



Agricultural Commodities Reimagined: The Disruptiveness of Blockchain Technology

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Abstract

Agricultural commodities not only feed the world's growing population but are also essential for building the economy. This thesis explores the disruptive potential of Blockchain technology in the agricultural commodity industry. It examines industry challenges and analyzes how Blockchain can revolutionize this commodity market.

A mixed methods approach, including quantitative and qualitative data gathering, provided insights into industry perspectives and readiness for Blockchain technology adoption. The findings showed very low adoption levels due to persistent doubts about the technology and lack of overall readiness. Despite recognizing potential benefits, experts identified numerous barriers such as technological immaturity or unclear regulatory environments. Nonetheless, experts confirmed its potential for transforming post-trading, risk management and trade finance processes.

Finally, although Blockchain technology has transformative potential, it is unlikely that it will be a short-term disruptor in the agricultural commodity industry. Instead, it more likely will take the role of being more of a sustaining innovation with early majority or late majority adopters.

Keywords: Agricultural commodities, Blockchain technology, Disruptive innovation, digitalization, commodity trading, efficiency, scenarios

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Sumário

As commodities agrícolas não alimentam apenas a crescente população mundial, mas também são essenciais para a construção da economia. Esta tese explora o potencial disruptivo da tecnologia Blockchain na indústria de commodities agrícolas. Examina os desafios da indústria e analisa como o Blockchain pode revolucionar este mercado de commodities.

Uma abordagem de métodos mistos, incluindo coleta de dados quantitativos e qualitativos, forneceu insights sobre as perspectivas da indústria e a prontidão para a adoção da tecnologia Blockchain. Os resultados mostraram níveis muito baixos de adoção devido a dúvidas persistentes sobre a tecnologia e falta de prontidão geral. Apesar de reconhecerem os benefícios potenciais, os especialistas identificaram inúmeras barreiras, como a imaturidade tecnológica ou ambientes regulatórios incertos. No entanto, os especialistas confirmaram seu potencial para transformar os processos de pós-negociação, gestão de riscos e financiamento do comércio.

Finalmente, embora a tecnologia Blockchain tenha um potencial transformador, é improvável que seja um disruptor de curto prazo na indústria de commodities agrícolas. Em vez disso, é mais provável que assuma o papel de ser uma inovação sustentável com adotantes da maioria inicial ou tardia.

Palavras-chave: Commodities agrícolas, tecnologia Blockchain, inovação disruptiva, digitalização, comércio de commodities, eficiência, cenários

Título: Commodities Agrícolas Reinventadas: A Capacidade Disruptiva da Tecnologia Blockchain

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List of Abbreviations

AI	Artificial Intelligence
ADM	Archer Daniels Midland
BT	Blockchain Technology
CIF	Cost, Insurance, and Freight
CF	Cost and Freight
CTRM	Commodity Trading and Risk Management
DCF	Discounted Cash Flow
DLT	Distributed ledger technology
FOB	Freight on Board
GDP	Gross Domestic Product
IoT	Internet of Things
PEOU	Perceived ease of use
PU	Perceived use
SW	Single Windows
TAM	Technology Acceptance Model
TCE	Transaction Cost Economics

Chapter 1: Introduction

The agricultural commodity sector has been essential to the global economy for centuries and today represents a \$13,398.79 billion industry globally (The Business Research Company, 2023). Agriculture produces, distributes, and sells everything from grain and oilseeds to livestock and dairy, and most importantly, accounts for 4% of global Gross Domestic Product (GDP) (World Bank, 2023a). Rising populations also emphasizes the importance of the industry as people require access to food resources. By 2050, world food production will need to increase by 70% to feed the entire population (Van Dijk et al., 2021).

Agricultural development has embraced advanced digitalization - in 2021 alone, funding reached a record-breaking 51,7 billion USD (AgFunder, 2023). However, the commercial aspect remains among the least digitalized sectors globally. This constrains the agricultural commodity market's "efficiency to acquire value from information" (Jothikumar, 2021). The industry also faces persistent challenges related to complicated traceability, lack of efficiency, and more transparency (Bhatia et al., 2023). Traceability plays a significant role in food contamination, efficiency is critical in minimizing spoilage and delivery time, and transparency has become essential for consumers to know the origin of the products (Lakkakula et al., 2020). International trade makes solving these challenges even more difficult – high costs along all supply chains, large-scale transactions, extensive documentation requirements, different standards, and financial restrictions make the digitalization process even more demanding (Lakkakula et al., 2020). Nonetheless, as society demands greater accountability from all parties, agricultural commodities have become a spotlight for disruption by blockchain technologies.

Usually associated with Bitcoin, blockchain has emerged as a disruptive force with the potential to revolutionize various sectors. Investments in technology have been growing, and by 2030, the global blockchain market is expected to reach 1,235.71 billion US dollars (Statista, 2023). Blockchain technology (BT) allows ubiquitous financial transactions among distributed, untrusted parties without intermediaries (Kamilaris et al., 2019). Technology experts suggest that BT includes multiple benefits – a higher degree of disintermediation (therefore reduced costs), eliminating the need for reconciliations, the ability to track assets, and data trustworthiness (Hughes et al., 2019). Moreover, BT can help improve the security and efficacy of transactions in the supply chain, ensuring cost-efficiency and speed (Korpela et al., 2017).

Blockchain also presents opportunities for agricultural commodities – it can make commodity transactions easily accessible to all entities, including buyers, traders, and other stakeholders across the supply chain (Lakkakula et al., 2020). It can also improve efficiency

through digitalization, automation, “quick payments via smart contracts, real-time accessibility of transaction information without a central authority, and security” (Lakkakula & Wilson, 2022).

Blockchain applications in the industry vary from agricultural insurance to e-commerce, the safety and security of farms, and many more (Sajja et al., 2023). However, the industry has viewed such innovations in the commercial part skeptically since higher transparency is expected to result in lower profits and fewer business opportunities. Today, BT has been primarily adopted within two bulk commodities – energy and oil trading (Payne, 2018) and is only being developed for others. Only two attempts were made to pilot the technology in agricultural commodities – the Covantis blockchain program, which mainly operates in North and South America, and Cerealia SA, which worked in the Black Sea region.

The most successful to date is the Covantis BT platform, which aims to make agricultural commodity trading execution simple, safe, and secure. The company seeks to optimize trade execution processes, boost efficiency, and cut operational risks (Byrne, 2021). The platform went live in February of 2021 after two years of piloting with 30 entities, including six founding members – Archer Daniels Midland (ADM), Bunge, Cargill, Cofco, Louis Dreyfus Company, and Viterra. The current use case covers bulk shipments of soybeans, corn, wheat, and sugar. Since the launch of the platform, the company has been able to achieve astonishing results. In 2022, 519 million metric tons were executed (246% increase versus 2021), with a 73% increase in legal entities and teams active on the platform (Covantis, 2023).

With the foregoing in mind, this study aims to illuminate the role of blockchain technology as a potentially disruptive force by exploring the following research question:

RQ: Can blockchain technology become a disruptor in the agricultural commodity industry?

Forecasting the market diffusion of a disruptive innovation is challenging (Linton, 2002). The nature of disruptive innovation is multidimensional (Guo et al., 2019), but understanding its potential can prevent incumbent failure (Christensen et al., 2013). Antonio and Kanbach (2023) distinguish two groups of factors. First, there is an industry’s susceptibility to disruption - industry dynamics or incumbent behavior. Second, there is emergence and diffusion - for example, consumer acceptance or investment. This research focuses on both groups of factors.

The findings are expected to contribute to understanding BT's transformative role. Also, it is a valuable resource for professionals interested in making the industry more transparent, efficient, and secure.

Chapter 2: Literature Review

To better understand how blockchain technology can create efficiencies for the agricultural commodity industry, this Chapter will build upon agri commodity trading as a concept, its challenges, and risks. Moreover, current digitalization attempts in the sector will be analyzed, as well as blockchain technology specifics and applications. Finally, theoretical frameworks that can be used to explore the relationship with BT will be discussed.

2.1. Agricultural Commodity Trading Process

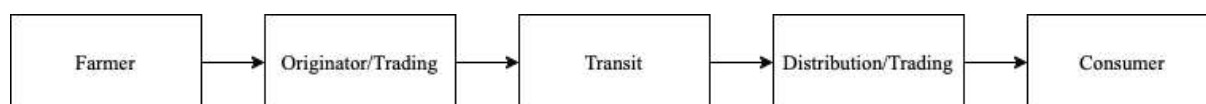
In the Introduction (*see Chapter 1*), we discussed the complexities of agricultural commodity trading. Essentially, commodity trading firms engage in commodities transactions "in space (logistics - from origination to destination), in time (from purchase to delivery), and in form (from trade to processing)." The primary function is to create value through these transformations (Prong, 2014). During this, firms face complicated supply chains, participate post-trading and vital documentation processes, and are exposed to risks.

2.1.1. Supply Chain

When commodities go from point A to point B, they pass through multiple parties, documentation, certification processes, demanding time, and high transaction costs, all intertwined with the bureaucracy (Lakkakula et al., 2020). These parties must ensure efficient documentation processes and trust to ensure the smooth flow of commodities. In the supply chain, trading companies are perceived as intermediaries who participate in commodities trading and other activities. They can also join in the production of commodities (upstream), transportation or storage (midstream), or even manufacturing and retailing (downstream) (Pirrong, 2014). *Figure 1* aims to illustrate a supply chain from a farmer to a consumer (the figure can be adapted to international and domestic trade).

Figure 1.

Agricultural Commodity Supply Chain



Note. Created by the author.

As depicted above, the supply chain begins with a farmer, who cultivates and harvests the produce and transports it to originators or sells it to the consumers. It is important to note that originators can also participate in trading (Brack, 2016). If a farmer decides to sell to the originator, he must choose the price at which he wants to sell the goods – at a flat or a premium price (which depends on logistics, quality of goods, etc.). If the good is sold at a premium before

the execution, it must be converted back to a flat price due to documentation and financing rules. Once a deal is made, the originator can make another contract (depending on the destination – domestic or international trade) with a trading company and trade the goods again. In this case, the originator will contact the trading company (usually through brokers) with a proposal to buy or sell commodities that meet various specifications – price, quantity, time and place of delivery, and payment terms (Slabotzky, 1984). In both cases, the trading company or originator, with the help of logistic companies, transits the goods via railways, trucks, or sea (depending on the destination) to the buyers. Once goods reach the destination, they can be either distributed straight to manufacturing (US Soybean Export Council, 2008) and later to consumers or sold again to different companies.

During these steps, buyers and sellers also deal with wide ecosystem of 3rd parties – surveyors, vessel owners, brokers, fumigation companies, labs, banks and ports/terminals. The length and complexity of the supply chain also depend on how many times the commodities are traded.

2.1.2. Post-trading Process

The European Banking Federation (2020) describes post-trading (execution) as processes “that take place once a trade has taken place and includes all the activities that enable the safe transfer of ownership of securities from the buyer to seller in return for payment. These activities include clearing, settlement, custody and asset servicing, and reporting”. A well performed execution process can add significant value to a contract, but as well can default the contract in case of error. Today, this process is “highly manual and costly part of the supply chain, with the industry spending significant amounts of money every year moving documents around the globe” (Louis Dreyfus Company, 2018). The control and style of the process varies between companies, but mainly includes three steps – pre-delivery, delivery of goods, and presentation of documents/payment. There are few factors that influence post-trading process – variability of commodity and quality, market fragmentation regarding legal requirements, high number of third parties involved and status of bill of lading.

2.1.3. Documentation and Contracting

In agricultural commodity trading and post-trade execution, documentation is a critical step. In case of disputes, the final say is determined by the documents and they also control risk and title transfers from one to another party. It is said that often “documents that are worth the money, not the actual commodity. When it comes to physical-commodity trading, it is the documents you trade, not the commodity itself” (Kingsman, 2017).

It is estimated that around 80% of agri commodities traded are under standard contracts of GAFTA (Machado, 2019). *Table 1* presents comparison of three main types of international contracts. Depending on the contract agreed upon, the seller might need to obtain different documents to perform a sale (*see an example of the contract in Appendix I*) (Lakkakula et al., 2020). These might include nominations, various licenses, inspection and custom documents, various certificates and many more (*see example of the contract - Baltic Agro UAB & Agrorodeo UAB, 2023*).

Table 1.

Payment responsibility based on the contract

Attributes	Freight on board (FOB)	Cost, insurance, and freight (CIF)	Cost and freight (CF)
Arrange a vessel at the port of exit	Buyer	Seller	Seller
Insurance	Buyer	Seller	Buyer
Import license	Buyer	Buyer	Buyer
Cost of moving goods at loading/discharge points	Buyer	Seller	Seller

Note. Created by Lakkakula et al. (2020).

2.1.4. Risks in Commodity Trading

Since the supply chain of agricultural commodity trading involves many steps and parties, trading companies must bear many risks. Several of these are – financial, economic, political, commercial, and operational (Cinar et al., 2016).

Most risks encountered are financial. These can include basis or spread risks, various liquidity risks like hedging, market or funding, or margin and volume risks (Pirrong, 2014). Traders are also exposed to exchange rate fluctuations. Credit risk is concern, too (Turvey et al., 2006). This can become an issue if smaller enterprises borrow from multiple financial institutions. At the same time, companies enter contracts with numerous counterparties creating a tangled web of financial obligations. Defaults can incur significant financial losses for entities with risk exposure (Bandyopadhyay, 2016).

Moreover, the political risk premium has recently risen due to tensions between countries, deglobalization, sanctions, and weak rules of law (Fildes, 2022). The agricultural sector is politically sensitive due to its centrality for food security, livelihoods, and even cultural identity (Resnick et al., 2023). Historical context also shows the age-old connection between food and political tensions. Food as warfare is also used today in the Russia-Ukraine war,

putting Ukraine’s economy under duress, and Russian exports command higher prices (Borger, 2023). Complicated electoral dynamics, agricultural lobbies, subsidies, protectionism, and varying import tariffs, create challenges for companies operating in multiple countries.

Commercial risk refers to potential losses from the partners and clients (Spekman & Davis, 2004) from insolvency issues or unwillingness to adhere to contract clauses (Nordea, n.d.). Finally, firms are subject to operational risks like delivery issues or different regulations.

To mitigate risks, commodity trading firms use a variety of tools. As discussed, one method is hedging, which protects against potential losses or adverse price movements (Pirrong, 2014). This is usually performed using derivative contracts or other methods to offset exposure. Diversification makes firms less dependent on idiosyncratic events in any given commodity (Billingsley & Chance, 1996). Also, risk can be reduced through integration in the value chain (Pirrong, 2014). This approach allows a firm to “identify various threats to which value chains are exposed, estimate the probability of occurrence and severity of such risks, and ensure risk prevention and mitigation through the use of a cost-effective combination of financial and non-financial instruments.” (Calatayud & Ketterer, 2016).

2.2. Digitalization in the Agricultural Commodity Industry

Digitalization has become a crucial subject across all industries. Big Data, Artificial Intelligence (AI), robots, the Internet of Things (IoT), and blockchain are technological advancements having an impact (*see Table 2 for an overview of the technologies*) (Javaid et al., 2022). However, the agricultural commodity market still lags other industries (COFCO International, 2021). Multiple constraints could be resolved with digitalization improvements. Considering all inefficiencies in trading and supply chain management, greater digitalization would benefit the industry by creating the “ability to extract insights through data analysis, obtain real-time business information, and reduce costs – all of which are critical considerations in a market with extremely thin margins” (Mulder, 2023).

Table 2.

Overview of various Digital Technologies

Big Data	AI	Robots	IoT	Blockchain
Data storage/management	Machine learning	Automated sorting/packing	Sensors, Actuators	Machine learning
Data processing/analysis	Computer vision	Robotic process	Automation, Control	Traceability

Predictive modeling	Natural language processing	Automation	Quality assurance
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Note. Created by Konfo et al. (2023).

Boston Consulting Group suggests four stages to complete digitalization in commodities trading (see Table 3) (Belt & Porsborg-Smith, 2019). The first step involves implementing the simplest platforms and elevating processing to enhance operational efficiency and cut direct costs. The second stage focuses on eliminating manual tasks, optimizing the timing of trades, and enabling automation of activities in front, middle, and back offices (like nomination or reporting) - this results in reduced risks, increased reactivity, and decreased execution costs. The third step is the most transformative. Here, the focus is entirely shifted from humans to algorithms, allowing computers to derive insights or even make decisions. The final stage is supposed to take the trader out of the equation and enable complete value chain digitalization.

Table 3.

The four stages of Digitalization

Stage 1	Stage 2	Stage 3	Stage 4
1. Use of electronic platforms instead of bilateral agreements designed by traders 2. Electronic clearing 3. Full application of straight-through processing	1. Deployment of parametric algorithms to automate tasks 2. Applicable to front, middle, and back offices	1. Establishment of a layer of algorithms to analyze data feeds 2. Application of algorithms' outputs to devise a trading strategy 3. Used by traders to make decisions, but executed by algorithms 4. Application of AI to perform tasks too time-consuming for humans	1. Full digitalization, including data collection, analysis; trade execution 2. Most of the trading organization skilled in or oriented toward mathematics and software engineering 3. Potentially includes high-frequency trading strategies

Note. Created by Boston Consulting Group (Belt & Porsborg-Smith, 2019).

2.2.1. Digitalization Advancements

One significant improvement is digitalization in the derivatives trading process (Marszk & Lechman, 2021). Standardization of the products allowed for data analytics and visualization, electronic trading platforms, blockchain, and decentralized finance technologies. This resulted in increased efficiency, more sophisticated decision-making, better use of resources, and lower operational risks (Bloomberg Professional Services, 2023).

As discussed above, trust is an issue in the agricultural commodity market. Information asymmetries create higher transaction costs (Jouanjean, 2019). However, new digital technologies provide opportunities to reduce these costs and risks. For example, big data analytics have emerged to collect and interpret information about global supply chains and create a scoreboard with various parameters (Clancy, 2017).

Another advance is online business-to-business platforms (Carballo et al., 2020), which start-ups are developing to disintermediate brokers (Prause et al., 2020). These platforms mitigate information asymmetries by allowing access to knowledge and contacts, reducing the need for intermediaries, and allowing even the smallest firms to participate in international trade (Jouanjean, 2019). New business models allow shippers to aggregate orders and take advantage of economies of scale (López González & Sorescu, 2021).

Commodity trading and Risk Management (CTRM) is another innovation in digitalization. A CTRM system manages buying or selling (Kirin, 2023) and “supports deal capture for physical contracts, commodity derivatives, and currencies, the logistics processes, and the financial settlement processes” (Mulder, 2022).

2.2.2. Challenges to Digitalization

One of the main challenges for digitalizing agricultural commodity trading and execution is going paperless. This means streamlining operations by introducing standardized contracts and straightforward processing (Belt & Porsborg-Smith, 2019) but also requires adapting analog systems to digital formats (Jouanjean, 2019). From a technical perspective, there are various ways to do this, but a fundamental difficulty is differences in standards between countries. Moreover, government agencies and customs departments do not share information (Jouanjean, 2019). An example is the Single Windows (SW), “a facility that allows parties involved in trade and transport to lodge standardized information and documents with a single-entry point to fulfill all import, export, and transit-related regulatory requirements” (UNECE, 2004). This process has been in operation for years but has not gained traction. For paperless trading to work, information must be unambiguous, with everyone understanding the information the same way.

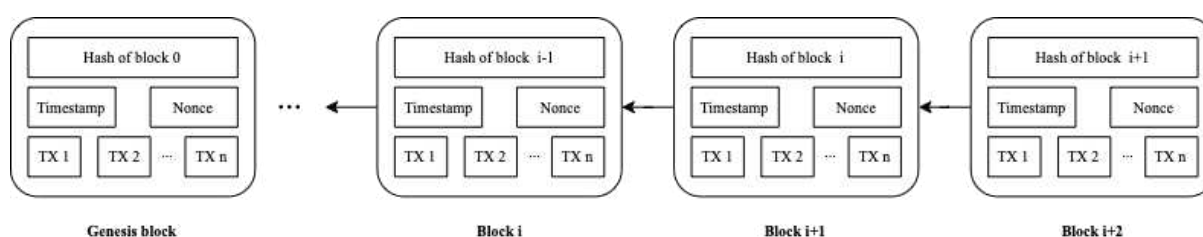
Questions about data ownership and privacy leaks are two other challenges impeding broader digitalization. Trading firms want to keep information private, and many resist digitalizing if other parties can access information (Ehmke, 2019). Moreover, if all information may be publicly visible, there is no transactional privacy (Kosba et al., 2016).

2.3. Blockchain Technology

Blockchain technology is a "digital, decentralized, and distributed ledger in which transactions are logged and added in chronological order with the goal of creating permanent and tamper-proof records" (Treiblmaier, 2018). Distributed ledger technology (DLT) is the foundation of BT, which facilitates peer-to-peer transactions without any need for intermediaries to update transaction information (Michael et al., 2018). *Figure 2* provides a typical example of a blockchain.

Figure 2.

Example of Blockchain



Note. Created by Wang et al. (2018).

This example includes data sets comprising a package chain, where each block includes multiple transactions (Nofer et al., 2017). Each block is extended by another, representing a ledger with all the transaction history. Every block can be verified cryptographically (meaning using hashes) (Lakkakula et al., 2020). Blocks contain a hash value (unique values, which prevents fraud) from the previous one and a nonce, a random number used to validate the hash, ensuring the entire BT's uprightness through the genesis block (Nofer et al., 2017). If most nodes in the network agree on the validity of transactions and partnerships, the block can be added to the chain.

2.3.1. Benefits of Blockchain Technology

Blockchain technology's main benefits or enablers are transparency, traceability, and authenticity (Li et al., 2021). The whole data in the supply chain is transparent to all members, as everyone has access to it. Moreover, the traceable data structure in the blockchain makes it possible to quickly trace the data backwards and forwards across the supply chain. Finally, the immutability property of BT ensures the authenticity of the products.

Another valuable benefit of BT is increasing the trustworthiness of participant nodes in the network (Rawat et al., 2020). As the system is built on peer-to-peer verifications, people trust the system's fault tolerance (Nofer et al., 2017). This gets rid of the need for intermediaries. The latter, as third centralized parties, are susceptible to data security breaches, but the decentralized blockchain is not vulnerable to these (Zyskind et al., 2015).

Furthermore, blockchain can significantly reduce transaction time and costs (Li et al., 2021). By eliminating unnecessary communication and digitalizing transactions, BT increases the speed and cost-effectiveness of transactions (Cole et al., 2019; Nandi et al., 2020).

Finally, blockchain technology can also promote sustainability by reducing greenhouse emissions, mitigating food waste with the help of traceability, and addressing consumer concerns regarding various aspects of the supply chain (Saberli et al., 2019).

2.3.2. Challenges of Blockchain Technology

There are several issues concerning cost and governance (Li et al., 2021). Firstly, the prices of blockchain technology acquisition and the learning curve may reduce adoption, especially for medium or smaller enterprises (Kshetri & DeFranco, 2020). Only large companies can adopt BT as they have the capital, technology, and infrastructure to capture and process data at every stage of complex supply chains. Secondly, there are problems related to data management, ownership, and retention regulations (Paech, 2017). The issue is that different supply chain members have already established data management regulations; therefore, BT requirements may conflict with those (for example, firms may want to keep sensitive information private) (Li et al., 2021).

Scalability is a further issue. As the number of transactions increases, the technology requires more and more storage. Another challenge is the energy consumption of BT. Since the transaction load is distributed among several components, transaction speed and accuracy increase, requiring a high-performance offloading architecture (Habib et al., 2022). Because of this, electricity consumption skyrockets. For instance, Bitcoin alone consumes 127 terawatt-hours per year, higher than Norwegian annual electricity consumption (Habib et al., 2022). Nonetheless, advocates of blockchain technology argue that switching to renewable energy and introducing carbon credits will resolve these issues (Sedlmeir et al., 2020).

2.3.3. Applications of Blockchain

Undoubtedly, blockchain technology, as a disruptive innovation, can transform significant industries (Nofer et al., 2017). *Table 4* presents various financial and non-financial blockchain applications.

Table 4.

Applications of Blockchain Technology

Type	Application	Description	Examples
Financial applications	Cryptocurrencies	Networks/mediums of exchange use cryptography to secure transactions.	Bitcoin Litecoin
	Securities issuance, trading, settlement	Companies going public issue shares directly, without a bank syndicate.	Medici Blockstream
	Insurance	Properties might be registered using the blockchain technology. Insurers can check the transaction history.	Everledger
Non-financial applications	Notary public	Central authorization by a notary is not necessary anymore.	Stampery Viacoin
	Music Industry	Determining music royalties and managing music rights ownership.	Imogen heap
	Decentralized proof of the existence of documents	Storing and validating the signature and timestamp of a document using blockchain.	www.prooffexistence.com
	Decentralized storage	Sharing documents without needing a third party using a peer-to-peer distributed cloud storage platform.	Storj
	Decentralized internet of things	The blockchain reliably stores the communication of smart devices within the Internet of Things.	Filament ADEPT
	Anti-counterfeit solutions	The authenticity is verified by the blockchain network consisting of all participants in electronic commerce.	Blockverify
	Internet applications	Instead of governments/corporations, Domain Name Servers are controlled by every user in a decentralized way.	Namecoin

Note. Created by Crosby et al. (2016).

2.3.3.1. Smart Contracts. Blockchain technology also facilitates the use of smart contracts. A smart contract is defined as a transaction code that completes the terms of a contract (Szabo, 1997). These contracts are immutable and cryptographically verified (Hewa et al., 2021) and essentially are executable codes run on top of blockchain to enforce agreements

between parties without the involvement of a third party (Buterin, 2014). Compared to traditional paper contracts, smart contracts allow users to codify agreements, enabling trust, avoiding tampering, and reducing the probability of human error (Singh et al., 2020). This way, blockchain can disrupt the transaction process in a secure, cost-effective, and transparent (Nofer et al., 2017).

Smart contracts can also be used in agricultural commodity industry for various purposes. Firstly, it can help in trade execution and risk management – deals are automatically executed once all the predetermined conditions are met (for instance, the price of a commodity reaching a specific threshold) or if the value of the commodity falls below a set level (Köksal, 2023). Smart contracts can also help track and manage the supply chain (record information like origin or transit points) and facilitate finance processes (invoice verification or release of funds). Finally, regulatory compliance can also be ensured by smart contracts and blockchain. Contracts can be programmed to meet specific requirements like location or quality standards (Köksal, 2023).

2.3.3.2. Application in Commodity Trading. As discussed in the Introduction (*see Chapter 1*), blockchain-based solutions have seen some success in oil and energy trading (Payne, 2018). VAKT is a BT-based platform focusing on digitalization and optimizing post-trade processes (VAKT, n.d.). Critical aspects of the technology include trade confirmation, settlement, data management, collaboration, regulatory compliance, document digitalization, and trade finance integration. The company aims to modernize various aspects of commodity trading and has received a vast amount of attention from investors like S&P Global Commodity Insights, Chevron, BNP Paribas, Shell, and many more (Atkins, 2021; Terazono, 2019). Platform users include companies responsible for almost two-thirds of all key deals (Terazono, 2019).

2.4. Analytical Framework

One of the main concepts we will use to analyze the impact of blockchain technologies on the agricultural commodities industry is innovation.

2.4.1. Innovation

Schumpeter (2013) introduced the concept of "creative destruction" in the early 1940s to describe "the process of industrial mutation [...] that incessantly revolutionizes the economic structure from within, incessantly destroying the old one, incessantly creating the new one". Rogers (1998) defined innovation as the "application of new ideas to the products, processes or any other aspect of firm's activities," mainly concerned with extracting value and commercializing the ideas. These ideas led to further exploration of different types, drivers, and

approaches to innovation like disruptive innovation (Christensen et al., 2018), demand-pull and technology-push innovation (Chidamber & Kon, 1994), diffusion of innovation (Rogers, 2010), and technology acceptance model (Davis, 1989).

2.4.1.1. Disruptive Innovation. The concept of “disruptive innovation” refers to a “unique type of innovation in which a specific process takes place, and incumbents are ultimately disrupted by new entrants” (Cozzolino et al., 2018). When Christensen (2013) first introduced “disruptive innovation,” he described its three principal components – more accessible products/services, incumbent’s focus on higher profits in mainstream markets and gradual market takeover and upward movement. In many industries, the demand for technological advancements is slower than technological advancements. This results in incumbents producing overly sophisticated products for their consumers and creating a gap that allows new market entrants to provide more straightforward solutions that fit customer needs (Christensen et al., 2018).

Firms can develop sustaining or disruptive innovation (Christensen et al., 2018). Sustaining innovation focuses on improving existing products and services, appealing to mainstream customers, and historical valuation of markets; this allows incumbents to increase their margins and profitability (Christensen & Raynor, 2013). Meanwhile, disruptive innovation is used more rarely. When initially introduced, these innovations are inferior. However, they also offer a unique blend of features that appeal to niche customers, especially those at the bottom of the market (Markman & Waldron, 2014).

Christensen argues that existing customers and business models limit investment in disruptive innovation (Christensen et al., 2018). This means that new entrants may be more likely to produce disruptive innovations. As a result, incumbents are disrupted by startups.

Christensen also points out two reasons why incumbents fail: management and the discounted cash flow trap (Christensen, 2013; Christensen et al., 2008). The discounted cash flow (DCF) trap is the predisposition to overvalue short-term and undervalue long-term financial metrics, another reason that incumbents fail (Christensen et al., 2008). Focusing on short-term financial metrics limits incumbents' ability to pursue new ideas and projects, stifling disruptive innovation.

2.4.1.2. Demand-pull and Technology-push innovation. Researchers debate whether innovation is driven by market demand or technological shifts (Chidamber & Kon, 1994). Analyzing whether an innovation is demand-pull, or technology-push can help to understand an innovation's success (Chidamber & Kon, 1994). Demand-pull (or market-pull) innovations arise when customer needs are not satisfied, creating a new demand to find solutions (Brem &

Voigt, 2009). Technology-push innovation comes from research and commercializing the knowledge (Brem & Voigt, 2009). Technology-push is often considered creative or destructive, leading to new improvements, while demand-pull is viewed as a substitute or replacement (Walsh et al., 2002). The main drawback of demand-pull is the risk of misidentifying needs. The risk for technology-push is targeting atypical users and producing a good that can be easily researched or evaluated (Burgelman & Sayles, 2004). *Table 5* summarizes the key differences between demand-pull and technology-push.

Table 5.

Differences between Demand-pull and Technology-push

Description/attribute	Demand-pull	Technology-push
Technological uncertainty	Low	High
R&D expenses	Low	High
R&D duration	Short	Long
Sales market-related uncertainty	Low	High
Time-to-market	Certain/known	Uncertain/unknown
R&D customer integration	Easy	Difficult
Kinds of market research	Quantitative verifying	Qualitative discovering
Need for change in customer behavior	Minimal	Extensive

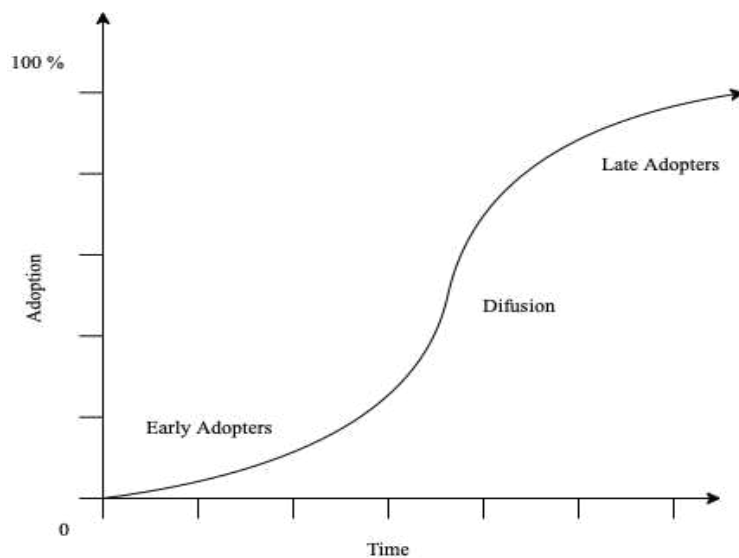
Note. Created by Gerpott (2005).

2.4.1.3. Diffusion of Innovation. Rogers (2014) defines “diffusion” as a process whereby innovation is communicated through different channels for members of a social system over time. The diffusion of innovations has four elements – innovation, communication channels, time, and social system (Rogers, 2014). The diffusion process occurs due to the combination of three aspects – the need for individuals to deal with uncertainty in the presence of new information, pressure to respond to perceptions the same as credible individuals, and social pressure to do the same as others (Dearing, 2009).

Research shows that if adopters make choices voluntarily and logically, a pattern of innovation dissemination becomes a mathematically consistent sigmoid curve – the S-shaped curve (Green et al., 1989). *Figure 3* presents the process of the diffusion of innovation. For any given innovation, the adoption rate is initially low, later accelerating because of word of mouth and slowly reaching maximum potential (Dearing, 2009). It is also important to mention that adopters follow a normal distribution in the case of successful diffusion (Dearing & Cox, 2018).

Figure 3.

Diffusion of Innovation

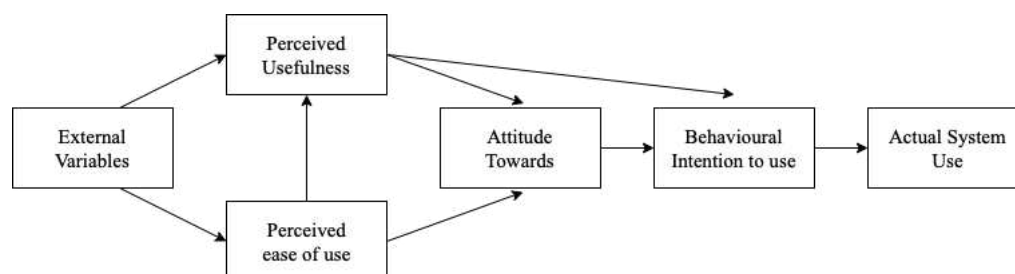


Note. Created by Dearing (2009).

2.4.1.4. Technology Acceptance Model. The technology acceptance model (TAM) was created to evaluate the acceptance of information technology (Davis, 1989). This model is based on the notion of reasoned action, which focuses on the relationship between attitudes and behaviors in specific situations (Legris et al., 2003). TAM aims to "provide a basis for tracing the impact of external variables on internal beliefs, attitudes, and intentions" (Legris et al., 2003). This should allow us to "predict the future of technology use [...] at the time that a technology is introduced" (Turner et al., 2010). *Figure 4* presents the original technology acceptance model. As depicted in the figure, two main factors explain use - perceived ease of use (PEOU) and perceived usefulness (PU). PEOU is "the degree to which a person believes that using a particular system would be free of effort," and PU relates to "the degree to which a person believes using a particular system would enhance his or her [job] performance" (Davis, 1989). This shows that people are more willing to use technology if it is easy to use and brings value.

Figure 4.

The original Technology Acceptance Model



Note. Created by Davis (1989).

Chapter 3: Research Methodology

This paper investigated whether blockchain technology can become a disruptive force in the agricultural commodity industry. The following Research Question is being interrogated:

RQ: Can blockchain technology become a disruptor in the agricultural commodity industry?

3.1. Research design

The research used several methodologies based on the triangulation method, which “increases scope, depth, and consistency in methodological proceedings” (Flick, 2002). The combination of methods included qualitative and quantitative data collection methods and a literature review (Bell et al., 2022; Sekaran & Bougie, 2016). The qualitative data collection method allowed the gathering of “information that is not in numerical form. For example, diary accounts, open-ended questionnaires, unstructured interviews, and unstructured observations” (McLeod, 2008). In this case, semi-structured interviews with various stakeholders were conducted to investigate the research questions.

Additionally, a survey was conducted to understand the perceptions and acceptance of BT among traders. Quantitative data analysis allowed for gathering data from interviews and surveys in “numerical form, which can be put into categories, rank order, or measured in units of measurement. This type of data can be used to construct graphs and tables of raw data” (McLeod, 2008). This included using various statistical analyses of the collected data. Finally, the literature review was tested as secondary research.

3.2. Data collection

In the subsequent paragraphs, the methods employed for data collection are described.

3.2.1. Primary Data – Survey

The Literature Review (*see Chapter 2*) underscored the importance of technology users embracing the spread of disruptive innovations. Therefore, it was decided to design a survey to test the acceptance phenomenon among commodity traders (Turner et al., 2010). Based on previous knowledge and analytical frameworks (*see Chapter 2.4*), a survey consisting of 19 questions was created (*see Survey in Appendix I*). Questions were developed in the six areas of (1) current industry landscape, (2) knowledge of blockchain, (3) benefits and (4) challenges of BT, (5) perception of innovativeness and adoption of BT, (6) demographics. The survey was conducted online using Qualtrics and distributed via LinkedIn or email. The limitations of the

survey are discussed in *Chapter 5*. Participants who did not complete survey were omitted from data set, leading to a final sample size (n) of 104.

3.2.2. Primary data – Expert Interviews

Rowley (2012) describes semi-structured interviews as standard in business research and discusses several benefits. First, they allow for observing non-verbal indicators (Barriball & White, 1994) and asking follow-up questions (Turner III et al., 2010). Moreover, semi-structured interviews explore the interviewees' attitudes, motives, and beliefs (Barriball & White, 1994; Magaldi & Berler, 2020).

Two guides were developed based on the knowledge acquired in the Literature Review. It consisted of questions about the (1) background of expertise, (2) current landscape of the industry, (3) benefits and (4) concerns about BT, (5) adoption and innovativeness trends, (6) future outlook and (7) recommendations. The interviews had an average length of around 38 minutes. Requests for interviews were sent via e-mail or LinkedIn for 26 potential interviewees. The 18 experts interviewed were experienced in blockchain or had agricultural commodity industry expertise (*see Overview in Table 6*). Interviews were carried out through phone calls or via Zoom/Microsoft Team platforms and were recorded. Responses were analyzed using qualitative content analysis with categorization (Mayring, 2014), which allowed to identify patterns and trends within the data (*see Chapter 4*). Summarized responses per question can be found in *Appendix II*.

Table 6.

Overview of Interviewees

Code/Name	Current position, experiences, and expertise
Karolis Šimas (IE1)	CEO of “Agrokonceino Grudai”, President of Lithuanian Grain Processors and Traders Association. 10+ years of experience.
Martin Brueggemann (IE2)	Senior trader at Agravis Raiffeisen AG. 10+ years of experience in oilseeds and grains, futures/options trading in Germany, Baltics, France.
Berry de Graaf (IE3)	Senior trader at Amaggi Europe B.V. 30+ years of experience in trade execution, origination, trading in Benelux, Baltics, Germany and France.
IE4	Head of Grain department in one of the biggest agribusinesses. 20+ years of experience in purchase, transport and marketing, working across EU.
Timo Sildvee (IE5)	Senior trader at Baltic Agro AS. Experienced in agri commodities trading in Europe and 3 rd World countries. 10+ years of experience.

Ginta Briede (IE6)	Head of trading at LPKS Latraps. Experienced in trade and execution in Europe and 3 rd World countries. 10+ years of experience.
IE7	Tech Business Process Coordinator in one of the largest agribusinesses in the world. 10+ years of experience in execution and operations.
Christian Tyliniski (IE8)	Risk manager at Agravis Raiffeisen AG. 10+ years of experience in oilseed crush and trading, risk management.
Philipp Schilling (IE9)	10+ years of experience in grain, oilseed, derivatives trading, merchandising, crush in Baltics, Scandinavia. Previous experience at Cargill as Regional Lead in Germany and Poland.
IE10	Commodities and derivatives trader with 10+ years of experience in oil and agricultural commodities trading.
Donald Campbell (IE11)	General manager at GrainCorp (Australia). 35+ years of experience in cross-border trading of cotton, veggie oil, grains and oilseeds.
Sayed Moineddin Ahamdi (IE12)	Grain trader at Al-Ghurair. 15+ years of experience in international grain trading (different origins and destinations).
Paul Sylvester (IE13)	20+ years of experience of international grain trading (based in USA).
BE1	Sales and client relations manager in one of Blockchain based platform companies. 10+ years of experience in tech, sales and commodity trading.
Sorin Albeanu (BE2)	Head of commercial at Covantis. 10+ years of experience in commodity markets, strategy development, sales & product marketing, management.
Demir Aksoy (BE3)	CEO at Cropto. 10+ years of experience in banking, IT and agricultural commodity markets. Ph.D. on Blockchain and grain trading in Turkey.
Santiago del Carril (BE4)	COO at Agrotoken. 10+ years of experience in agricultural commodities trading in South America.
Filipe Pohlmann Gonzaga (BE5)	Creator of world's first platform for grain trading in BT. Experience in issuance of tokens for grains. Owner of grain trading firm.

Note. Created by the author.

Chapter 4: Analysis and Discussion

The survey and expert interviews are analyzed in the following chapter. An approach of triangulation, incorporating perspectives from both primary and secondary data (*see Chapter 2*), is used to assess BT's disruptive potential and possible applications in agricultural commodity trading (*see Chapter 5*).

4.1. Analysis of the Survey

The traders' perception towards blockchain was generalized from the survey and compared with Literature Review (*see Chapter 2*). Survey data was analyzed using descriptive statistical analysis and creating ordinal logistic regressions in R software. Ordinal Logistic Regression is a widely used method where dependent variable is an ordinal scale, like a Likert scale, and independent variables are categorical. This approach is very common in social sciences or market research. After performing Regressions, Brant Test was performed on all models to check for potential Proportional Odds Assumption violations. If assumption was violated, additional actions were taken to fix data.

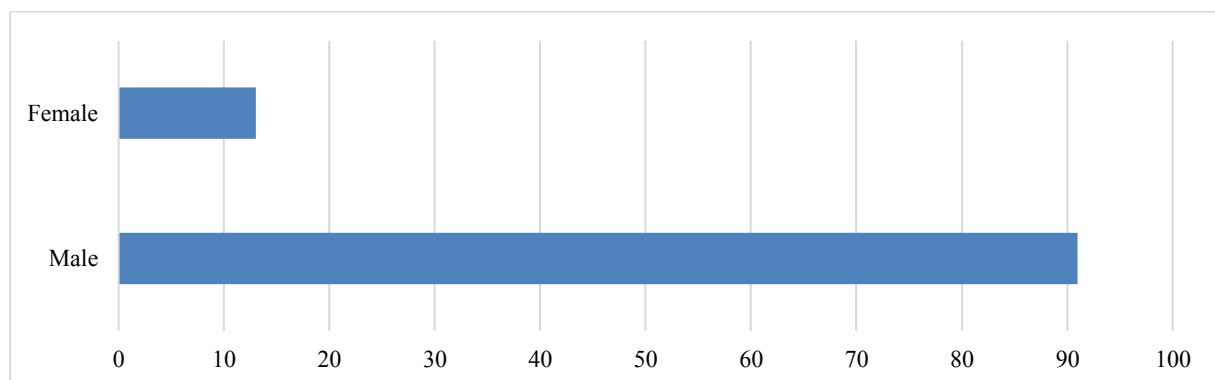
Final conclusions on traders' perception, BT's disruptive potential and limitations associated with the survey and the analysis are discussed in *Chapter 5*.

4.1.1. Demographics

Most respondents identified as a male (87,5%) (n=91), while only 12,5% as a female. None of the respondents identified as a non-binary or third gender. Also, none of the respondents chose to not to say their gender.

Figure 5.

Gender distribution



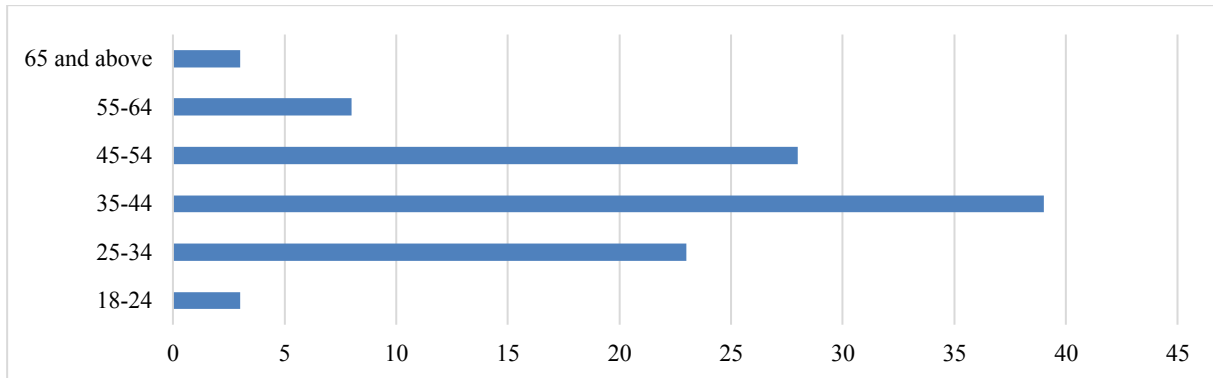
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Most of the respondents were located in European Union (mainly in Netherlands, Lithuania, Latvia, Denmark, Spain, Poland, Switzerland). A smaller proportion was from United Arab Emirates, United States, India, Brazil or other countries. Age distribution was

skewed towards middle-aged (35-55 years) group (see Figure 6). Only 23% of the respondents fall within young adults (18-35 years) group. 7,7% of the respondents were in the group of 55-64 years old and 3 were above 65 years.

Figure 6.

Age distribution

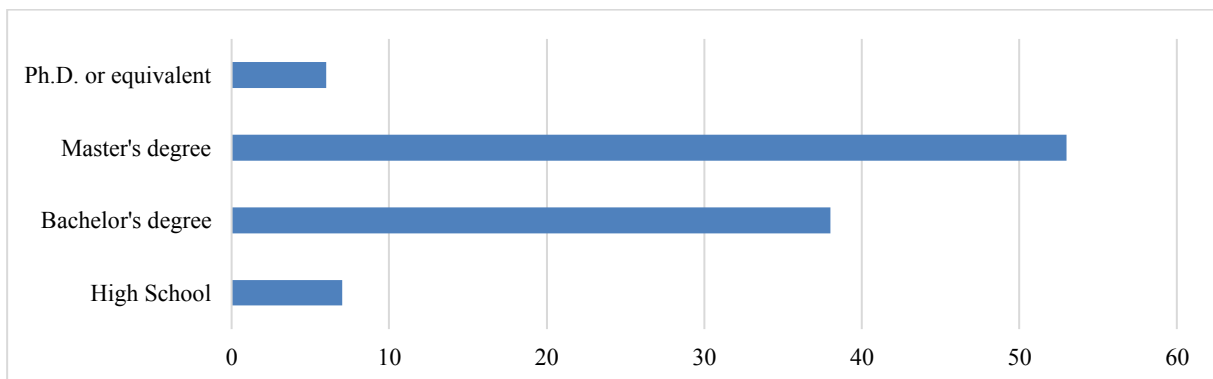


Note. Created by the author.

Most of the respondents (50,1%) had a master's degree or bachelor's degree (36,5%). 7 respondents reported having a high school degree. 5,8% of respondents had Ph. D. degree.

Figure 7.

Education level

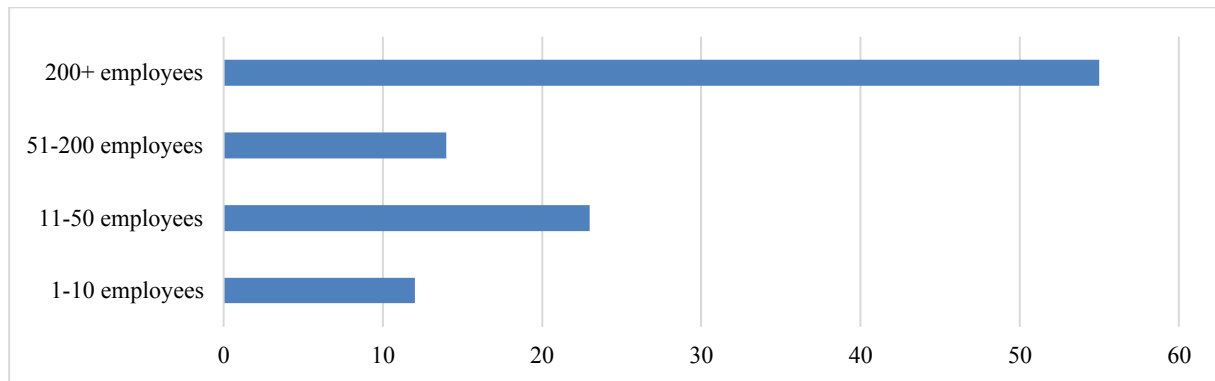


Note. Created by the author.

More than a half of respondents (73,1%) indicated having more than 10 years of experience in the industry. Second largest group (15,4%) held experience of 6-10 years. 11 respondents indicated having 1-5 years of experience and only 1 indicated having less than 1 year. Figure 8 presents a distribution on the size of the company that respondents indicated working at. Largest part (52,9%) were part of large companies that have 200+ employees. Moreover, 22,1% of respondents were working for companies that have 11-50 employees. Smallest group, 12 respondents, indicated working for the smallest group of companies.

Figure 8.

Company size



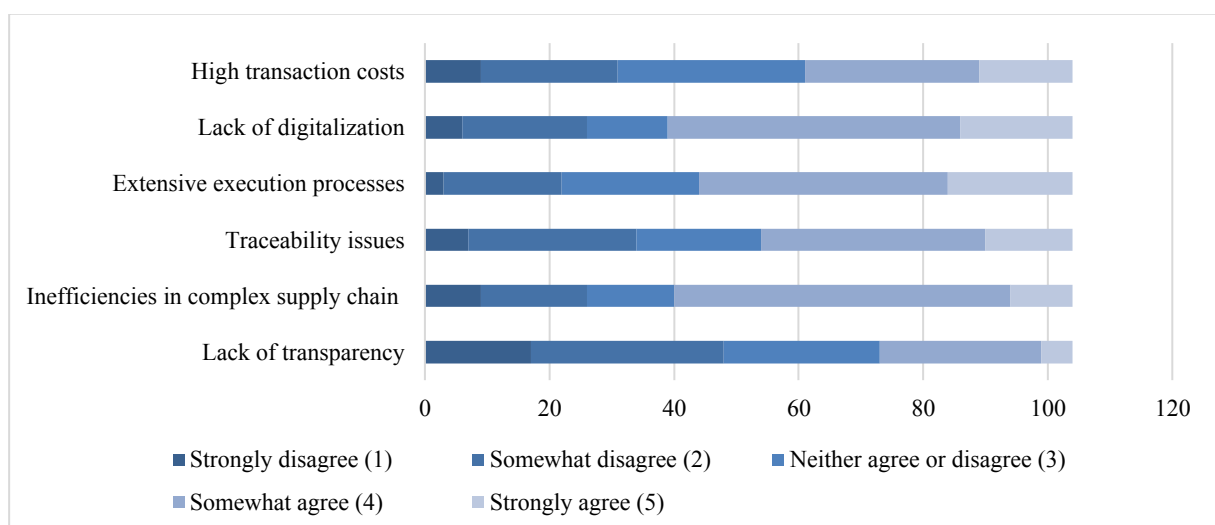
Note. Created by the author.

4.1.2. Current landscape of the Industry

Survey respondents were asked to indicate their level of agreement (using 5-point Likert scale) on the most significant challenges in the industry, that were indicated in the Literature Review (see Chapter 2). High transaction costs were not indicated as an important challenge. Regarding the lack of digitalization, 45,2% of respondents somewhat agreed and 17,3% strongly agreed to the issue. Respondents felt similarly about extensiveness of the execution process – 38,5% somewhat agreed, 19,2% strongly agreed and 21,2% were unsure. Perception towards traceability issues were somewhat equally distributed. Inefficiencies in supply chain were rated as one of the most significant challenges – 51,9% of respondents somewhat agreed and 9,6% strongly agreed. Finally, lack of transparency was the least significant challenge.

Figure 9.

The most significant challenges in the Industry



Note. Created by the author.

Ordinal Logistic Regressions (or Ordinal Logit Regression) were created to investigate demographic factors against the perception of significance of indicated challenges (see

regressions' outcomes in Tables 7 and 8). For all models, except model 5, the assumption of Proportional Odds did hold. To fix the issue in model 5, it was decided to exclude gender variable from the model. Results of regression models revealed that age shows significant effects on some of the issues in the industry. Age groups of 25 to 34, 35-44 and 45 to 54 had an impact on lack of transparency and inefficiencies in supply chain – positive coefficients indicated the increase in the log-odds of rating the challenge as more severe. The two oldest age groups also had the same impact on lack of transparency. Moreover, gender showed a significant negative effect on inefficiencies in the supply chain, meaning that being a male decreases log-odds of perceiving this challenge as more significant. Respondents having a high school degree or Ph.D. (or equivalent) showed a significant positive effect on the issue of lack of digitalization. Various company sizes did not show any significant effects on any of the challenges. However, two groups of experience (6-10 years and more than 10 years) had a significant negative effect on the severity of lack of transparency in the industry. The second group also had the same effect on inefficiencies in supply chain. Finally, respondents who had less than 1 year of experience had a very significant effect on lack of digitalization. Since the coefficient is very high, it can be indication of an outlier.

Table 7.

Impact of demographics on significance of challenges in the Industry

	Dependent variable:					
	Lack_of_transparency (1)	Inefficiencies_in_supply_chain (2)	Traceability_issues (3)	Extensive_execution_processes (4)	Lack_of_digitalization (5)	High_transaction_costs (6)
Age25-34	3.767** (1.474)	2.705* (1.496)	0.964 (1.284)	1.069 (1.208)	0.926 (1.362)	-0.327 (1.257)
Age35-44	4.532*** (1.635)	3.613** (1.667)	-0.198 (1.395)	1.145 (1.368)	0.758 (1.473)	0.393 (1.430)
Age45-54	4.348*** (1.676)	3.458** (1.712)	-0.096 (1.459)	0.968 (1.434)	-0.195 (1.527)	-0.338 (1.489)
Age55-64	5.093*** (1.787)	3.474* (1.810)	-0.187 (1.566)	1.556 (1.615)	-0.312 (1.669)	-0.096 (1.629)
Age65 and above	6.171*** (1.956)	3.438* (1.975)	0.150 (1.861)	0.390 (1.735)	0.269 (1.795)	0.491 (1.747)
GenderMale	-0.713 (0.562)	-1.968*** (0.684)	0.474 (0.558)	0.104 (0.602)		-0.658 (0.542)
EducationHigh School	0.134 (0.889)	-0.258 (0.862)	0.558 (0.850)	0.852 (0.885)	2.462*** (0.955)	0.716 (0.885)
EducationMaster's degree	0.271 (0.415)	-0.477 (0.440)	-0.163 (0.411)	0.500 (0.415)	0.582 (0.409)	-0.509 (0.414)
EducationPh.D. or equivalent	0.762 (0.893)	1.223 (1.113)	1.389 (1.099)	0.664 (0.847)	2.206** (0.873)	0.253 (0.844)
Company_Size11-50 employees	0.322 (0.717)	-0.136 (0.761)	-0.674 (0.735)	-0.052 (0.733)	-0.067 (0.720)	-0.104 (0.724)
Company_Size200+ employees	0.260 (0.627)	-0.859 (0.700)	-0.052 (0.662)	0.237 (0.661)	0.880 (0.667)	0.539 (0.643)
Company_Size51-200 employees	-0.300 (0.763)	-1.000 (0.824)	-0.886 (0.816)	0.387 (0.836)	0.750 (0.805)	0.192 (0.779)
Experience6-10 years	-1.772** (0.826)	-0.154 (0.924)	0.217 (0.792)	0.164 (0.738)	0.165 (0.786)	0.227 (0.772)
ExperienceLess than 1 year	2.636 (2.067)	2.956 (2.482)	0.830 (2.071)	1.447 (2.010)	19.270*** (0.00000)	0.105 (1.952)
ExperienceMore than 10 years	-2.663*** (0.975)	-1.756* (1.034)	-0.314 (0.860)	-0.369 (0.881)	0.588 (0.872)	-0.484 (0.935)
Observations	104	104	104	104	104	104

Note:

*p<0.1; **p<0.05; ***p<0.01

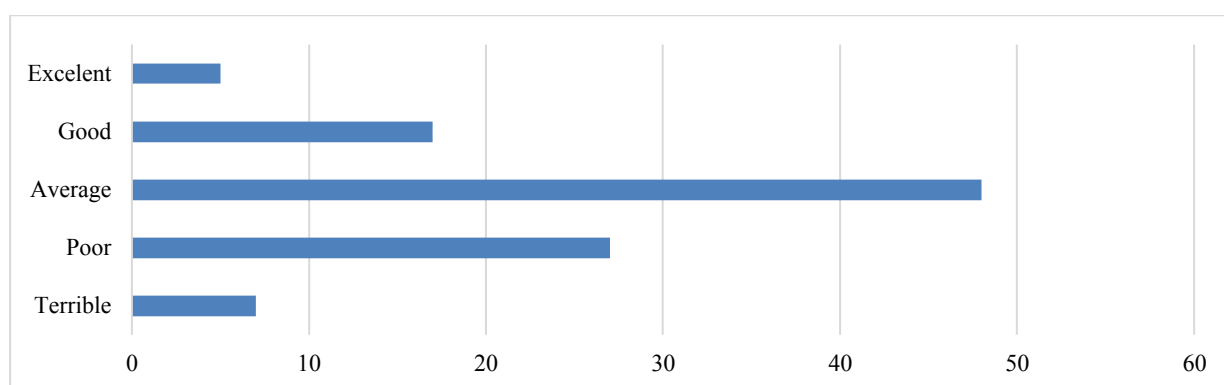
Note. Data retrieved form R.

4.1.3. Knowledge on Blockchain

Looking at the overall respondents' level of familiarity with the concept of blockchain technology, the distribution skew towards average or poor level (*see Figure 10*). It was chosen to test level of familiarity, as it can significantly affect Perceived Ease of Use and Perceived Usefulness factors in Technology Acceptance Model, which in Literature Review was indicated as one of the most important models to test technology's adoption in the industry (*see Chapter 2.4.*). This relationship is tested in *Chapter 4.1.5*. Finally, only 12,5% of the respondents indicated currently using Blockchain technology in their daily work.

Figure 10.

Level of familiarity with Blockchain Technology



Note. Created by the author.

An Ordinal Logistic Regressions was created to investigate demographic factors against the level of familiarity with BT. Proportional Odds Assumption hold for the regression. Also, two more models were created to analyze factors influencing usage of technology (*see regression' outcomes in Table 8*). In this case Multinomial Logistic Regression was chosen, as both, dependent and independent, variables were categorical. As for the first model, it showed that holding Ph. D. degree had a significant positive effect on familiarity with Blockchain. Age, gender, company size and years of experience had no significant associations. Model 2 showed that most of age groups had significant negative associations with being "unsure" about BT usage. It also revealed that men are more likely to be unsure about BT usage compared to females. Higher education levels were also significantly associated with being unsure. Also, respondents from smaller companies and having less than 10 years of experience were significantly negative associated about being unsure of BT usage. As for the last model, it showed lower Blockchain usage levels between older respondents. Moreover, experience in the industry were also positively associated with usage of BT. High coefficient values for Models 2 and 3 indicated that there were not a lot of respondents who were unsure or using BT.

Table 8.*Factors influencing level of familiarity and BT usage*

	Dependent variable:		
	Level_of_familiarity ordered logistic (1)	Unsure multinomial log-linear (neural networks) (2)	Yes multinomial log-linear (neural networks) (3)
Age25-34	1.022 (1.441)	-4.260*** (0.000)	-4.403*** (0.909)
Age35-44	1.686 (1.580)	0.586*** (0.175)	-5.308*** (0.679)
Age45-54	0.768 (1.627)	-21.609*** (0.000)	-5.977*** (0.700)
Age55-64	-0.017 (1.772)	-9.619	-73.515*** (0.000)
Age65 and above	-1.410 (1.883)	-8.290*** (0.000)	-80.115*** (0.000)
GenderMale	0.633 (0.632)	38.237*** (0.175)	-0.002 (1.193)
EducationHigh School	-0.297 (0.879)	0.956	1.305 (1.576)
EducationMaster's degree	0.593 (0.430)	25.514*** (0.175)	0.372 (0.823)
EducationPh.D. or equivalent	2.361** (0.931)	2.509*** (0.000)	2.037 (1.248)
Company_Size11-50 employees	-0.896 (0.712)	-14.134*** (0.000)	0.399 (1.305)
Company_Size200+ employees	-1.034 (0.640)	12.891*** (0.175)	0.422 (1.235)
Company_Size51-200 employees	0.091 (0.777)	-20.497	0.105 (1.582)
Experience6-10 years	0.489 (0.819)	-16.759*** (0.000)	69.853*** (0.901)
ExperienceLess than 1 year	2.145 (2.180)	-2.105*** (0.000)	152.899*** (0.000)
ExperienceMore than 10 years	-0.793 (0.926)	17.043*** (0.175)	71.449*** (0.816)
Constant		-96.542*** (0.175)	-68.367*** (0.899)
Observations	104		
Akaike Inf. Crit.		133.255	133.255

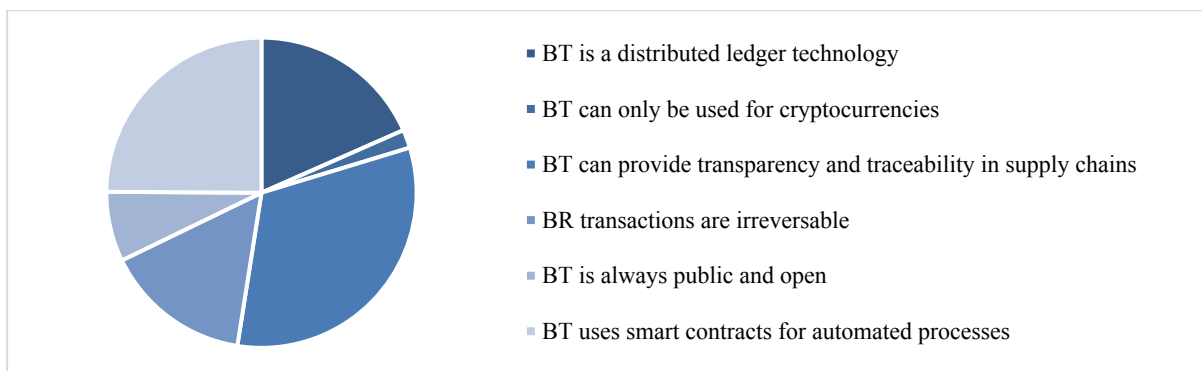
Note:

*p<0.1; **p<0.05; ***p<0.01

Note. *Data retrieved form R.*

Respondents were also asked to select the statements that accurately describe BT. Literature described blockchain technology as "digital, decentralized, and distributed ledger" (Treiblmaier, 2018), which facilitates transactions without intermediaries (Michael et al., 2018). Respondents most described blockchain as a technology that can provide transparency and traceability in supply chains and that it uses smart contracts for automated processes (*see Figure 11*). Moreover, 46,2% of respondents described it as a distributed ledger technology. The least popular choice was "Blockchain can only be used for cryptocurrencies".

Figure 11.*Statements describing Blockchain Technology*



Note. Created by the author.

4.1.4. Blockchain Technology's role in the Industry

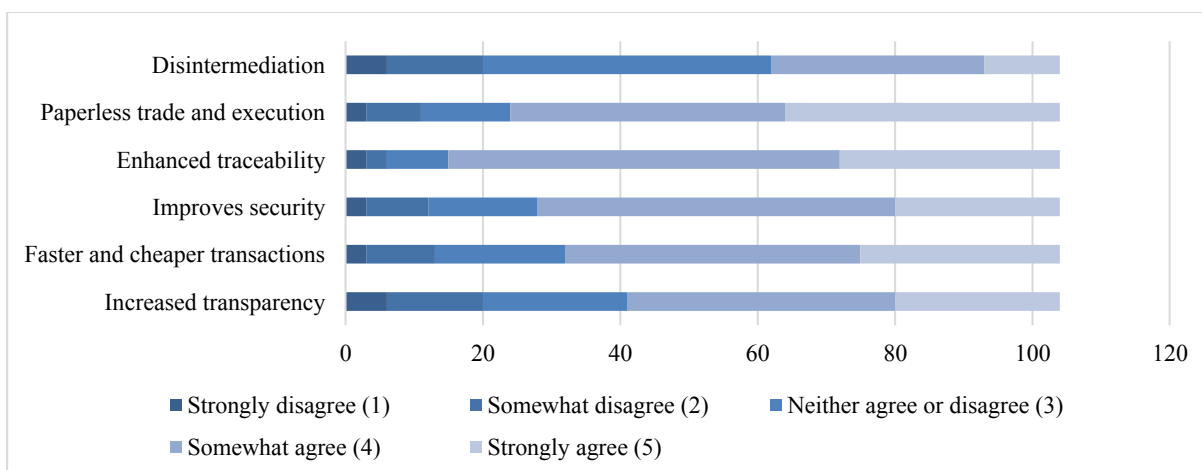
To analyze BT's potential role in the industry, it is important to look at how respondents perceive various benefits and challenges of the technology.

4.1.4.1. Perceived significance of BT's benefits.

The literature indicated several blockchain technology benefits or enablers - transparency, traceability, and authenticity (Li et al., 2021), increased trustworthiness of participant nodes in the network (Rawat et al., 2020), data security (Zyskind et al., 2015,) and increased speed and cost-effectiveness of transactions (Cole et al., 2019; Nandi et al., 2020). Respondents rated the significance of benefits in according to 5-point Likert scale. The most important benefits rated were enhanced traceability (54,8% of the respondents somewhat agreed, 30,8% strongly agreed) and paperless trade and execution (38,5% of the respondents somewhat agreed or strongly agreed). The least significant perceived benefit was disintermediation – 19,2% of the respondents strongly disagreed or somewhat disagreed with its significance. Respondents felt the most unsure about the importance of disintermediation, increased transparency, and faster and cheaper transactions.

Figure 12.

Perception towards the most significant benefits of Blockchain Technology



Note. *Created by the author.*

To investigate potential factors influencing perception towards significance of the BT's benefits, several factors were chosen – age, gender, company size, experience and usage of BT. Ordinal Logistic Regressions was created to investigate (*see regressions' outcomes in Table 9*). Proportional Odds Assumption hold for all regressions. Age only had a significant positive impact on disintermediation benefit (specifically age groups of 35 to 44 and 55 to 64). Gender had no impact. Size of the company had the significant negative effect on BT introducing faster and cheaper transactions, meaning variable decreases log-odds of perceiving this benefit as more significant. Company size of 51 to 200 employees also had the same effect on disintermediation benefit. Years of experience in the industry only had a significant negative effect on the before mentioned benefit (group of 10+ years of experience). Finally, being unsure about usage of BT in daily work, significantly positively affected all benefits except improved security and paperless trade and execution. Using Blockchain technology in daily work had no impact on the significance of the benefits.

Table 9.

Impact of demographics on significance of BT's benefits

	Dependent variable:					
	Increased_transparency (1)	Faster_and_cheaper_transactions (2)	Improves_security (3)	Enhanced_traceability (4)	Paperless_trade_and_execution (5)	Disintermediation (6)
Age25-34	-0.945 (1.436)	-0.370 (1.602)	1.185 (1.336)	0.629 (1.441)	1.132 (2.318)	0.670 (1.345)
Age35-44	-0.701 (1.572)	-0.643 (1.751)	1.147 (1.551)	1.200 (1.612)	1.225 (2.435)	2.905* (1.527)
Age45-54	0.344 (1.625)	-2.077 (1.807)	1.118 (1.602)	0.892 (1.679)	0.126 (2.473)	2.501 (1.583)
Age55-64	-0.220 (1.734)	-0.724 (1.903)	0.058 (1.727)	-1.329 (1.798)	-0.173 (2.528)	3.618** (1.681)
Age65 and above	-0.279 (1.841)	0.675 (2.146)	3.159 (2.014)	2.936 (2.048)	0.966 (2.788)	2.023 (1.807)
GenderMale	-0.009 (0.580)	0.106 (0.563)	-0.189 (0.614)	-0.423 (0.605)	0.193 (0.568)	0.955 (0.598)
Company_Size11-50 employees	0.091 (0.679)	-1.438* (0.801)	-0.151 (0.859)	-0.101 (0.758)	-0.427 (0.701)	-0.817 (0.749)
Company_Size200+ employees	0.118 (0.618)	-1.283* (0.716)	-0.991 (0.777)	-0.565 (0.676)	-0.563 (0.613)	-0.483 (0.682)
Company_Size51-200 employees	-0.873 (0.773)	-2.243** (0.882)	-1.070 (0.897)	0.369 (0.826)	-0.409 (0.775)	-1.354* (0.819)
Experience6-10 years	0.259 (0.776)	0.732 (0.782)	0.117 (0.821)	0.212 (0.826)	0.389 (0.761)	0.801 (0.847)
ExperienceLess than 1 year	-1.992 (2.137)	-1.808 (2.385)	-2.316 (2.122)	-0.837 (2.397)	0.389 (2.874)	-2.209 (2.108)
ExperienceMore than 10 years	-1.338 (0.896)	0.674 (0.943)	-0.719 (1.023)	-1.063 (0.993)	0.935 (0.958)	-2.072** (1.024)
BT_usageUnsure	17.430*** (0.00000)	16.380*** (0.00000)	0.600 (1.748)	18.281*** (0.00000)	-1.014 (1.615)	16.340*** (0.00000)
BT_usageYes	-0.525 (0.568)	0.329 (0.616)	0.536 (0.615)	0.273 (0.607)	0.194 (0.629)	-0.023 (0.563)
Observations	104	104	104	104	104	104

Note:

*p<0.1; **p<0.05; ***p<0.01

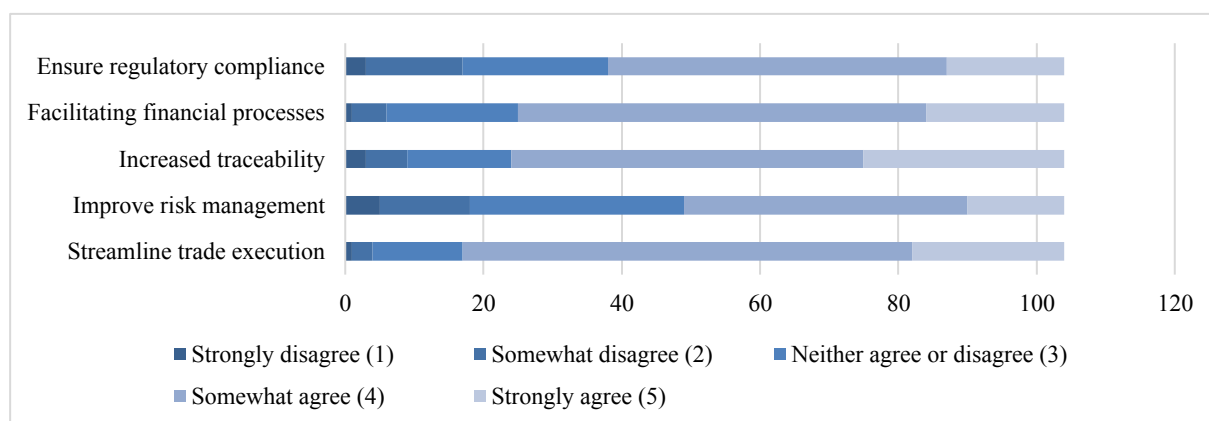
Note. *Data retrieved form R.*

4.1.4.1. Perceived significance of benefits of Smart contracts.

The literature discussed smart contracts as one of the possible and the most beneficial applications of BT in agricultural for various purposes (*see Chapter 2.3*). These contracts compared to paper contracts, enables trust, avoids forgery, and reduces the probability of errors (Singh et al., 2020). Smart contracts hold potential in trade execution and risk management, as well as ensuring regulatory compliance (Köksal, 2023). In the survey respondents rated streamlining trade execution as the most significant benefit of smart contracts – 62,5% somewhat agreed and 21,2% strongly agreed with its significance. Second rated came increased traceability and third – facilitation of trade finance and third – increased traceability. Improved risk management was rated as the least significant benefit – 29,8% or respondents were unsure about its significance and 17,3% somewhat disagreed or strongly disagreed. Respondents also felt the most unsure about this benefit as well as ensuring the regulatory compliance.

Figure 13.

Perception towards the most significant benefits of Smart contracts



Note. Created by the author.

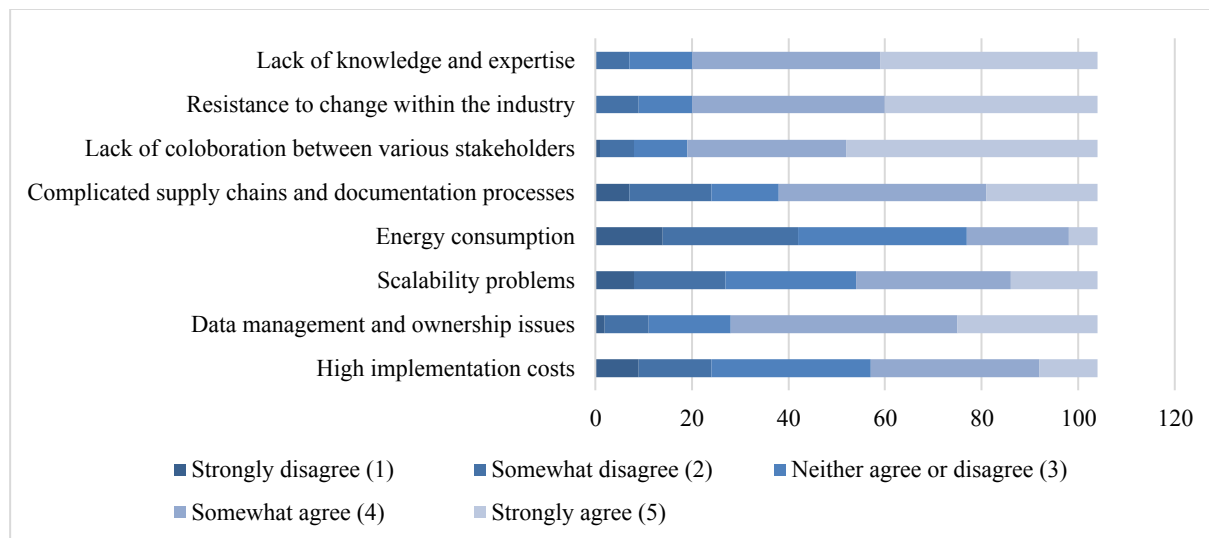
4.1.4.2. Perceived significance of challenges related to adoption of BT.

Regarding the main challenges related to the adoption of Blockchain technology, literature mentioned several issues concerning cost and governance, data management, ownership, and retention regulations, scalability and energy consumption of the of the technology. In the survey, respondents were asked to evaluate significance of these challenges. As the most significant ones, respondents rated three obstacles – lack of knowledge and expertise about BT (32,7% somewhat agreed and 43,3% strongly agreed), resistance to change within the industry (38,5% somewhat agreed and 42,3% strongly agreed), and lack of collaboration between stakeholders (31,7% somewhat agreed and 50% strongly agreed). Data management and ownership, and complexity of supply chains and documentation processes were also important challenges to the respondents. The most unsure or respondents felt about

the significance of energy consumption of BT, scalability of the technology, and high implementation costs. These challenges we also rated as the least important.

Figure 14.

Perception towards the most significant challenges of BT adoption



Note. Created by the author.

An Ordinal Logistic Regressions was created to investigate various factors against the challenges of BT's adoption. Regressions were created to hold Proportional Odds Assumption (see regression' outcomes in Table 10). Results revealed that for the issue of high implementation costs age group of 25 to 34 and group of 65+, as well as being unsure about using BT in daily work significantly increased importance of the issue. However, variable size of the company (11-50 employees) posed opposite effect. For scalability, only being unsure about using BT had a positive significant effect. The same factor had an opposite effect for energy consumption issue. Having experience for more than 10 years in the industry, also influenced the obstacle in an equal way. Regarding the complexity of supply chains and documentation processes, age was the most significant factor that had a positive effect – only a group of 35-44 years old did not have an influence. Age and short experience had a significantly positive effect on importance of collaboration between stakeholders' issue, but increasing company size had the opposite effect. Resistance to change had the same influence of the company size, but being the least experienced and being unsure about BT's usage had a positive effect, meaning variable increases log-odds of perceiving this issue as more significant. Finally, lack of knowledge was perceived as more significant obstacle by respondents aged 55-64 and being least experienced in the industry. Using BT resulted in lower significance of the issue.

Table 10.

Relationship between demographics and level of significance of challenges of BT's adoption

	Dependent variable:						
	High_implementation_costs (1)	Scalability (2)	Energy_consumption (3)	Supply_chains_and_documentation_processes (4)	Coloboration_between_stakeholders (5)	Resistance_to_change (6)	Lack_of_knowledge (7)
Age25-34	2.344* (1.287)	0.187 (1.260)	-0.147 (1.604)	2.834** (1.256)	2.840** (1.317)		1.595 (1.365)
Age35-44	1.789 (1.444)	0.823 (1.402)	0.100 (1.718)	2.298 (1.409)	3.568** (1.528)		1.684 (1.600)
Age45-54	1.586 (1.501)	-0.293 (1.463)	-0.928 (1.775)	2.562* (1.481)	2.343 (1.551)		1.891 (1.667)
Age55-64	1.994 (1.589)	0.496 (1.545)	-0.183 (1.836)	3.493** (1.597)	4.650*** (1.748)		3.242* (1.794)
Age65 and above	3.236* (1.806)	0.789 (1.767)	1.187 (2.006)	3.499** (1.769)	1.548 (1.777)		2.551 (2.178)
Company_Size11-50 employees	-1.395* (0.784)	-0.372 (0.719)	-0.335 (0.673)	-0.887 (0.685)	-2.109** (0.965)	-0.517 (0.747)	1.156 (0.797)
Company_Size200+ employees	-0.261 (0.691)	0.391 (0.656)	0.802 (0.598)	0.185 (0.604)	-2.229** (0.914)	-1.021 (0.670)	-0.704 (0.646)
Company_Size51-200 employees	-0.662 (0.816)	0.198 (0.780)	0.275 (0.759)	-0.250 (0.801)	-1.881* (1.043)	-1.565** (0.788)	-0.534 (0.788)
Experience6-10 years	-1.008 (0.807)	0.260 (0.770)	-0.700 (0.795)	-0.853 (0.815)	0.390 (0.942)	0.573 (0.808)	0.979 (0.924)
ExperienceLess than 1 year	-1.073 (2.083)	11.529 (161.507)	-2.379 (2.316)	1.894 (2.076)	13.201*** (0.00003)	15.775*** (0.00000)	19.910*** (0.00000)
ExperienceMore than 10 years	-1.009 (0.908)	-0.161 (0.894)	-1.874** (0.954)	-1.543 (0.990)	-1.091 (1.059)	-0.427 (0.655)	-0.906 (1.146)
BT_usageInsure	15.886*** (0.00000)	17.558*** (0.00000)	-18.644*** (0.00000)	0.600 (1.638)		15.104*** (0.00000)	0.133 (1.653)
BT_usageYes	-0.674 (0.609)	0.534 (0.588)	-0.479 (0.611)	-0.354 (0.615)		-0.731 (0.599)	-1.867*** (0.673)
Observations	104	104	104	104	104	104	104

Note: *p<0.1; **p<0.05; ***p<0.01

Note. Data retrieved form R.

4.1.5. Adoption and development trends

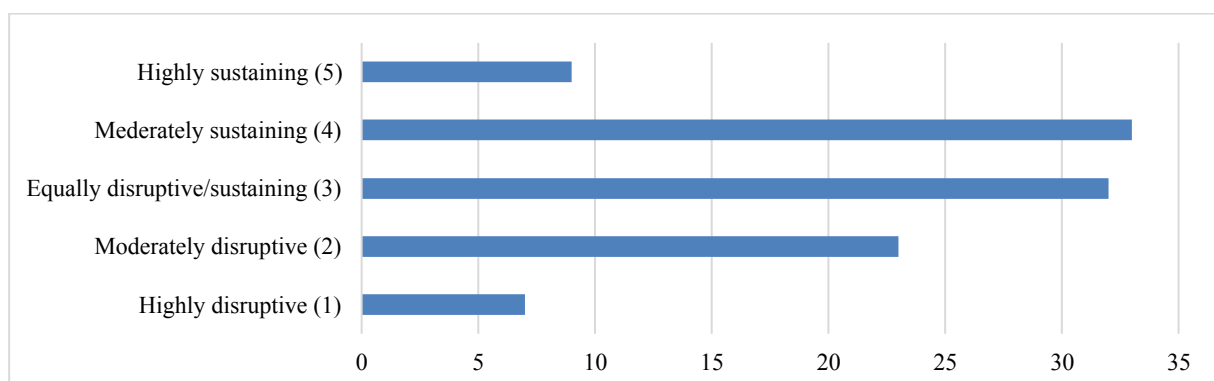
To understand disruptiveness and adoption possibilities, several innovation concepts were chosen as analytical framework (see Chapter 2.4.).

4.1.5.1. Disruptiveness and primary users.

The literature proposed that disruptive innovation is pursued by firms more rarely compared to sustaining innovation (*see Chapter 2.4.*). However, disruptive innovations are associated with features that appeal to niche users in the market. 40,4% of respondents expressed an opinion that Blockchain will have more of the sustaining role, 30,8% thought that technology will be equally sustaining and disruptive (*see Figure 15*). Only 6 indicated BT being highly disruptive. Regarding early adopters, most of the respondents somewhat agrees that BT will be primarily adopted by niche users or specialized segments (*see Figure 16*). 24% somewhat or strongly disagreed, 22,1% of respondents were unsure.

Figure 15.

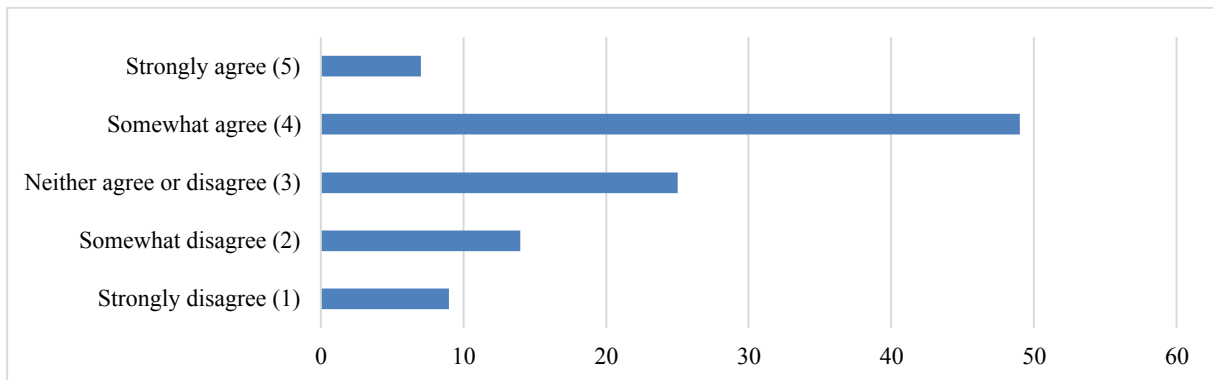
Perception towards disruptiveness of Blockchain technology



Note. Created by the author.

Figure 16.

Perception towards niche companies as early adopters



Note. Created by the author.

Ordinal Logistic Regressions were created to investigate whether disruptiveness of the technology has an influence on the type of early adopters. Output of the regression can be seen in *Table 11*. Results showed different implications than suggested in Literature review. It can be seen that rating BT as highly disruptive resulted in a point of view, which expects technology to be firstly adapted by large players rather than niche.

Table 11.

Influence of technology's disruptiveness on type of early adopters

Dependent variable:	
Niche_users	
DisruptivenessHighlyDisruptive	-1.713** (0.865)
DisruptivenessHighlySustaining	0.251 (0.698)
DisruptivenessModeratelyDisruptive	-0.369 (0.498)
DisruptivenessModeratelySustaining	0.256 (0.466)
Observations	104

Note: *p<0.1; **p<0.05; ***p<0.01

Note. Data retrieved form R.

4.1.5.2. Key drivers for adoption and development.

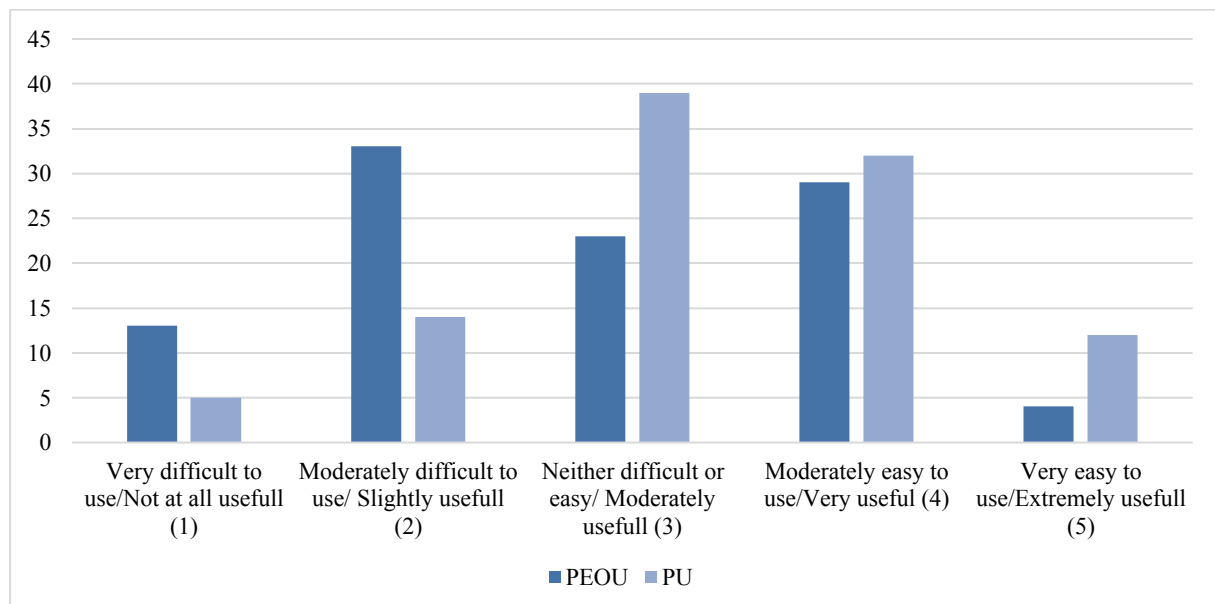
The literature emphasized Perceived Ease of Use and Perceived Usefulness as key drivers for people to be willing to use the technology. Also, adoption can be influenced by pressure of credible individuals. Moreover, demand for technological advancements usually is

slower than the pace of invention of new technologies (*see Chapter 2.4.*). Technology-push innovations are considered as creative or destructive, while demand-pull as a substitute (Walsh et al., 2002).

Figure 17 presents respondents' evaluation of PEOU and PU of Blockchain technology. Difficultness of use was rated similarly – 45,2% rated it as very or moderately difficult to use, 31,7% as moderately easy or very easy to use. 24 respondents were unsure. As for Perceived Usefulness, most of the respondents rated it as moderately or very/extremely useful (42,3,4%). 38,5% of respondents claimed that these factors would be key drivers for BT's adoption, 26,9% were unsure about the impact, and 26,9% expressed an opinion that they would have no effect on the adoption rate.

Figure 17.

Evaluation of PEOU and PU of Blockchain technology

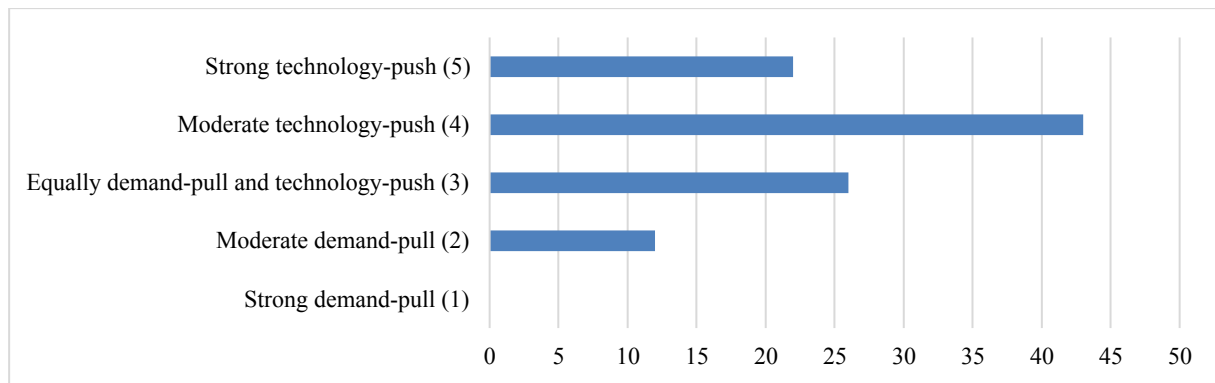


Note. Created by the author.

Figure 18 shows respondents' perceptions towards drivers of technology's development. Majority of respondents – 62,5% - expressed an opinion that development of the technology is being pushed by the technology itself rather than pulled by the actual demand. 25% of respondents rated both drivers playing a role.

Figure 18.

Perception towards drivers of Blockchain technology



Note. Created by the author.

Several Ordinal Logistic Regressions were created to see what factors influence perception towards significance of key factors for adoption and development (see outputs in Table 12). It can be seen that only size of the company (from 11 to 50 employees specifically) had a significant negative effect. It means that variable increases log-odds of perceived usefulness being less significant driver when considering adoption.

Table 12.

Impact of demographics on significance of key factors for adoption and development of BT

	Dependent variable:		
	Perceived_usefulness (1)	Perceived_ease_of_use (2)	DemandPull_vs_TechnologyPush (3)
GenderMale	-0.052 (0.537)	-0.075 (0.542)	0.656 (0.535)
Company_Size11-50 employees	-1.285* (0.715)	-0.759 (0.719)	-0.155 (0.705)
Company_Size200+ employees	-1.006 (0.636)	-0.647 (0.647)	-0.808 (0.648)
Company_Size51-200 employees	-0.865 (0.770)	-0.659 (0.770)	-0.931 (0.757)
Experience6-10 years	0.096 (0.743)	0.686 (0.724)	0.049 (0.712)
ExperienceLess than 1 year	-1.869 (1.785)	-1.158 (1.751)	-0.362 (1.786)
ExperienceMore than 10 years	-0.434 (0.627)	0.603 (0.588)	-0.174 (0.591)
Observations	104	104	104

Note: *p<0.1; **p<0.05; ***p<0.01

Note. Data retrieved form R.

4.1.5.3. Expected time horizon for adoption.

According to diffusion of innovation framework, for any given innovation, the adoption rate is initially low, later accelerating because of word of mouth and slowly reaching maximum potential (Dearing, 2009). Respondents were asked to indicate expected time horizon for Blockchain technology to become significant enabler in the industry. Majority (42,3%)

indicated that it will have a significant impact in 5 to 10 years. 31 respondents thought that it will take 3-5 years.

4.2. Analysis of the Expert interviews

Interviews were conducted with experts of blockchain technology and professionals from agricultural commodity industry. Outcomes were analyzed using qualitative content analysis with categorization (*see Chapter 3.2.2.*). The categorized themes are detailed in *Appendix III*. Observations were cross-validated through a literature review (*see Chapter 2*) and survey data (*see Chapter 4.1*) to pinpoint similarities or inconsistencies within the data. Final conclusions on BT's disruptive potential can be found in *Chapter 5*.

4.2.1. Current landscape of the Industry

To understand blockchain technology's disruptive potential, discussion of current agricultural commodities industry's landscape was performed. This included key challenges in the industry and its readiness to adopt emerging technologies.

4.2.1.1. Key challenges.

The literature described complex supply chains as one of the key challenges in the agricultural commodity industry (*see Chapter 2.1.1.*). According to the experts, market is decentralized (IE10, BE2) and experts were unanimous that many different entities included complicates collaboration. This was also confirmed by survey respondents. As many decisions depend on timing and intuition, trust becomes another factor that influences complexity of supply chains (IE1, IE2, IE4, IE10, BE5). Moreover, lack of standardization in processes and goods creates adds more complexity and inefficiencies (IE1, IE3, IE5, IE8, IE9, IE10, BE1, BE2). Finally, existing talent shortage (IE2, IE4, IE9, BE2) means less people understand full supply chain and its nuances.

Kingsman (2017) discussed the importance of documents in the industry and Louis Dreyfus Company (2018) emphasized that execution is still highly manual process that creates significant costs (*see Chapters 2.1.2 and 2.1.3.*). Between companies there are different execution systems and styles (IE1, IE2, IE9, BE2, BE5) which increases probability of misunderstandings and margin of error. Survey respondents also emphasized the complexity of the post-trade process.

Literature review also discussed the high number of risks that businesses need to manage (*see Chapter 2.1.4.*). Unpredictable events like natural disasters, geopolitical conflicts, weather, currency fluctuations directly create supply and demand issues (IE4, IE8, IE10). Another risk arises from huge amount of information that companies can access today (IE8) – perception of

risks heightens due to overload and contributes to uncertainty. Turvey et al. (2006) highlighted the importance of credit risk in the industry and Bandyopadhyay (2016) explained how capital flow issues can create defaults. Increasing cost pressures (IE4) and decreasing margins in the business (IE5, IE7, IE9, BE2) puts additional constraints on the companies. However, interestingly IE13 mentioned that this industry currently also lacks risk takers.

Finally, the emphasis on traceability and transparency is increasing (IE1, IE2, IE3, IE5, BE1, BE4) as companies are facing more regulations towards sustainability or quality of goods (IE2, IE4, IE11, IE12, BE1). However, survey showed that most of the traders are not that concerned about significance of transparency issues.

4.2.1.2. Readiness for Technology adoption.

Although farmer side is largely digitalized, commercial side of the business lags (IE1, IE5, IE11) and still strongly rely on traditional methods (IE1, IE3, IE6, IE7, IE10, IE12, IE13, BE2). Survey respondents and literature analysis also confirmed lack of digitalization. It is also important to note, that digitalization levels vary a lot in different countries (IE1, IE7, IE9). Also, there is a lot of resistance to change in the industry (IE3, IE5, IE7, IE1, IE12). And although there is some eagerness to embrace new ideas (IE2, IE6, IE13), improvements like emerging online marketplaces (Carballo et al., 2020), remain with low adoption rates (IE2, IE5, IE6, IE7, IE9). Levels of digitalization also depend on size of the company (IE3, IE5, IE9).

According to the literature review (*see Chapter 2.2.2.*), biggest challenges towards digitalization arise due to lack of process and software standardization, issues of switching from analog to digital systems, and concerns towards data ownership and privacy, which was also confirmed by some of the experts (IE6, IE7, IE8, IE11, IE12, BE1, BE2). Moreover, experts raised doubts about comparable costs of technologies and human capital as well as ambiguity around actual benefits (IE2, IE3, IE5, IE7, IE9, IE10, IE11). Finally, lack of regulations (IE8) and education on emerging technologies (IE3, IE6, IE7, IE8, BE1) also make companies reluctant towards embracing digitalization.

The Literature Review (*see Chapter 2.2.2.*) mentioned that the biggest changes have been achieved in derivatives trading (Marszk & Lechman, 2021), experts also pointed to improvements in smart communication, internal software and risk management tools (IE4, IE6, IE9, IE10) as well as information accessibility (IE5).

4.2.2. Blockchain Technology's role in the Industry

Experts also discussed potential Blockchain application and its benefits to the industry. Some of the most significant challenges to the adoption were also analyzed.

4.2.2.1. Potential applications.

As for potential applications, experts mentioned a few. Most of them identified an opportunity in execution (IE1, IE3, IE6, IE7, IE8, IE10, IE11, IE13, BE1, BE2, BE5), however with the need for standardization of processes and documents beforehand (IE1, IE4, IE5, IE9, IE11, BE1). IE3 and IE10 emphasized potential in farming and potential in quality control of goods (IE10, IE12). Also, some mentioned limited applications in trading itself (IE4, IE9, IE13). Another major suggested area of application suggested, was trade finance (IE6, IE8, IE9, IE10, IE11, IE13). Smart contracts applications included suggestions for paper market (IE2, IE3, IE4), certificates management (like sustainability) (IE3), or risk management (IE4, IE7, BE5). BE4 also suggested application of smart contracts to generate rules and better clearing techniques. Finally, BE3, BE4 and BE5 suggested the smart contract use for tokenized payment system

4.2.2.2. Perceived benefits.

Regarding the benefits of blockchain, experts indicated similar ones compared to literature and survey respondents. As the most valuable benefit, process automation and cost-efficiency increase were mentioned (IE1, IE2, IE3, IE4, IE5, IE6, IE7, IE8, IE9, IE10, IE11, IE12). Traceability, transparency and increased trust between the stakeholders was also important (IE2, IE3, IE5, IE8, IE9, IE10, IE11, IE12, BE4, BE5). Reduced intermediation was not the most significant benefit for experts too. Security of the technology also proved its benefits (IE7, IE8, BE1, BE2) as well as reduced errors (IE5, IE6, IE7, BE5). Experts BE3 and BE4 suggested, that blockchain could bring more liquidity to the market. However, some experts mentioned that there is a lot of ambiguity around BT's benefits in general (IE2, IE3, IE5, IE8, IE11).

4.2.2.3. Perceived challenges and obstacles to adoption.

Some of the experts, the survey respondents and literature insights suggested that there are a lot of concerns about data safety and management (IE1, IE6, IE7, IE8, IE10, IE11, IE12, BE1, BE2). Also, the lack of standardization was noticed as one of the most important challenges (IE1, IE2, IE3, IE4, IE5, IE9, BE2). Environmental concerns were not a popular concern for experts too, only two mentioned it (IE2, IE3). There were some questions raised also about assurance of compliance and financial capital confirmation with unknown parties in the chain (IE1, IE6). Experts also almost unanimously raised concerns about lack of collaboration between stakeholders in the industry (this was also verified by survey respondents) (IE1, IE2, IE3, IE5, IE6, IE8, IE9, IE10, IE11, IE12, IE13, BE1, BE2, BE3, BE4, BE5). BE4 emphasized the importance of large market players adopting the technology, otherwise there is potential for slow adoption of the technology and high possibility of under-

execution. Other concerns included legal considerations (IE6, IE8, BE5), risks of token economics (BE3), unifying different blockchain platforms (IE6, IE9, IE13).

4.2.3. Adoption and development trends

Based on key innovation theories, experts also discussed blockchain technology's adoption and development trends to evaluate its potential disruptiveness.

4.2.3.1. Disruptiveness and primary users.

Experts were almost unanimous regarding disruptiveness of the BT. Most of them agreed that the technology would be rather sustaining innovation (IE1, IE2, IE3, IE4, IE5, IE6, IE7, IE10, IE11, IE13, BE1, BE2, BE3, BE5). Same as in the survey, only a small part of experts thought that it will have a disruptive role (IE8, IE9, IE12, BE4). This confirms literature review finding that disruptive innovation is used more rarely compared to sustaining innovation (*see Chapter 2.4.*).

However, type of primary users for experts differed from survey respondents. Majority of the experts expressed an opinion that it will be firstly adopted by the big market players (IE1, IE2, IE3, IE4, IE5, IE6, IE7, IE10, IE11, BE1, BE2, BE3). This is consistent with Markman & Waldron (2014) idea that sustaining innovations are more adopted by large companies first.

4.2.3.3. Key drivers for adoption and development.

The TAM model suggested that emphasized Perceived Ease of Use and Perceived Usefulness as key drivers for people to be willing to use the technology. Experts emphasized that perceived usefulness is more important factor than ease of use (IE1, IE2, E3, IE4, IE5, IE7, IE8, IE9, IE10, IE11, BE2). This view was also confirmed by survey respondents. Some of the experts also discussed cost-efficiency and price of platform as drivers (IE8, BE2). Moreover, it was suggested that push for adoption will also come from other players in the market (IE1, IE8, BE4). IE12 also mentioned, that proof of BT's success in other industries could be an additional motivation for adoption.

Demand-pull and Technology-push innovation notions suggested that demand for technological advancements usually is slower than the pace of invention of new technologies (*see Chapter 2.4.*). Respondents expressed an opinion that development of the technology is being pushed by the technology itself rather than pulled by the actual demand. Majority of the experts agreed with this view (IE2, IE2, IE3, IE4, IE7, IE8, IE9, IE10, IE11, IE12, BE1, BE5). Three of the experts suggested that it is a mix of both Demand-pull and Technology-push (IE13, BE3, BE4).

4.2.3.4. Expected time horizon for adoption.

The Diffusion of Innovation framework argues that for any given innovation, the adoption rate is initially low, later accelerating because of word of mouth and slowly reaching maximum potential (Dearing, 2009). This was also supported not only by most survey respondents, but also experts indicating time horizon of 5 to 10 years. Only three (IE1, IE8, IE10) suggested that it will take more than 10, and two, faster than 5 years (IE13, BE4). IE5 argued that it will depend a lot on the regions.

Chapter 5: Conclusions

The final chapter discusses main findings and summarizes limitations of the research. Finally, recommendations for the future research are provided.

5.1. Main findings

Based on findings in *Chapter 4*, the assessment of Blockchain technology's disruptive potential is provided in the following paragraphs.

5.1.1. Current levels of Blockchain Technology's use

Overall, survey and expert interviews indicated, that current levels of Blockchain technology's use are very low in the industry. This could be explained by limited options of platforms offered, lack of knowledge about technology itself (which is influenced by age and level of experience of the respondents), and general resistance in the industry towards use of digital technologies (*see Chapter 4*). Nonetheless the ambiguity around BT's benefits, that is felt in the industry, both experts and survey respondents indicated several benefits that could be significant in agricultural commodity market. These included increased traceability, paperless trade and execution, improved security, increased operational and costs efficiency, and improved trust between stakeholders. These benefits were also suggested by the literature findings. Smart contracts were also evaluated as potential solution for improving trading processes such as execution, trade finance, quality, certificates or document control and management. This indicates actual existing potential of Blockchain technology in the industry.

Dearing (2009) discussed that for any given innovation, initial adoption rate is very low, latter accelerating because of various factors. Davis (1989) highlighted the role of PEOU and PU in people's willingness to use technology (*see Chapter 2.4*). Perception towards these factors can help to predict future of the BT's use. Experts also confirmed the importance of technology's usefulness as key driver for adoption. Traders perceived BT as somewhat difficult to use but having a very high usefulness level (*see Chapter 4*). Moreover, Dearing (2009) and Rogers (2014) discussed role of social pressure in diffusion of innovations process. Industry and Blockchain experts also argued, that pressure from other industry players will be a key in wider adoption of BT in the industry.

5.1.2. Barriers to adoption of Blockchain Technology in the Industry

In the near future, investments to the Blockchain's adoption in various industries will continue to grow (*see Chapter 1*). However, no matter the significance of the benefits that it offers, there will be several barriers were identified to wide adoption in the industry. As identified in literature analysis, lack of standardization in products and processes makes any

digitalization complicated. Survey responses and expert interviews confirmed this issue – without strong standardization grounds, it will be extremely hard to adopt BT across all supply chain. Since most of the trade is international, it will make solving this challenge even more difficult – different rules, standards and restrictions makes standardization almost impossible (Lakkakula et al., 2020). Moreover, lack of collaboration between industry’s stakeholders slows down any potential advancements on the topic.

At present, there is limited awareness and knowledge of Blockchain technology which creates a lot of ambiguities around its benefits and potential in transforming the industry. Experts described the industry as one of the most conservative, which means that building awareness and gaining acceptance among various stakeholders in the industry will take time. Lack of education towards various technologies and lack of regulations the use and development of technology also significantly reduces trust in BT or other technologies.

Another challenge is proving that benefits of BT are worth more than its costs. Survey respondents and experts indicated that development of the technology is driven more by Technology-push rather than actual demand in the industry (size of the company was a moderator in the relationship). This signals the risk of technology targeting atypical users. And although traders in the survey expressed an opinion that BT will be firstly adopted by niche users, experts highlighted one significant reason for opposite view. One of the main risks in trading is credit risk which becomes significant issue for small enterprises that tend to face multiple financial obligations. This limits their capital potential to invest in technologies like Blockchain.

5.1.3. Disruptive potential of Blockchain Technology

Forecasting the market diffusion of a disruptive innovation is challenging (Linton, 2002). This statement also applies to the complex challenge of evaluating Blockchain technology’s potential disruption in one of the most important industries in the world (*see Chapter 1*). This thesis shed light on key determinants in adopting and developing BT. These insights are the ground for scenario analysis. It is important to note, that “scenarios are not concerned with getting the future “right”, rather they aim at challenging current paradigms of thinking and broadcast a series of stories in which attention is direction to aspects that would have been otherwise overlooked” (Schoemaker, 1995; Chermack et al., 2001).

The Two-Axis Method was chosen for scenario planning, as it is one of the most widely used approaches in research (Ramirez & Wilkinson, 2013). This method uses two high impact-high uncertainty contextual factors to structure possible future scenarios. An advantage of this approach is that it allows clear and simple frame to identify and compare storylines. Two

dimensions were chosen to identify potential scenarios in BT's disruptiveness – (1) uncertainty in technology adoption (actual usefulness, costs compared to returns, and key drivers for adoption) and (2) adoption timeframe and industry readiness. *Table 14* presents scenarios, their probabilities and factors influencing each. To evaluate probabilities of each scenario, a base line of 25% probability was assumed. Later, these were refined based on the research insights from literature, survey outcomes, and expert interviews.

Table 13.

Summary of Scenarios

Scenario 1	Scenario 2	Scenario 3	Scenario 4
Adoption			
Low	Low	High	High
Timeframe/Readiness			
Low	High	Low	High
Probability			
20%	15%	30%	35%
Factors that increase the probability			
Resistance to technological change; High costs/low benefits; Complex implementation; Concerns about tech being driven by tech-push rather than demand-pull	Availability of more suitable tech; BT not meeting industry needs; Conflicts between BT requirements and regulations; Ambiguity around benefits	Proof of benefits; Shift in industry's mindset; Difficulties in educating industry players about BT; Risk of targeting atypical users	Advancements in BT; increased demand for transparency/efficiency; Competitive pressure; Potential appealing to smaller and larger companies alike
Factors that decrease the probability			
Evidence of benefits in other sectors; Cost-efficiency increase; Increasing pressure for	Recognition of unique benefits; Absence of better alternatives; Importance of	Rapid tech advancements outpacing ability to adapt; Lack of infrastructure; Role	Regulatory challenges; tech complexities; Industry inertia; Perceived difficulty of

transparency and efficiency	sustainability regulations	of social pressure and industry trends	using BT, despite high usefulness
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Note. *Created by the author.*

The first scenario assumes low technology adoption and low timeframe/readiness. Rationale behind this is that given the increasing interest in BT in various industries it is not very likely that BT will be deemed not useful and not cost-benefit effective. However, here companies are in risk of the discounted cash flow trap (Christensen, 2013; Christensen et al., 2008), as their focus on short-term vision could limit ability to pursue new project therefore stifling disruptive innovation. Also, the strong resistance to change in the industry will moderate and slow down the adoption. Second scenario implies also low-tech adoption but high timeframe/readiness. In this case industry may be ready for various digital transformations, but blockchain technology might not meet specific needs and requirements of the agricultural commodity industry. Moreover, some better technological alternatives could emerge. Third scenario assumes high adoption but low timeframe/readiness. Here BT could prove its benefits while being cost-effective, but the conservative nature of the industry could slow down the adoption of the technology. Finally, fourth scenario implies both high adoption and timeframe/readiness – growing digitalization and BT trends and proof of benefits in other industries will lift the adoption rates, especially if combined with competitive landscape of the industry.

To conclude, the disruptive potential of BT may be considered low in short or mid-term in the industry. Following Rogers' Diffusion of Innovations framework (2010), BT will primarily appeal to early majority or late majority adopters. This suggests that adopters will include both niche and larger players in the market, when the BT will be proven to be effective and well-established. This will increase Perceived Usefulness and Perceived Ease of Use. Davis (1989) argued that increase in these factors will also increase willingness to use the technology. It is expected that going further innovation development will shift from being technology-push to demand-pull. It can be seen that Blockchain technology holds actual promise in the agricultural commodity industry, however its potential to disrupt it in the near future is low.

5.1.4. Theoretical and practical implications

This research contributes to body of literature on agricultural commodity trading and Blockchain that, to date, has been extremely limited. BT's disruptive potential was assessed using management frameworks based on factors like disruption, diffusion, and acceptance.

5.2. Limitations

The following paragraphs discuss limitations in survey and expert interviews, which might have an impact on the generalizability of findings.

5.2.1. Survey

Online surveys offer many benefits however there are also disadvantages that need to be considered (Wright, 2005). One is sampling error, which sometimes can be too late to discover (Weisberg & Bowen, 1977). A sample size of 104 could be considered small, but Isaac & Michael (1995) argued that small sample sizes are justifiable when study also includes significant amount of data gathered from interviews. Another risk is response bias – respondents could provide answers that are socially acceptable rather than their true beliefs. Survey questions also usually lack depth, which may not capture detailed information, making it difficult to understand full image. There is also a risk of misinterpretation of questions – with lack of contextual data or poorly formulated question, it can lead to more difficult analysis.

5.2.2. Expert interviews

The expert interviews were conducted with industry professionals and blockchain experts. However, since there is not a lot of literature around blockchain, or companies that prove such platforms, it was difficult to find equal amount of blockchain experts as industry professionals. The semi-structured interviews also have a disadvantage of covering only limited scope and may include subjectivity and bias. Several experts provided their insights in e-mail due to time zone differences or complex schedules. Another challenge with semi-structured interviews is response variability, which makes data analysis difficult. Finally, although qualitative analysis with categorization is one of the most valuable research methods to identify patterns, it may include subjectivity bias of the researcher.

5.2.3. Implications on findings

There is no doubt that various limitations make an impact on reliability of the findings. The Two-Axis approach for scenario planning also hold implications on the results. One of the main limitations is that it is only two-dimensional, whilst in reality, scenarios usually are multidimensional. It is also challenging to identify key critical factors to place on the axes. Moreover, although scenarios were planned using findings from literature, survey responses and expert interviews, probabilities to each scenario were based on hypothetical situations. Finally, as blockchain development and adaptation is still in its early stages in the industry, its dynamics are uncertain, and it may be difficult to capture all relevant factors.

5.3. Future research

Future researchers could investigate larger populations, that are more demographically diverse (for instance, that include more female respondents). Contrasting countries or different BT platforms is another possibility to gain more insights. For more precise predictions of BT's disruptiveness, longitudinal studies could be an answer. Additional experts, such as government representatives or policymakers, could be interviewed for additional insights. Finally, future researchers could calculate and evaluate various BT's platforms effectiveness in trading operations.

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Appendices

Appendix I: Outline of Survey questions

Table 14.

Outline of Survey questions

Question	Question type	Answer options
1. Please indicate your level of agreement with the statement: <i>“The most significant challenge in the agricultural commodity market today is: (1) Lack of transparency; (2) Inefficiencies in complex supply chain; (3) Traceability issues; (4) Extensive execution processes; (5) Lack of digitalization; (6) High transaction costs”</i> .	5-point Likert scale	Strongly disagree (1) – Strongly agree (5)
2. Please indicate your level of familiarity with the concept of blockchain technology.	5-point Likert scale	Strongly disagree (1) – Strongly agree (5)
3. Please select the statements that accurately describe blockchain technology. <i>(You can select multiple options)</i>	Multiple choice	(1) BT is a distributed ledger technology; (2) BT can only be used for cryptocurrencies; (3) BT can provide transparency/traceability in supply chains; (4) BT transactions are irreversible; (5) BT is always public/open; (6) BT uses smart contracts for automated processes.
4. Please indicate your level of agreement with the statement: <i>“The most significant benefits that blockchain</i>	5-point Likert scale	Strongly disagree (1) – Strongly agree (5)

<p><i>can bring to the market are: (1) Increased transparency; (2) Faster and cheaper transactions; (3) Improved security; (4) Enhanced traceability; (5) Paperless trade and execution; (6) Disintermediation”.</i></p>		
<p>5. Please indicate your level of agreement with the statement: <i>“Smart contracts are a prominent feature of blockchain technology. How could they benefit the industry? (1) Streamline trade execution; (2) Improve risk management; (3) Increased traceability; (4) Facilitating financial processes; (5) Ensure regulatory compliance”.</i></p>	5-point Likert scale	Strongly disagree (1) – Strongly agree (5)
<p>6. Please indicate your level of agreement with the statement: <i>“The main obstacles or concerns related to the adoption of blockchain technology in the agricultural commodity industry are: (1) High implementation costs; (2) Data management and ownership issues; (3) Scalability problems; (4) Energy consumption; (5) Complicated supply chains and documentation processes; (6) Lack of collaboration between various stakeholders (like government agencies, customs departments, etc.); (7) Resistance to change within the industry; (8) Lack of knowledge and expertise”.</i></p>	5-point Likert scale	Strongly disagree (1) – Strongly agree (5)

7. Do you foresee blockchain technology having a disruptive or more sustaining role within the agricultural commodity industry?	5-point Likert scale	Highly disruptive (1) – Highly sustaining (5)
8. Do you anticipate blockchain technology primarily being embraced by niche users within the agricultural commodity industry?	5-point Likert scale	Strongly disagree (1) – Strongly agree (5)
9. How would you assess the perceived ease of use and perceived usefulness of blockchain technology in the context of the industry? How might these factors influence its adoption/acceptance among market participants?	5-point Likert scale	Very difficult to use (1) - Very easy to use (5); Not useful (1) - Highly useful (5); Strongly Hinder Adoption (1) - Strongly Promote Adoption (5)
10. Could you share your insights on whether the demand from agricultural commodity market participants is driving the development of BT or if technological advancements are pushing the industry toward adopting blockchain?	5-point Likert scale	Strong Demand-Pull (1) - Strong Technology-Push (5)
11. In your opinion, what is the expected time horizon for blockchain technology to become a significant enabler in the agricultural commodity industry?	Multiple choice	Within the next 1-2 years; 3-5 years; 5-10 years; More than 10 years; Unsure
12. Do you currently use any blockchain technology in your daily activities?	Multiple choice	Yes; No; Unsure
13. If you use blockchain technology in your activities, what kind of platform do you use?	Open question	

14. How old are you?	Multiple choice	18-24; 25-34; 35-44; 45-54; 55-64; 65 and above
15. In which country do you currently reside?	List	List of nations
16. What is your gender?	Multiple choice	Male; Female; Non-binary; Prefer not to say
17. Please indicate the highest level of education or the highest degree you have achieved.	Multiple choice	High School; Bachelor's Degree; Master's Degree; Ph.D. or equivalent
18. Please indicate the size of the company that you work in.	Multiple choice	1-10 employees; 11-50 employees; 51-200 employees; 200+ employees
19. Please indicate years of experience in the industry.	Multiple choice	Less than 1 year; 1-5 years; 6-10 years; More than 10 years

Note. *Questions were created by the author.*

Appendix II: Summarized answers of Expert Interviews

The semi-structured interview guides were created to gain deeper insights into blockchain technology and its opportunities to disrupt the agricultural commodity market. Two versions were developed – one for blockchain technology experts and one for industry experts.

The following pages include summarized responses, sorted by the interview questions (*see Table 16 and Table 17*). The first question about expert's background was excluded, the profiles of the interviewees can be found in *Table 6*. *Table 18* includes technical information about the interviews.

Table 15.

Summary of Industry Experts' interviews

Q1: Can you describe the current state of the agricultural commodity industry and its readiness for adopting emerging technologies?
IE1: Farm side is mostly digitalized, other processes depend on paper. Our partners often rely on traditional methods, limiting digitalization. A significant portion of buyers are from economically disadvantaged countries, where digitalization is minimal.
IE2: There's eagerness to embrace new ideas. When it comes to actual adoption, the enthusiasm dwindles. For example, the introduction of online marketplaces. Despite logical

appeal, adoption rates remain low. The issue is the lack of tangible benefits. The costs were comparable to a traditional broker, but the personal touch was missing.

IE3: Our market is quite traditional. When it began, there were no premiums involved. Over time, premiums started to be incorporated. The main digital aspect we encounter is pricing over futures. Now, with BT, we find ourselves not participating in this trend.

IE4: Trading houses are advancing with smart communication and improved internal software. Automation is becoming more prominent, simplifying tasks and standardizing. Despite advances and attempts at automated trading, the personal touch remains important.

IE5: There have been attempts to digitize, but efforts haven't materialized. The biggest change is in information accessibility. However, grain trade - contract formation, execution – didn't have significant changes. The reason is achieving consensus on standardization.

IE6: In our region, we are lagging Europe in terms of IT development. We need improvement, like handling/analyzing big data. Accessing information on production/internal consumption is challenge. The COVID-19 has forced some shifts.

IE7: Digitalization in across Latin America remains quite basic. Clients generally prefer traditional methods and are hesitant to adopt advanced digital technologies. They are used to the old ways and usually lack financial resources to invest in these advancements.

IE8: We see how rapidly advancements occur. However, the potential of technologies is not fully realized, primarily due to security concerns. The readiness is increasing with advancements. The key enabler for maximizing lies in the establishment of regulations.

IE9: The landscape is varied, depending on the location, types of companies, and the specific segment of the supply chain. At the grassroots there's a lack of readiness for adopting technologies. Larger entities often use sophisticated systems. Challenge is the lack of uniformity in the software used by different companies, impeding effective interconnectivity.

IE10: It is very conservative industry. And we do many processes in very old school way. In risk management, there were some digitalization advancements. A lot of people who are resistant to change because they don't want to take risks.

IE11: It is developing rapidly among farm, resource use efficiency, crop monitoring/mapping, application tech, crop output assessment. Readiness is high.

IE12: In general grains business is a traditional and old school business, which was adopted to recent technologies in the past 15 years.

<p>IE13: Considering the consolidation that has occurred in the industry I would guess that now is the time for adopting emerging technologies like Blockchain. Especially if it can positively impact their overhead in their logistics/execution/credit departments.</p>
<p>Q2: What are the key challenges currently faced by the agricultural commodity industry?</p>
<p>IE1: One of the challenges is the lack of standardization due to varying standards. Each country has its own, and it is impossible to fit everyone's needs. You could only compare them at some levels. Traceability is another issue, and it seems that it is impossible to solve. Different execution systems and styles among the stakeholders also complicate the work.</p>
<p>IE2: The industry faces talent shortage. Also, with tightening regulations on traceability and CO2, such system could aid greatly. This would integrate the supply chain and manage environmental data without needing extensive extra resources.</p>
<p>IE3: In general, resistance to change. Also, physical products lack standardization, but we have standardization in operations. We still rely on emails for document exchange. Decisions depend on the timing, intuition, and trust between parties.</p>
<p>IE4: Nowadays, we're navigating increasing regulations. Every year brings different challenges, like weather or currency fluctuations. Cost pressures are rising. Due to job function separation means fewer people understand the entire chain.</p>
<p>IE5: Transparency is very important. We also lack standardization in products (for instance quality parameters between countries). We defy a lot of standard rules because of nature of negotiations. And it is hard to reach consensus between everyone.</p>
<p>IE6: Trust in technology is an issue. In Latvia the average IT skills are low, which contributes to mistrust towards advanced technologies. People tend to rely on tangible, traditional methods, such as paper documentation, because it's perceived as more reliable.</p>
<p>IE7: Resistance to change is a challenge. In this industry margins are small; therefore, everyone has the interest to keep them. Moreover, lack knowledge on various technologies.</p>
<p>IE8: The main challenge is uncertainty. Another risk is weather, as it directly creates supply/demand issues. Moreover, unpredictable events like natural disasters/geopolitical conflicts are beyond our forecast. Another complexity is the huge amount of information. Our perception of risks heightens due to this overload and contribute to uncertainty.</p>
<p>IE9: The industry is undergoing a consolidation phase, with risk management emerging as a critical. This has become pertinent considering the market volatility. Alongside, financing</p>

has become a concern. With margins around 1%, and interest rates exceeding 5%, managing finances is complex. Another challenge is the retention of skilled employees.

IE10: There is a lot of players in the industry, very decentralized market which results in many inefficiencies. And because of huge competitiveness we lack trust in each other (for example farmers do not trust originators to get the best price for their goods). Products lack standardization, they are not homogenous. Also, there are a lot of risks and uncertainties.

IE11: Cost of various technologies compared to returns. There have been a lot of examples when technology costs a lot of money but brings no actual returns.

IE12: There are different challenges, however the main issue is governmental regulations for import or export, different standards, procedures and regulations.

IE13: Lack of risk takers. Many companies have simply become supply chain managers. For example, when a company has an inquiry for export, they have to start from square one. Kind of akin to trading “back-to-back” like an international trade house would seek an origin offer, add margin/financing/freight, and offer to the destination.

Q3: How do you view the role of BT in addressing these challenges?

IE1: I am not sure what benefits it would bring. Also, I am not sure it could work unless all commodities would be standardized globally. I don't think it would help with traceability. In execution, I think some parts could be digitalized, but only if all parties use the same system.

IE2: I'm uncertain whether blockchain is necessary for our purposes. The suitability it greatly depends on the type of technology being considered. Essentially, what blockchain offers is a trustless system, where the integrity of transactions is maintained without centralized authority. These features are crucial today, where accountability is increasingly valued.

IE3: In a paper market scenario, it could be highly effective. For farmers, utilizing blockchain technology is viable. Given my experience, I don't value in digital communication. For me, the importance lies in direct conversation. When you talk to someone, you can sense their tone, hesitations, intent. These nuances are often lost in a message or an email.

IE4: BT has the potential to improve processes and make things easier, but it's not universally applicable across entire business model. From my perspective, there are limitations in the trading department. Each contract we handle tends to have unique aspects. While there are processes that could be automated, it's not a solution for every aspect of trading.

IE5: Implementing would require everyone to agree on a set of rules. This standardization is crucial. If achieved, it would streamline operations. However, the challenge arises with non-standard transactions. Adjusting the system to these unique cases could be complex.

IE6: Blockchain could simplify processes, allowing for electronic correction and reissuance of documents, saving significant time and reducing the risk of misunderstandings. Another benefit is role in standardizing execution.

IE7: I think blockchain technology could address some of the challenges in the industry.

IE8: BT could revolutionize some aspects. It offers a secure record of transactions and could be linked to real-time data. This integration could reduce the need for physical inspections and paperwork, thereby cutting costs. Blockchain not only ensures the integrity of the supply chain but also streamlines it, making the entire process more efficient and cost-effective.

IE9: BT, while offering benefits in terms of transparency and traceability, presents a nuanced picture when applied to various aspects of the agricultural supply chain, particularly in the risk management. Its application seems more fitting for products where tracing the origins is crucial. When it comes to raw materials, the advantages are not as immediately evident.

IE10: Blockchain is very suitable for our industry. Especially if we consider biological farming or commercial side of the business. I believe it bring a lot of positive change.

IE11: I see it as an enabling technology that underwrites productivity and security.

IE12: Blockchain is a useful tool for quality control, tracking the origin of the grain from farm down to the end user. It is a very useful tool.

IE13: I don't think BT can impact the trading side because this will always require a "human touch." Although, when government entities tender for grain offerings, this may be a more user-friendly approach to accurately trace information coming in on said tenders- removing the possibility of human error by those holding tenders for the purchase of grains.

Q4: Can you highlight any specific benefits blockchain technology could bring to the agricultural commodity market?

IE1: I can't think of anything for trading but for execution; firstly, it would eliminate all paper documents, automatically making processes faster and more cost-efficient.

IE2: In our case, we require a solution that is low-cost and efficient. Ideally, this would be a system that offers traceability while incurring minimal fees. Such approach would ensure the benefit from the advantages without bearing unnecessary costs. Also, blockchain or similar technologies could significantly enhance aspects like traceability, trust, and transparency.

IE3: The potential applications are vast. For instance, sustainability certificates, which are increasingly important in our industry, could be managed through blockchain. Issues like deforestation and other environmental concerns are areas where blockchain could be particularly beneficial, allowing for transparent and secure tracking of various metrics.

IE4: I'm uncertain about the benefits, as it's challenging to quantify these aspects. I believe there is some, or else it wouldn't be considered for adoption. I see value in data gathering and connectivity within execution. It enables efficiency, automating steps in the supply chain.

IE5: BT could reduce delays and misunderstandings caused by minor errors. This could benefit small companies, which do not have the same financial robustness as large corporations. This would minimize manipulation, particularly by less reputable players. But the decision to adopt technology will always be weighed against its cost and the benefits.

IE6: The potential benefits could be significant, especially in streamlining processes. Processes, involving the collection of documents from various sources and their verification, is time-consuming and delays cash flow, which is crucial during peak seasons. Streamlining this process could save days and allow to focus on more productive tasks.

IE7: One of the benefits is having everything in one place, this saves a lot of time. Also, it is nice to have a very big part of our clients and partners using the platform, it also speeds up transactions. Another important benefit is a reduced amount mistakes in daily tasks.

IE8: It can streamline trade finance. It provides a secure way to confirm/record transactions. This eliminates the need for multiple checks, cutting down on time and costs. It allows for a more efficient flow of capital, when timing and financial accuracy are paramount.

IE9: The real potential of blockchain may lie in the financial and documentation sectors. The technology could streamline the voluminous paperwork involved, enhancing transparency and efficiency. This becomes increasingly relevant as industries demand greater supply chain transparency, not just for regulatory compliance but also for sustainability reasons.

IE10: It allows to track a lot of data, which results in better risk management and brings some structure. It would increase traceability and would be perfect for ecological agriculture. It has potential to trace money, reduce fraud, ensure compliance, streamline trade finance procedures, enhance efficiency. Also, it would allow to save money on human capital.

IE11: I see its benefits in payment exchange (documents a supplier presents buyer in exchange for payment of goods). In food supply chains – increasing traceability. And of course, it helps to map evolving sustainability standards.

IE12: It could help end users to have a better insight on the origin of the good. It could help the regulator/authorities at destination to check the authenticity and any detail related from the moment it was harvested until the time it exported, shipped and discharged for usage.

IE13: I think the value of Blockchain in our industry is in the logistics/execution of contracts. Here is where time sensitive information can cause significant problems for counter parties.

Vessel nominations, document instructions, e-document distribution, and payment are the areas where I see that Blockchain can benefit the industry.

Q5: Smart contracts are a prominent feature of blockchain technology. Considering the agricultural commodity industry's complex nature, how can smart contracts play a role in trading, execution, risk management, and regulatory compliance?

IE1: I remember one company tried to make a platform for trading using smart contracts. It was supposed to fulfill contracts automatically and eliminate the role of the brokers. But this was used for feed commodities. I think, again, in the execution, this could have a significant impact, but I am not sure how it could work in trading (mentions standardization issues).

IE2: I believe there will be applications, but it doesn't seem as necessary in our context. For instance, the futures market is efficient. For a technology to be relevant, there would need to be an appropriate market framework in place to facilitate bids/offers. I'm skeptical about immediate relevance of creating something like a decentralized finance market.

IE3: In a paper market, it could be effective. The potential applications are vast. For instance, sustainability certificates could be managed by it. Issues like environmental concerns are where BT could be beneficial, allowing transparent and secure tracking of various metrics.

IE4: BT shows promise in risk management due to its automated system capabilities. Standard paper contracts could be integrated as a hedging tool, but we already have futures. Direct access to futures often makes paper contracts redundant. The current geopolitical climate has also impacted the liquidity. In trading, the human element remains crucial.

IE5: The lack of standardization makes it challenging to fully transition to electronic systems. This issue is compounded by the privatization trends in trading, where qualities of goods are negotiated for a single vessel, involving different quantities and specifications. These negotiations require human involvement and can't be entirely automated.

IE6: While technology like CM Navigator can provide useful information, human interaction is crucial. These programs might offer insights, but they can't replace direct communication. Although these platforms could evolve to include more detailed trading options, I don't foresee this happening in the immediate future, certainly not within the next 1 to 3 years.

IE7: In execution it could work quite nicely I think, it allows facilitation of the processes and makes it easier to follow specific requirements in the contracts.

IE8: It faces significant challenges, primarily in the education, security, and regulation. For it to make an impact, it needs not only robustness but also clarity in terms of regulation. An

effort towards education, security, and regulation could pave the way to revolutionize this sector, particularly in the areas of contract management and transaction security.

IE9: From a trader's viewpoint, in physical trade, the flexibility and negotiability of details are crucial. BT's nature of setting fixed terms could potentially hinder the nuanced negotiations essential in large volume trades. Smaller might benefit from this, but there are additional complexities, especially when dealing with quality issues and the variability.

IE10: It could work, but I am not sure how popular it would be. People are interested in keeping their profit margins up and smart contracts could threaten that (if used for trading). Broker role in this will not disappear, disintermediation will stay. You don't want to leave your decisions for technologies, so smart contracts would more work for execution.

IE11: In physical trade it's a challenge – payment documentation comes from different sources; the arrival of documents occurs at different timeframes; these documents need to be collated then presented for validation. For adoption of digital doc exchange, all documents required for payment need to be of digital, otherwise you introduce more complexity.

IE12: It will save a lot of time, energy and cost. Control and background check of cargo will be quicker and efficient. The information is shared on time between stakeholders of the cargo.

IE13: No concerns about documents being dispatched by courier with possible mistakes. No concerns about documents falling into the wrong hands (specifically BL's). Companies are always looking to eliminate risk/save money. Blockchain in this arena can be very helpful.

Q6: What could be the main obstacles/concerns related to the adoption of blockchain technology in the agricultural commodity industry, and how can these be mitigated?

IE1: Firstly, standardization. Then, there are issues regarding the trust. If you don't trust your client, you cannot do business. I am unsure how blockchain could ensure the compliance of all users, their capital limits, and so on. Moreover, everyone feels very sensitive about the safety of the data, as every bit of it counts to the competitive advantage.

IE2: Main challenge is the ambiguity around benefits. BT is associated with Bitcoin, which has a reputation for being environmentally harmful. Advantages are a grey area. Educating about them, such as the reduced failure, could be key. The transparency/security offered are apparent, but whether they are sufficient to outweigh the challenges is still a debate.

IE3: The main issue seems to be a lack of awareness about the possibilities of BT, as well as uncertainty about how to utilize it. Also, there are practical difficulties that people face. For example, a small error such as a misplaced dot can cause significant issues. My concern is that blockchain might have similar challenges in terms of managing detailed accuracy.

IE4: Standardization is a challenge due to the variability. We're dividing tasks in multiple steps and utilizing technology where feasible, though it cannot replace humans. Our industry is unpredictable. We depend on factors beyond our control, like farmers' selling decisions. Moreover, the impact of BT might be less pronounced due to the small size of teams.

IE5: The challenge is the human factor, as platform effectiveness depends on the accuracy of the data input by humans. Regarding costs, they must be reasonable. We can't justify expenses for a technology that only offers marginal improvements. On the trading side, setting a price and expecting automatic matches won't work. There's a lot of discretion.

IE6: There might be multiple platforms available, and challenge would be in harmonizing them. Another aspect is the legal recognition. For them to be effective and widely used, they must be accepted by financial and regulatory bodies. Legal acceptance and compliance are critical to be viable in handling contracts, transactions, and dispute resolutions.

IE7: One of the challenges is making this platform user friendly. The interface must not take a lot of time to navigate. Another challenge is making clients and partners also adopt the platform – if not everyone in the chain is using it, the value decreases. And another challenge is learning how to use it and switching from different platforms to only one.

IE8: The current understanding of BT is superficial, even among those who might interact with it at a high level. This lack of deep knowledge creates barriers to effective implementation. The education gap extends to its regulatory/security aspects. People need to be informed about how it is regulated and how it integrates with existing systems.

IE9: A risk is the loss of flexibility in dealing with materials that are non-homogeneous in quality. Integrating BT into existing systems would require cooperation not just among large international players, but also with local collectors/farmers. This would involve connecting hundreds of different software's used by companies, a task of enormous complexity.

IE10: Main concerns lie in who will manage the data and ensure the security. Also, the cost of it and proving real benefits will be hard because of general resistance. If we talk about contracts, it will never be fully in blockchain because of lack of standardization in products, maybe you could transfer 30% of them, not more.

IE11: First, the cost of technology. Not all players have financial resources for this. Second, we need to have a material benefit, which shows what benefits technology brings.

IE12: Not all parties who are involved in the chain are eager to use or adopt to this technology (same as all other previous new technologies), there is a tolerance to the change. When it comes to the government sector their adaptations are slower and more difficult.

IE13: I think the adoption of “new” and untested methods of doing business in a way that has existed for many years. The grain industry has been painfully slow to adopt any change at all. But this new generation of managers in the business today are always open to new ideas on how to improve efficiencies.

Q7: How do you perceive collaboration between industry stakeholders in ensuring successful blockchain integration in the agricultural commodity sector?

IE1: There is a lack of collaboration between all stakeholders in the industry. One of the reasons is a lack of trust between each other. There is much room for improvement here because now everyone is just looking out for their best interest, not the industry’s.

IE2: There is lack of collaboration. Covantis platform, developed through collaboration among industry players, is in the right direction. Such collaborations have the scale and influence to engage with regulators, instead of individual entities negotiating separately and developing their own systems. It's about finding common ground that benefit the industry.

IE3: There is lack of it. There is high competition and large companies are looking mor for themselves, as they have resources to implement such technologies. However, for smaller companies, it seems less feasible. The successful integration requires well-developed systems and a clear understanding of benefits and limitations.

IE4: There is quite enough collaboration to ensure successful integration.

IE5: Main challenge is dealing with authorities who are always well-informed or responsive. Currently, we don't receive sufficient support, and finding accurate, updated information for each transaction is cumbersome. Furthermore, inconsistency in export destinations means we often relearn procedures for different countries.

IE6: No, there is not enough. Collaboration in the industry is vital. This includes also policymakers and technology experts. Policymakers need to understand the technological and operational nuances to create supportive legal frameworks. Similarly, technology experts should be aware of specific challenges to develop suitable platforms.

IE7: We have very nice collaboration of all parties in Columbia I think, at least when we were implementing Covantis, we had no issues in lack of collaboration.

IE8: The call for BT integration is not a grassroots movement. Industry is looking for "top-down" initiatives, where policymakers/regulators provide clear guidelines, security assurances, and a framework for use. There's a consensus that without top-down directive, widespread adoption in conservative industries is unlikely, and now we are lacking this.

IE9: There is lack of it. Everyone is working more on their own. Big partners are a double-edged sword: while it provides the necessary support and resources, it also creates a dependency that can stifle innovation and hinder widespread adoption.

IE10: We have a lot of institutions included in supply chains and this creates a lot of inefficiencies automatically. Everyone have different interests, so agreeing on something is usually very hard. There is a lot of bureaucracy, which complicates things.

IE11: It is very hard. There are a lot of competing technologies, companies, and so on. To standardize industry and have everyone onboard is an extreme challenge.

IE12: This process is slow, difficult to push forward and in some cases rejected at first sight, but it needs more follow up from all companies who are active in this industry worldwide with cooperation and acceptance from banks and shipping industry.

IE13: Covantis is already operating amongst their shareholders. And the biggest of the BIG grain companies are involved. All trade between these firms is utilizing this newfound technology for trade execution purposes and at first glance is running well. There are some issues that need to be addressed, but this will come in due time.

Q8: What other potential risks or benefits do you foresee for the agricultural commodity industry with the adoption of blockchain technology?

IE1: If blockchain emerged, small players could be eliminated. Another risk is possibility of losing competitive advantage. One of the benefits is the elimination of third parties in standardized products. But I don't think that brokers will be eliminated. They play a vital role in the success of our business, and I don't think any technology could change it.

IE2: The complexity of execution and standardization is a challenge. Each has its own system, leading to inconsistencies. However, it requires a balance of simplicity and effectiveness. The execution is most complex and pressing issue we face. I wonder if the complexities of our industry might be too great for it to be a practical solution.

IE3: It needs standardization. Then ethical consumerism, sustainability, transparency, availability. A lot of these issues are influenced by political actions. Energy consumption - growing challenges in managing resources and their consumption. For example, in the Netherlands, companies are struggling to access the energy due to capacity limitations.

IE4: The main challenge lies in determining the setup and identifying areas where blockchain can be most effective. However, I've already noticed its benefits in terms of data connectivity, suggesting its practical utility in specific areas of our operations.

<p>IE5: Implementing BT could ensure quicker payments and reduce the administrative hassle. There's often resistance to new technologies – it's a natural human response. Overcoming this initial skepticism is crucial. The system must prove its worth in everyday use. The challenge is effectively communicating and demonstrating the system's benefits.</p>
<p>IE6: I think major benefit is making everything more efficient and faster.</p>
<p>IE7: One other benefit that this is a very secure technology. So, it reduced the chance for fraud or security breaches. I am not sure about it reducing transaction costs – I think they stayed pretty much the same, from the time we started using the platform.</p>
<p>IE8: BT transactions can be applied to the physical business. For instance, a transaction involving the paperwork can be securely recorded on the blockchain. However, the appetite for technology remains low. Although the advantages of blockchain are understood, the lack of clarity, coupled with a general sense of uncertainty, forms a significant barrier.</p>
<p>IE9: The industry's hesitance to invest in technologies like blockchain is a significant barrier. Many companies prefer to wait for others to develop and prove the efficacy of these solutions before committing resources. This approach slows down the pace of innovation and adoption.</p>
<p>IE10: It would be beneficial in handling documents between all parties in supply chain. It would save a lot of time, and of course reduce paper use. Execution would benefit the most.</p>
<p>IE11: I think main risks are about technology's security and then certainty of application.</p>
<p>IE12: Frauds, hack and IT bugs are some of the concerns that minimizes the exposure to this.</p>
<p>IE13: My concern is that there are issues with different operating systems communicating properly with one another. Unless of course the industry adopts one system and charges non-shareholders a fee to utilize that platform.</p>
<p>Q9: In your expert opinion, do you foresee blockchain technology having a disruptive role within the agricultural commodity industry?</p>
<p>IE1: More sustaining, the change will take a lot of time.</p>
<p>IE2: More sustaining. A trustless, decentralized, and transparent system is exactly what's needed. Such a system could play a pivotal role in various sectors. While it's true that such technologies could be misused for activities like money laundering, it's important to remember that traditional systems have also been susceptible to similar abuses.</p>
<p>IE3: Sustaining. Not all companies will need it at the beginning and as technology evolves, it's important that its development benefits all parties.</p>
<p>IE4: I personally see it as sustaining rather than disruptive. Once implemented, blockchain could simplify processes, potentially reducing mistakes and errors.</p>

<p>IE5: The adoption depends on its effectiveness. If it's a well-developed system, the key factor then becomes human acceptance. People need to personally see and understand the benefits it brings. If they recognize that it genuinely aids, they'll be more inclined to use it.</p>
<p>IE6: More sustaining mode. The gradual move away from traditional, paper-based systems to more streamlined, technology-driven processes is a sustainable change that aligns with the broader digital transformation happening across various sectors.</p>
<p>IE7: More a sustaining role, it will not happen quickly.</p>
<p>IE8: This change, while leading to greater efficiency and profitability in the long run, may cause disruptions, particularly in terms of job displacement. Transformation in any industry drives growth. As processes become more efficient through technological advancements, businesses can generate higher profits, allowing further investment and growth.</p>
<p>IE9: Maybe not disruptive in the traditional sense, where a single player completely overturns the market. The hesitation of bigger players to engage in the riskier aspects that smaller entities manage limits the potential for disruption. It will gradually reshape landscape, contributing to a more consolidated market with larger players gaining more influence.</p>
<p>IE10: It will be sustaining, because a lot of changes will have to be made in the process.</p>
<p>IE11: Sustaining role. Competing technologies and broad approaches from different geographies make wholesale adoption difficult.</p>
<p>IE12: It's a new technology and once its adopted and in use, it will eliminate many of old fashion parts of the quality control. This is a disruption to some sectors which causes a rejection at first stages.</p>
<p>IE13: Sustaining... But only in logistics/execution/credit departments.</p>
<p>Q10: Do you anticipate blockchain technology primarily being embraced by niche users or specialized segments within the agricultural commodity industry? If yes, how do you envision the transition from niche use to becoming more widely integrated into mainstream practices in the agricultural commodity market?</p>
<p>IE1: Firstly, some significant players in the market will be the adopters. And it will work in some commodities first, like rapeseed, soybeans, sugar, or corn.</p>
<p>IE2: Niche. Integrating such technologies can increase familiarity/reduce misconceptions, potentially leading to wider acceptance. However, it carries hacking risks. Despite, blockchain is one of the safest options. Public perception of security is influenced by news of hacks in the crypto, which might affect image.</p>
<p>IE3: Big players, for small ones it will be just too difficult and expensive.</p>

<p>IE4: I believe the adoption of new systems will likely start with the big players setting the precedent. If a dominant player in the market establishes certain rules, others in the industry often follow, especially if these changes simplify processes.</p>
<p>IE5: Big players for sure. It already appears to be an initiative introduced by them.</p>
<p>IE6: The adoption industry is likely to be driven by major players, simply due to their scale and influence. As a smaller player, ability to dictate changes is limited. Currently, the lack of a strong push from major players means there's no need to rapidly adopt these technologies.</p>
<p>IE7: I think it is both, like now we have various sizes of companies using it, so I am not sure if size of the company really impacts the adoption.</p>
<p>IE8: The adoption is likely to follow a pattern like other technological innovations, characterized by a gradual buildup followed by rapid widespread adoption. Initially, niche users and early adopters start experimenting with the technology. These early adopters are crucial as they test, refine, and demonstrate the technology's potential.</p>
<p>IE9: Smaller companies often lack the resources to adopt these costly technologies. In contrast, larger companies can afford these investments, which gives them a competitive edge and a certain degree of scalability advantage.</p>
<p>IE10: I think niche. Those companies are more eager for changes, quicker, interested in innovations and this will allow them to be more competitive in the market. For big companies it takes a lot of time and other resources to make changes.</p>
<p>IE11: Large multinational companies. Adoption depends on the cost/practicality.</p>
<p>IE12: If it needs to be used cost effective, needs to be used more universally rather than only on niche users. However, niche users or specialized segments need to pay a higher cost for this technology to be used (or better to say, to be forced to be used).</p>
<p>IE13: Yes - specialized segments. Throughout my career I have recognized that we more/less trade documents and not necessarily grain. But in the world of containers where you have one set of documents for each BL, the same amount of documentation exists for a full panamax of grain. Making the document requirements so much more sensitive of an issue.</p>
<p>Q11: What would you consider to be the primary driver of adoption? Is perceived ease of use a main driver? Perceived usefulness?</p>
<p>IE1: I have questions regarding usefulness. But I don't think that if it would work, the technology itself would be complicated to use. But the acceptance would be driven more by the usefulness. If we don't see the concrete benefits it can bring, we are unsure if we need that technology. The pressure of other stakeholders will drive the adoption.</p>

IE2: I think it is quite easy to use, but as mentioned, the usefulness remains questionable. Of course, if proved, it would significantly improve the adoption rates.
IE3: I have no idea. Usefulness maybe.
IE4: If BT can simplify processes, it's likely to be embraced and utilized extensively. The technology's success may be somewhat hard to measure precisely, but I anticipate it will be evident in the ease and efficiency it brings to operations. The emphasis is on creating a system that is not only easy to use but also aligns with industry standards and regulations.
IE5: There's no doubt that the idea is promising. The critical aspect lies in the execution of this idea. A good concept can only be as effective as its implementation. The system's efficacy, user-friendliness, and integration into existing workflows will determine its success.
IE6: The ideal vision would be for it to be user-friendly and intuitive. It should be a system that one can easily navigate and understand what actions to take. This initial step would involve digitizing and contracts, followed by managing documentation and payments.
IE7: Usefulness is of course very important. But ease of use should be the focus in creating the platforms. It would increase adoption.
IE8: There are three elements: effectiveness and cost saving, business enablement and follow-the-leader mentality. This hierarchy of factors illustrates the approach of businesses: prioritizing cost savings initially, then exploring avenues for business expansion, and finally, ensuring alignment with industry trends and competitor actions.
IE9: It is often a blend of necessity and convenience. For faster adoption, it's crucial that it is user-friendly. The decision to use new technologies might lean more towards the pressure to stay competitive/compliant with regulations, rather than the direct benefits.
IE10: Main point is proving the usefulness. If people are already so resistant to new technologies, they really need to see benefits of it to decide to use it.
IE11: It needs to prove usefulness. Because now it reminds law of hammer.
IE12: The more this technology being used in other industries, the easier it will be to convince the agricultural commodity industry to use it.
IE13: Our industry is slow to change. However, the major multi-national firms have come together with a platform of their own already. I suspect it won't be long before the industry gets enough positive feedback to allow for expansion or enough negative feedback where they decide to scrap things altogether and return to "business as usual."

Q12: Do you think demand from market participants is driving the development and implementation of blockchain technology? Or are technological advancements pushing the industry toward adoption?
IE1: It's more driven by the technology push so far.
IE2: I would say now, it's more Technology push.
IE3: Technology-push. It's not because of the demand. We have a lot of that in the world.
IE4: The push towards adopting technology is driven by technological advancements rather than specific demand within the industry.
IE5: The development is driven by practical needs rather than being an IT-driven venture. It appears to be an initiative by major players who have put together a team to create a solution that addresses real challenges. This suggests that there's a need for the system.
IE6: The advancement is happening against a backdrop where profit margins in trading are becoming slim. This trend highlights the need for efficiency and cost-saving measures.
IE7: Technology push. Before I did not feel the need for such technology.
IE8: There's no significant advocacy group pushing for BT within many companies, even those that could substantially benefit from implementation. Responsibility lies with technology companies. They should take the lead in educating industries.
IE9: Technology push, but at the same time someone must show us that we need it.
IE10: It's like chicken and egg problem. It is a complex thing and both sides are pushing it at different times. But today maybe we need it more than technology is pushing us.
IE11: Technology push. Blockchain was designed for a different use, but now looks for a broader adoption.
IE12: Technology push. I think it is easier to adopt this technology on a local scale. Once that circle is performed successfully, then push it to outside of the country for exports to the destinations which are open and willing to adopt to this technology in the grain business.
IE13: I read this as a "chicken and egg" scenario. It is my belief that technological advances have provided the world with this technological gift, and now our industry recognizes that there are possibilities to improve efficiencies and thus provide cost savings. If utilized correctly it's a win-win scenario.
Q13: What is the expected time horizon for blockchain technology to become a significant enabler in the agricultural commodity industry? What factors could influence the speed of adoption?

IE1: We are several decades away from it becoming something significant. If digitalization alone is such a challenge, I don't see us using it any time soon, not in 10 years at least.
IE2: It always goes quicker than you think, but 5-10 years. As mentioned, integrating technologies into everyday can increase acceptance. When people use these technologies in their jobs, it becomes evident how other applications can be practical for various purposes.
IE3: I don't know. 10 years?
IE4: The integration of BT into our industry has already begun; it's an ongoing process. The impact is expected to grow. I believe it could take several years – perhaps 5 to 10.
IE5: There might be regional differences in how quickly they're embraced. The key is the amount of effort players are willing to invest. Where the volume of trading is significant, the effort might yield benefits with relatively less effort compared.
IE6: The pace of technological change is accelerating, and within 5 years, we can expect significant transformations. The evolution to more digital approaches has been rapid, especially when considering how we used to fetch prices via phone calls a decade ago.
IE7: In our region, in 2-3 everyone will probably be using Covantis or other blockchain platform. In Europe I think it will take around 5 years.
IE8: The current landscape of technology is showing promising developments. The uptake of these technologies is potentially exponential. Once the challenges are addressed, I expect a rapid adoption. While this shift may not happen within the next two years, I anticipate a timeframe of 10 to 15 years for these technologies to truly transform our world.
IE9: Next 10 years. For rapid and effective implementation of these technologies, two key factors could play a crucial role: regulation and the influence of major players in the industry
IE10: The change will be slow, at least 10 years.
IE11: It will depend a lot on cost and practicality of a solution. But I am uncertain if it reaches critical mass. It will take a lot of time.
IE12: Seeing how fast technology is growing in the recent years, within 10 years we will see more usage of blockchain technology in our industry. Even partially if not totally.
IE13: It feels like we are in the first quarter of a sporting event, with the initial rollout underway. The second quarter will be for feedback and fine tuning. Quarter three will be about finding a way for this technology to exist within the entire framework of a company's business units. And the fourth quarter will ultimately be the push to get "outsiders" to join the platform. All in all, I think it takes 12-18 months from now for full scale use of the technology in our industry.

Q14: Do you know any specific use cases or examples where blockchain technology has demonstrated significant value within the agricultural commodity market?
IE1: No, I don't know any successful use cases so far.
IE2: There are only a few projects that seem to exhibit tangible value. However, there are other out there which claim to aim for similar goals. Whether these projects are effective or not is something I'm not certain. Covantis is one such project that has been mentioned.
IE3: Only Covantis, but I also have doubts about its value.
IE4: We are using Covantis and one internal blockchain platform. We've made significant progress with some departments. BT is proving useful in streamlining processes.
IE5: No, not yet.
IE6: I've heard about Covantis, But I am not sure about its value yet.
IE7: Only Covantis. I think it already shows some valuable improvements in our work, but more time must pass to see full impact.
IE8: There are several out there, although I'm not deeply educated on all of them to provide detailed insights. The issue lies in the regulatory framework surrounding these blockchain applications. While the technology is available and its potential is recognized, there's a notable gap in regulation which creates uncertainty and hesitancy among potential adopters.
IE9: Covantis. And I know that Cargill did something some years back. But mostly those who tried, failed unfortunately.
IE10: No, so far, I have not heard of any significant platforms.
IE11: I am uncertain if this is delivering value, however, Covantis is a collaboration of major agricultural commodities trade players attempting to improve global trade process.
IE12: I've seen some trials but didn't see any proper example of a large-scale business.
IE13: Not specifically just yet... I am only seeing it in action from afar. As a broker I am not involved in the communications across the platform. But I do receive feedback from those directly involved and they believe it adds value to certain areas of our business.

Note. *Questions were created by the author.*

Table 16.

Summary of Blockchain Technology Experts' interviews

Q1: Can you describe any examples where BT has demonstrated significant value in supply chain management, trading, or related areas within the agriculture industry?

BE1: There are several companies exploring applications. Specifics of how companies utilize it vary, but it's evident that it is adapted for different purposes. Covantis stands out as the platform focusing on post-trade and execution utilizing blockchain technology.

BE2: There are some, but success often hinges on ownership and market structure. The success it's about the strategic approach to market penetration and user engagement. In the B2B it's challenging to see many platforms that successfully roll out these strategies.

BE3: I knew several companies in Turkey that tried to apply blockchain in the industry, like for a supply chain management, but then after half a year none of them demonstrated value and therefore stopped the projects.

BE4: Our solution has demonstrated value. It takes care of payments - links with grains/digital barter; VISA Agrotoken card backed with grains, financing - digital grains as credit collateral for financial institutions, and sustainability/traceability - tokenization is a fundamental tool when it comes to validating and providing information to monetize.

BE5: It's mostly related to the hashes of trade documents to ensure authenticity.

Q2: What are the major challenges in the agri commodity industry? Can you share your perspective on how blockchain technology can address challenges?

BE1: A key issue is digital security. One aspect is the lack of regulation. Sustainability, traceability, and environmental concerns are also pressing. BT can address these challenges. However, while blockchain offers unique benefits, it's not the only solution available.

BE2: Inefficiencies, operational risks, and working capital. A key is the extended duration of financing, with companies needing to minimize capital involvement. Market complexity varies too. Manual processes dominate, with reliance on emails/paper documents. This lack of standardization hinders efficiency, increases the risk of fraud and environmental impact.

BE3: Fluctuation of prices of goods is a challenge. It mainly happens due to various uncertainties or influence of the big players. This also limits opportunities for small players. Also, we have increased food consumption which adds to rising prices. Another issue is that this sector is very conservative. I think commodity tokens can solve some of these issues.

BE4: One of the biggest challenges is integrating agribusiness with the rest of the industries and potential investors that could be located globally, but with a huge interest in being able to invest in food production, biofuels, etc. Through a transparent, accessible and secure asset.

BE5: Ensuring document authenticity and creating a permanent track record. In a later and more developed stage, I could see the usage of smart contracts, where tokenized ownership

of physical assets would be exchanged in smart-contracts. Nonetheless, the ecosystem doesn't allow for it yet, but it would make sense.

Q3: What are the primary features and advantages of blockchain technology that make it well-suited for integration into the agricultural commodity market?

BE1: The common praises for BT revolve around data security and immutability, but these can also be achieved with non-blockchain cryptography. However, BT with its blend of real benefits and 'shiny new thing' appeal, offers a rallying point for these advocates. It provides a platform for introducing digital innovation in an industry often resistant to rapid change.

BE2: The key advantage is data immutability. This ensures that data entered the blockchain, cannot be altered, providing a high level of security and reliability. Another is a closed ecosystem, which enhances security by reducing the risk of hacking and fraudulent activities.

BE3: First, decentralization. Also, it provides with transparency and security, which allows easier audit. It would also allow to trade 24/7. Moreover, it would give smaller players opportunities to trade goods easier by speeding up and simplifying trade.

BE4: Agility and transparency, fraction ability, liquidity, 24/7 information, transparent clearing processes.

BE5: It's a business based on trust. Negotiations are confirmed over the phone, with a following business confirmation in writing, and, if it comes to be, a contract between the parties. Later, the execution brings a lot of paperwork. Blockchain could help ensure that the exchanged documents are true in its form and content, if it comes the case of a dispute.

Q4: Smart contracts are a prominent feature of BT. Can smart contracts revolutionize trading, execution, and risk management in the industry?

BE1: While being innovative, they ultimately exist within society's established legal frameworks. Any smart contract must interface with a country's legal system. This is overlooked. People get enthralled by the potential, forgetting that they operate within a broader societal and legal context.

BE2: There are challenges in liquidity and standardization due to reliance on relationships and manual processes. Brokers play a pivotal role, and there's limited interest in full market transparency. While electronic markets develop in more standardized and liquid asset classes, the physical bulk trading in grains/oilseeds may not fully transition to electronic platforms.

BE3: Smart contracts could replace paper-based futures contracts. You create price for future of the tokens with these futures contracts programmed with smart contracts.

BE4: Yes, they can be a super applicable tool to generate rules and better clearing techniques throughout the flow of agribusiness operations.

BE5: It could, but the ecosystem is not yet strong enough, A smart contract needs two tokenized assets to be exchanged automatically. Considering the monetary volume related to a trade, cryptocurrencies would be a no-go. Also, bank compliance would likely block a 1m USD transaction on crypto. The acceptance of a tokenized ownership it's also a legal debate.

Q5: What technical challenges/limitations should be considered when implementing blockchain solutions in the agricultural commodity sector, and how can these challenges be mitigated?

BE1: While it promises enhanced data security and immutability, the overall security of any system is limited by its weakest link. Vulnerabilities such as social engineering and man-in-the-middle attacks remain potent threats, regardless of whether a system is blockchain-based or not. These are enduring challenges that need to be addressed in any secure system.

BE2: In the B2B world, BT is utilized more for specific solutions. However, this use is quite distinct from the public blockchain networks associated with cryptocurrencies like Bitcoin. Blockchain, in this context, is an enabler of trust and security. The primary concerns for clients are data security, fraud prevention, and operational efficiency.

BE3: There would be some risks in token economics and the need for fair distribution of technology and price management in the sector.

BE4: If the large agricultural players begin to adopt blockchain technology within their transactional flow, it will lead medium and small players to follow the same steps, a clear example is COVANTIS, talking about trade execution activities.

BE5: Would first start on execution, maybe with cheap transaction fees and demystifying blockchain related to crypto.

Q6: How do you perceive collaboration between industry stakeholders in ensuring successful blockchain integration in the agricultural commodity sector?

BE1: Covantis and similar initiatives are contributing to overcoming reluctance. This isn't universal across all companies; many embraces modern digitalization strategies, often led by COOs or CTOs with experience in other technologically progressive industries. These leaders are instrumental in driving a more forward-thinking approach.

BE2: It is a challenge. The complexity lies in achieving consensus, especially when these parties are competitors. All must agree on a common problem, the solution, and a business

<p>plan. Despite agreeing on term sheets, market dynamics can derail the entire effort. The key to a success is motivation, effective management, and buy-in from the leaders.</p>
<p>BE3: Everyone is a bit on their own. Small companies struggle with this issue a lot.</p>
<p>BE4: There are integrated companies with technological profiles and agricultural knowledge, there shouldn't be challenges that are impossible to achieve. The most challenging thing is to quickly interpret the details of each sector and understand where the pain points are to start with the highest value-added processes of each chain.</p>
<p>BE5: Legal. Some jurisdictions accept, some don't. Imagine now implementing blockchain. It's leapfrogging lots of technologies in a traditional industry. Public companies, they have to report to shareholders and be audited, if they want to use a public blockchain, they need to keep crypto in their books in order to pay for the transactions. Shareholders would want to understand how to hedge for the crypto volatility.</p>
<p>Q7: What other potential risks or benefits do you foresee for the agricultural commodity industry with the adoption of blockchain technology?</p>
<p>BE1: The key is ensuring the system works reliably/efficiently. The platform must perform effectively without being hindered by the BT integration. The second challenge is user education. Despite its growth, many people still lack a clear understanding of blockchain.</p>
<p>BE2: Blockchain also introduces the concept of wallets and tokens, potentially revolutionizing the way physical commodities are represented digitally. The idea is to transition to digital tokens, representing physical assets in an electronic format. However, this shift requires careful management to ensure industry acceptance.</p>
<p>BE3: I think blockchain could bring some standardization into products. Also, it could improve liquidity from end-users. Of course, it can speed up transactions, streamline trade finance and simplify international trade in general.</p>
<p>BE4: I think that although it is insufficient for now. It is evolving strongly; Brazil is a great example.</p>
<p>BE5: Little to no collaboration. Policy makers are slow, technology experts do not address the pain points in the industry.</p>
<p>Q8: How can blockchain adoption become more accessible to a wider range of market players, including smaller enterprises?</p>
<p>BE1: The goal for these companies is to increase efficiency and have a single, reliable system that manages all post-trade activities. This approach reduces error rates and the risks of</p>

<p>incurring penalties. While many companies are aware of blockchain, have explored its benefits, and even conducted pilot projects, it's not the focus of our conversations with clients.</p>
<p>BE2: Pricing model must consider account size, a key in determining the costs. Onboarding needs to be straightforward. Goal is to show the long-term benefits, which although not directly reflected in immediate financial results, contribute to operational improvements. We need to educate about the changes, the impact, and how it affects their daily operations.</p>
<p>BE3: Such things as tokens can enable small players to gain competitive advantage against big ones. So, it is important to educate and make it simple to use for everyone.</p>
<p>BE4: I think it is key that the leading players in each market get involved, if this does not happen the risk of a very slow adoption or possibly under-execution is high.</p>
<p>BE5: I don't see any increased risk, only on the contrary, would bring risk mitigation.</p>
<p>Q9: In your expert opinion, do you foresee blockchain technology having a disruptive role within the agricultural commodity industry?</p>
<p>BE1: I see it having more of a sustaining role.</p>
<p>BE2: In B2B, the role of BT is more of a supportive rather than a standalone solution. BT can build trust with its features, such as immutability and decentralized verification.</p>
<p>BE3: Sustaining. The change will take time and will happen in slow and sustainable way.</p>
<p>BE4: Definitely, the next 2 or 3 years are key for this to be put into action and in specific business cases in countries such as Brazil, Argentina, Mexico and the US.</p>
<p>BE5: Not in the short term. May be in 20y time, when the current digital generation is taking leadership positions and can change.</p>
<p>Q10: Do you anticipate blockchain technology primarily being embraced by niche users or specialized segments within the agricultural commodity industry? If yes, how do you envision the transition from niche use to becoming more widely integrated into mainstream practices in the agricultural commodity market?</p>
<p>BE1: I think it's both, niche and big players. We already see this, that adoption not really depends on the size of the company. We have users that vary a lot in size.</p>
<p>BE2: I think it needs to begin with bigger players, it's the only way to do it successfully.</p>
<p>BE3: I think niche users, because large companies may not feel the need for this now.</p>
<p>BE4: Niche users, it takes a long time for big players to validate the real value of this technology.</p>
<p>BE5: I'd think there's a higher value in niche markets, and a higher value in markets with a high number of scammers (e.g. sugar markets), especially the adoption of a smart-contract</p>

and secured transactions. This would eliminate counterparty risk. Nonetheless, I think its usage as a digital notary to ensure docs authenticity as the first step.

Q11: What would you consider to be the primary driver of adoption? Is perceived ease of use a main driver? Perceived usefulness?

BE1: User experience cannot be overstated. The change towards software usability is evident when organizations are faced with multiple options. This is relevant in industries that are seen as conservative. However, software that has a focus on user experience can ease the transition. The simplicity/intuitiveness, play a role in its acceptance and eventual success.

BE2: The usefulness, especially if it can demonstrably increase a company's efficiency, is key to gaining buy-in from senior management. For end-users' usability takes precedence. The concern is whether the software makes their work. The balance between usefulness and usability varies depending on the nature of the business.

BE3: It needs to be both, easy to use and bring real benefits. Otherwise, no one will be using the technology.

BE4: I think it is key that the leading players in each market get involved, if this does not happen the risk of a very slow adoption or possibly under-execution is high.

BE5: Perceived ease of use.

Q12: Do you think demand from market participants is driving the development and implementation of blockchain technology? Or are technological advancements pushing the industry toward adoption?

BE1: The trajectory of BT can be explained by the Gartner hype cycle. Initially propelled by a surge of tech push, it emerged as a groundbreaking innovation. This initial phase was characterized by high expectations. As the novelty of the tech started to wane the industry entered 'trough of disillusionment.' Presently, the shift is moving to a demand-driven pull.

BE2: It's driven more by the demand-pull.

BE3: I think it is a mix of both.

BE4: Mix of them. Depends on the sector and specific market.

BE5: I don't think there's this demand. As a blockchain expert, and owner of a grain trading firm, I've not joined any platform that currently exists on blockchain for grain trading. Takes too much extra steps, better to leave things as they are.

Q13: What is the expected time horizon for blockchain technology to become a significant enabler in the agricultural commodity industry? What factors could influence the speed of adoption?

BE1: BT is already proving to be a significant enabler in various industries, creating solutions that were previously unattainable. However, the future of blockchain is not about it becoming ubiquitous, as its functionalities can be replicated through other means.
BE2: It is a gradual process. Developing a meaningful technological framework involves significant changes, such as the introduction of electronic documents, automated payments, and the use of AI for contract management, data extraction from documents. These shifts that require time to implement and deliver their value, even when the network is in place.
BE3: Not in 5 years. More. It will be a very slow process.
BE4: Next 2-3 years are critical. It is key that the leading players in each market get involved.
BE5: I think more regulations would speed adoption. Creating a strong blockchain legal ecosystem, then, framework for smart contracts, having a very strong legal framework on stable coins. So, it's easy to hedge for currency volatility and trade in a secure environment.
Q14: What recommendations/best practices would you provide to organizations/stakeholders looking to integrate blockchain in agricultural commodity trading and execution?
BE1: Due diligence is important when considering new technology. The decision-making process should not differ whether the technology in question is blockchain-based or not. The focus should be on understanding the benefits that the technology will bring. Additionally, it is crucial to ensure that the company providing the technology is trustworthy.
BE2: Adapting to digital transformation doesn't require to make specific changes. Instead, it's about having an openness to optimizing processes and moving towards a digital world. This willingness to embrace change is crucial, and it varies among companies based on their size, the specific problems they're aiming to solve, and the complexity of their operations.
BE3: Be open to changes if you see that technology brings value to your business.
BE4: Be very patient and persevering because it takes a long time for big players to validate the real value of this technology, and obviously be very consistent in always seeking to solve specific problems for the different members of the chain.
BE5: Understand how it works, use a public blockchain.

Note. *Questions were created by the author.*

Table 17.

Summary of key information of Experts' interviews

Code	Date	Time	Duration	Type
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IE1	2023 10 31	3 pm	40 minutes	Cellphone
IE2	2023 11 12	4 pm	47 minutes	Teams
IE3	2023 11 14	1 pm	34 minutes	
IE4	2023 11 14	4 pm	30 minutes	
IE5	2023 11 15	9 am	45 minutes	
IE6	2023 11 15	12 am	27 minutes	
IE7	2023 11 16	2:50 pm	21 minutes	
IE8	2023 11 20	10 am	44 minutes	
IE9	2023 11 20	2 pm	37 minutes	
IE10	2023 11 21	7 am	42 minutes	
IE11	2023 11 24	8 pm	-	
IE12	2023 12 01	8 am	-	
IE13	2023 12 12	2 am	-	
BE1	2023 11 15	3:30 pm	48 minutes	Teams
BE2	2023 11 17	4 pm	39 minutes	
BE3	2023 11 28	3:30 pm	37 minutes	Zoom
BE4	2023 12 04	5 pm	-	Email
BE5	2023 12 14	5 am	-	Email

Note. Created by the author.

Appendix III: Coded categories based on Expert interviews

Table 18.

Coded categories based on Experts' interviews

Category	Key words and phrases
1.Key industry challenges	<p>Lack of standardization due to varying standards;</p> <p>Different execution systems complicate work;</p> <p>Talent shortage;</p> <p>Tightening regulations on traceability/transparency/sustainability/import/export;</p> <p>Decisions depend on timing/intuition/trust between parties;</p> <p>Uncertainty in weather, currency, freight, market;</p> <p>Rising cost pressures;</p> <p>High amount of information changes perception of risks;</p> <p>Financing issues: low margins/increasing interest rates;</p>

	<p>Integrating agribusiness with the rest of the industries/potential investors; High competition, decentralized market.</p>
2. Readiness for technology adoption	<p>Farm side is digitalized, commercial side rely on traditional methods; Different digitalization levels across the world; Lack of tangible benefits, costs are comparable to humans; Advances in smart communication/internal software; The biggest change is information accessibility Key challenge – achieving consensus on standardization; Some companies lack capital to invest in technologies; There are a lot of concerns about security of technologies; Key enabler lies in establishment of regulations; Lack of uniformity in the software systems; Resistance to change; Lack of knowledge about various technologies.</p>
3. Role of BT	<p>Potential role in execution digitalization/standardization/quality control; It is not universally applicable across entire business model; Role in increasing transparency and traceability; Very suitable for biological farming; Trade finance facilitation (in the future – tokens for payments); Tool to generate rules and better clearing techniques; Smart contracts could replace paper-based futures contracts.</p>
4. Specific benefits of BT	<p>Streamlining processes, increase cost-efficiency, speed; Increased traceability/transparency/trust in supply chains; Document management; Execution digitalization (possible usage of smart contracts); Reduced errors; Security in transactions; Ability to improve risk management; Trade 24/7; Increase standardization and improve liquidity.</p>
5. Obstacles to BT adoption	<p>Lack of standardization in processes and products; How to ensure compliance and financial capital of parties; Data security – leaked data reduces competitive advantage;</p>

	<p>Ambiguity around BT's benefits;</p> <p>Reputation of being environmentally harmful;</p> <p>How to manage detailed accuracy;</p> <p>Legal aspects, like acceptance or transfer of ownership;</p> <p>Harmonizing different platforms;</p> <p>Making platform user friendly;</p> <p>All parties in supply chain must be using platform to work;</p> <p>Lack of knowledge and education about BT;</p> <p>Cost of technology;</p> <p>Lack of collaboration between stakeholders;</p> <p>Risks of token economics.</p>
6. BT's disruptive potential	<p>More sustaining role, gradual move;</p> <p>It depends on effectiveness;</p> <p>It will cause disruptions in job displacement;</p>
7. Adoption trends	<p>Adoption will start with big players, and only with a few commodities;</p> <p>Niche players can increase competitiveness by adopting technology first;</p> <p>It might be too expensive for small companies;</p> <p>Size has no impact towards adoption;</p> <p>Perceived usefulness is a key driver to adoption;</p> <p>It has to be user-friendly/intuitive for quicker adoption;</p> <p>Cost saving and pricing model are another two drivers;</p> <p>Technology-push is mostly driving the adoption;</p> <p>Development is being driven by practical needs;</p> <p>It's like chicken and egg problem;</p> <p>The trajectory can be explained by the Gartner hype cycle;</p> <p>Expected time to become enabler: 2-3 years are critical, 5-10 years, 10+.</p>

Note. Created by the author.