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# Blockchain technology as a potential solution for cross-border trade challenges: a systematic literature review

Renato Daniel Janeiro Ferreira

Master in Management

Supervisor:
PhD candidate Ulpan Tokkozhina, Invited Assistant,
ISCTE – University Institute of Lisbon

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BUSINESS
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Department of Marketing, Strategy and Operations

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**Resumo**

A tecnologia blockchain tem estado no centro de vários estudos nos últimos anos devido ao seu potencial para melhorar e revolucionar a gestão de cadeias de abastecimento e o comércio transfronteiriço. Esta tese visa identificar as vantagens da utilização e barreiras à adoção desta tecnologia no comércio transfronteiriço e como pode contribuir para resolver os desafios existentes nesta área. Para tal, foi realizada uma revisão sistemática da literatura utilizando a metodologia PRISMA, integrando a literatura selecionada na teoria dos stakeholders. Este estudo apresenta uma abordagem original da categorização das vantagens e barreiras à adoção desta tecnologia através da classificação das características de acordo com a perspetiva das organizações que podem potencialmente adotá-la e de que forma as afetaria (internamente, externamente ou tecnologicamente). Esta abordagem pretende simplificar a compreensão dos potenciais impactos causados pela adoção desta tecnologia. Através da investigação, é possível identificar que a tecnologia blockchain pode melhorar o comércio transfronteiriço, nomeadamente com a digitalização, rastreabilidade, resolução de litígios, integridade e segurança da carga, confiança e conformidade. Contudo, para alcançar uma adoção mais abrangente da tecnologia blockchain entre os participantes no comércio transfronteiriço são necessárias soluções para as barreiras existentes.

**Palavras-chave:** Blockchain; Comércio transfronteiriço; Teoria dos stakeholders; PRISMA; Revisão sistemática de literatura

**Classificação JEL:** M10, Y40

**Abstract**

Blockchain technology has been at the centre of several studies in recent years due to its potential to disrupt and improve supply chain management and cross-border trade. This thesis aims to identify the advantages and constraints of using this technology in cross-border trade and how it can contribute to solving the existing pain points in this field of trade. To achieve that, a systematic literature review using the PRISMA methodology was performed followed by the systematisation of the literature selected, integrating it within the stakeholder theory. This study presents an original approach to the categorisation of advantages and constraints of this technology by labelling them according to the perspective of organisations that may potentially adopt it and how it would affect them (internally, externally, or technologically). This approach provides a simplified understanding of potential impacts caused by the adoption of blockchain technology in organisations. Through the investigation, it is possible to identify that blockchain technology can improve cross-border trade, namely with digitalisation, traceability, dispute resolution, cargo integrity and security, trust, and compliance. However, to achieve a wider adoption of blockchain technology amongst cross-border trade participants, the constraints identified need to be addressed.

**Keywords:** Blockchain; Cross-border trade; Stakeholder theory; PRISMA; Systematic literature review

**JEL codes:** M10, Y40

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**Glossary of acronyms**

AEO – Authorized Economic Operator

BC – Blockchain

BCT – Blockchain Technology

DLT – Distributed Ledger Technology

GSBN – Global Shipping Business Network

IoT – Internet of Things

PRISMA - Preferred Reporting Items for Systematic Reviews and Meta-Analyses

SC – Supply Chain

SLR – Systematic Literature Review

WCO – World Customs Organizations

WTO – World Trade Organization

# 1 Introduction

In the second half of the 20th century, the implementation of trade liberalisation policies and the wide-scale adoption of containerized freight allowed companies to source, manufacture and export products to different parts of the world, contributing to an unprecedented growth of international trade. Not only the number of supply chain participants increased, but they became scattered across the globe (Bernhofen et al., 2016).

The Trade Facilitation Agreement implemented in 2017 by the World Trade Organization (WTO), strengthened the idea of global trade, creating measures to expedite the movement, release and clearance of goods and frameworks for cooperation between customs and other authorities regarding trade facilitation (WTO, n.d.).

In 2021, the value of global trade of goods generated an estimated 22.3 trillion US dollars. In comparison, this figure was 6.5 trillion US dollars in 2000. The causes of this increase were mostly related to globalization and the increase in trade between the different countries, as well as the advancements in technology (Sabanoglu, 2022).

The growing number of participants as a result of globalization adds to the existing complexity of managing supply chains (SCs). Besides that, "international SCs face particular pressure from the added complexity of different legal requirements, longer transport distances and diverse business cultures, amongst other factors" (Elliot et al., 2021, para. 2).

Furthermore, today's supply chains are more complex than ever before due to the associated risks related to geopolitical, technological and economic uncertainty. A significant percentage of companies still face limited visibility into their SCs and many more either rely on paper-based processes or are not integrated technologically. Although companies and governments are aware of these limitations, the adoption of new technology crucial to improving the value of the whole SC is moving at a slow pace (Y. Chang et al., 2020). Despite technological improvements in later years, businesses and governments still have difficulties dealing with issues such as traceability of products, bureaucracy and disputes (Batta et al., 2020; Yoon et al., 2020). Eventually, all these factors create additional costs and delays that are passed to the different parties involved in the supply chain. In fact, the full digitisation of all the Asia-Pacific region's trade-related paperwork could reduce costs by up to 31% and boost exports by as much as 257 billion US dollars per year (Y. Chang et al., 2020).

To ensure that businesses, public and private organisations recognise the need to adopt the latest technology and improve cross-border trade, the World Customs Organization (WCO) and

the WTO used their global sphere of influence to raise awareness and promote discussions about this topic. Specifically, several reports have been issued and are constantly updated with projects and technologies that leverage internet usage and can have a significant impact on trade costs (WTO, 2018; WCO & WTO, 2022a). In like manner, in recent years companies prefer to embark on projects with a shorter implementation timeframe that can be easily migrated in the future, easing the financial pressure of the project. The "key to the new methodologies used is the principle of failing fast, and recovering quickly." (WCO & WTO, 2022a, p. 16).

In this context, SC and trade players have been exploring the development and application of different technologies to address these challenges. Internet of Things (IoT) devices, blockchain-based solutions, big data, data analytics, machine learning and artificial intelligence are some examples of new technologies investigated and introduced recently at different stages of trade processes (Juma et al., 2019). Al-Shorman et al. (2023) found that the use of those technologies in SCs can lead to improvements in the cost and quality of production, lead time and waste management. Additionally, other impacts can be noted such as "supply chain flexibility and integration, enhanced SC visibility, effective supply chain tracking, timely supply chain decisions, faster rates of delivery, and enhanced customized products." (Al-Shorman et al., 2023, p. 108).

One example of a technology currently emerging that sparked interest in the trade industry is blockchain (BC). Not only in SC management and trade (Kafeel et al., 2023; Tiwari et al., 2023) but also in other sectors such as energy trading (Burger & Weinmann, 2022), banking and finance (Weerawarna et al., 2023), healthcare (Cerchione et al., 2023), real estate (Wouda & Opdenakker, 2019) among others have done research and pilot projects to test its viability. According to Mao et al. (2019, p. 3440), the root of this interest stems from the innate characteristics of the technology that make it possible to do business without intermediaries, since "applications that could previously run only through a trusted intermediary, can now operate in a decentralized fashion".

Concerning SCs and trade, the implementation of blockchain technology (BCT) can bring enhancements to areas such as trade finance, customs, certifications, transportation, distribution, logistics and procurement. Such enhancements would be achieved by increasing process efficiency or by cutting costs (Ganne, 2018).

In the specific case of customs, the adoption of BCT can improve a whole range of processes, namely clearance and declarations, inter-agency communication, verification of certificates and identity, compliance requirements, revenue collection and post-clearance audit.

Currently, Argentina and Uruguay already completed the full deployment of this technology in their respective Customs authorities. A further 22 members of the World Customs Organization are testing proofs of concept and 15 members are testing pilot projects (WCO & WTO, 2022b).

Additionally, the interest in BCT is due not only to its decentralized nature but also due to its traceability capabilities and data immutability features, which make it tamper-proof and improve SC transparency (Juma et al., 2019).

Businesses rapidly realised the potential of BCT and started developing their own projects. According to a study published by Statista (2022) where the typology of BC use cases in 2021 was analysed, cross-border payments and settlements (15.9%) and trade finance & post-trade/transaction settlements (10%) were the first and third most popular use cases, respectively. This reinforces the idea that companies in the finance and SC industries are amongst the heaviest investors in BCT.

Despite all the interest surrounding BCT, governments and their respective agencies are taking longer than businesses to adopt a dedicated strategy. According to a survey done by WCO & WTO (2022b), 21 out of 105 responding countries, still do not have a strategy for the adoption of IT tools and information management. Additionally, 45 out of 110 (41%) still have no plans regarding BCT specifically. 26 countries (24%) have plans to adopt it in the next 3 years. This lack of a governmental guiding plan affected mostly the businesses that made efforts to develop BC applications from an early stage, such as Maersk and Walmart but had to alter their projects due to a lack of participants. Governments and customs have an impact on the perceived value that businesses place on this technology and contribute to the delay in its adoption (Cecere, 2022).

The literature available on the topic of BC and cross-border trade and supply chain management is diversified in nature. On the one hand, various theoretical studies performed qualitative analysis and presented conceptual frameworks (Min & Joo, 2022) or systematic literature reviews (Batta et al., 2022). On the other hand, the empirical papers, through a mix of qualitative and quantitative analysis, have added to the knowledge by performing surveys, interviews, case studies or field experiments (Balci & Surucu-Balci, 2021; Kowalski et al., 2021).

The aim of this thesis is to systematise the knowledge of BCT in cross-border trade and to achieve that, this study will address the following research questions (RQ):

RQ1: What are the advantages and constraints identified in the academic literature regarding blockchain technology adoption in cross-border trade?

RQ2: How can blockchain technology contribute to solve the current pain points in cross-border trade?

The objectives for this study are then stated as the following:

- describe the main challenges in cross-border trade and their causes;
- identify how BCT can improve cross-border trade processes;
- integrate the perspective of BCT usage within the stakeholder theory.

Despite the increasing number of articles published about BCT applied to cross-border trade, Y. Chang et al. (2020) found that there is a lack of systematic literature reviews of BC applications in cross-border trade. Most topics are addressed from the SC point of view, but not from a trade perspective (Biswas et al., 2022; Centobelli et al., 2022). Additionally, in recent years there is an increased interest of scholars and businesses to study the application of BCT to financial trade instruments, such as letters of credit (S. Chang et al., 2020; Fridgen et al., 2021). Here, too, systematic literature reviews providing a synthesis of findings are scarce.

Balci & Surucu-Balci (2021) highlighted the need to include schools and universities in the BC ecosystem to develop knowledge and awareness. Additionally, the same authors point out that future studies should focus their attention on stakeholders' resistance behaviour.

Min & Joo (2022) suggest that future researches identify factors that may significantly contribute to the success and/or failures of BCT implementation, such as organisational resistance or lack of BCT knowledge.

This research will address the above-mentioned gaps by performing a systemic literature review of current academic literature on BCT applications for cross-border trade while identifying potential factors of success and failure, framing them within the stakeholder theory. The rest of the thesis is structured as follows. In Chapter 2, a literature review is presented, and background information is provided regarding BCT and cross-border trade challenges. A review of various BCT projects in international trade is also performed and the stakeholder theory is introduced. In Chapter 3 the methodological approach followed in this research is described and the research design, data collection and data analysis are presented. Chapter 4 addresses the findings and discussion, including this thesis' contributions and implications for practice. Lastly, Chapter 5 presents the conclusion of the research, its limitations and future paths for research are suggested.

## 2 Literature Review

To better understand the potential impact of BCT as well as the current limitations and difficulties faced by the different organisations involved in cross-border trade, an analysis of the current literature about the topic was performed.

### 2.1 Current challenges of cross-border trade

The concept of "cross-border trade" or international trade, "refers to the exchange of goods and services between countries and economies" as well as all the processes and preparations involved such as customs clearance, cross-border logistics, international payment settlement and third-party freight forwarders (Tian et al., 2022, p.1).

Processes with a considerably high number of stages will require an even higher amount of parties involved, namely Authorized Economic Operators (AEOs). These refer to any "party involved in the international movement of goods in whatever function that has been approved by or on behalf of a national Customs administration as complying with WCO or equivalent supply chain security standards" (WCO, 2018, p. 4). The trade participants that usually receive this denomination are mostly "manufacturers, importers, exporters, brokers, carriers, consolidators, intermediaries, ports, airports, terminal operators, integrated operators, warehouses, distributors" (WCO, 2018, p. 4). Banks, payment agencies and other financial operators can also be designated as AEOs since they participate in trade as intermediaries (Tian et al., 2022). The increasing number of participants in these processes associated with the pre-existing difficulties of such complex environments exacerbated the pain points present in supply chains (Y. Chang et al., 2020). Across the literature, the pain points identified are relatively similar, with the exception lying on the fact that some authors merge two or more different issues into specific situations.

Traceability refers to the capacity to track and monitor the location, movement and ownership of goods, products and information across the whole supply chain. It requires updated records from the origin until the end consumer. It may be achieved through the use of different technologies such as IoT and RFID (Duan & Patel, 2018; Y. Chang et al., 2020; Tian et al., 2022).

Dispute resolution refers to the process of solving problems and conflicts that may arise between importers/exporters and buyers/sellers should either of the parties fail to deliver what was established in the agreement. Such disagreements may arise if the cargo was compromised

or any of the parties fail to complete their designated contractual obligations. Usually, the solution for disputes is a fine or compensation. However, the audit processes to find the origin of the problem can be lengthy, costly, and can create uncertainty depending on the jurisdiction where it is evaluated (Y. Chang et al., 2020).

Compliance refers to the monitoring and adherence to rules of "product safety and integrity, technical regulations, supplier social and environmental responsibility, ethical sourcing, etc" (Y. Chang et al., 2020, p. 2085). Additionally, it also refers to the adherence to legal requirements defined by governmental regulation or trade agreements that govern cross-border transactions, such as import and export laws, customs procedures, tax declarations, or other related procedures (Tian et al., 2022).

According to Y. Chang et al. (2020), trade is a legacy industry still heavily reliant on paper documents. Studies show that all participating partners in trade moving these procedures to a digitalised version could save time and money. Paper-based transactions are also prone to be duplicated and faked by third parties; digitalisation could prove crucial to ending such issues. For this reason, the digitalisation of trade processes refers to the use of different technologies to streamline the different trade processes such as the exchange of documentation and digital signatures, traceability, payment settlement, custom procedures and cargo tracking and verification (Y. Chang et al., 2020; Ganne, 2021; Tian et al., 2022).

Another common pain point in cross-border trade and global supply chains has to do with potential frauds or cargo that has been spoiled or damaged. Cargo integrity and security refers to all the measures implemented to prevent any fraudulent attempts as well as ensure that all the goods are securely delivered as per agreement and fit to be resold or consumed. These measures can include verification of sellers' identity, using trusted third parties to serve as intermediaries, employing technology to monitor container temperature or tampering attempts and other safety checks throughout the transaction and transport process (Y. Chang et al., 2020).

The high number of participants in the trade processes increases the difficulty of establishing a relationship of trust between them, especially if those participants do not have a business history between them (Duan & Patel, 2018). Third parties and intermediaries, such as banks, started to be included in business transactions to ensure that both parties deliver their part of the agreement, however that increases the time and the cost it takes to do business. In this regard, trust refers to confidence and reliance that businesses involved in transactions have in the other party to fulfil their obligations and commitments in time and in an efficient way. This takes particular relevance in cross-border trade since it is common that business partners do not know each other before doing business and any legal actions can become complex due

to the different jurisdictions involved. Therefore, the due-diligence process of verifying potential business partners is paramount to the success of the transactions but can easily become lengthy and expensive. For example, fool-proof identity and origin certificates are required to fast-track such scenarios in which trade participants cannot establish trust based on previous interactions (Juma et al., 2019; Y. Chang et al., 2020). This also affects the trade finance processes, using banks as intermediaries for payments and setting up letters of credit (Toorajipour et al., 2022).

The above represents the main pain points identified in the literature reviewed. Although some authors present different perspectives, the core of the different problems have been discussed.

## 2.2 Blockchain and its main technological features

Blockchain is a time-stamped, distributed ledger technology for recording and maintaining transactions' data on a permanent and immutable manner using cryptography (Nakamoto, 2008; Juma et al., 2019). The records held in the ledgers are "shared, replicated, synchronized and maintained by the participants of a decentralized network" not having a single point of failure and distributing a copy to all participants (Y. Chang et al., 2020, p. 2082). These features also give name to the larger group of technologies called Distributed Ledger Technology (DLT), of which blockchain is one kind. Each participant, or "node", in the blockchain holds a copy of the ledger containing the entire transaction history, making this a decentralized technology (Toorajipour et al., 2022). The ledger is composed of several blocks, each containing several transactions (Juma et al., 2019).

Following a hashing protocol, the integrity of the data contained in the blocks is ensured, since a change in one of the block's values would disconnect it from the chain and be rejected by the other nodes (Juma et al., 2019).

A consensus mechanism is then employed, through which all the nodes designated in the blockchain reach an agreement regarding the validity of the data. All peers write new transactions on a temporary ledger, and when a new block is proposed, the consensus procedure is triggered to validate it. If the designated approving nodes agree, the new block is added to the chain, otherwise it is deleted from all records. The number of transactions in each block is predetermined based on purpose and requirements of the blockchain (Juma et al., 2019).

Currently, BCs can be classified into one of three categories: public, private and consortium. Public BCs were the first to be created and the initial purpose of these platforms

was to trade Bitcoin and other cryptocurrencies (Nakamoto, 2008). These BCs are permissionless and the most permissive of all three types, since anyone can join them. Any user can read the records, send transactions as well as participate in the approval process, also known as consensus mechanism. In this context, trust is established because all participants have the same rights. These BCs are the most decentralized of the three, since it requires a majority of users to approve new records. Although these blockchains are relatively easy to access and anyone can see the transaction history, public BCs take a long time to process transactions and consume large amounts of energy when compared to private and consortium BCs. Some of the consensus mechanisms employed are Proof of Work and Proof of Stake. Of all the types, this is the hardest to tamper since it would require attackers to control 51% of the BC's computing power (Mao et al., 2019).

At the other end of the spectrum, there are private BCs. These are permissioned BCs, meaning that only approved participants can join the BC. Private BCs are mainly used by organizations on their own. Mao et al. (2019, p. 3340) describes them as being "completely isolated". Since the consensus process is restricted to one or a limited number of approving nodes, the transactions can be processed faster, however these BCs are more susceptible to data breaches and are not always distributed since not all nodes hold a copy of the ledger. Therefore, companies use it mostly for in-company auditing and other similar purposes (S. Chang et al., 2019; Mao et al., 2019).

Consortium blockchains, despite being considered permissioned, have some characteristics from the other two types of BC. Firstly, they can accommodate multiple participants, even competitors in the same industry, while ensuring better data privacy than public blockchains (R3, n.d.). Similarly to private blockchains, the consensus mechanism is performed by a predefined number of nodes, processing transactions rapidly. Despite this, some rules and restrictions can be more fluid, depending on the needs of the businesses using it and the purpose it serves. For example, the right to read can be set as public, if companies want to share some details of the transactions with clients. For this reason, consortium blockchains are the most appropriate for business scenarios involving different participants (Mao et al., 2019).

Another feature of BC are smart contracts. These are programmable protocols containing predetermined business rules, that self-execute when certain terms are met and can automatically trigger payment, compensations or fines if compliance with pre-set conditions is violated (Y. Chang et al., 2020; Chuah, 2022). The contractual conditions may or may not be premised on any pre-existing agreements between the parties and these contracts are executed at lower costs than traditional intermediators (Juma et al., 2019; Y. Chang et al., 2020; Chuah,

2022). According to Chuah (2022, p.3), “This automated execution of the terms of the arrangement is ideally suited to the global trading environment where distance, costs and lack of trust could lead to contract failure”.

### 2.3 How can blockchain facilitate cross-border trade?

Numerous studies about this topic have been done, either from an empirical or theoretical perspective, although only a part of them have been tested. Additionally, some of the biggest players in different industries such as Maersk, IBM, Walmart, BBVA among others have piloted projects to evaluate the validity of the technology, identify use cases and establish industry-wide practices from an early stage (Y. Chang et al., 2020; Chuah, 2022). Some of these projects are presented in Table 2.1, namely Tradelens, Walmart’s Food Traceability Initiative, R3 and Global Shipping Business Network.

Despite all the above, going from theoretical frameworks to everyday use in different industries is proving hard. Despite some early use cases previously mentioned developed in retailing, merchant shipping, pharma among others, very few companies have been able to implement sound BCT-based solutions. Additionally, the interest of academia in studying BCT applications in different areas, namely global trade and supply chain management, has been growing since this technology was created in 2008. Governments on the other hand, have taken longer to explore this technology. Although there are some exceptions, a significant amount of countries have not prepared a roadmap for BC implementation (Y. Chang et al., 2020).

On that topic, Cao and Shen (2022) have studied how governments can use BCT to prevent less sustainable products from entering their markets. Other studies have shown governmental institutions how BC-based frameworks could be adopted. Juma et al. (2019) created such framework for Dubai Port Customs. Same authors mention that at some point, BCT-based solutions will simplify international trade, however that is limited until governments establish their own systems and promote cross-border agreements.

Additionally, it is important to note that due to technological limitations, scalability is still a problem, which is deterring bigger businesses from adopting such solutions (Juma et al., 2019). In that regard, “Scalability is defined as the ability to scale up the size of the network (number of transactions) without any interruption to the business process” (Juma et al., 2019, p. 184117). In practice, even if large businesses wanted to adopt BCT, the computational power of the existing BCs might not be enough to cope with the existing business’s demands.

One last example of the application of BCT to cross-border trade procedures was studied by Toorajipour et al. (2022). Using BCT to build trust between the trade partners and eliminate the need for intermediaries such as banks, reducing paperwork, intermediation costs and the time needed to complete the procedure.

## 2.4 Stakeholder theory

In 1984, Freeman defined stakeholders as "any group or individual that can affect or is affected by the achievement of a corporation's purpose". This new approach presents the idea that those in charge of running a business should consider the interests of all stakeholders during the decision-making process and not just those of shareholders (Freeman et al., 2010, p. 54).

The same theory was then developed to a comprehensive view of business management impact in society and how it ties with the ethics realm. Freeman (1994) claims that stakeholder theory offers a more ethical and comprehensive view of corporate responsibility than conventional shareholder-focused approaches.

Donaldson and Preston (1995) added to the existing theory by classifying it as descriptive (provides concepts to describe businesses, how they work and affect the surrounding environment), instrumental (managing stakeholders can lead to the achievement of business objectives), prescriptive (provides guidance and recommendations about business management) and managerial (affects managerial behaviour and the relations with those surrounding the corporation).

Throughout the years, the stakeholder theory was subject to plenty contributions from different authors. They questioned and tried to define who are the stakeholders of a business and how to integrate ethics into the decisions without affecting the other purposes of businesses which was to grow and create value. This led to a global review and updated version of the theory done by Freeman et al. (2010), in which the revised definition of stakeholder became "those groups without whose support, the business would cease to be viable". This involves the primary stakeholders such as its employees, financiers, customers, suppliers and the communities affected. Additionally, the secondary stakeholders are business competitors, the government, consumer advocate groups, special interest groups and the media.

Having established the theoretical basis of this research, it can then be related to the introduction of BCT in cross-border trade. According to Kramer et al. (2021), the challenges related to the introduction and adoption of new technologies in a corporation are not only technical but also behavioural, specifically any resistance or difficulties that might occur from

the stakeholder to implement the new solutions and making it work. The same authors studied how stakeholders could affect the adoption of BCT in coffee supply chains and found that a normative approach resulted in a high level of technology acceptance amongst stakeholders.

Other studies tried to relate the effect of stakeholder theory with BCT adoption. Jang et al. (2023) found through an empiric study that the early stages of development of BCT led to employees in the food service industry to resist when asked to use it. Sansone et al. (2023) argues that four aspects of BCT, namely reliability, transparency, decentralization and accessibility support technology adoption by improving the social conditions of stakeholders. Lastly, Gong et al. (2022) found that the constraint holding a large-scale adoption of BCT in supply chain finance is the lack of stakeholders motivation and regulation to adopt the technology.

The theoretical background described above highlights the importance of involving all stakeholders in the decision-making process of adopting BCT. For that reason, this study will analyse the major advantages and constraints of this technology from the stakeholder perspective.

Table 2.1 *Summary of projects using blockchain technology in cross-border trade*

| **Project name** | **Description** | **References** |
|---|---|---|
| Tradelens | Tradelens is a project developed jointly by container shipping company Maearsk and IBM first launched in 2018 to develop a blockchain application to digitalise maritime shipping and end-to-end supply chains. The platform counted hundreds of participants including customs and government authorities, ocean carriers, terminals depots and intermodal providers. The platform also includes a trade document module called ClearWay, which allows participants to collaborate in interorganizational processes and the automation of import and export clearances using smart contracts. However, in December 2022, Maersk announced it would stop operations on the platform. Albeit being the most relevant blockchain-based project in supply chain and logistics, the unwillingness of other players in the industry to cooperate and join the platform to increase SC visibility meant that it could not become financially viable and the purpose of integrating SC management could not be achieved. | Ganne, 2018; Batta et al., 2020; Y. Chang et al., 2020; Yoon et al., 2020; Balci & Surucu-Balci, 2021; Elliot et al., 2021; Chuah, 2021; Cecere, 2022; Maersk, 2022 |
| Walmart Food Traceability Initiative | Together with IBM in 2016, US retailer Walmart developed a blockchain-based platform to increase food security and traceability. The goal is to increase supply chain transparency and track products from farm to fork, especially in cases where food contamination might have occurred and the infected lots need to be quickly recalled. The pilot project involved tracking mangoes sold in the U.S. and finding their farm of origin in Mexico in just 2.2 seconds. Before, it would have taken 7 days. Another test involved tracking the source of pork meat sold in their Chinese stores. For this process, the blockchain was used to upload the certificates of authenticity and expedite the process and increase transparency and trust. Other products have since been added to the blockchain such as strawberries, leafy greens, yogurt, almond milk and others. Walmart even declared that all its direct suppliers would have to be part of their blockchain initiative by 2019, however the difficulty of digitalising the record-keeping of farmers has delayed the process significantly and it is taking longer to add new products to the traceability initiative. For those that joined the BC initiative, the results are visible with the percentage of disputed invoices decreasing from 70% with legacy methods to 1% with BCT. | Mao et al., 2018; Y. Chang et al., 2020; Elliot et al., 2021, Sristy, 2021; Vitasek et al., 2022; Green, 2023; Hyperledger Foundation, n.d. |

Table 2.1a *Summary of projects using blockchain technology in cross-border trade*

| **Project name** | **Description** | **References** |
|---|---|---|
| R3 | R3 Corda is a consortium blockchain dedicated to banks, financial institutions, exchanges, regulators and trade associations. It is the first regulatory-compliant DLT platform for financial services and it serves as the technological platform where blockchain-based applications can be developed. Participants can use automated workflows and processes, increase settlement speed and manage digital assets and currencies. This platform also solves other common problems of blockchain such as data privacy by only showing transaction details to those directly involved in the transaction without affecting its speed, contrary to other BC platforms. | S. Chang et al., 2019; Mao et al., 2019; S. Chang et al., 2020; Chuah, 2022; R3, n.d. |
| Global Shipping Business Network (GSBN) | GSBN is another BC-based platform that intends to digitalise trade, expedite cargo processing time and facilitate trade finance. The founding eight members include some of the most relevant shipping and terminal companies such as Cosco, Hapag-Lloyd, Hutchison ports, OOCL and PSA. Amongst the almost 300 members there are other shipping lines, freight forwarders, and shipping software providers such as Cargosmart. One of the products offered aims to reduce the trade finance gap and enable financial partners to leverage data usage in the underwriting process and risk management of logistics companies. The company also has a dedicated advisory board to explore different technical and legal frameworks and improve global supply chains. The other product is dedicated to cargo release, namely using technology to implement paperless transactions and verifications, involving all participants at the port of import. GSBN claims that the platform can reduce the time needed to prepare cargo for expedition from days to a few hours. | Balci & Surucu-Balci, 2021; GSBN, 2023 |

# 3 Methodology

The rise in interest in BCT from businesses, organisations and academia led to a surge in the number of applications and projects testing the viability of the technology in supply chains and cross-border trade. At the same time, academic publications increased the number of articles on the topic, including systematic literature reviews (SLRs) that gathered the most important developments in BCT applied to SC management, such as Chang and Chen (2020). More recently, Tokkozhina et al. (2022) applied the PRISMA methodology to find relevant knowledge on the same topic.

In parallel, some studies evaluated the progress of BCT in cross-border trade by performing SLRs, albeit in smaller number (Y. Chang et al., 2020), and focused on specific parts of international trade (Batta et al., 2020; Balci & Surucu-Balci, 2021). In this thesis, a SLR will be performed to fill the existing gap in cross-border trade literature and provide an updated view of recent BCT developments in this area.

## 3.1 Research design

SLR was selected as the preferred method to systematise the current knowledge, as the "replicable, scientific, and transparent" nature of this approach reduces potential bias and should present a summarized version of all information about a phenomenon in a thorough manner (Denyer & Tranfield, 2009, p. 672).

Through a systematic literature review, different goals can be achieved, namely: address matters through a global perspective that is unattainable through individual studies; provide guidance for future studies by identifying gaps in primary studies; compile a systematisation of the current knowledge in a field and direct future research; and appraise or generate new theories (Page et al., 2021).

The research for this thesis relied on secondary data gathered from the sources identified in the subsection 3.2. A qualitative review of content and semantics was performed. For the later, a keyword co-occurrence networks analysis was performed. Additionally, a citation network analysis was conducted to find any relation between the articles chosen for the SLR, through the use of citations.

## 3.2 Data collection

The methodology selected for this SLR was the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist because it ensures clarity in the review process due to the structured process it follows (Page et al., 2021).

As required by the PRISMA, the results of the search and selection process of the literature are presented in a flow diagram in Figure 3.1, which summarises the information relative to this study. The diagram presented in this paper was adapted from a study that also followed a SLR approach for BCT-based applications (Tokkozhina et al., 2022).

The sources consulted were academic databases, namely Scopus, Web of Science and ABI/Inform. These are respected repositories for academic searches and ensure a wide disciplinary scope of articles and journals.

Concerning the keywords chosen to query the databases selected, there were two sets which retrieved all documents with these on the title: “blockchain AND trade” and “blockchain AND export”. These keywords have a broad enough scope, covering different areas within the same topic such as international and cross-border trade, exports, and others without deviating from the main subject. Keywords such as “supply chain” and “logistics” were not included in this research. Albeit relevant and more commonly used in academia articles, most of the publications retrieved would focus on areas that are not related to international trade directly. This way, the emphasis of this research in cross-border trade is ensured.

All peer-reviewed articles written in English and available until October 2022, without filtering prior years were selected.

The number of documents retrieved from each platform was the following: 455 from Web of Knowledge, 136 from Scopus, 38 from ABI/Inform, which amounted to a total of 629. It is worth noting that the query including the “trade” keyword generated a substantially higher number of results (n= 611) compared to “exports” (n= 18). Once all duplicates were removed (n= 118), there were 511 articles left.

The next step was a screening of the articles based on title and abstract content, which resulted in the removal of a further 419 articles leaving 92 valid articles. The goal of this stage was to keep only the studies focused on the use of BCT in cross-border trade, supply chain management and logistics. Examples of topics removed included energy trade, electric vehicle grids, smart-city applications, digital content management, carbon markets, BC security protocols among others as well as articles that addressed technical frameworks of the technology and did not fit the scope of this study.

The next stage involved applying an unbiased filter of quality to the remaining articles. It is important to ensure that the sources used are reliable, accurate and up-to-date since that will impact the quality of the findings and the credibility of this research. To that purpose, only articles in the Q1 and Q2 of the Scimago Journal Rank were kept. This is a respected source in the scientific community for Journal rankings. That step excluded 57 articles and left 35 for full analysis.

The last stage involved reviewing all the remaining texts, where an additional 5 were removed for not fitting the topic of this thesis. The 30 articles that qualified via the PRISMA process were selected for the systematic literature review and are listed in Annex A.

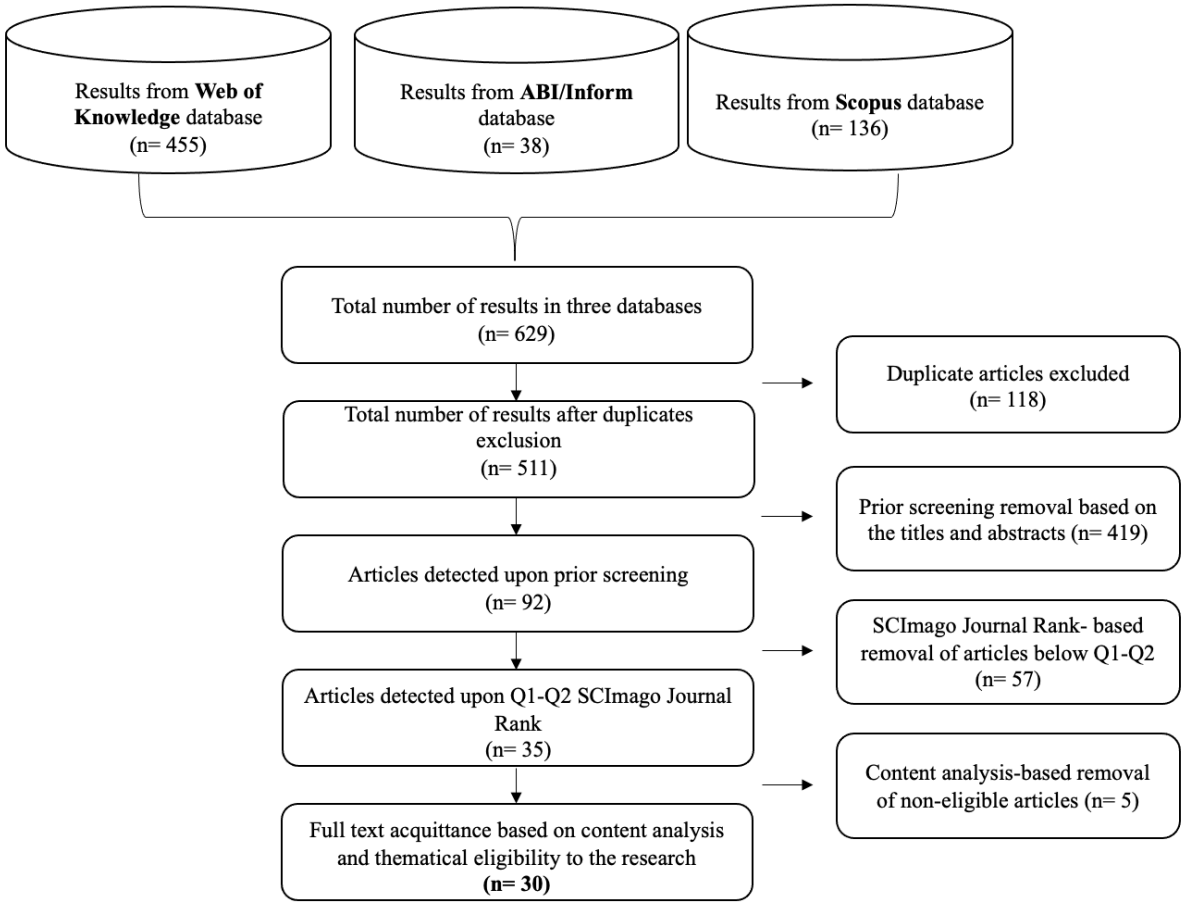


Figure 3.1 *PRISMA workflow diagram for literature selection*

### 3.3 Data analysis

To draw insightful information from the articles selected, a content analysis covered the main topics addressed and identified the main advantages and constraints to BCT adoption in cross-border trade and how this technology in particular can address some of the existing challenges in international exchanges.

To perform the keyword co-occurrence network analysis, the software VOSviewer was used. Regarding the existing links between articles through citations, the online tool Litmaps was selected to identify any that may exist.

The limited number of articles available for the systematic literature review is related to the recent and still expanding nature of this topic. Unlike other topic such as “supply chain” and “logistics”, the use of BCT in cross-border trade as an area of study is still growing, hence the lower quantity of studies available.

# 4 Findings and discussion

Following the analysis of the studies selected with the PRISMA methodology, the findings of all articles were systematised and the advantages and constraints of BCT adoption are presented in this chapter. Additionally, a keyword co-occurrence and a citation analysis were conducted to unveil further relations between the studies selected.

To analyse the content of titles and abstracts of the articles selected, a semantic analysis was conducted using the software VOSviewer. This software allows the creation of different kinds of bibliometric analysis to find relevance and connections between different articles. A keyword co-occurrence network was chosen to highlight similarities between the set of articles selected for the SLR. All the terms that occurred at least twice were selected and irrelevant terms were excluded. A total of 12 terms were identified and grouped into three clusters based on its relevance and co-occurrence. Figure 4.1 shows the results of this analysis.

The first cluster (in red), named “blockchain applied to trade” includes the main keyword “blockchain” as well as “supply chain”, “global trade”, “logistics” and “supply chain management”. It gathers the keywords related to the main topic of this study, specifically the application of BCT in global trade and supply chain management. Given that the application of BCT in global trade and supply chain management is the overarching topic of this thesis, this is the most significant cluster of the network.

The second cluster (in blue), named “blockchain and trust in trade” includes the keywords “smart contracts”, “international trade” and “letter of credit”. This cluster is built by the articles that address potential alternatives to the existing letters of credit using BC-based solutions, specifically smart contracts. Smart contracts and letters of credit are widely discussed in the articles as means of establishing trust but are not the focus in most studies.

The third cluster (in green), has the keywords “trade finance”, “distributed ledger”, “blockchain technology” and “trade supply chain”. These are broader terms that do not hold a specific common topic amongst them but are used multiple times in the different articles.

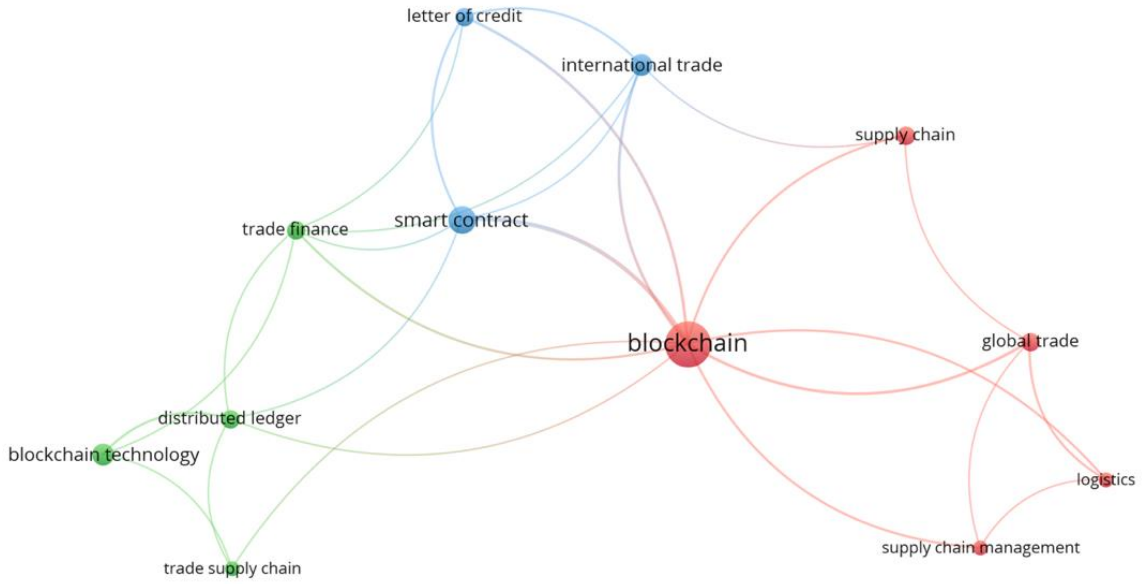


*Figure 4.1 Keyword co-occurrence network of the articles selected* built using VOSviewer software

To better understand how the articles selected are related, the online tool Litmaps was selected to create a map of citations and references of 30 articles. Figure 4.2 is organized by publication date on the x-axis and by number of citations on the y-axis.

One of the initial takes that can be drawn from this visual analysis is the condensed date scope of the articles. The earliest articles selected are from 2018 and the newest are from 2022. Although this is expected since BCT is relatively recent and its application to trade and supply chain management is still developing, the drawback from this limitation is that the progress of the technology throughout the years cannot be easily evaluated yet, since some of the conceptual frameworks proposed do not have follow-up publications.

Regarding the information provided by the distribution of the papers on the y-axis, the findings are threefold. Firstly, the results of the queries used for this research have not returned papers that are intricately related to each other, as most of them are not related by citation or referencing. Secondly, apart from Y. Chang et al. (2020) which has been cited over 170 times, the remaining papers have a much lower number of citations. This could indicate that the research of the topic in analysis may be taking place from different angles, e.g., from a supply chain perspective rather than trade. Additionally, this article by Y. Chang et al. (2020) is one of

the earliest and most comprehensive SLRs on the topic which might have served as a starting point for other studies. Lastly, it is worth noting that some recent articles from 2021 are being cited in other studies which confirms the interest of the scientific and academic community on the topic.

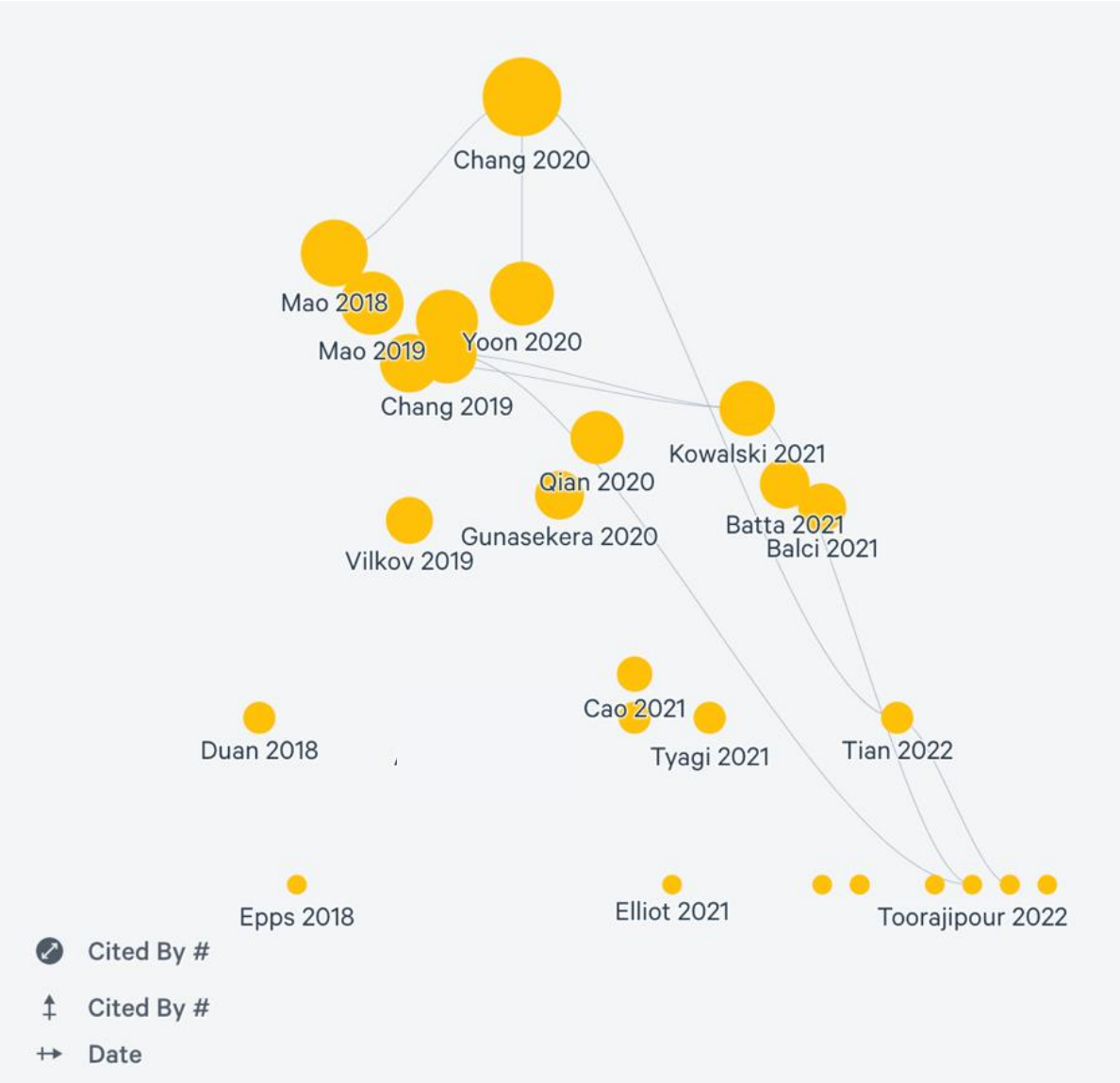


Figure 4.2 *Literature map of date and citation networks using Litmaps*

Throughout the literature selected for this study, the authors discussed different advantages, disadvantages and constraints to the adoption of BCT. The systematisation of the different advantages and constraints is presented in subchapters 4.1 and 4.3, respectively.

To start, it is important to note that several authors classify certain aspects of BCT such as the high computation power required (Mao et al., 2018), the code rigidity of smart contracts

(Lamela et al., 2022), inter alia as disadvantages. However, most of those points already have solutions or are likely to be improved in the future with the enhancement of the technology. One example is the case of R3 blockchain, which allows financial institutions to perform transactions whilst ensuring fast transaction speeds and data privacy, which were common problems in older blockchains (R3, n.d.). For that reason, this study focused only in advantages and constraints to BCT adoption in cross-border trade.

It is also important to mention that when authors discuss the characteristics of BCT, they are referring mostly to public BCs. In some cases, the separation between public, private and consortium BC is done but details and explanations are not provided. Furthermore, factors extensively referred to such as immutability (Elliot et al., 2021) or high energy requirements (Gunasekera & Valenzuela, 2020) do not apply in private and consortium BCs since they were designed for business purposes and prevent those issues from affecting the technology's efficiency.

Only a small subset of studies goes as far as detailing the differences between public, private and consortium BCs, referring how each differentiates the administrative roles, the permissioned access, the data integrity protocols and other controls (S. Chang et al., 2019; Juma et al., 2019; Mao et al., 2019).

BCT applications in cross-border trade are mostly used in business-to-business and business-to-government scenarios (ex. Customs authorities), with just some exceptions taking place in public BCs (WCO & WTO, 2022a). All these participants require, among other things, fast transaction speeds, scalability, high level of privacy in their transactions as well as a certain level of flexibility in terms of changing the data records they send to other parties to correct potential errors, re-negotiations or adjustments required. As it will be presented later in this chapter, that is best achieved using private or consortium BCs (Fridgen et al., 2021) and the differences are mentioned and discussed in the specific areas where they exist.

For the remaining of this chapter, the advantages and constraints of BCT adoption present in the literature are presented and discussed. Other studies such as Elliot et al. (2021) classified the constraints based on their nature: technological, governance or organisational, operational and legal.

Contrary to that, the classification in this thesis introduces the novelty of classifying BCT's advantages and constraints from the perspective of the institutions that may adopt it. This is particularly relevant since stakeholders can then better understand how this technology will affect specific areas of their organisations. Having defined the lenses through which the analysis is made, the next step involved grouping advantages and constraints with similar effects. Since

the lack of knowledge regarding BCT was one of the factors discussed in the literature (Batta et al., 2020; Elliot et al., 2021) the definition of these cohorts was kept simple and direct.

Once all factors were identified, it was possible to establish that decision-makers can use BCT to improve internal processes of the organisation, improve external processes (those involving partners) and optimise the use of technological solutions in the company. Even though internal and technological factors have a similar purpose, the impact each causes in the businesses is different, and for that reason they were kept separate.

In a similar way, the reasons that might prevent AEOs from adopting BCT might have to do with inefficient internal processes, limitations on the partner's side or current technological restrictions. Therefore, advantages and constraints presented in this study will be evaluated from internal, external and technogical perspectives.

## 4.1 Advantages of blockchain adoption

There are several benefits that BCT could bring to cross-border trade. Over the course of this chapter, the different advantages identified in the literature are discussed and grouped into one of three categories: internal, external or technological. Table 4.1 shows the classification of the advantages identified in the literature according to the categories defined in this study.

Table 4.1 *Advantages of blockchain technology in cross-border trade context*

| Perspective | Advantage identified | References |
|---|---|---|
| **Internal** | Operational efficiencies | Duan & Patel, 2018; Mao et al., 2018; S. E. Chang et al., 2019; Batta et al., 2020; S. E. Chang et al., 2020; Chang et al., 2020; Gunasekera & Valenzuela, 2020; Qian et al., 2020; Yoon et al., 2020; Balci & Surucu-Balci, 2021; Cao, 2021; Lian, 2022; Tian et al., 2022 |
| | Sustainable supply chains | Vilkov & Tian, 2019; Chang et al., 2020; Cao & Shen, 2022 |
| | Verifiability | Duan & Patel, 2018; Vilkov & Tian, 2019; S. E. Chang et al., 2020; Chang et al., 2020; Elliot et al., 2021; Min & Joo, 2022 |
| **External** | Impacts in the economy | Vilkov & Tian, 2019; Elliot et al., 2021; Kowalski et al., 2021; Lin, 2022 |
| | Improved supply chain management | S. E. Chang et al., 2019; Vilkov & Tian, 2019; Batta et al., 2020; S. E. Chang et al., 2020; Chang et al., 2020; Cao, 2021; Elliot et al., 2021; Fridgen et al., 2021; Ganne, 2021; Tyagi & Goyal, 2021; Min & Joo, 2022; Tian et al., 2022 |

Table 4.1a *Advantages of blockchain technology in cross-border trade context*

| Perspective | Advantage identified | References |
|---|---|---|
| **External** | Enhanced business transactions | Duan & Patel, 2018; S. E. Chang et al., 2019; Mao et al., 2019; Batta et al., 2020; S. E. Chang et al., 2020; Chang et al., 2020; Gunasekera & Valenzuela, 2020; Kowalski et al., 2021; Elliot et al., 2021; Fridgen et al., 2021; Lin, 2022; Min & Joo, 2022; Tian et al., 2022; Toorajipour et al., 2022 |
| | Disintermediation | Vilkov & Tian, 2019; Batta et al., 2020; S. E. Chang et al., 2020; Chang et al., 2020; Fridgen et al., 2021; Ganne, 2021; Lian, 2022;Lin, 2022; Min & Joo, 2022;Tian et al., 2022; Toorajipour et al., 2022 |
| | Establishing trust | Duan & Patel, 2018; Mao et al., 2018; Mao et al., 2019; Vilkov & Tian, 2019; Batta et al., 2020; S. E. Chang et al., 2020; Chang et al., 2020; Qian et al., 2020; Cao, 2021; Elliot et al., 2021; Ganne, 2021; Kowalski et al., 2021; Chuah, 2022; Lian, 2022; Min & Joo, 2022; Tian et al., 2022; Toorajipour et al., 2022 |
| **Technological** | Data Integrity | Juma et al., 2019; Mao et al., 2019; Min & Joo, 2022; Tian et al., 2022 |
| | Data privacy | S. E. Chang et al., 2019; Juma et al., 2019; Mao et al., 2019; Vilkov & Tian, 2019; Toorajipour et al., 2022 |
| | Data security | S. E. Chang et al., 2019; Juma et al., 2019; Batta et al., 2020; Chang et al., 2020; Qian et al., 2020; Yoon et al., 2020; Balci & Surucu-Balci, 2021; Elliot et al., 2021; Ganne, 2021; Tyagi & Goyal, 2021; Chuah, 2022; Lian, 2022; Lin, 2022; Min & Joo, 2022; Tian et al., 2022; Toorajipour et al., 2022 |
| | Interoperability with other technologies | Juma et al., 2019; Vilkov & Tian, 2019; Batta et al., 2020; S. E. Chang et al., 2020; Cao, 2021; Min & Joo, 2022 |
| | Immutability | S. E. Chang et al., 2019; Juma et al., 2019; Vilkov & Tian, 2019; S. E. Chang et al., 2020; Chang et al., 2020; Balci & Surucu-Balci, 2021; Elliot et al., 2021; Ganne, 2021; Tyagi & Goyal, 2021; Lamela et al., 2022; Min & Joo, 2022; Tian et al., 2022; Toorajipour et al., 2022 |
| | Decentralization | Juma et al., 2019; Mao et al., 2019; Qian et al., 2020; Balci & Surucu-Balci, 2021; Elliot et al., 2021; Tyagi & Goyal, 2021 |

Table 4.1b *Advantages of blockchain technology in cross-border trade context*

| Perspective | Advantage identified | References |
|---|---|---|
| **Technological** | Asset Traceability | Duan & Patel, 2018; Mao et al., 2018; S. E. Chang et al., 2019; Juma et al., 2019; Mao et al., 2019; Vilkov & Tian, 2019; Batta et al., 2020; S. E. Chang et al., 2020; Chang et al., 2020; Yoon et al., 2020; Balci & Surucu-Balci, 2021; Cao, 2021; Elliot et al., 2021; Fridgen et al., 2021; Ganne, 2021; Cao & Shen, 2022; Chuah, 2022; Lamela et al., 2022; Min & Joo, 2022; Toorajipour et al., 2022 |

### 4.1.1 Internal advantages

Internal advantages are benefits that can impact companies involved in cross-border trade if BCT is adopted and integrated into their internal processes. These come as operational efficiencies, development of sustainable supply chains and increased verifiability.

Operational efficiencies and improved productivity are a result of enhanced and reengineered processes, saving time and costs associated with unoptimized processes. According to Gunasekera & Valenzuela (2020), the adoption of the technology alone would contribute to an important rise in output which could be incremented by a wider adoption of the technology in other industries such as financial services.

Whilst BCT could indeed contribute to improve business processes and productivity, it is also worth considering that such efficiencies could be achieved, albeit at a lower degree, with other current technologies. However, for long businesses have struggled to agree on a common platform and could not influence legacy intermediaries such as banks to adapt their requests to the current needs. With BCT threatening banks' position as preferred intermediary and COVID-19 causing disruption on processes and requirements, even traditional industries were forced to acknowledge the importance to modernise their processes (Ganne, 2021).

Consequently, sustainability in supply chains is also improved in different ways. Specifically, the verifiability of BC ledgers will give the possibility of detecting any malicious stakeholders or any attempt to tamper the records (Elliot et al., 2021). Products can have a tamper-proof certificate of origin faster and easier to be reviewed by customs authorities (Tyagi & Goyal, 2021). Governments can also regulate less sustainable products and prevent or deter them from entering an incumbent's market, requiring the use of BCT to trace its origin (Cao & Shen, 2022). Lastly, sustainability is becoming more important for customers during the

decision-making process to buy a product. Vilkov & Tian (2019) found that by adopting BCT, companies will have the tools to easily provide customers with all the necessary information regarding the product origin and all the processes involved in the extraction, production, and transport. They can also promote the product as sustainable and can easily prove it. The competitiveness of the product is improved compared to other alternatives that do not provide similar information to the customers, because customers will be able to judge which option is more sustainable.

A pilot project by Heineken (2019) traced a batch of hops used in one of their beers and by scanning a QR code on the bottles' label, costumers could access information such as the year and location of cultivation of the crops and their carbon and water footprint. Although sustainability might not be one of the primary reasons why companies would adopt BCT, it can be an added benefit they can explore and add value to their products once implemented.

### 4.1.2 External advantages

External advantages are benefits and improvements that affect positively the trade processes and the way a company or organisation does business with its partners caused by the adoption of BCT.

Firstly, every BC keeps a record of transactions which can be useful in different trade scenarios. One example of its usefulness is to control the ownership and completion of bills of landing, since BCT can be used to transfer ownership of documents and cargo as well as verifying which party is holding the documents at a certain stage. This could expedite cross-border trade at different levels, since it would make stages, such as shipping and customs clearance that currently lengthy and heavily reliant on paperwork which needs verification, into faster and smoother processes (Ganne, 2021).

In terms of the overall positive impacts in the economy caused by the adoption of BCT, a wide array has been described in the literature. Vilkov & Tian (2019) highlight the creation of new jobs related to the development, implementation and management of the technology in businesses and institutions as well as the important step that it represents in the development of digital economies.

Although it is true that Web 3.0 and Industry 4.0 have the potential to create jobs in different areas and related to the new technologies involved in trade, it is also worth considering that with automation inherent to this technology, there is also the risk of eliminating existing jobs (Vilkov & Tian, 2019). For this reason, as governments introduce policies to regulate and

promote new technologies, these should go along with plans to requalify the current workforce that faces the risk of redundancy and lacks qualification to re-join the labour market.

CEOs interviewed by Elliot et al. (2021) refer that the adoption of BCT enables new business models although further details are not provided. Another aspect presented is that BCT can be used as a basis for a new platform that would rival the SWIFT monopoly for international settlements, since BC can easily integrate with digital currencies, preventing the United States of America from dictating which countries can access the platform (Lin, 2022). In this regard, it is important to consider that SWIFT and USD settlements play an important geopolitical role, however, this is considered an "advantage" to respect the authors point of view, i.e., a Chinese perspective of the matter which would prefer an independent platform that cannot be influenced by other countries. Even though this topic goes beyond cross-border trade and although the purpose for the suggestion of this idea is clear, in practice it would struggle to gain relevance. Other financial institutions and consortiums tried to create alternatives to the SWIFT, especially to carry international transactions with countries that are affected by sanctions, on platforms and technologies that were easier to adopt than BC. Even then, those alternatives struggled to gain relevance.

Implementing BCT will lead to improvements in management of current SCs. First the inherent digitalisation of SCs, as previously described. The communication inside companies and with their respective partners improves too (Batta et al., 2020; S. Chang et al., 2020; Tian et al., 2022), providing "immediate synchronization and reconciliation among participants" (Ganne, 2021, p. 420). The traceability features along with data integrity allow the origin of products to be traced to its origin and accompany them with a certificate of origin (Tyagi & Goyal, 2021), which is of vital importance in highly regulated products such as pharmaceutical goods (Juma et al., 2019). This provides a higher level of visibility and transparency into the supply chain that is not possible with current technology. The easy access to accurate date and shipment or cargo tracking details would lead to better informed decision makers and more efficient supply chains reducing current SC challenges such as the bullwhip effect (Yoon et al., 2020).

Lastly, the deployment of BCT requires a revamping of SC infrastructure across the different partners to ensure the technology can be exploited efficiently (Vilkov & Tian, 2019). However, this can also be one of the main causes of failure of BC implementation, according to Cecere (2022). The author pointed that the high cost required to implement the technology and digitalise the supply chain, meant that although many parties involved in cross-border trade were interested to pilot the technology in Tradelens and were backed by two giants in their own

industry (Maersk in shipping and IBM in IT), they did not succeed at creating a sustainable business model that would make it worth it or even profitable. Additionally, most businesses involved were not willing to share their corporate information in an external network. Walmart faced similar issues when trying to digitalise their food chains. Having only added one product to the digital chain in four years, the main constraint to the project had to do with process digitalisation at the farmers-end.

Another crucial advantage of BCT is its capacity to build trust between unfamiliar parties. On one side, partners rely on the technology to ensure that the other side's obligations are fulfilled instead of relying on third parties, creating an environment where trust is ensured by BCT (Toorajipour et al., 2022). On the other side, the record of transactions in BC facilitates the referencing process of a potential partner, having access to their history to ensure past obligations have always been fulfilled (Batta et al., 2020). Furthermore, the creation of a BC-based platform for trade finance or BC-based letters of credit would benefit small and medium enterprises who currently struggle to have their requests approved by banks due to the difficulty in building trust, and around 60% of their trade finance requests are rejected (Kowalski et al., 2021). To put this into perspective, the current trade finance gap, which measures the unmet demand for trade finance requests and is measured based on denied applications for funding is currently worth around 3.4 trillion US dollars, a figure that rose sharply after the Covid-19 pandemic (Beck, 2022; GSBN, 2013). According to Kowalski et al. (2021), the origin of this improvement is due to the data security structure of BC and the way the trust relationship is established using this technology. Lian (2022) developed this topic by creating a credit evaluation system for international trade enterprises which returned superior results compared to traditional models.

The use of BC could also enhance business transactions by making them cheaper, faster, risk-free and simplified. One of the ways this would be achieved is by cutting intermediaries. BC mechanisms create trust between parties without the need of authorised third parties involved in the transactions (Mao et al., 2019). By removing these intervenient, there would be less bureaucracy involved, streamlining processes and cutting time and intermediation costs inherent to current transactions (Toorajipour et al., 2022). Lastly, payments processed by BC are "irrevocable and unconditional", preventing claims from ill-intended business partners (Min & Joo, 2022, p. 225).

Despite BCT's potential to change corporate trust, a full disintermediation scenario is not likely to occur in the early stages of the adoption. An example of such limitation occurs in trade finance where banks have their own interests in the trade process and will make BCT adoption

harder if that means they will get excluded from it. (Fridgen et al., 2021). Additionally, “banks role as liquidity provider (…) is oftentimes neglected…” meaning that although BCT can be adopted in trade finance, it is more likely to represent a change of platform and process optimization rather than a full process disruption without intermediaries (Fridgen et al., 2021, p. 570). Lin (2022) made a similar proposal where companies would use a BC-based platform to submit documents, but banks would still participate in the trade finance process.

One example of what is aforementioned is R3 Corda, a regulatory-compliant, permissioned DLT platform created for financial institutions. It is currently the largest consortium of financial institutions developing DLT applications, with over 200 banks, regulators, trade associations and others (Mao et al., 2019). Those involved can develop their own BC-based, peer-to-peer applications in a scalable way while ensuring the benefits of private BCs such as privacy, security and interoperability. The platform supports fiat and digital currencies as well as the implementation of smart contracts (r3, n.d.).

### 4.1.3 Technological advantages

Technological advantages are improvements brought by the adoption of BCT compared to other technologies currently in use. These are characteristics of BCT and cannot be easily replicated in other technologies.

Across the literature, different technological advantages of BCT adoption are discussed. The assurance of data integrity is the first advantage. In this regard, the immutability feature of BCT assures its users that data contained in the ledgers is original (Juma et al., 2019). To achieve this, each user controls its own ledger with records that are approved and equal to that held by the majority of other users in the same BC. Holding the ledgers in a decentralized manner where the approval is achieved through a consensus mechanism is key to ensure integrity and similarity among all ledgers (Lamela et al., 2022).

There are substantial differences depending on the type of BC in use, however the commonality among the three types is that it is not easy to tamper the records on the ledger. In public BCs, it would be necessary to control the majority of the computing power to change the records, which makes it tamper-proof, in theory. In private and consortium BCs, the administrative nodes would need to approve the requested changed.

At the same time, and making use of the same characteristics, the security of those ledgers is also ensured. Due to the use of cryptography to provide security (Tian et al., 2022), a malicious attacker would require high computational power to change ledgers in a BC. For this

reason, it can be said that the technology is tamper-proof. However, the level of security changes from private to public BCs. While private BCs have a limited number of approving nodes, public BCs assign approving rights to all nodes, increasing substantially the system's security (Mao et al., 2019).

Though there are certain concerns regarding data privacy in BCs, in most cases, especially in private and consortium BCs, companies can securely send and receive data without the risk of information leakage. Regardless of the decentralized feature of this technology, only the approved nodes can see details present in the communication (for instance, a company and its supplier) without the risk of competitors accessing details such as purchase price and quantities (Tradeix, 2017, as cited in Toorajipour et al., 2022).

Additionally, BCT can integrate seamlessly with other technologies such as 5G, RFID, NFC, AI among others. However, most studies analysed point to the integration with IoT, since there are several benefits that can be taken from that coupling. Specifically, the trace and tracking capabilities of IoT while sending data to the BC, the use of IoT sensors to track different parameters in different conditions (for example, temperature of cargo containers), the replacement of human data-input with IoT input to eliminate data entry errors among others. Lastly, BCT also allows the creating of digital twins, capturing different data points of physical goods in real time (Batta et al., 2020).

BCT is commonly referred as a decentralized technology because the control of the ledgers is not under one party, but rather distributed amongst participants. Although this is true for public BCs, the level of decentralization changes if it is a consortium or private BC. In those cases, there is a single or a group of administrative participants responsible for ensuring the smooth running of the BC, which makes the BC only partially decentralized or centrally managed (Mao et al., 2019). This is relevant to the participants of cross-border trade since, ideally, the platforms adopted for this purpose would be either private or consortium. This way, only the participants would have access to transaction data ensuring data privacy, faster transaction speeds and specific features necessary in business scenarios such as flexible immutability (capacity to change transaction data in case it is necessary and agreed by all parties).

Traceability is another characteristic of BC that can add value to cross-border trade. Every transaction is recorded in the BC is time-stamped and immutable. Companies can use the technology to ensure that products (ex. food) originate from sustainable sources. Additionally, because the technology is time-stamped, the date of the transaction is recorded on the ledger

but other features such as location can also be kept in the BC and be seen by all participants, increasing transparency of the SCs.

## 4.2 Deploying blockchain-based solutions to solve cross-border trade challenges

Having analysed the most relevant benefits that BCT can bring to businesses and institutions involved in cross-border trade, it is possible to understand how this technology can relieve the pain points described earlier in the thesis and systematised in Table 4.2. The individual contribution of the advantages to each challenge is displayed in Figure 4.3

Firstly, BCT is crucial to digitalise trade, specifically by enabling secure paperless transactions and improving the transparency speed and cost of doing business transactions (Y. Chang et al., 2020). Besides that, adopting digitised processes in cross-border trade is the cornerstone to solve other pain points identified such as compliance, fraud prevention and traceability. Additionally, the paper documents required in cross-border trade can be lost or outdated if changes are not recorded. Digital bills of landing, customs declarations and other documents used in cross-border transactions would ensure every party involved had access to the latest information in real time and expedite customs procedures (Ganne, 2021). However, BCT is only a part of the solution. The integration with other technologies such as IoT and AI is an important step to exploit the benefits of technology in trade to its full potential. On one hand, IoT would improve the quality and quantity of data inputs in the ledgers and other the other hand, AI has the potential to disrupt SC management, improving optimal routes calculation or the way customs verifications are done.

However, the outcome of the pilot project done by Walmart shows that BCT would be better applied at this stage in industries that already have some level of digitalisation, for ex., in shipping trade. Additionally, according to a report by WCO and WTO (2022b), even though some customs agencies are becoming fully digitalised, there is still a lack of agreement regarding standardization (ex. data formatting) which hinders the development and implementation of a solution where all parties involved can perform transactions.

Another area that can be improved with the introduction of BCT is traceability. Currently technologies struggle to keep stakeholders informed of the history of location and ownership of cargo and documents. Due to its architecture, BCT contributes to the solution of that problem, providing time-stamped records of owners and location of assets. Additionally, if coupled with IoT devices, the level of detail recorded can improve other aspects of SC management such as food chains and cold chains.

| | Trade digitalisation | Traceability | Dispute resolution | Cargo integrity and security | Trust | Compliance |
|---|---|---|---|---|---|---|
| Operational efficiencies | x | x | x | | x | x |
| Sustainable supply chains | x | x | | | | x |
| Verifiability | x | x | x | | x | |
| Impacts in the economy | | | | | x | x |
| Improved supply chain management | x | x | x | | | |
| Enhaced business transactions | x | x | x | | | x |
| Disintermediation | | | x | | x | |
| Establishing trust | | x | x | | x | x |
| Data integrity | x | x | x | | x | |
| Data privacy | | | | x | | |
| Data security | x | | | x | | |
| Interoperability | x | x | x | x | | |
| Immutability | | x | x | x | | x |
| Decentralization | | | | | x | |
| Asset traceability | x | x | | | | x |

Figure 4.3 *Advantages of blockchain technology adoption and its contribution to solve cross-border trade challenges*

Dispute resolutions are another area that can be improved with the implementation of this technology. One way to achieve that is with the use of smart contracts in the transactions between parties. Since these agreements are automated and based on pre-conditions agreed by both parties, as long as both sides fulfil their obligations, the transaction will be completed. In case either side fail to complete the required steps at the different stages of the smart contract, the transaction will fall through. To ensure that BCT does not become a burden instead of a solution, further regulation is needed to clarify those involved about the right ways to employ the technology in the agreements.

Regarding cargo integrity and security, BCT can support with the prevention of different kinds of fraud and theft. Security at ports can be upgraded to ensure that third party logistics, freight forwarders or other transportation companies involved are the only ones accessing their

containers. Additionally, the implementation of IoT devices can track the location of containers and record every time someone accessed the cargo. In food chains, this could be used to verify the temperature stayed within the optimal range and ensure the quality is not affected.

Furthermore, the immutability features and the record of transactions of each ledger will prevent ill-intended parties from double charging a business for the same cargo. Currently, that is possible due to the processes reliant on paperwork and not having one system updated at all times. BC could prevent that by being the most updated source to track all transactions.

However, it is worth considering that the application of BCT to cross-border trade needs regulation since some of the characteristics of BCT facilitate money laundering schemes. In particular, regulators should pay attention to the paperless nature of the technology and procedures, the ease of establishing new contracts, the decentralization of networks, the disintermediation and lastly, the potential use of cryptocurrency or virtual assets to settle transactions (Chuah, 2022).

BCT can also contribute to the improvement of compliance requirements. An example is the optimization of the current processes of custom authorities pointed by Batta et al. (2020). Not only would be customs declarations become digital, the customs agents would have improved visibility regarding the declared goods and the different customs authorities could be linked in a single platform for improved connectivity and transparency (WCO, 2018). According to the latest reports from WTO and WCO, the projects in this specific area are gaining momentum with dozens of agencies implementing pilot projects and proofs of concept, with 2 countries having fully implemented BC-based customs solutions. In business-to-business transactions, BCT can help with a faster verification of all the requirements regarding safety, integrity, sustainability, sourcing and others since all that information is recorded on the BC during the different stages a product goes through.

Lastly, trust is another area already being impacted by BCT. Placing the trust mechanisms on the technology rather than on intermediaries, businesses can change the way transactions are processed, improving both the speed and the cost it takes to do business. It is also easier to verify the history of an unknown partner and all the information related to the products exchanged is recorded in a tamper-proof ledger, preventing any sort of misconduct. Furthermore, although BCT is often seen as a way to cut out third parties and intermediaries, that is not the reality yet and banks and financial institutions are amongst some of the most interested parties to develop BC-based applications, such as the case of R3. The role of banks goes beyond the functions of holding and transferring funds to both parties in the transactions, they are also liquidity providers and cannot easily be replace. With the use of BCT, they can

simplify and even automate some of the current processes that are heavily reliant in paperwork and extensive credit checks. With that, smaller businesses might have the opportunity to access trade finance liquidity solutions.

For all these reasons, BCT has the potential to optimize and potentially disrupt some cross-border trade processes. However, that are aspects to the technology and some business-related facts that need to be addressed before BCT reaches a stage where it can be adopted by a larger number of businesses and organizations. Those factors will be discussed in the next subchapter.

Table 4.2 *Current challenges in cross-border trade*

| **Challenge** | **References** |
|---|---|
| Traceability | Duan & Patel, 2018; Mao et al., 2018; S. Chang et al., 2019; Juma et al., 2019; Mao et al., 2019; Vilkov & Tian, 2019; Batta et al., 2020; S. Chang et al., 2020; Chang et al., 2020; Gunasekera & Valenzuela, 2020; Qian et al., 2020; Yoon et al., 2020; Balci & Surucu-Balci, 2021; Cao, 2021; Elliot et al., 2021; Ganne, 2021; Cao & Shen, 2022; Chuah, 2022; Lamela et al., 2022; Min & Joo, 2022; Tian et al., 2022; Toorajipour et al., 2022; Yang et al., 2022 |
| Dispute resolution | S. Chang et al., 2019; Juma et al., 2019; Vilkov & Tian, 2019; Batta et al., 2020; S. Chang et al., 2020; Chang et al., 2020; Gunasekera & Valenzuela, 2020; Balci & Surucu-Balci, 2021; Ganne, 2021; Chuah, 2022; Lamela et al., 2022; Min & Joo, 2022; Toorajipour et al., 2022 |
| Cargo integrity and security | Duan & Patel, 2018; Juma et al., 2019; Vilkov & Tian, 2019; Batta et al., 2020; S. Chang et al., 2020; Chang et al., 2020; Qian et al., 2020; Balci & Surucu-Balci, 2021; Elliot et al., 2021; Fridgen et al., 2021; Ganne, 2021; Tyagi & Goyal, 2021; Chuah, 2022; Kowalski et al., 2021; Lamela et al., 2022; Min & Joo, 2022; Toorajipour et al., 2022 |
| Trade digitalisation | Mao et al., 2018; S. Chang et al., 2019; Epps et al., 2019; Juma et al., 2019; Mao et al., 2019; Vilkov & Tian, 2019; Batta et al., 2020; S. Chang et al., 2020; Chang et al., 2020; Gunasekera & Valenzuela, 2020; Qian et al., 2020; Yoon et al., 2020; Balci & Surucu-Balci, 2021; Cao, 2021; Elliot et al., 2021; Fridgen et al., 2021; Ganne, 2021; Kowalski et al., 2021; Tyagi & Goyal, 2021; Chuah, 2022; Lamela et al., 2022; Min & Joo, 2022; Tian et al., 2022; Toorajipour et al., 2022; Yang et al., 2022 |

Table 4.2a *Current challenges in cross-border trade*

| Challenge | References |
|---|---|
| Compliance | Epps et al., 2019; Juma et al., 2019; Vilkov & Tian, 2019; Batta et al., 2020; S. Chang et al., 2020; Chang et al., 2020; Qian et al., 2020; Balci & Surucu-Balci, 2021; Cao, 2021; Elliot et al., 2021; Ganne, 2021; Tyagi & Goyal, 2021; Cao & Shen, 2022; Chuah, 2022; Lamela et al., 2022; Min & Joo, 2022; Tian et al., 2022 |
| Trust and stakeholder management | Duan & Patel, 2018; Mao et al., 2018; S. Chang et al., 2019; Mao et al., 2019; Juma et al., 2019; Vilkov & Tian, 2019; Batta et al., 2020; S. Chang et al., 2020; Chang et al., 2020; Gunasekera & Valenzuela, 2020; Qian et al., 2020; Balci & Surucu-Balci, 2021; Cao, 2021; Elliot et al., 2021; Fridgen et al., 2021; Ganne, 2021; Kowalski et al., 2021; Chuah, 2022; Lamela et al., 2022; Lian, 2022; Lin, 2022; Min & Joo, 2022; Tian et al., 2022; Toorajipour et al., 2022; Yang et al., 2022 |

## 4.3 Constraints to blockchain adoption

Similar to the classification applied to the advantages, the constraints identified were also assigned to one of the three categories that cover the potential perspectives of decision-makers in different organisations: internal, external and technological. These are factors currently limiting the adoption of BCT by a larger number of AEOs involved in cross-border trade. Table 4.3 shows the constraints assigned to the categories defined previously.

Table 4.3 *Constraints to blockchain technology adoption in cross-border trade context*

| Perspective | Constraint identified | References |
|---|---|---|
| **Internal** | Lack of knowledge and understanding about BCT | Batta et al., 2020; Balci & Surucu-Balci, 2021; Elliot et al., 2021; Min & Joo, 2022 |
| | Lack of organisational readiness and competence | S. Chang et al., 2019; Vilkov & Tian, 2019; Batta et al., 2020; Elliot et al., 2021; Min & Joo, 2022; Toorajipour et al., 2022 |
| | Investment and running costs | Juma et al., 2019; S. Chang et al., 2020; Balci & Surucu-Balci, 2021; Elliot et al., 2021; Fridgen et al., 2021; Min & Joo, 2022; Toorajipour et al., 2022 |
| | Sustainability | S. Chang et al., 2019; Elliot et al., 2021; Kowalski et al., 2021 |

Table 4.3a *Constraints to blockchain technology adoption in cross-border trade context*

| Perspective | Constraint identified | References |
|---|---|---|
| **Internal** | Security concerns | S. Chang et al., 2019; Mao et al., 2019; Vilkov & Tian, 2019; Batta et al., 2020; S. Chang et al., 2020; Qian et al., 2020; Balci & Surucu-Balci, 2021; Elliot et al., 2021; Kowalski et al., 2021; Tyagi & Goyal, 2021; Min & Joo, 2022 |
| **External** | Adoption of BCT by business partners | S. Chang et al., 2019; Juma et al., 2019; Vilkov & Tian, 2019; Batta et al., 2020; Balci & Surucu-Balci, 2021; Elliot et al., 2021 |
| | Lack of regulation | Epps et al., 2019; Juma et al., 2019; Vilkov & Tian, 2019; S. Chang et al., 2020; Gunasekera & Valenzuela, 2020; Qian et al., 2020; Balci & Surucu-Balci, 2021; Elliot et al., 2021; Ganne, 2021; Kowalski et al., 2021; Tyagi & Goyal, 2021; Chuah, 2022; Lamela et al., 2022 |
| **Technological** | Data accuracy | Kowalski et al., 2021; Tyagi & Goyal, 2021; Lamela et al., 2022; Min & Joo, 2022 |
| | Early stage of development and lack of early adopters | S. Chang et al., 2019; Batta et al., 2020; S. Chang et al., 2020; Vilkov & Tian, 2019; Balci & Surucu-Balci, 2021; Elliot et al., 2021 |
| | Immaturity of the governance model | Vilkov & Tian, 2019; S. Chang et al., 2020; Elliot et al., 2021 |
| | Integration and interoperability | Juma et al., 2019; Vilkov & Tian, 2019; Batta et al., 2020; S. Chang et al., 2020; Gunasekera & Valenzuela, 2020; Qian et al., 2020; Elliot et al., 2021;Kowalski et al., 2021; Min & Joo, 2022 |
| | Lack of standardisation | Vilkov & Tian, 2019; S. Chang et al., 2020; Qian et al., 2020; Min & Joo, 2022 |
| | Performance and scalability | Mao et al., 2018; S. Chang et al., 2019; Juma et al., 2019; Mao et al., 2019; Vilkov & Tian, 2019; S. Chang et al., 2020; Gunasekera & Valenzuela, 2020; Elliot et al., 2021; Kowalski et al., 2021; Lamela et al., 2022; Min & Joo, 2022 |

### 4.3.1 Internal constraints

Internal constraints are those preventing participants of cross-border trade from adopting BCT due to the organisation's structure, internal processes or limitations. The organisation has some power to affect these constraints.

In terms of internal factors, across the literature analysed, one of the factors mentioned hindering the adoption of technology is the lack of knowledge and understanding about BCT, specifically decision-makers'. Elliot et al. (2021) found that such deficiencies limit those in charge of creating business models and applying best practices that exploit the advantages of this technology. In a survey conducted in the same study, despite 57% of respondents claiming to know what "blockchain" is, only 11% consider themselves as "knowledgeable or very knowledgeable" about the topic (Elliot et al., 2021).

Despite BCT in trade being a recurrent topic at least since 2018 when the WTO launched the first report on the matter, business owners and decision makers are still significantly unaware and unknowledgeable about the topic. Part of this might be due to the lack of a solution ready to be deployed in most businesses since at the moment, most projects are at the pilot stage or proof of concept stage. A potential solution for this would be increasing the awareness of the topic, not only in academia, preparing the current students that will soon join the labour market as well as sessions for management executives, to spread knowledge about the topic and support the decision making process regarding the technological transition.

Another factor widely discussed in literature is the lack of organizational readiness and competence. For starters, most companies do not have professionals in-house qualified to implement a change of this dimension. Adopting a BC-based solution might require a deep change in a company's IT department and lack of technical expertise will be one of the biggest barriers. Additionally, BCT is more demanding in terms of computational power and energy requirements than current IT platforms, therefore the existing infrastructure of most companies would have to be replaced which would require time and significant funds (Elliot et al., 2021).

The lack of technological infrastructure affects not only the adoption of BCT but also all the other technologies previously referred in this study that can disrupt cross-border trade, especially the internet-based ones. Many companies still rely on manual processes that could be digitised or even automated, however, the lack of technological infrastructure is holding them from adapting and will eventually affect their competitivity. Not only that, other businesses in their SC trying to digitalise their processes might be affect by smaller businesses relying on paper-based workflows, as was the case with Walmart. In the case of the American retailer, the adoption of a BC-based platform is struggling to gain momentum because a large amount of farmers in their supply chain rely on paper-based processes (Green, 2023).

At the same time, even if an organization decides to move forward and adopt BCT, there are risks associated with the implementation such as disruption of the business, unforeseen

problems and costs and ultimately system faults or deficiencies that could result in a reversibility to the older system and consequent waste of resources (Vilkov & Tian, 2019).

Implementing new systems also require new training for staff and reengineering processes if the change is disruptive as it is the case with BCT. In like manner, most companies are not ready add these risks to business continuity since it could affect the way the company is run and its performance for customers and clients (Balci & Surucu-Balci, 2021; Toorajipour et al., 2022).

Lastly, other factors to consider is that organizations trust their current intermediaries and are not looking to change to a decentralized solution or initiating the process of building trust with new partners (Vilkov & Tian, 2019). Moreover, some companies might be locked-in to contracts with their current providers and cannot easily transition to a BC-based alternative (Batta et al., 2020).

All of the changes and disruptions discussed come at a cost. Besides the time spent and opportunity cost of interrupted business, adopting this technology requires a financial investment that most companies might not be ready to make as well as supporting the higher maintenance costs due to the infrastructural and technological requirements (Juma et al., 2019; S. Chang et al., 2020; Fridgen et al., 2021; Min & Joo, 2022).

Another factor holding companies from moving forward with BCT is the concern regarding sustainability. BCs require high computational power and energy use, especially the ones using Proof-of-Work consensus mechanism. Businesses are therefore concerned that using this technology will not only affect their sustainability goals negatively but also be forced to make changes further down the road if any legislation is passed concerning energy efficient BCs (S. Chang et al., 2019; Elliot et al., 2021; Kowalski et al., 2021).

An additional constraint mentioned in the literature selected concerns data security and privacy concerns. This is composed of different layers. Firstly, is the lack of trust towards BCT usually ensured via authorized third-parties such as banks and other intermediaries, BCT has the capacity to generate a trusted environment of its own. However, depositing trust in this new technology is still a big step take since stakeholders do not understand BCT enough to trust it (S. Chang et al., 2020). As Balci & Surucu-Balci (2021) mention, this can be related either to the innovative way this technology is built or because it is mistaken with the cryptocurrencies and associated volatility.

Secondly, there are privacy concerns regarding sharing business sensitive information in BC platforms. The same author presented the specific example of maritime supply chains, where data such as “customers, suppliers, and freight details” could be accessed by their

business partners. As mentioned before, this could be detrimental to the business model of forwarders and intermediaries that benefit form information asymmetry (Balci & Surucu-Balci, 2021, p. 7). Similar concerns were identified by Tyagi & Goyal (2021) regarding the privacy of details shared in the BC used to validate country of origin certificates. In the proposed framework, the details of the importers and exporters would be left exposed. Another concern to consider is the potential loss of data of the access key is lost or stolen. Part of the security architecture of BCT relies on user's private keys, although this is a bigger concern of frameworks using public BCs (S. Chang et al., 2019; Vilkov & Tian, 2019).

Adding to the security discussion is the decentralised characteristic of BCT. According to (Juma et al., 2019, p. 184130), "Centralisation and decentralisation are not absolute values". Although commonly referred to as such in different studies, that is not always the case. The same author clarified this providing examples. In some instances, decentralized BCs might need to attribute authority roles to trade regulators or e-commerce platform while relying on many nodes to validate and control the ledgers. On the contrary, critical business scenarios requiring a role of authority such as validation of documents and assessment of shipments at a customs bureau will be handled differently. In such cases, the automation of those administrative processes would be achieved "using centralised permissioned blockchain" (Juma et al., 2019, p. 184130).

The last point to be considered is the security of different types of BCs. In permissionless BCs, an attack would require the attackers to control the majority of the nodes. This would be made even more difficult due to the large amount of user that public BCs can have. On the other hand, private and consortium BCs have a smaller number of approving nodes and users, which makes a malicious attack more viable, however, due to the limited number of participants it is also possible to use other safety features to increase the overall security of the platform (S. Chang et al., 2019).

### 4.3.2 External constraints

External constraints are factors external to the organisation that affect whether BCT is considered. The organisation does not have enough power to affect these factors by itself.

In terms of external constraints, the lack of regulation regarding BC transactions is the biggest impediment as it stands. Businesses have been asking for BCT-related regulation for years, however, governments are still discussing frameworks in international organisations or are taking a long time to implement them at a national level (Kowalski et al., 2021). For that

reason, businesses will not proceed to adopt the technology and digitalise trade processes if they do not have laws to fall back onto in case there are serious trade disputes. Business stakeholders claim that "legal developments need to keep pace with technological advancement" (Ganne, 2021, p. 421). According to the same author, due to the unexpected limitation during the Covid-19 pandemic, banks were forced to ease some requirements, proving the misalignment between current legislation and practices. However, the number of regulators adopting the same practice was much lower (Ganne, 2021).

There are three main pieces of regulation required to promote trade digitalisation. Firstly, the recognition of e-signatures. Secondly, recognition of electronic documents and respective transfers between owners (bills of landing, bills of exchange, warehouse receipts, promissory notes, etc.). Thirdly, clearing existing doubts regarding rights and liability frameworks of using BCT, for example regarding the customs clearance, since BCs can have contributions from different participants opposed to the current rules requiring only one liable declarant (Ganne, 2021).

Other authors also point the necessity for a framework agreement for smart contracts and to define which rules apply to the BC transactions, whether that is the seller or buyers' country's rules or if there will be a special global legislation to regulate BCs (Gunasera & Valenzuela, 2020; Elliot et al., 2021; Ganne, 2021).

Regulatory agreements should be reached with a global approach to ensure the optimization of the trade digitalisation process. Such discussions can be reached in the World Customs Organization or via trade agreements between the different jurisdictions (Ganne, 2021).

One country that already has specific legislation in place for DLT and smart contracts since 2019 is Italy. Not only it provides the legal definition it also ensures that agreements in these platforms are valid and enforceable, ensuring that these are equivalent to traditional contracts. However, the legislators still recommend caution on the use of these agreements due to the lack of international agreements (WCO & WTO, 2022b).

Businesses are limited in the adoption of BCT by their trade partners, too. Balci & Surucu-Balci (2021) discussed the lack of support from influencing stakeholders, since those are the ones that have the power to convince other partners in the supply chain to adopt BCT. More specifically, Balci & Surucu-Balci (2021) presented findings for maritime supply chains, stating that those who have more urgency to adopt this technology, such as container lines and port/terminals are not always the same that have the power to implement BC at a wide-scale in the supply chain. According to the same author, beneficial cargo owners/shippers, customs authorities, government authorities (other than customs) and container lines held the biggest

power in their supply chains while only the later overlaps in both categories (Balci & Surucu-Balci, 2021).

Besides, the purpose of BCT adoption in cross border trade and global supply chains is to create an uninterrupted flow of information to track the products from origin until it reaches the customer. However, to achieve that, a large number of stakeholders are required to adopt it, since the number of players involved in manufacturing, transportation and distribution can easily amount. This is particularly important in supply chains that are adopting BC-based solutions to prevent the sale of counterfeit goods such as drugs, where the whole process should be tracked (Min & Joo, 2022). Players in the supply chain that resist or refuse to adopt the technology might defeat the whole point of using technology as a certificate of origin and authenticity. It is worth considering that some businesses may resist the adoption because they cannot clearly see the benefits since technological adoption in their industry is low and they will not benefit from economies of scale (Batta et al., 2020; Gunasekera & Valenzuela, 2020). In such cases, the most powerful stakeholders in the supply chain are required to decide whether they are willing to have missing nodes on the BC or instead, force the business partners to adopt the technology and choose new ones in case they decline. This was the strategy adopted by Walmart when the company wanted to implement BCT in some of their food supply chains. Accordingly, "the registration of some of the manufacturers, freight forwarders, or even shipping agents as active participants in the blockchain may be barred" which presents another challenge to the stakeholders (Juma et al., 2019, p. 184130).

Lastly, it is worth considering that the transparency provided by BCT might not benefit all member of trade supply chains. This is particularly true for forwarders/3PLs, cargo brokers, and small and medium cargo owners who benefit from information asymmetry to improve their revenues (Balci & Surucu-Balci, 2021). The same applies for banks and other financial intermediaries whose business models, specifically cross border transactions and Letters of Credit, can be affected by the disintermediation via BC. This conflict of interest is outside the realm of a business's decision making (Fridgen et al., 2021).

### 4.3.3 Technological constraints

Technological constraints are related to current limitations of BCT affecting negatively the decision to adopt the technology. Businesses might prefer to postpone the transition until some of these factors are resolved, since they cannot affect them by themselves.

In this study, six technological constraints were identified. Firstly, the early stage of development and lack of early adopters of BCT creates a snowball effect preventing further adoption in businesses. Most common claims revolve around the lack of early adopters, especially big stakeholders that can influence their own supply chain partners as well as the absence of fully implemented projects that could serve as a real-life proof of concept and setting blueprints for other projects. Additionally, the limited functionalities of the current BC solutions available adds to the difficulty of convincing businesses and other institutions to adopt the technology since they struggle to clarify the benefits at this stage (Vilkov & Tian, 2019).

Secondly, the absence of a solidified governance model is another technological aspect worth considering. Companies need further clarity regarding their decision-making rights and accountability. Considering the current GDPR regulation, if a data breach occurs, it is unclear which party would be held accountable for it, the business who uses the BC and inputted the data or the company who developed the BC and is responsible for its security (Elliot et al., 2021)?

The governance of the financial transactions needs further clarifications too. Traditional banks have procedures in place to prevent financial fraud and money laundering but those checks and balances have not been fully developed for BC-based platforms. Additionally, the nonexistence of a governing body of the BC to investigate and control exploits of the system means consumers will not have anyone to "provide simple services or cancel previously conducted transactions if necessary" (Vilkov & Tian, 2019, p. 394) .

Interoperability between different BCs is another barrier to adoption. Due to the lack of standardization and international agreements, interoperability and lack of standardization are limiting factors since these affect negatively not only the adoption but also the development of the technology. Studies point out that the lack of coordination and standardized rules between businesses, academia and government to define a common ground to the different platforms might hinder the development of BC-based solutions. That could eventually limit the establishment of consortiums as different BC applications might not be linked, defeating the purpose of wide adoption, affecting the productivity and creating additional processes that could have been streamlined if there were interfaces between the different BCs (Vilkov & Tian, 2019; Y. Chang et al., 2020; Min & Joo, 2022).

Y. Chang et al. (2020) pointed that solutions like Cosmos or Polkadot could solve the problem of interconnectivity between different BCs and transfer assets between decentralized ledgers. These platforms are meant to serve as bridges between the different BC-based applications and avoid the development of connections between each BC. However, since that

study was done the problem remains the same and according to WCO and WTO's research (2022b), interoperability between BCs is one of the main factors affecting BC efficiency.

On the other hand, interoperability with existing technologies is not easier and besides being a complex procedure, it can also be an expensive one. Although BCT can integrate with newer technologies such as IoT, linkage to current enterprise resource planning software is not fully developed yet although some solutions are already available on the market, such as SAP (Macaulay, 2022). Additionally, current literature suggests the integration of processes that are not digitalised and reliant on paperwork can be a challenge to some businesses since it would require them to revamp other aspects of the business. Lastly, some businesses are tied to existing legacy systems on long contracts, preventing them from adopting newer solutions (Batta et al, 2020; WCO & WTO, 2022b)

BC as a technology prioritizes security over performance, and as more layers of security are added to it, the performance of the BC will be negatively affected (Juma et al., 2019). Currently, there are four main barriers to scalability, namely the high computational power and large internet bandwidth required (Juma et al., 2019), high energy input required (Gunasekera & Valenzuela, 2020), large data storage needs (S. Chang et al., 2019) and lastly, the speed of transactions, limited by the approval of all nodes required (Mao et al., 2018). All these processes lead to low efficiency transactions that limit the potential size of the BC. This is particularly relevant for the biggest businesses currently performing several thousand of transactions per second and constantly in need of scaling their technological platforms. This is one of the reason why pilot projects struggle to move towards large-scale implementation, since operational resiliency of systems cannot be ensured (Juma et al., 2019).

As Juma et al. (2019) presents it, public BCs such as Ethereum that were used as the basis of different conceptual frameworks studied, can process around 15 transactions per second. On the other hand, private BCs such as IBM's Hyperledger Fabric, more suitable for business environments, support circa 3500 transactions per second. Both figures lag considerably behind the processing needs of Visa, for example, which required 25,000 transactions per second.

The technology has evolved considerably and solutions like R3 based on a consortium BC, used by banks and other financial institutions can now meet some of the demands of private businesses in terms of scalability and transaction speed whilst keeping the security levels high. As BCT progresses it is expected that these solutions can meet the largest businesses' needs.

Lastly, the energy consumption in all types of blockchains has decreased significantly with the introduction of a new consensus mechanism that goes beyond the focus of this thesis (Mao

et al., 2019). Even then, different authors point out that adopting BCT could affect businesses' sustainability goals and claims (S. Chang et al., 2019; Elliot et al., 2021; Kowalski et al., 2021).

The last technological constraint identified is code rigidity and data accuracy. Although immutability is presented in this study as an advantage too, there is a practical trade-off worth considering that potential adopters still do not know how to solve. Unchangeable data can lead to errors if the input is incorrect (by mistake or malicious attempt) or in case there is a need for changes, hacks, unforeseen circumstances and renegotiations. In such scenarios, updating smart contracts would be a valuable feature (Elliot et al., 2021). One possible solution is the creation of data integrity protocols, since the technology to detect such errors is not yet developed. Furthermore, "incorporating the BC ecosystem with the Internet of things, which further reduces human input, might be a possible solution in this regard." (Kowalski et al., 2021, p. 7).

Furthermore, the code rigidity of smart contracts might prove negative in certain business scenarios given that some changes might be needed but hard to implement. One way to solve this was presented by Toorajipour et al. (2022) by setting up smart contract in different stages, meaning that in case of any alterations the process could be stopped in time. Despite this tool's capability to enhance the trade processes, the automation mechanisms create additional risks that can be dangerous since they carry values and rights to assets (Kowalski et al., 2021).

### 4.4 Contributions to the existing theory

The theoretical contributions of this study are threefold. Firstly, the research done in this thesis fills the gaps identified in current literature concerning the lack of systematic literature reviews in cross-border trade, identification of the major contributing factors and stakeholder's perspectives. This study can be used as an updated source of systematised information for future researchers looking for an updated view on the topic. This thesis also addresses cross-border trade as a whole, whilst other SLRs have focused in specific stages such as shipping or transportation only (Batta et al., 2020; Balci & Surucu-Balci, 2021).

Secondly, a thorough search of literature yielded no results regarding systematic literature reviews of cross-border trade articles using the PRISMA methodology. To the best of the author's knowledge, this thesis is the first to apply this methodology to this particular topic.

Lastly, the classification of advantages and constraints in three categories according to businesses' perspectives is original to this study and the main link to the stakeholder theory which is the foundation of this study. Other studies have classified advantages and constraints by their nature, whilst this study focuses on the potential adopters' perspectives. The intent of

this approach was, on one hand, to understand if there are any major benefits prompting decision-makers to adopt BCT or conversely, what is holding them from doing it. On the other hand, decision-makers can refer to this study to quickly understand how BCT would impact their organisation.

Furthermore, the involvement of all stakeholders in a complex process such as technological transition is paramount to its success. In fact, throughout this study it became clear in some examples the lack of a coordinated approach involving most stakeholders contributed to the failure and slow development in the major projects here described such as Tradelens or Walmart's. In both cases, the non-alignment with suppliers and governments created difficulties to the widespread adoption of BCT.

### 4.5 Implications for practice

On a managerial level, this thesis provides a clear perspective to stakeholders involved in trade (corporations, governments, agencies, organisations, academia and others) about what is the latest state-of-the-art of the most relevant projects and barriers preventing BCT adoption. BCT is at a crucial stage for its large-scale implementation, however some concerns need to be addressed while the technology implementation is in its early stage to prevent costly barriers further ahead.

BCT might be considered by some smaller players as a subject of the future rather than a solution for today's problems. Although the biggest companies have identified the potential of the technology and created pilot projects, not enough business partners and competitors wanted to participate mostly because they could not see the benefits beyond the investment. Besides the issues of scalability addressed in different studies, as it happens historically, the cost of technology tends to decrease significantly following the first years of its appearance and the quality of the solutions is expected to increase. Similarly, some BC-based application already have viable energy requirements. Although its efficiency is expected to increase further in coming years, it means that one of the major constraints is being dealt with.

For this reason, it is expected that the big projects developed by the private sector restart once further legislation is implemented and when customs agencies roll-out their own BC solutions.

# 5 Conclusion and Recommendations

BCT has been discussed in several studies as being potentially disruptive across several industries and sectors, including trade. This study was an attempt to systematise the current knowledge of existing studies related to BCT in cross-border trade. The aim of this thesis was twofold: firstly, identify the advantages and constraints of BCT in cross-border trade, and secondly, understand how BCT can be used as potential solution for the current pain points in cross-border trade.

Using the PRISMA methodology to find the relevant articles for this systematic literature review, it was then possible to perform a keyword co-occurrence analysis using the software VOSviewer and a citation network analysis using the online tool Litmaps. Additionally, the advantages and constraints identified were split into three categories, according to the perspective of the business and organisations that can adopt BCT: internal (related to their own processes), external (procedures involving partners) and technological (how BCT compares to current solutions). These were the three main spheres of influence identified that can lead decision-makers to either adopt the technology or postpone that decision.

The internal advantages of BCT identified were operational efficiencies, sustainable supply chains and verifiability. The external advantages are impacts in the economy, improved supply chain management, enhanced business transactions, disintermediation and establishing trust. The technological advantages identified were data integrity, data privacy, data security, interoperability with other technologies, immutability, decentralization and asset traceability.

On the other hand, some constraints might affect the adoption of BCT by those involved in cross-border trade. These constraints are lack of knowledge and understanding about BCT, lack of organisational readiness and competence, high investment required and running costs, sustainability and security concerns at an internal level. Externally, the adoption of BCT by business partners and the lack of regulation. At a technological level, factors such as data accuracy, early stage of development and lack of early adopters, immaturity of the governance model, integration and interoperability challenges, lack of standardisation of the technology and performance and scalability barriers.

Once all factors were considered, it is clear that BCT can contribute to solve the current pain points in cross border trade, namely digitalisation, compliance, traceability, cargo integrity and security, dispute resolution and trust. However, it is important to consider that some concerns have been in discussion for some years, not only in academic papers but also in international organisations such as the WTO and WCO without significant improvements. On

one hand, the lack of regulation in most countries and at international level still deters those in cross-border trade from investing in BCT since there is not legal clarity regarding rights and liabilities. On the other hand, different companies, consortiums and institutions have been developing BC applications without an overarching agreement regarding standardization and interoperability of BCs. This could become a problem in the future when it becomes clear that separate BCs cannot be connected which limits the value of BC-based solutions.

Lastly, governments took longer than businesses to develop their BC-based applications, which harmed the pioneer projects of the private sector such as Maersk's Tradelens and Walmart's. Because a BC requires the involvement of many different SC partners to be effective, it also makes it harder succeed. Some businesses, in particular, those smaller with less expendable capital, had difficulty assessing the benefits of the investment and did not join the projects. On the contrary, governments and customs agencies have been implementing BCT more recently, however the added benefit of linking private and public sector's BCs is unfeasible at the moment since some big projects in the private sector have been halted since they were not financially stable due to high costs and lack of partners' interest.

The success of BCT implementation in customs is paramount to the adoption of the technology in the different parts of cross-border trade. Together with governmental action to define legal frameworks and actions of international organisations to increase awareness, customs have the power to require more businesses to join BC-based solution as a mean to 1) increase the value of their platforms and exploit BCT benefits 2) restart the interest in the topic and show businesses that there is value in BCT investments.

## 5.1 Limitations

Besides the findings highlighted throughout this research regarding the potential benefits and current constraints towards BCT adoption in cross-border trade, this thesis has limitations. The topic of cross-border trade pain points is more often studied from the perspective of supply chains and that is visible in the number of studies available in academic databases. Even though that limitation was known, it had to be acknowledged. Early studies of this topic will be affected by this limitation, however they are still necessary to provide new findings.

## 5.2 Future research opportunities

Having completed the analysis of academic literature and reports published by organisations recognized in international trade, it is possible to present some guidelines for future paths of research.

The WTO and WCO continue with the ownership of BCT promotion in cross-border trade directly to its participants with long-term actions (ex. to standardize the datasets and BC interoperability) and projects spanning multiple jurisdiction such as the definition of new legislation standards.

Academia on one hand and researchers on the other hand, can support with different types of research that will improve the transition of Customs and AEO's to this new technology. The limited number of articles available for this SLR is an example that additional research is required in the BCT field, however empirical studies are the ones requiring more attention. New studies with different methods such as case studies, interviews and focus groups are necessary to develop and test new conceptual frameworks. This can only be achieved if academia and businesses work together to share knowledge and test the viability of the proposals. An increase in the amount and quality of studies available will allow businesses to transition to BCT in a smooth fashion.

Additionally, academic researchers can investigate how to bring up to speed the different parts of the supply chain that might delay the process of switching to newer technologies. Specifically, what is the best way to digitalise more participants of the trade process, as well as introduce technology in businesses and industries that are still heavily reliant on paper-based processes.

Research can also be drawn upon the topic of interoperability, not only to simplify the process and allow the transfer of different asset between BCs but also if it would be possible to circumvent the use of intermediaries such as Cosmos and Polkadot, which are currently the best solutions for that purpose.

Lastly, the lack of an efficient governance model for BC platforms is one of the constraints identified in several articles and reports. For that reason, those responsible for managing the platforms can work alongside academia to define the best practices that must be adopted.

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## Annex A - List of articles selected using PRISMA methodology

| Authors | Title | Publish year | Journal |
|---|---|---|---|
| Duan, J., & Patel, M. | Blockchain in global trade | 2018 | Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics) |
| Mao, D., Hao, Z., Wang, F., & Li, H. | Innovative blockchain-based approach for sustainable and credible environment in food trade: A case study in Shandong Province, China | 2018 | Sustainability (Switzerland) |
| Chang, S. E., Chen, Y. C., & Wu, T. C. | Exploring blockchain technology in international trade: Business process re-engineering for letter of credit | 2019 | Industrial Management and Data Systems |
| Epps, T., Carey, B., & Upperton, T. | Revolutionizing Global Supply Chains One Block at a Time: Growing International Trade with Blockchain: Are International Rules Up to the Task? | 2019 | Global Trade and Customs Journal |
| Juma, H., Shaalan, K., & Kamel, I. | A Survey on Using Blockchain in Trade Supply Chain Solutions | 2019 | IEEE Access |
| Mao, D., Hao, Z., Wang, F., & Li, H. | Novel Automatic Food Trading System Using Consortium Blockchain | 2019 | Arabian Journal for Science and Engineering |

| Authors | Title | Publish year | Journal |
|---|---|---|---|
| Vilkov, A., & Tian, G. | Blockchain as a Solution to the Problem of Illegal Timber Trade between Russia and China: SWOT Analysis | 2019 | International Forestry Review |
| Batta, A., Gandhi, M., Kar, A. K., Loganayagam, N., & Ilavarasan, V. | Diffusion of blockchain in logistics and transportation industry: an analysis through the synthesis of academic and trade literature | 2020 | Journal of Science and Technology Policy Management |
| Chang, S. E., Luo, H. L., & Chen, Y. C. | Blockchain-enabled trade finance innovation: A potential paradigm shift on using letter of credit | 2020 | Sustainability (Switzerland) |
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