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Blockchain-driven handling of digital freight information: a tensions perspective

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ABSTRACT

Blockchain technology is provoking significant transformations in the logistics industry, creating a complex environment that challenges business change. This study endeavors to advance the research regarding blockchain-based logistics management by identifying tensions and paradoxes accompanying blockchain adoption for handling digital freight information. Addressing the gap of scarce empirical research on adopting this technology, we conducted 12 expert interviews in the German logistics industry. While confirming and advancing previous research, we found several incompatibilities between the technology and its application, as practitioners tend to adopt blockchain features selectively instead of full acceptance of the respective privacy model. Our analysis reveals that the automation of several functionalities on a platform is among the features of blockchains with the greatest potential to create change in handling digital freight information when related governance mechanisms are in place. Building on these findings, the study proposes main strategies to manage the observed tensions, particularly separation, differentiation, and integration strategies. Thereby, our research contributes to the understanding of digital transformations based on immutability and disintermediation when logistics service providers are engaged in blockchain projects.

KEYWORDS: Blockchain · transport logistics · digital freight information · tensions and paradoxes.

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1. INTRODUCTION

In 2020, the European Parliament approved the European Union (EU) regulation on electronic freight transport information, which requires not only companies in the logistics sector but also public authorities to accept and forward electronic freight information [1]. This will oblige EU member state authorities to send legally binding electronic documents and certificates to private companies and vice versa. The regulation is due to come into force in four years and will be directly applicable as law for each EU state. In Germany, various systems for handling electronic freight transport information (eFTI[1]) are currently being tested [2]. In related projects to test eFTI applications, logistics companies were trained by the German Federal Association of Road Haulage, Logistics, and Disposal (BGL) to use existing information-sharing platforms, such as myAEOLIX, Transport Portal, and TransFollow [2,3]. Compared to Denmark, the Netherlands, the Czech Republic, and Switzerland, however, Germany has still hardly begun to use electronic freight documents. To a considerable extent, legal requirements still restrict the implementation of digital consignment notes (e-CMR[2]) – at least at present. While the legal situation in Germany will be adjusted according to new EU regulations in the near future, this will eliminate the need for vehicle documents, company and community licenses, driver activity data, as well as consignment notes to be physically present in vehicles for roadside checks. According to the BGL [2], up to € 600 million in costs can be saved if the digital version of the consignment note is introduced for

1 Please note that the present study uses the term electronic freight transport information and its abbreviation eFTI in the sense of German civil law, §408(3) HGB (German Commercial Code).
2 In contrast to other countries, Germany has not ratified the optional protocol of the e-CMR yet. Only when all relevant countries have signed the optional e-CMR protocol and the EU regulation on electronic freight transport information is in force, all legal prerequisites are set out.

freight transportation. Given this economic potential, the present study aims at a structured analysis of the opportunities and limitations in using electronic freight documents beyond the legal framework.

Blockchain technology provides a novel opportunity for logistics service providers to exchange, manage, and save eFTI. Now that blockchain technology has been widely applied to many industries, including transport logistics, it has become a promising instrument for mitigating platform risks and solving platform-related supply chain issues [4,5]. The advantage of blockchains is that they can establish a reliable and secure system that ensures transparency and immutability of data, while smart contracting facilitated by blockchain systems enhances operational performance [6]. Blockchains can further help supply chains to improve end-to-end data transparency, reduce costs and risks, and enhance sustainable operations [7]. Furthermore, blockchains address the phenomenon of information silos through processes that integrate procurement, production, logistics, sales, and source tracking [6]. Hence, blockchain technology is promising for handling electronic freight documents across companies and governmental institutions. However, in recent studies, authors have explored challenges in blockchain applications in the logistics sector. For instance, Sternberg et al. [8] found increased IT handling complexity to be a perceived obstacle by users. They also identified organizational immaturity as a barrier to blockchain implementation. Acknowledging these contradicting poles of blockchain implementations in the logistics industry calls for additional research shedding light on related inconsistencies.

We respond to this call by scrutinizing the challenges of implementing blockchain technology for handling eFTI through the angle of a tensions and paradox perspective, which generally applies a win-win, trade-off, integrative, or paradoxical approach [9,10]. Tensions in this vein refer to contradictory demands that may exist between present and future temporal contexts or between competing elements [11]. Further, paradoxical tensions are defined as *"contradictory yet interrelated elements, that exist simultaneously and persist over time"* [11]. While paradoxical tensions are perceived as innately given and persistent, however, the center of paradox theory is that competing elements that underscore the paradox may foster innovation in a company, for example, by functioning together as a catalyst for development and change [12,13]. Facilitating a tensions and paradox perspective to study blockchain-driven handling of eFTI, the following research questions guided our research: *Which tensions and paradoxes exist for logistics service providers in applying blockchain technology to facilitate the implementation of electronic freight documents? How can they be managed?*

To answer the proposed research questions, the authors applied a qualitative and explorative approach to answer the research questions [14]. Since the research mainly addresses logistics operations, 12 expert interviews were conducted with logistics service providers, software developers, consultants, a transport insurance company, and representatives of a logistics association. While most of the extant literature on blockchain adoption is conceptual [8], our empirical results contribute to theory-building and refinement as well as guide future research on technological transformations with disruptive innovations for this specific application. To deepen researchers' and practitioners' understanding of incompatible requirements in blockchain applications, one premise for this research is that tensions provide a more rigid and holistic lens to understand incompatibilities in detail. Hence, the empirically derived results were coupled with the theoretical lens of corporate tensions and paradoxes as well as related strategies to manage them.

As a result, the current research analyzed the tensions present between the decentralization of data and automation opportunities of blockchain applications as well as the perceived privacy concerns of the users, particularly the logistics service providers. The advancement of the privacy model, rather than focusing on technical aspects, is necessary to overcome specific transparency challenges and increase overall operational performance. Specifically, perceived challenges in sharing sensitive information must be addressed by separation and differentiation as well as integration strategies to manage tensions in digital transformations. In this regard, our paper adds to the discussion of alternative designs for disintermediated, peer-to-peer (P2P) platform models in logistics and supply chain management.

The present study is structured as follows. In Section 2, a review of the extant literature is provided that summarizes the essential blockchain applications in the logistics sector and adoption principles. Section 2 also includes some prominent use cases in transport logistics. Section 3 elaborates on the tensions and paradox perspective, which serves as an analysis scheme for the empirical data. Section 4 presents the applied research design, while Section 5 provides the empirical results of the qualitative content analysis approach, and Section 6 elaborates on existing tensions. Lastly, the empirical results are discussed in Section 7, while Section 8 concludes the findings while also showing the limitations of this study.

2. LITERATURE BACKGROUND

2.1. Blockchain applications in transportation logistics

In recent years, academic interest in blockchain technology and its business applications has rapidly increased, leading to intensified research activities. However, empirical insight into the success and failure of blockchain implementation projects is still limited [6], while supply chain innovations within blockchains and/or related technologies remain understudied in the literature [15]. As of today, small- and medium-sized logistics service providers hardly apply any blockchain technology in their businesses [16]. In contrast, larger, international companies are beginning to define their own use cases and are trying to develop them further in joint projects, particularly in the maritime shipping industry [4,16]. Here, blockchain applications can be incorporated to create a distributed shipping system and interconnect all business activities in the view of a shipment [4,17]. By reviewing real-world applications in the shipping industry, Dutta et al. [4] concluded that an improvement of supply chain visibility and transparency, product provenance and information, are the main features of blockchain applications. More generally, Chueng et al. [18] found digital technologies promising to increase the quality of services and cybersecurity in the logistics industry. Blockchain thereby has been flaunted as the latest solution to the problem of achieving end-to-end transparency in supply chains [19].

Regarding blockchain-based handling of eFTI, the electronic bill of lading has been studied by Takahashi [20]. He concluded that a blockchain-based bill of lading, although not yet a reality, offers several advantages, such as a guarantee of uniqueness and decentralization where no prior subscription to membership is required. At the same time, obstacles like a missing legal framework, insufficient security, costs, and confidentiality concerns prohibit the use of an electronic bill of lading via blockchains [20]. Particularly in sea freight logistics, some prominent use cases include the Global Shared Container Platform (GSCP) and the TradeLens platform by Maersk and IBM [21,22], while funded projects like Hansebloc and EconBill test blockchain applications for handling eFTI. TransFollow, although not operated on blockchain technology, is an important use case for handling eFTI [3] and is briefly presented in Table 1.

2.2 Blockchain features and characteristics

A blockchain is a distributed P2P system consisting of data copies in a network of computers. It forms a decentralized database in which data and information are recorded in connected and organized blocks protected by digital signatures as an element of cryptography (i.e., cryptographic hash functions) [23]. Each block consists of a finite set of transactions without the need for a third party to verify these transactions since verification is performed by the nodes (computers) connected in a decentralized manner [6]. If approved, the block is added to the chain, which locks the timestamped transaction and provides a permanent transaction record [24]. Thus, a blockchain is a fully decentralized, distributed ledger for electronic transactions without relying on trust between the transacting parties [25] and functions as an immutable ledger allowing for transactions to occur directly between anonymous and, therefore, untrustworthy parties [26]. Table 2 presents a related overview of blockchain properties to summarize the essential key features.

While all members in a blockchain technically have equal rights (e.g., within the Bitcoin blockchain) [26], participants in public blockchains can read and submit transactions without permission. Additionally to permissionless, public blockchain, permissioned configurations in form of consortium or private

Table 1: Blockchain applications in transportation and logistics.

Use case	Description
Global Shared Container Platform	The GSCP project aims to enable a global container platform using blockchain technology that aims to provide tracking of containers and reduce the number of empty containers worldwide. In addition, the GSCP is designed to simplify the purchase and release of containers and minimize fraud. To track a container, the platform requires sensor technology, which collects container data and transfers it to the blockchain. [21]
Trade Lens	In 2018, the Danish shipping company Maersk Group A/S and the American information technology (IT) company IBM Corp. announced the formal launch of the TradeLens platform to automate and standardize data exchange and updates, view transport routes and supply chains from beginning to end, establish a smooth administrative process for public authorities, and reduce time-consuming and manual work processes. The TradeLens platform is set up as a permissioned blockchain with user access restrictions. [22]
Trans Follow	TransFollow is a Dutch company that deals with digitizing freight documents via a centrally controlled platform. This platform is designed to enable shippers, haulage contractors, and consignees to carry out paperless transports in the interest of greater predictability at lower costs. The digital transmission of relevant information enables eFTI to be issued and shared with business partners. TransFollow thereby developed a solution that makes it possible to create, edit, and share eFTI even when using different types of software with end-users. [3]

blockchains are discussed in the literature. However, the introduction of permissioning impacts the fundamental properties of blockchain architecture negatively [27], aligning them rather towards shared databases [5,28]. Originally, Nakamoto [25] developed a privacy model, wherein transactions are public and visible to all. Privacy is ensured by protecting the transacting parties' identities and relies on the anonymity enabled by public-key cryptography. As any node can invoke transactions in the public, a consensus mechanism is required to validate the transactions. In contrast, not all users of private or consortium blockchains are equally allowed to access and read the transaction history or validate the transaction status. This increases trust between the permissioned users, while blockchain trust based on transparency becomes redundant. However, permissioned blockchains can benefit by consensus algorithms aiding synchronization with unreliable nodes [28]. Accordingly, the ability to identify the nodes the ability to control access and a lower degree of decentralization in private blockchains reduces transparency [24,27].

3. THEORETICAL BACKGROUND

So far, multiple studies have explored barriers and challenges in blockchain applications in logistics and supply chain management [e.g., 4,6,8,20,24]. In contrast to this extensive work, research facilitating a tensions or paradox perspective on change processes with blockchain technology is scarce. In the following subsections, we provide a brief theoretical background on tensions and paradoxes as well as give an overview on empirical research on tensions and paradoxes in blockchain application.

3.1 Tensions and paradox theory

Many of the challenges, which are observable in transformation processes where blockchain technology is involved, can be framed as paradoxical tensions. While the single elements of paradoxical tensions seem logical and desirable in isolation, they are perceived as irrational when juxtaposed [11]. Instead of viewing interrelated features as either positively interrelated (win-wins) or contradictory (trade-offs), the paradox

Table 2: Blockchain characteristics.

Key features	Description
Decentralization	No single central governance and infrastructure is implemented in public blockchains. Participants provide the required resources, installing robustness, redundancy, security, and availability. Without reliance on a centralized actor, participants are free to join or withdraw from the network. [26,29,30].
Anonymity	The anonymity of the transacting party is required to protect the privacy of the transactions. To prevent de-anonymization, neither transactions nor transacting parties can be linked [26,29,31]. However, anonymity can be lifted when some form of central authority is established to permission user access [5,27].
Transparency	Each member of a blockchain has access to the entire data and its history. Transactions are visible to all, allowing the verification of transactions' validity through every participant. Confidentiality is protected through anonymity. [26,29,31]
Group consensus	In the absence of trust between anonymous participants, trust in the transactions is generated through the process of group consensus. Vulnerability toward a single governing entity is removed [25]. Consortium or private blockchains will require users to decide to trust at least some of the other participants. Therefore, the purpose of consensus shifts from providing trust towards synchronization of system nodes. [32]
Immutability	The blockchain ledger is append-only, and validated transactions are resistant to change. Blocks of transactions are linked to each other through hash trees, securing content, sequence, and validity. Modified transactions are detected and rejected by the users, preventing transaction fraud. Users' trust in the integrity of the information replaces governance by a central authority. [6,25,31]
Automation	Blockchain transactions can consist of autonomous and self-executive codes in the form of smart contracts. To execute, the smart contract requires access to network resources. Due to the decentralized nature of the blockchain, the created contract and the initiating participant expect no further direct interaction. [33,34]

perspective offers a more nuanced perspective on tensions and oppositions [11,35]. Following the conceptualization by Hahn et al. [9], tensions can be categorized into three main dimensions: level, context, and change. Regarding organizational levels, tensions might arise from the embeddedness of individual and corporate decisions in a wider organizational context [10]. Hence, constraints by organizational cultures and policies might create tensions between individual actions, organizational and supply chain strategies [9]. Concerning a specific domain, e.g., by referring to different business contexts or levels of analysis, tensions might also arise from the temporal and spatial distance between actions and their effects [9]. Change processes themselves are a possible source of tensions, such as in the case of blockchain implementations [8]. As strategy implementation practices are particularly relevant in the application fields of supply chain management and innovation management, tensions arise from conflicts during the transition [9]. Facilitating the conceptualization by Hahn et al. [9], we particularly aim to address the paradoxical tensions inherent between organizational and supply levels as well as through the change process towards the use of blockchains for eFTI itself.

Open-system and paradoxical thinking are powerful approaches to facilitate successful strategies to manage tensions and paradoxes. To resolve potential paradoxical tensions, extant literature suggests three main strategies, particularly acceptance, separation/differentiation, and integration strategies [35,36]. The first step in managing sustainability tensions is recognizing paradoxical situations and relationships on an operational level [11]. Without acknowledging tensions and their inherent contradictions, managers are limited to win-win and trade-off approaches. Accordingly, acceptance strategies bear the potential to live with a conflicting goal without focusing on one goal or merging both goals [35]. In this line, Smith et al. [36] advise for *"adopting an abundance mentality and embracing paradoxical thinking"* (p. 468). Following a paradox perspective, contradictions can also be managed through temporal or spatial separation of opposing poles [11]. Through spatial separation, tensions might be addressed by clarifying and segregating individual and corporate levels. Through temporal separation, tensions and paradoxes might be resolved by focusing on conflicting goals during different periods of time [35]. Similarly, Smith et al. [36] advise for *"recognizing the distinct value of each side of competing demands"* (p. 464). From an integrative perspective, tensions can be resolved by the transformation into a more manageable situation, e.g., through adding new strategic elements to link oppositional demands [11]. Such a synthesis can also occur on spatial or temporal levels [9]. In this line, Smith et al. [36] advise for *"identifying creative synergies between contradictory elements"* (p. 466).

3.2 Tensions and paradoxes in blockchain applications

Based on a case study in the logistics sector, for instance, Sternberg et al. [8] found increased IT handling complexity to be a perceived obstacle by blockchain users. They also identified organizational immaturity as a barrier to blockchain implementation. Further, Huang et al. [24] see significant challenges in the immense amount of redundant data created through a decentralized architecture, leading to costs from network traffic, storage, and processing multiplied across the network. Similarly, the need for sufficient computing power to achieve consensus within the P2P network is seen as a downside of blockchain applications [4]. Besides these technical challenges and the related immaturity, organizational challenges have hindered the extensive use of blockchains thus far, pointing to inevitable organizational tensions and contingencies. For instance, greater transparency in terms of transaction history might lead to resistance from single business partners when rival business relations are present [8]. In addition, corporate compliance is challenged by the decentralized environment, whereby data is being exchanged between the anonymous participant across borders and across numerous national jurisdictions. This can lead to of the inadequate oversight and governance of blockchain based transactions allowing nefarious activities [37]. Furthermore, international trade requires collecting and sending data across borders, such as names, addresses, billing information. However, national data-residency constraints can restrict the mobility of data to country's borders. As a consequence, it might be required that a copy remains in a countries' borders, or illegal to transfer information out of the national jurisdiction [38]. Although these studies seldom explicitly talk about tensions and paradoxes, the underlying contradictions call for conceptualizations from a tensions and paradox perspective.

Prominently, Sternberg et al. [8] identified tensions between traceability and efficiency, between visibility and privacy, and between trust and investment, as well as between performance and commitment. Although not focusing on the logistics sector, Schmeiss et al. [39] describe the so-called paradox of openness inherent to platform ecosystems operating on blockchain technologies. This paradoxical tension becomes inherent between the poles of creating value with multiple actors and, at the same time, maintaining enough control to capture value from related interactions [39]. Similarly, Zavolokina et al. [40] identified tensions in consortium management, business value creation, and governance of blockchains. Although not particularly focusing on blockchain implementations, some studies have applied the theoretical lens of tensions to the supply chain logistics domain, such as Pålsson and Sandberg [41] for packaging paradoxes, Gruchmann et al. [42] for paradoxical tensions in sustainable warehousing, and Sternberg et al. [8] for tensions and paradoxes in a

Table 3: Tensions and paradoxes in blockchain applications [8,39,40].

Tensions	Description
Consortium management tensions	While blockchain technology offers a trustless environment [6], tensions might arise from the need for mutual trust between the participating organizations in the consortium [40]. Accordingly, trust in the collaboration and investment into technological infrastructure cannot be replaced by the trust build through anonymity in the system's design [8,26,40].
Value creation tensions	While the purpose of open platforms is increased value creation, it limits effective value capturing for the participating users at the same time, also referring to the paradox of openness [39]. Particularly in public blockchains, the access to and usage of data leading to higher transparency provides business opportunities but also increases competition [40].
Governance tensions	While governance in blockchains is based on group consensus [25,43], governance rules translated into IT governance practices need to be agreed on upfront, also referred to as off-chain governance [40]. However, the off-chain design phase might require a centralized and trustworthy governing actor to build the infrastructure for decentralized on-chain processes in the future [40].

blockchain case. Table 3 gives an overview of relevant tensions and paradoxes in blockchain applications.

4. RESEARCH DESIGN

To test and identify paradoxical tensions in the context of handling eFTI and propose specific strategies to manage these tensions in line with the literature and theoretical background as described in the previous sections, we applied a qualitative research design.

4.1 Data collection

In the context of qualitative research, interviews are often used as a source of explorative knowledge production [44]. Accordingly, we conducted 12 semi-structured expert interviews with experts from various fields, including logistics service providers, software developers, consultants, and representatives from a transport insurance company and a logistics association. The experts possessed detailed knowledge on developing blockchain applications and applying them in the logistics context (see Table 4), and each had at least five years of experience in their field. Furthermore, most companies had already started to develop/test blockchain-based applications for handling eFTI. The interviews lasted 43 minutes on average and were structured by an interview topic guide. The data collection was stopped when no new insights were obtained during the last interview, and

Table 4: Interviewees.

Respondent	Company type	Role of interviewee	Length
Expert A	Insurance company	Lawyer of transportation law	56 min.
Expert B	Software developer	Associate Director Maritime Economy	42 min.
Expert C	Software developer	Head of Blockchain Technology and Digitalization	42 min.
Expert D	Logistics service provider	Head of IT, Controlling and Logistics	28 min.
Expert E	Logistics service provider	Manager Business Development Transportation	72 min.
Expert F	Logistics service provider	Owner of a transport carrier	32 min.
Expert G	Blockchain consultancy	Consultant for product development	38 min.
Expert H	Blockchain consultancy	Senior Consultant	42 min.
Expert I	Blockchain consultancy	Consultant for blockchain implementation	42 min.
Expert J	Logistics association	Business Promoter	32 min.
Expert K	Logistics association	Business Promoter	34 min.
Expert L	Blockchain consultancy	Transformation Manager	53 min.

theoretical saturation was achieved. The interviews were subsequently recorded and entirely transcribed. The insights from the expert interviews were further triangulated with qualitative data from company presentations, newspaper articles, and press releases, while comparisons with the extant literature were conducted as suggested by Riege [14].

4.2 Data analysis

To evaluate the interview transcripts, the qualitative content analysis approach, according to Mayring [45], was used to structure, define, and make sense of the available data [46]. Mayring's [45] content analysis is a method that systematically analyses texts in a structured, abductive manner by processing material based on a category system that is guided by theory, whereby individual text passages are allocated to the codes of a previously selected coding scheme. In the first step, a deductive category system derived from the literature was used to code the empirical data (see Table 2). Further constructs were built inductively when respondents mentioned them frequently and were based on the researcher's interpretation of each interviewee's explanation of the specific construct. This allowed for flexible coding and clustering of the results in a second step, while the clusters are described as tensions' core categories. In this way, we were also able to identify relationships between and among the abductive, first-order constructs to aggregate them new second-order constructs, which allowed us to achieve a higher level

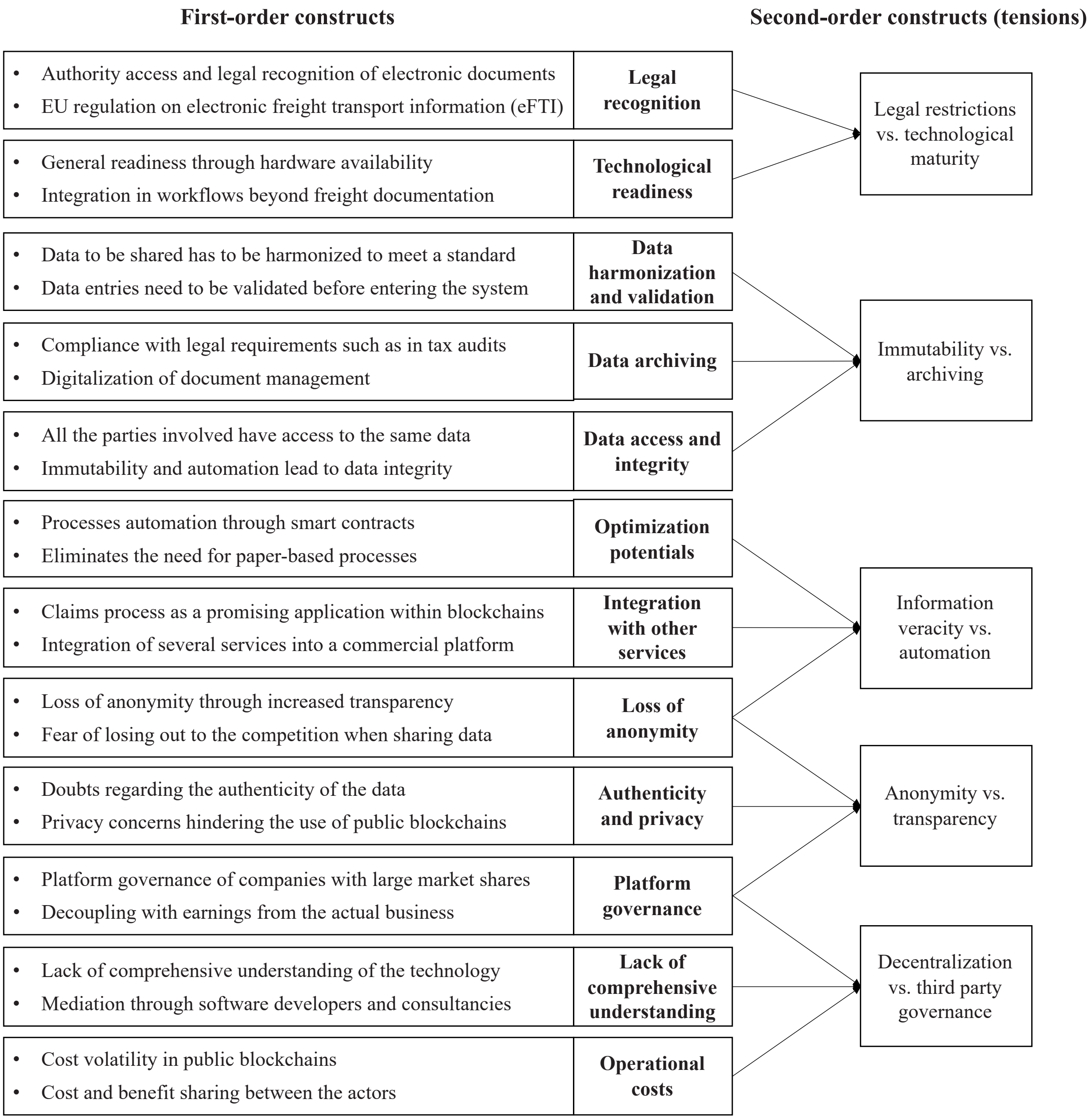

Figure 1: First-order constructs and second-order themes.

of theoretical abstraction [47]. Based on the clustered core constructs explored through qualitative content analysis, we accordingly structured the relationships between first-order constructs to construct related tensions. Thereby, we followed the theory-building approach proposed by Gioia et al. [47]. Along this line, the preexisting analytical categories system from the literature, which guided our analysis in the first step, were enhanced by adding inductive codes as the analysis progressed. Figure 1 summarizes the key codes. It shows the first- and second-order constructs and illustrates the process of clustering.

According to Yin [48], quality procedures concerning internal validity, external validity, construct validity, and reliability must be in place when analyzing qualitative data. The transcript coding was performed by two researchers and cross-checked independently regarding internal validity. Comparisons with existing conceptualizations were conducted to target external validity, thus allowing for theory-led abstraction and a certain degree of theoretical generalization of our results [14,48,49]. Construct validity was pursued by basing the analysis on sound conceptual underpinnings and strengthened by collecting data from multiple sources, while reliability was enhanced by exposing relevant parallels across multiple sources.

4.3 Theory elaboration

In a third step, strategies to manage the observed tensions were developed abductively based on theory elaboration [49]. Theory elaboration is the process of conceptualizing and executing empirical research using preexisting conceptual ideas or a preliminary model as a basis for developing new theoretical insights by contrasting, specifying, or structuring theoretical constructs and relations to account for and explain empirical observations [49]. In contrast to theory refinement, theory elaboration uses a "reverse-engineering" process to extract fundamental features of impactful theory to make them explicit and actionable [49]. Accordingly, the strategies for managing sustainability tensions can be advanced by empirically exploring relations between known constructs (bottom-up) and theoretically elaborating these constructs using preexisting conceptual models from the literature (top-down).

5. EMPIRICAL FINDINGS

In the following subsection, the empirical findings regarding the second-order constructs are presented, which emerged from clustering the first-order constructs (see Figure 1). After explaining each first-order construct in detail in the following subsections, which are mutually exclusive and collectively exhaustive, we present the related tensions based on the relationships between the single constructs and elaborate on their strategies to manage them.

5.1 Legal and technological maturity

Currently, there is no *legal recognition* for electronic freight documentation in international transportation (e-CMR) in Germany and other EU member states such as Italy. Since issuing a document is often subject to the obligation of carrying it when transporting goods, the question arises as to how access to the electronic documents can be assured in agreement with their legal recognition. In order to be able to safeguard a digital version of the freight documents, physical signatures need to be transferred to a digital level to guarantee the authenticity of the documents. The experts stated the following legal prerequisites for the successful use of eFTI: *"Third parties must be able to add changes and re-sign them, such as, for example, damage or quantity discrepancies"* (Expert A), and *"third parties, such as the driver or an inspecting officer, must be able to view the document. A consignment note is, after all, a document that contains instructions"* (Expert D). The experts thereby pointed to the EU regulation on electronic freight transport information as public law component which is required to secure a wide acceptance among all stakeholders in addition to the existing civil law (i.e., §408(3) HGB for Germany).

The subject of *technological readiness* is crucial to *"bring all the different players in the market together. This is definitely one of the very, very big challenges that we see with various customers"* (Expert B). *"It is difficult to find enough participants to use one system in order to make it attractive to others"* (Expert C). The experts mostly see technical challenges when onboarding many users to paperless applications (Expert E, Expert I, Expert F). *"So, the scanning was actually an essential part that had to exist in order to get away from a paper at all and to make tracking possible. [...] Also, Tablet PCs and printers and so on. There must also be a WiFi connection on the truck. [...] So, I have to create a technical solution that makes it possible to create these documents anywhere in Europe. And then I can imagine that you can hold out the tablet to a police officer or a BAG [Federal Supervisory Authority for Long-Distance Freight Transport] officer"* (Expert E).

5.2 Data management

The use of data standards is another antecedent to handling eFTI on blockchain applications. *"That would probably make future work much easier across the entire digital world for transport and processes"* (Expert A). However, the data that are later used in a blockchain have often not been prepared to meet a certain standard. In order to connect to a blockchain, interfaces must be created, and individual adjustments need be made in the users' IT systems so that the interfaces are compatible: *"In fact, it is not the case that there is any kind of data harmonization or that there are somehow standards where you can say: 'Okay, if we are going to build interfaces between us here, then let's do it exactly according to this standard.' It is more* *of a patchwork of individual developments"* (Expert B). Another expert stated that *"we have written software that has interfaces from existing systems, from SAP or TMS [transport management system] system. We have learned that there are different situations in which we receive data and map the process of filling in necessary fields, collecting the first signature from the sender, the second signature from the carrier, and the third signature from the recipient in a blockchain, but also to validate them. If someone copied their signature in or corrected any number, then we can still prove with validation that this document is not forged"* (Expert I).

From the perspective of the logistics service providers, *archiving* documents in a blockchain seems to be a great benefit. This means that documents for which legal and non-regulations on the retention of documents are in place can also be saved. This can also be useful in the event of a tax office audit. The blockchain can provide evidence that a particular vehicle completed an activity on a particular day or time (Expert D). *"The second point of digitization is archiving. Any authority—in the transport industry, it is the BAG—that makes checks on the way and says: 'Show me your document. What about dangerous goods? What is the technical status of your vehicle?' Moreover, the BAG also frequently does tax audits. When there are electronic documents that are archived in a correct structure, [...] that is also a lot easier"* (Expert E).

Blockchain's database security enables *data access* to be retained in an extensive system with many parties. As all data have already been distributed to all network members, it can be retrieved without delay as soon as it has been approved. From the point of view of the experts, blockchain technology offers considerable benefits in terms of using shared data for additional processes, which are usually still carried out on paper (Expert A; Expert E). To date, there is still no standardized way to view all the relevant data for the claims process, for instance. If all the parties involved have access to the same data, this can save a considerable amount of time managing claims. *"Today, such a process can sometimes take anywhere up to 6–8 weeks from start to finish. And if all the data are on the table, we can process the claim much faster and close the file"* (Expert A). Another driver for facilitating blockchain technology is the high level of data integrity provided through its features. "*In combination with the blockchain, I have the technological component of smart contracts. This enables process automation and, based on the manipulation security, I can also automate processes securely and then share trustworthy information beyond company boundaries. This is still a big advantage. I have outstanding data integrity"* (Expert H).

5.3 Opportunities from platform technology

Optimization potentials involved in the use of blockchains are primarily related to savings in terms of time and effort. From the perspective of the experts, it would make sense to agree on a common platform that everyone involved could use and *"would not require everyone to develop their own platform"* (Expert D). The users therefore do not have to start collecting all the available data to any party when needed; instead, it is available on demand. Data and documents can be transmitted digitally if required, saving time and effort. Processes can be automated through smart contracts, eliminating the need for paper-based processes. This reduces the number of queries regarding process flows, allowing trucks to have less downtime during loading due to missing documents. Since the same data are shared and passed on by all those involved, transmission errors can also be avoided (Expert A; Expert B; Expert D). "*This increases the productivity and efficiency of the transport process immensely because we can see today that often or quite frequently downtimes are caused at many points in the process in international transport due to queries about documents that are not available or something like that"* (Expert D). Another expert stated that an additional *"incentive for the companies to take part in something like this is to get rid of the paper. Paper is expensive, not just the sheet of paper, but also the handling. [...] and the costs come, as I understand it, mainly from the fact of the handling of the paper, the sending, the archiving"* (Expert I).

The experts stressed that freight documents are often used as receipts to prove that the transport has taken place, which creates further workflows, such as billing (Expert E). Accordingly, processes beyond the pure digitization of freight documents must be in place to gain organizational benefits. *"The proof of delivery is important, that is, they have to prove that the transport has been completed. Right now, the only way to prove it is by showing the paper with the signatures. Sometimes, however, that happens weeks later because the truck driver drives ten trips across Europe. That means it takes a long time to get the proof. [...] It is extremely compelling for them to get an electronic proof of delivery the second the signature is actually given"* (Expert I).

Besides the electronic handling of the freight documents themselves, the experts see further benefits through *integration with additional services*. Here, several experts have seen the claims process as a promising application with blockchain technology (Expert A, Expert I). This can lead to extended business models for logistics service providers and software providers. *"I have already called several TMS software providers on the phone. You can integrate this into your software, or you could offer it as an intermediary on the market who sells the additional service [...], and that is a different type of business model that we also think about long term here"* (Expert I). Such services might increase customer loyalty since it is more difficult to switch to a competitor (Expert E). Another expert stated that *"it is the platform created here. In other* *words, this is not just about the fact that individual freight forwarders have a great piece of software that digitizes the paper and thus saves costs for themselves in their operations, but that this is a system [...] that could pour it into a commercial platform. [...] So, the big companies have developed something, and that doesn't cost them anything because they get it back from the market and even earn money from it"* (Expert I).

5.4 Transparency and privacy

Increased transparency is one of the obstacles to using blockchain technology. Especially when third parties are involved, the participants in the supply chain want to avoid sharing their data because they fear losing out to the competition: *"Nobody wants to be an open book as to what data they have and what it looks like"* (Expert A). Even if it is possible to anonymize transactions, there are fears that third parties could uncover the data. Metadata could end up being stored, analyzed, and potentially de-anonymized: *"Anonymity is lost, while you are not really anonymous on a blockchain either. You just have your public-private key, which is about pseudonyms. That means if I carry out several transactions with the same key pair, then somebody can recognize the patterns"* (Expert H). Another expert stated that "*transparency, which nobody really wants, is very selective. This is so transparent that a recipient can understand what happened to the CMR and the transport"* (Expert I). The experts are also recognizing the sensitivity of the transactional data. *"There is a very, very large amount of data that at first glance, you don't think so. Personal data or personal data. Am I not allowed to write personal data on the blockchain"* (Expert B). Here, potential legal restrictions connected to adoption of the blockchain need to be obeyed (Expert B, Expert C). Furthermore, there is an appreciation of the potential exposure to legal and reputational risk: *"Of course, you will always be judged by the fact that you comply with the subject of data protection and that sort of thing. We already had that before"* (Expert A).

The question of trust applies not only to the various parties within a blockchain toward one another but also trust in the data itself. This also includes the *authenticity* of the data: *"A secure storage of data in the blockchain does not help me very much if I cannot ensure that the data are authentic. Nevertheless, suppose I now assume that I use sensor data at regular intervals, for example, to ensure that a certain temperature was not exceeded and that these intervals are so small that it is not plausible that it was considerably warmer in the meantime. In that case, I can say very, very definitely that a cold chain was maintained"* (Expert H). Generally, the experts identify a decreasing trust between the actors, which hinders the implementation of public blockchains, mainly because of *privacy concerns*: *"We rather need fewer, large public blockchains that run specific use cases and simply provide the data basis for new cases. I simply bundle more innovation into fewer sources or more innovation into fewer blockchains. Of course, you have to make sure that everyone sees only what they should see. But that's a technical question that you can solve. So, I would already agree to the tendency that things are currently more in the direction of private blockchains"* (Expert G).

From the point of view of the software consultants, the question of participation is primarily discussed at the management level (Expert L). While operational departments are already thinking about concepts regarding technical implementation, *governance* issues are handled at managerial levels. "*So, if I imagine a situation where I have a software provider that is only used by the haulage contractor and the haulage contractor says: 'Everyone join my system,' then I don't know what views will be available to the haulage contractor afterward, what he can then filter out and what he will know about afterward"* (Expert A). Another expert stated that *"such a platform should have a certain moderation from a neutral third party. If this is a platform that is run by a large logistician, for example, as in the case of TradeLens from IBM, a joint venture between IBM and Maersk, then they have the problem that Maersk is a big player. [Maersk] helped develop and run it, is responsible, and earns money with it. Now, when another logistician comes along, he'll say, 'I don't pay license fees for any software to my competitor.' You have to be a little careful who is operating, anyone who has a bit of a special role in terms of credibility, [...] so that he does not earn anything from the actual process"* (Expert I).

5.5 Implementation challenges

Many companies or potential blockchain users seem to *lack a comprehensive understanding* of the technology. Since a decentralized system involves other migration concepts, there is still a widespread lack of experience, and basic understanding of blockchains, not only in terms of the technology but also in terms of understanding where and how it can be used: *"Because using blockchain is a completely different way of thinking than what companies are used to"* (Expert C). According to one of the haulage contractors interviewed, it is, above all, the in-house software providers who need to have in-depth knowledge of blockchain technology, their in-house formats, and the various interfaces of the software. Having the necessary in-house IT know-how can reduce the time and effort required when customers (of the haulage contractor) make changes within the system, which subsequently means that the code in the system must be adapted (Expert D). From the perspective of the software developers, different solutions have to be offered depending on the maturity level of the customers. Another consultant confirmed that *"one building block is definitely empowering people with the topic. But I don't mean to discuss in detail which consensus algorithms exist. But what does it bring* *me? Why should I use this? Because ultimately it is the business people who use the money to implement this"* (Expert G).

A significant amount of time and effort for using blockchain technology is required for data preparation and creating interfaces associated with implementation. To make blockchains attractive for a company, the *operational costs* must be calculated against potential benefits. For a public blockchain, calculating the hash total for the hash function is a substantial cost factor, as entire data centers are required for this purpose. Within private blockchains, this may be different. Another cost factor is system maintenance from the point of view of software development. Aspects such as marketing may also have to be considered, as a blockchain can only exist if it has enough participants. Allocating direct costs to the various parties regarding the use and development of a blockchain tends to be difficult. This mainly depends on the governance structure and, as described above, on the type of blockchain (Expert A; Expert C). Another vital cost challenge is associated with the price volatility that a particular public blockchain experienced in the past. *"The difficulty now arises that the transaction costs have skyrocketed over the past six months. It is becoming more expensive. [...] Ethereum has tens of thousands of nodes in the world, it has great security, but it also has a very volatile price. At the moment, it goes up and down. With a CMR, I can only pay a few cents for notarization. Otherwise, none of this makes sense for economic reasons"* (Expert I).

6. TENSIONS INHERENT IN BLOCKCHAIN APPLICATIONS FOR HANDLING EFTI

6.1 Observed tensions

Analyzing the perspectives of logistics service providers, software developers, and consultants, different tensions and paradoxes regarding the implementation and use of blockchains were identified. Particularly the 'decentralization vs. third party governance,' 'anonymity vs. transparency,' and 'information veracity vs. automation' can be classified as paradoxical tensions, while the other tensions are modifiable and non-persistent over time [11,50]. Table 5 summarizes the observed tensions constructed from the first-order constructs and provides related examples from the interview transcripts. Further literature comparisons were performed to triangulate and inform the empirical observations, partially confirming previous findings for the specific context of eFTI such as the paradox of openness [39].

Table 5: Observed tensions and related examples from the interviews.

Tensions	Description
Decentralization vs. third party governance	Decentralization is a key feature of blockchains, in which the consensus mechanism replaces the mediator [23]. Decentralization thus mirrors in many aspects the governance structure of the platform. However, most interviewees tend to prefer private blockchains with moderation from a neutral third party to cope with the heterogeneous interests of the users and thereby represent a paradoxical tension for the decentralization of data. Similar paradoxes in the off-chain governance phase were already found by Zavolokina et al. [40], while they become also inherent in on-chain governance when handling eFTI.
Example from the interviews	*"But still we want to make a blockchain, where actually everyone indirectly controls each other, and the control is not that everyone is watching, but that nodes are distributed here, and implicitly everyone takes care that nobody cheats. And how did this come about, how can you achieve this balance, how can you reconcile these constraints of seemingly total opposites?"* (Expert I)
Anonymity vs. transparency	Furthermore, a high presence of centralized, mediating authorities in private blockchains impacts the level of anonymity in the blockchain, while access to the system as a whole and a specific function within the system requires some form of governance [21]. To be validated, partners will have to give up their anonymity, enabling the de-anonymization of their data and thus creating a paradoxical tension between anonymity and transparency. This paradox confirms that the blockchain's trust-building based on anonymity is a necessary prerequisite but not sufficient for blockchain governance [8,40].
Example from the interviews	*"Because we simply cannot imagine that all the haulage contractors, forwarding agents, consignors, and the shipping industry, in particular, will adopt one single system"* (Expert A).

Information veracity vs. automation	Transparency/traceability on information can be a source of competitive advantage of the supply chain, but sharing might weaken the position when negotiating contracts with suppliers or competing within the market [26]. At the same time, information sharing is necessary to achieve process optimizations through automation. Accordingly, the flow of information veracity is a prerequisite and a source of paradoxical tensions for automating a blockchain, for example, through smart contracts, at the same time. The paradox can be subsumed under the paradox of openness [39].
Example from the interviews	*"One advantage is simply the unbelievable security against manipulation and traceability, which makes it possible to design processes without intermediaries that would usually be handled with intermediaries. That is, many parties have to interact with one another that have conflicting interests and do not necessarily trust each other"* (Expert H).
Immutability vs. archiving	Blockchain's approach to chaining and validating data records strengthens the immutability of information [6]. However, the correction of erroneous data as well as removing or archiving expired data from fast data pools is limited. In this regard, archiving from the immutable blockchain creates tensions as data in ever-growing volumes inflate resource requirements, system latency, and system costs.
Example from the interviews	*"It is also a topic of findability; archived things are a topic. You just got a tax audit and now need to find the consignment note from four years ago"* (Expert I).
Legal restrictions vs. technological maturity	Disintermediation and decentralization require data distribution to all the participants, potentially being processed worldwide. Consequently, the data is exposed to multiple national jurisdictions with various data-residency and retention policies. Thereby, tensions are created between the disintermediated architecture of the system and compliance with national legal, oversight and governance requirements.
Example from the interviews	*"The second strand is, of course, a legal framework. There is also a lot going on at the EU level to set conditions in order to be able to use blockchain and to clarify who actually owns which information. [...] Because, quite clearly, without legal certainty, there will be no such thing on a broad scale"* (Expert G).

6.2 Observed strategies to manage tensions

After having identified relevant tensions in blockchain implementations for eFTI based on the empirical results, related strategies to manage the observed tensions are derived as described by the interviewees and triangulated with a paradox theoretical perspective [36,50]. We elaborate on three main strategies to manage the observed tensions of acceptance, separation/ differentiation, and integration. The first step in managing tensions is recognizing paradoxical situations and relationships on an operational level [11]. In the case of blockchain-based handling of eFTI, the interviews provide evidence that software developers and consultants are aware of the inherent tension in implementing blockchain applications. In this regard, the tendency of their customers to prefer private blockchains was articulated in the interviews: "*Actually, it doesn't really make sense if you have a separate blockchain for each case, and somehow a private blockchain and a separate solution"* (Expert G). This does not mean that the involved companies ignore the paradox, but they live with it [50]. In this vein, the acceptance approach is recognized as a catalyst toward change and renewal [12,13] to find new governance mechanisms in applying blockchains for handling eFTI.

From a paradoxical perspective, contradictions can be managed through the temporal or spatial separation of opposing poles [35]. To tackle tensions about the technical maturity level of their customers in the case of eFTI, one consultant for blockchain implementation used a separation/differentiation strategy to attract customers with both low and high technological readiness for their eFTI applications: *"Our strategy is as follows: we offer two ways of participating in our project. The first type is named under the hashtag 'I am a big one'; we call it the core participants, who fully work in terms of content, who install a blockchain node, install the software, who operate it themselves. The second hashtag is 'I am a small one' [...] we also want to make special software multi-client-capable and thus offer it as software-as-a-service via simple cloud mechanisms, so that even smaller, maybe very small companies would be able to create a CMR manually via a web interface [...] and let's say the medium-sized ones, which already have a transporter management system, and can use an interface via a cloud service, but still do not have to operate anything"* (Expert I). With such solutions, software developers and consultancies can simultaneously meet their customers' competing demands by separating them [35], at least regarding disruptive technology transformations [51].

From an integrative perspective, tensions can be resolved by transforming them into a more manageable situation, for example, by adding new strategic elements to link oppositional demands [35]. To implement blockchain applications for eFTI, a consultancy also applied an integration strategy to bridge the paradoxical tensions between anonymity and privacy through a hybrid model. *"It is more likely that we use a hybrid model, where we have a private blockchain to secure the entire process flow and, once a CMR is ready, it is archived by notarizing it again on a public blockchain, so that afterward the tax authorities and the recipients can check again whether these documents are correct"* (Expert I). Accordingly, new perspectives are applied that can diminish paradoxical tensions. As argued by Poole and van de Ven [35], some paradoxes may stem from conceptual limitations that can be eliminated by new perspectives. Analyzing the identified strategies, however, these cannot fully address all observed tensions. While they mainly address decentralization vs. third party governance and anonymity vs. transparency paradoxes, tensions concerning information veracity and immutability were not tackled yet.

7. DISCUSSION

The hype around blockchain technology is reflected in many of the interviews [52]. To some degree, the experts know and understand the underlying mechanisms related to blockchain applications and even reflected some of the tensions inherent in its implementation [8]. However, a deeper appreciation of the relationships and tensions between the technological concepts appears to be lacking so far, at least with the logistics service providers. Summarizing the findings of this study, many of the benefits claimed by the experts because of potential blockchain adoption originate from general digitization and the replacement of error-prone manual processes. Similarly, many of the observed prerequisites for the efficient handling of eFTI, such as sufficient data quality, are independent of the blockchain implementation itself while necessary for any digital transformation. Nonetheless, some aspects of the technologies adopted by blockchains can improve the implementation of eFTI, such as automation and integration with other functionalities on a common platform. In the following, we discuss the main challenges leading to tensions in using blockchain technology for eFTI.

With regard to the privacy model, sufficient trust-building, as an expected consequence of blockchain immutability, cannot be assumed in the context of handling eFTI right away. The experts view the confidentiality of the shared information as necessary to their competitive advantage [26] and may not be willing to share critical information due to privacy concerns. Although blockchain enforces the privacy of the transparently stored data through participant anonymity [4], the interviewed experts are skeptical and instead vote for private blockchain solutions as they assume that the flow of identifiable items might enable the de-anonymization of the participant's identity [8]. However, replacing blockchain's privacy model with a rights permissions-granting system not only impacts anonymity but also introduces trust and renders blockchain's trust redundant, creating anonymity vs. transparency paradoxical tensions. Additional trust-building mechanisms accordingly are supposed to accompany blockchains implementations rather than replacing them, which, however, will not come without additional transaction costs.

Changes to the privacy model through centralization and linkages of transactions or identities also carry the risk of systematic de-anonymization [53]. Therefore, governance mechanisms are still required to achieve a critical mass for benefiting from handling eFTI with blockchain technology in the context of decentralization vs. governance tensions. Generally, public access to the information is not desired, while security demands more than blockchains' current ability to prevent fraud. When distinct users, with permissioned authority, perform malicious data manipulation, actions can be traced back, fraud identified, and abusers held liable for their actions. Therefore, implementing a blockchain in a private or permissioned configuration defeats the central idea behind blockchain, makes the computational trust and its associated cost redundant, and the system ultimately indistinguishable from other shared databases [5]. Following the rule 'whoever controls the consensus controls the governance of the blockchain', the question arises of how the remaining blockchain characteristics benefit the goals of an eFTI implementation, as similarly perceived in general platform environments [39].

Operating across large, dynamic groups of participants with diverse requirements can lead to high costs. The fact that much of the eFTI system is about handling documentation and decentralized storage with fast access to information is seen as highly beneficial. However, decentralization triggers delays and resource requirements across all participants. Network size and data volumes lead to a multiplication of processing, storage, and communication efforts, which, together with missing sharing and economy of scale effects, will lead to increased costs across the whole network [54]. Additionally, network size, volume, and velocity of data lead to delays in new, verified, immutable data becoming available to the nodes [30]. Furthermore, the involved immutability creates challenges when erroneous or expired data require correction or deletion, also leading to immutability vs. archiving tensions. In contrast, the competition that blockchains will pose on traditional platforms due to the token effect might reduce costs [55].

Last, blockchain's radical transparency of rich data, distributed across different economic zones, creates uncertainty regarding the applicable laws and regulations. Restrictions rooted in firms' need to protect confidential data limit the willingness of companies to share their data. Legal, regulatory, and policy restrictions of the global territories relevant to companies participating in blockchain restrict data availability [20]. Consequently, liability challenges might arise for data owners, systems providers, and data recipients [56]. In the case of the eFTI, as for most system development initiatives, a specific set of business requirements should form the basis of selecting an appropriate set of technologies, rather than investigating how blockchains can be applied to address the business challenge. This is even more relevant when considering the scarceness of blockchain knowledge and the apparent incompatibilities between eFTI requirements and blockchain characteristics.

8. CONCLUSION AND FUTURE RESEARCH PERSPECTIVES

Concluding the present study on paradoxical tensions in applying blockchain technology, it can be predicted that blockchain's disruptive privacy and governance model will not come to fruition for handling eFTI, at least in the near future. Our analysis also reveals that the automation of several functionalities on a platform is the feature of blockchain with the most significant potential to create change in handling digital freight information. Nonetheless, the present tensions between the decentralization of data and automation opportunities of blockchain applications, as well as the perceived privacy concerns of the users, challenge its application. Although concrete strategies to manage these tensions were found, it is first necessary that the privacy model is advanced to overcome specific transparency challenges as well as to increase the overall operational performance. Specifically, perceived challenges in sharing sensible information can be addressed by separation and differentiation as well as integration strategies to manage digital transformations with blockchain technology. In this vein, our research makes several contributions to the literature. The study particularly moves away from the traditional win-win and trade-off perspectives applied in logistics research [9,10] by answering the calls for empirical studies on tensions [8]. In addition, our empirical study is among the first to study responses to inherent tensions in logistics and supply chain research [57] and transferring the observed paradoxical tensions in blockchain implementations into the specific context of handling eFTI.

While providing an opportunity to empirically advance our understanding of how blockchain technology facilitates the implementation of electronic freight documents in the logistics industry, the applied research design is not without limitations. Aiming to complete the picture of how tensions and paradoxes arise for logistics service providers in applying this technology, the interviews might have been biased by the personal expectations and desires of the interviewees. Another limitation lies within the sample size, allowing only a theoretical generalization of the findings. Accordingly, future research can build on the specific insights generated in this qualitative-explorative study and test the empirical results with survey research. Besides applying quantitative research, engaged methods such as action research have the potential to both refine and extend the present study's insights to examine the tensions inherent in digital transformations with blockchain technology more closely.

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