1–10.

Younis, H., Sundarakani, B., & O'Mahony, B. (2020). Investigating the relationship between green supply chain management and corporate performance using a mixed method approach: Developing a roadmap for future research: Green supply chain management and corporate performance. *IIMB Management Review*, *32*(3), 305–324. https://doi.org/10.1016/j.iimb.2019.10.011

Zhang, M., Chen, J., & Chang, S. H. (2020). An adaptive simulation analysis of reliability model for the system of supply chain based on partial differential equations. *Alexandria Engineering Journal*, *59*(4), 2401–2407. https://doi.org/10.1016/j.aej.2020.03.002

Appendix-1:

Field Visit Schedule

Method	Field Type / Interact With	Observation / Discussion Area of the Tea Supply Chain	No. of Visit/ Interaction
Observation	Estate-Tea-Gardens	Tea cultivation process and plucking strategy	22
	Small-Tea-Gardens	Tea cultivation process and plucking strategy	41
	Estate-Tea-Factories	'made-tea' processing strategy	22
	Bought-Leaf-Factories	'made-tea' processing strategy	03
	Kolkata Tea-Auction-Centre	Collected the basic information about tea auction	02
Focus Group Discussion	Laborers of the Estate-Tea-Gardens	Plucking timing, plucking season, plucking strategy, and nursing of the tea plants	12
	Laborers of the Estate-Tea-Factories	Different phases of the 'made-tea' process	07
	Plucking laborers of the Small-Tea-Gardens	Plucking season, plucking timing, and plucking strategy	17

	Laborers of the Bought-Leaf-Factories	Different phases of the 'made-tea' process	08
Interview	Employee of the Small Tea Gardens	Plucking and pruning strategies	24
	Small Tea Growers	Limitations/challenges faces during cultivating, harvesting, and selling of the Tea Leaves	37
	Tea-Leaves-Agents	Selling and buying opportunity of the plucked Green Tea Leaves	07
	Supervisors of the Tea-Estates-Gardens (plucking laborers are working under a supervisor)	Plucking, pruning, and nursing strategies	16
	Assistant Managers (field laborer manager) of the Estate-Tea-Factories	Limitations/challenges face during cultivating and harvesting	08
	Assistant Managers (field manager) of the Estate-Tea-Factories	Factors responsible for producing the best quality GTLs and 'made-tea' (plucking standard, day-of-plucking, organic cultivation, nursing the Tea plants, duration between plucked Green Tea Leaves, and start processing)	06
	Assistant Managers (administrative manager) of the Estate-Tea-Factories	Use of Logistic and Logistic cost; Distribution channel	07
	Managers of the Estate-Tea-Factories	Roll of the Tea Leaves Agents, Made Tea Agents and Tea Brokers; Roll and responsibilities of the individual players of the Tea Supply Chain	05
	Assistant Managers (administrative manager) Bought-Leaf-Factories	Use of Logistic and Logistic cost; Distribution channel	06
	Managers of the Bought-Leaf-Factories	Roll of the Tea Leaves Agents, Made Tea Agents and Tea Brokers; Roll and responsibilities of the individual players of the Tea Supply Chain	03
	Scientists of Tocklai Tea Research Institute	Role of the Tea Research Centers in tea cultivation and processing; Quality of the finished Tea	03
	Distributors and Retailers	Blending and packing; Distribution channel	11
	Tea Consumers	Purchase trends	14
Informal Discussion	Made Tea Brokers	Roll and responsibilities of the Tea-Auction-Centre; Distribution channel	02
	Employees of the Reputed Companies' Tea-Estates	Factors responsible for producing the best quality made-tea and finished Tea; Distribution channel	05
	Employees of the Tea-Branding-Companies	Factors responsible for producing the best quality the finished Tea; Distribution channel	04