

Article

Blockchain Solutions for International Logistics Networks along the New Silk Road between Europe and Asia

Bernard Aritua ¹, Clemens Wagener ², Norbert Wagener ^{3,4,*} and Michał Adamczak ³ ¹ Transport Global Practice, The World Bank Group, Washington, DC 20433, USA; baritua@worldbank.org² BLG Logistics Group AG & Co. KG, 14612 Falkensee, Germany; clemens.wagener@googlemail.com³ Faculty of Management and Logistics, Poznan School of Logistics, 6 Estkowskiego Street, 61-755 Poznan, Poland; michal.adamczak@wsl.com.pl⁴ Wagener & Herbst Management Consultants GmbH, Zeppelinstrasse 136, 14471 Potsdam, Germany

* Correspondence: n.wagener@wagener-herbst.com

Abstract: The primary research that underpins this paper seeks to explore the applications of blockchain technology on a specific international corridor and to draw policy implications for decision makers. To analyze the bottlenecks of operating on the New Silk Road and to identify opportunities for applying the blockchain technology on this corridor, a survey was conducted among main train operators and experts working on this route. These responses provide insight into the issues related to the adoption of blockchain technology from front-line actors. The top three challenges are lack of capacities, congestion at transshipment terminals, and slow border crossing. Through the application of blockchain technology, the operators are presented with opportunities for improved accuracy in the processing of data and information, higher reliability of information flows through failure-free transfer of information, and improved traceability of supply chains through irrevocable input of status information. Currently, 50% of the respondents have started to implement blockchain applications or have an actual interest to apply blockchain solutions. For a wider implementation of blockchain solutions, business models need to be developed allowing private and permissioned access that is accepted and open for parties involved. Policy makers should facilitate these digital innovations through flexible and harmonized legal regulations on an international level.

Keywords: New Silk Road; blockchain; international logistics networks; supply chains



Citation: Aritua, B.; Wagener, C.; Wagener, N.; Adamczak, M. Blockchain Solutions for International Logistics Networks along the New Silk Road between Europe and Asia. *Logistics* **2021**, *5*, 55. <https://doi.org/10.3390/logistics5030055>

Academic Editors: Herwig Winkler and Robert Handfield

Received: 28 April 2021

Accepted: 12 July 2021

Published: 16 August 2021

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.



Copyright: © 2021 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

1. Introduction

The concept of Industry 4.0, and especially the application of digital transactions, data platforms, sensor technologies, and artificial intelligence, distributed ledger technologies (DLT) and blockchain solutions which can then create new opportunities to control and facilitate trade and transport services along the New Silk Road. DLT is used as an “umbrella term for technologies that store, distribute or exchange, publicly or privately, value between entities/users/peers based on shared transaction ledgers [1] (p. 7).” It is “frequently described as an ‘authoritative shared truth’ ... in a peer-to-peer fashion without needing to rely on a single, centralized, or fully trusted party [2] (p. 10).”

Blockchain is “a specific type of DLT which distributes the storage, organization, and verification of hash pointers to a group of computers as opposed to storing them in a central database of an enterprise resource planning (ERP) system [3].”

“Blockchain is one type of DLT in which each piece of new data (a block) added to the shared ledger is attached in a sequential order to all the previous blocks (the chain) [4] (p. 6).” The registered users of a blockchain jointly have the permissions to write, read, and store data and information. This distinguishes it from a conventional database, which is usually maintained by one central authority. With blockchain technology, transactions between companies, individuals, or public institutions can be carried out and verified almost in real time without an intermediary.

The objectives of the research which underpins this paper were to identify challenges for the traffic on the New Silk Road and to explore the motivation of market players to use blockchain technology and their expectations of the possibility of blockchain technology applications to increase efficiency and security of the trade and transportation. The paper aims to derive recommendations for entrepreneurs and policy makers for implementing blockchain technology on this specific international corridor.

The research questions were: (1) which challenges exist for operating on the New Silk Road?; (2) which opportunities do front line actors see for blockchain technology to meet these challenges?; and (3) what should be done to facilitate implementation of blockchain on the New Silk Road?

The scope of this paper is limited to blockchain technology in its application to the New Silk Road and focuses on economic and institutional problems, primarily.

The methodology applied for the purpose of this paper consists of a literature review, analyzing benchmark cases and practical examples (TradeLens, DB Schenker, Essen, Germany) as well as a survey among market players who are active on this corridor. The survey which was based on the stated preference method consisted of three closed multiple choice and two open questions. The survey was conducted online in one round with follow-up during the period from September 2020 to March 2021.

A total of 23 questionnaires were sent to major train operators, terminal operators, shippers, and researchers active in this field, such as train operators or terminal operators offering transport services along the New Silk Road. Out of 23 questionnaires the survey received 14 responses, all from senior managers or executive-level decision makers. Although this number might be considered as comparably low, it can be seen as significantly representative survey on the very narrow niche market of the New Silk Road with a small number of operators.

Blockchain technology makes it possible to track different transactions along the whole supply chain in a secure and traceable manner. The documented transactions and data are irrevocably stored in the blockchain and cannot be used or read without consensus. Every time a consignment is being transported or handled, the transaction can be documented, creating a permanent history from the manufacturer to the trader or consumer. If the parties agree to use a certain blockchain platform, time delays because of missing or incomplete information could be reduced and incorrect data can be detected easily. Through automated data processing and auto-executing algorithms (if > then)—so called “smart contracts”—the manual processing of data (e.g., checking and confirming) can be eliminated which saves costs and time.

Although the practical applications of blockchain solutions in logistics are still in their nascent phase, there have been several papers and studies on blockchain in supply chains [5] (p. 884). For the maritime transport, a comprehensive literature review of positive impacts and challenges/barriers was performed in [6]. The authors identified and described 20 positive impacts and 20 challenges [6] (pp. 6, 7, 11, 12).

A review of blockchain projects in all industry sectors showed that food supply chains is the most represented area for application with 22 solutions out of 43 identified applications. Concerning the transport sector, the review identified two applications [7] (p. 728).

Nevertheless, what is missing and urgently needed is a body of knowledge and experience related to the application of blockchain technology to actual logistics systems.

Especially for very complex and global supply chains, blockchain technology can offer the unique advantages of guaranteeing consensus, immutability, and highest levels of security. Moreover, blockchain plays a potential role in enabling autonomous supply chains (Arun Samuga, cited in [8]). This is especially relevant for regulated supply chains of highly sensitive commodities where blockchain technology is seen as a preferred solution for secure traceability, e.g., for pharmaceutical products (see [9]).

Much of today's international trade transactions are still documented using traditional paper documents, such as Bill of Lading (B/L) in seaborne trade. The submission of a clean, original paper B/L to the bank is still a precondition for the approval of delivery and

release of payment according to trade contracts including Letter of Credits (L/C). In the current traditional system, a “clean” B/L means that there are no remarks on this paper document in relation to damages or incompleteness of the delivery. With application of a smart contract using blockchain technology, the proof of delivery (including condition of the consignment) and the corresponding release of payment can be realized automatically and in a secure manner.

The potential savings in cost and time through the replacement of paper documents by digital information is enormous as largely paper-based processes slow down almost all steps and are also susceptible to a high error rate due to the iterative, manual transmission of information. It is estimated that the present analogue system costs about one trillion dollars or 5–10% of the value of the goods traded internationally each year [10] (p. 20).

Blockchain technology can be applied to assist managing cargo flows as well as assets such as containers, trailers, pallets, handling equipment, and rail and road infrastructure. [11].

Of course, blockchain solutions are not a panacea. The disadvantages are well documented and include relatively higher costs, time-consuming information transfers, and the required capacity to handle big data [4] (pp. 14–17). Another disadvantage of blockchain indicated in the literature is the high consumption of energy used for data storage and processing. One of the first publications to pay attention to these issues was work carried out by O'Dwyer & Malone. These researchers analyzed the energy consumption by Bitcoin [12]. Estimating the amount of energy used to implement blockchain is made more difficult due to the fact that data can be stored in many places on various devices. The lack of knowledge of their full specification excludes the possibility of estimating the amount of energy consumed by them [13] (p. 7). This is an evolving area of research and evidence.

According to another team of authors, the energy consumption needed for blockchain is significantly higher than in the case of centralized data storage and processing systems. The differences in energy consumption, however, are not so large that they could be perceived in the context of the entire economy. Additionally, these authors point out that the increase in the number of data and processing operations does not significantly increase energy consumption. Thus, the expansion of systems supported by blockchain should not cause a large increase in energy consumption [14] (p. 607).

Nevertheless, the advantages outweigh any drawbacks. The primary research that underpins this paper sought to explore the applications of blockchain technology on a specific international corridor and to draw policy implications for decision makers.

2. Blockchain Application in Supply Chains

Due to its characteristics, blockchain is widely used in supply chains. A bibliometric analysis of the subject entries was carried out in two popular databases of the scientific journals *Scopus* and *Web of Science Core Collection* (WoS CC). Two queries were developed for the analysis. In both queries the subject entries were searched in: title, abstract, and keywords. The first query searched for “Blockchain” and “case study” and “supply chain”. The second query searched for: “Blockchain” and “best practice” and “supply chain”. The analyses were conducted on 6 April 2021. The results of the analysis are presented in Figure 1.

The results presented in the above charts show that the number of scientific publications on using blockchain in supply chains is growing every year. Similarly, the number cited, although this relationship is not so obvious here, is clearly visible only in the *Web of Science Core Collection* database. It should be noted that the subject of blockchain is up-to-date and has been described for about four years. According to Fu and Zhu, blockchain technology will reduce the costs of the supply chain and logistics by 15%, which will affect the profits and profitability of enterprises [15]. Dujak & Sajter indicate the possibility of using blockchain in three areas in supply chains: traceability and visibility enhancements, improved demand forecasting, and open access [16] (p. 36). From the point of view of this publication, improved demand forecasting is of the least importance. The remaining areas will be described in more detail.

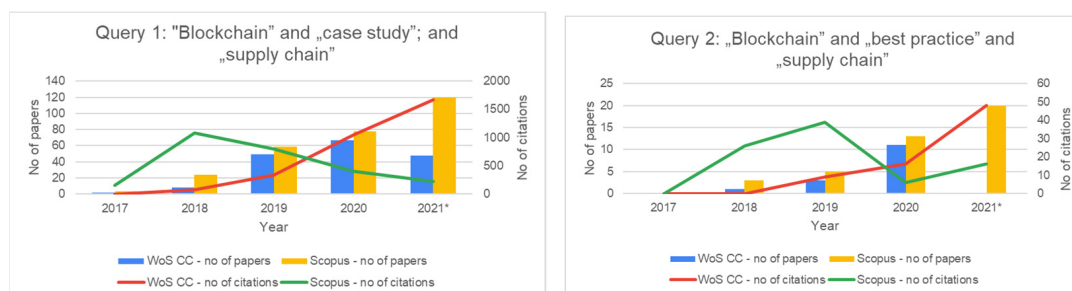


Figure 1. Results of the bibliometric analysis. (Source: own elaboration) (2021* The number of publications and citations in 2021 was estimated based on the numbers from the first quarter of 2021 (a linear model was used, the numbers from the first quarter was multiplied by 4)).

The use of blockchain to improve security and traceability is one of the basic areas of its application in supply chains. There are many examples of the use of this technology in literature. The widely known Walmart-IBM case study used blockchain technology for tracking mangoes from farm to store. By using blockchain, there was a reduced time of tracking the package of mangoes from the farm to the store, from several days to two seconds. [17]. A solution was also developed to increase the availability of information about food products, thanks to the consumers having full information about the products they buy [18]. In the area of open access, the greatest benefits for supply chains are obvious. Maersk and IBM have developed an open blockchain solution for container tracking. This solution is useful not only to partners in the supply chain, but also to insurance companies and banks. The use of blockchain to track cargo reduces risk and lowers insurance rate [19]. The IBM solution is delivered to a wider range of companies including General Motors, Procter and Gamble, Agility Logistics, Singapore Customs, Peruvian Customs, APM Terminals, PSA International, and Guangdong Inspection and Quarantine Bureau for trade corridors in and out of China [20].

Kumar et al. indicate the importance of blockchain in the implementation of smart contracts, i.e., those framed between the exporters and importers which record the quality, quantity, delivery date, and other clauses decided by the trading entities while agreeing. If the conditions are met, the payment is released automatically to the exporter. These authors also indicate the most important areas of blockchain application in the supply chain: data integrity, decentralized processing, and traceability [21].

Blockchain can also support the implementation of the concept of sustainable development. It supports sustainable development in aspects such as market disintermediation, operational efficiencies, cost efficiency, value creation opportunities (economic sustainability), empowering trust, food safety (social sustainability), and reducing the environmental logistic footprint (environmental sustainability) [22] (p. 366). Blockchain also allows for the constant tracking of material and commodity flows on trade routes, supply chains, and supply networks. It is therefore possible to identify the origin of raw materials and products. Thus, blockchain technology has potential to support ethical sourcing strategies [23].

Venkatesh et al. present the concept of blockchain-based supply chain social sustainability management (BSCSSM) system. The system consists of main modules such as production and logistics traceability, supply chain transparency, labor and human rights, and workplace health and safety. Thanks to it, it is possible to comprehensively manage aspects of sustainable development throughout the entire supply chain. According to the authors, such a solution can also be successfully used in the case of trade routes, such as the New Silk Road [24].

Shoaib et al. explored blockchain-based supply chain success factors. As a result of literature, research, and surveys on a sample of 64 people (from 22 countries), the authors determined the leading success factors as trackability, traceability, simplification of current paradigms, data access control in SCM, human safety, auditability in SCM, problem solution, quality fairness, environmentally friendly, and automation [25] (p. 2127).

It should also be noted that the results of the conducted research also indicate the concerns of enterprises related to the use of blockchain and the resource requirements in this solution [26].

To sum up, the use of blockchain in supply chains is very broad and is becoming increasingly popular. The identified applications and good practices which are potentially applicable on the New Silk Road include traceability and visibility enhancements, supporting open access, smart contracts, and supporting sustainable logistics development.

3. The New Silk Road as an International Intermodal Logistics Network

The New Silk Road or the “Iron Silk Road” consists of several rail corridors connecting China and Europe. The four major corridors run from China directly via Russia, Mongolia/Russia, Kazakhstan/Russia, or Central Asia/Caucasus/Turkey to Europe (see Figure 2).



Figure 2. China Express Railway Plan. (Source China Rail Express Plan, cited in [27] (p. 163)).

Although the vast majority of trade between China and Europe uses the sea connection (“One Road”), the Iron Silk Road (“One Belt”) has been developing dynamically since the early 1970s. Nonetheless, real progress has been recorded over the last ten years. The rail links between Europe and Asia have proved as efficient and resilient connections within an international logistics network, as shown in Figure 3.

A peculiar characteristic of the land-based Silk Road is the relatively higher number of parties and infrastructure involved, compared to that in sea transport. The network consists of a variety of structural elements (parties, infra- and supra-structure) and complex information and physical flow processes. Major reasons for this complexity are the involvement of different national administrations and railway organizations with different technical and regulatory standards, border crossings, and parties involved.

This high complexity often results in a lack of traceability and delays due to different IT systems and platforms, partly still paper-based procedures and bottlenecks at border crossings. This results in often non-transparent, slow and consecutive workflows of the parties involved.

Therefore, expanding the New Silk Road from a niche market to “mainstream” would require, among others, the establishment of highly efficient and reliable processes and control of the interactions between all interlinked partners.

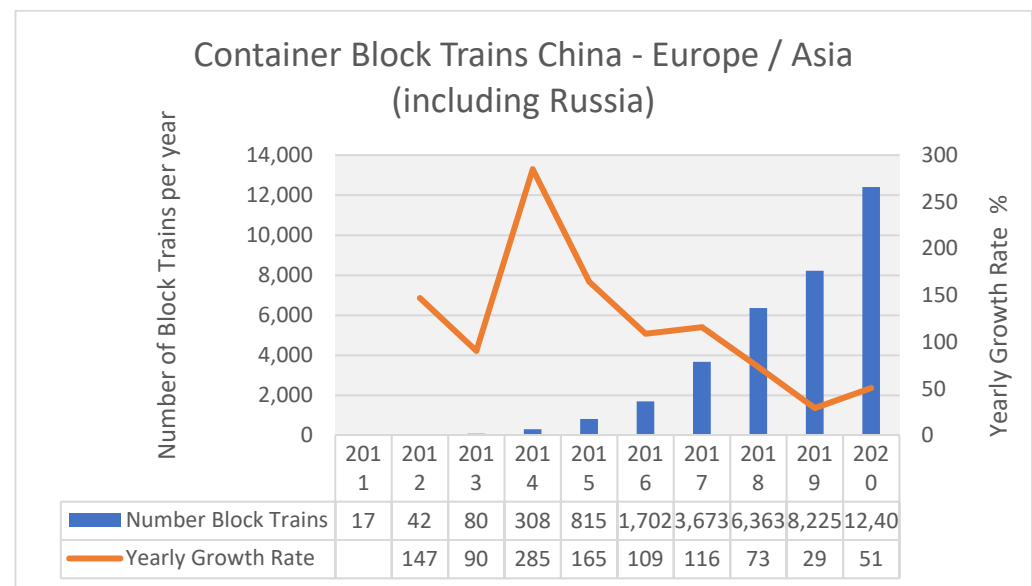


Figure 3. Container block trains between China and Europe/Asia (compiled from China Railways, Belt and Road Portal).

4. Challenges and Opportunities for Blockchain Solutions along the New Silk Road

To analyze the bottlenecks of operating on the New Silk Road and to identify opportunities for applying the blockchain technology on this corridor, a survey was conducted among main train operators and experts working on this route. Out of 23 requests, the survey received 14 responses (feedback rate of 61%). Detailed characteristics of the respondents are presented in Table 1.

Table 1. Detailed characteristics of the respondents (source: own elaboration).

Country/Company Type	Forwarding	Research	Shipper	Terminal Operator	Train Operator	Total
China				1	2	3
Germany		1		1	1	3
Croatia	1					1
Lithuania		1			1	2
Netherlands		1				1
Poland	2		1			3
Russia			1			1
Total	3	3	2	2	4	14

These responses provide insight into the issues related to the adoption of blockchain technology from front-line actors.

Figure 4 shows a high concentration of answers received in the median range with a high proportion of respondents claiming to have knowledge and experience with blockchain technology i.e., rating 3 (experienced) with 64.3%. An equal number indicated high or low experience i.e., 14.3% each. Only 21.4% of the participants rate themselves with low experience and little knowledge considering blockchain and smart contracts topics, cumulating rating 1 (low experience) with 7.1% and rating 2 with 14.3%.

Overall, a high percentage share of 78.6% of the participants assess themselves as having gained significant experience and knowledge in this area. Moreover, neither the extremes, 0 = no experience available or 5 = highly experienced, were chosen by the participants. Both arguments being presented could underline that, on the one hand, profound content will be reflected upon when looking to the other questions due to the high percentage share of professionals answering the survey, but also that some potential

in terms of gaining experience and knowledge in blockchain and smart contracts can still be achieved.

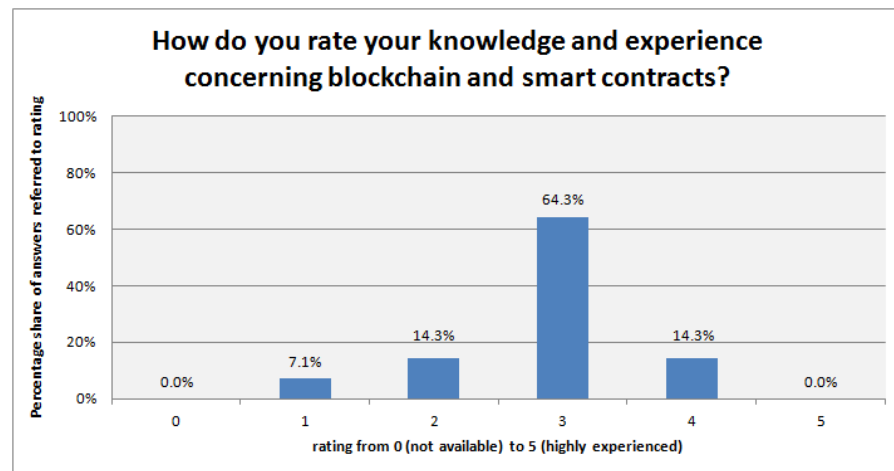


Figure 4. Knowledge and experience concerning blockchain and smart contracts (source: own elaboration).

Considering the challenges on the New Silk Road, the survey reveals that slow operation at border crossings is seen as the highest risk with a 36% share of received answers with the rating “high”. (see Figure 5) The congestion at transshipment terminals is second when looking to possible challenges with rating “high”. In this survey, 29% of participants rate this challenge as high. The third place is shared by five other challenges, namely lack of capacities, unpunctual or unreliable rail operation, the lack of information on the actual status of the container, the low capacity utilization, and damages and pilferage, which each score a 14% share of answers received.

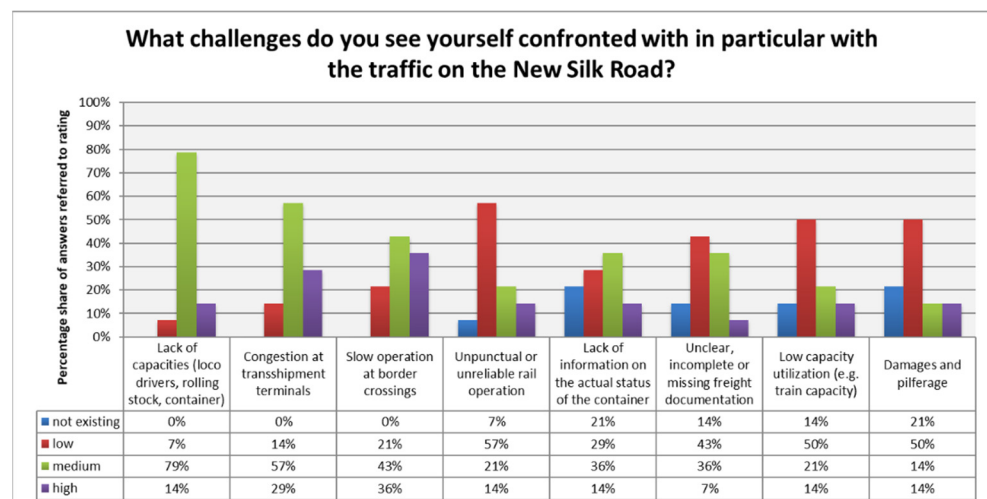


Figure 5. Challenge for the traffic on the New Silk Road (source: own elaboration).

When considering challenges with “high” or “medium” ratings, the top three are lack of capacities (93% of all ratings), congestion at transshipment terminals (86% of all ratings), and slow border crossing (79% of all ratings). Interestingly, these top three as medium- and high-rated challenges share the same answer possibilities which one could argue reflects the common orientation of realistic challenges being confronted with the traffic on the New Silk Road. The high importance of these challenges reflects the present, and often problematic, situation at border crossings and terminals, which is mostly caused by insufficient capacities but also by slow commercial procedures. It is remarkable that 43% of all respondents stated that unclear, incomplete, or missing freight documentation is a medium or high challenge for the traffic.

Looking to the lowest ratings, unpunctual or unreliable rail operation is rated lowest by 57% of respondents, followed with 50% each to the challenges of low capacity utilization and damages and pilferage. Interestingly, 21% of the participants highlighted the latter challenge as a non-existing challenge when focusing on security and safety along the New Silk Road. When considering challenges ratings with “not existing” or “low”, the top three are damages and pilferage (71% of all ratings), low capacity utilization (64% of all ratings), and unpunctual or unreliable rail operation (64% of all ratings). This is remarkable because, in the early years of rail traffic along these routes, unreliability, damages, and lack of security were seen as major problems. Obviously, these former challenges seem to have been solved by modern block train concepts and operations.

Figure 6 presents the ratings of the participants referring to whether the possible area could have a low, medium or high impact on efficiency and security of trade and transport when considering blockchain solutions. By far “*improved accuracy for processing of data and information*” with a 79% share of received answers in this area reflects the highest rating, followed by “*higher reliability of information flows through failure free transfer of information*” with 64%, and, as third place, “*traceability of supply chains through irrevocable input of status information*” with a 57% share of answers received. In total, five out of seven possible areas have a higher rating in “high” than in “medium” or “low”, thus reflecting the significant impact on efficiency and security of trade and transport when focusing on blockchain solutions.

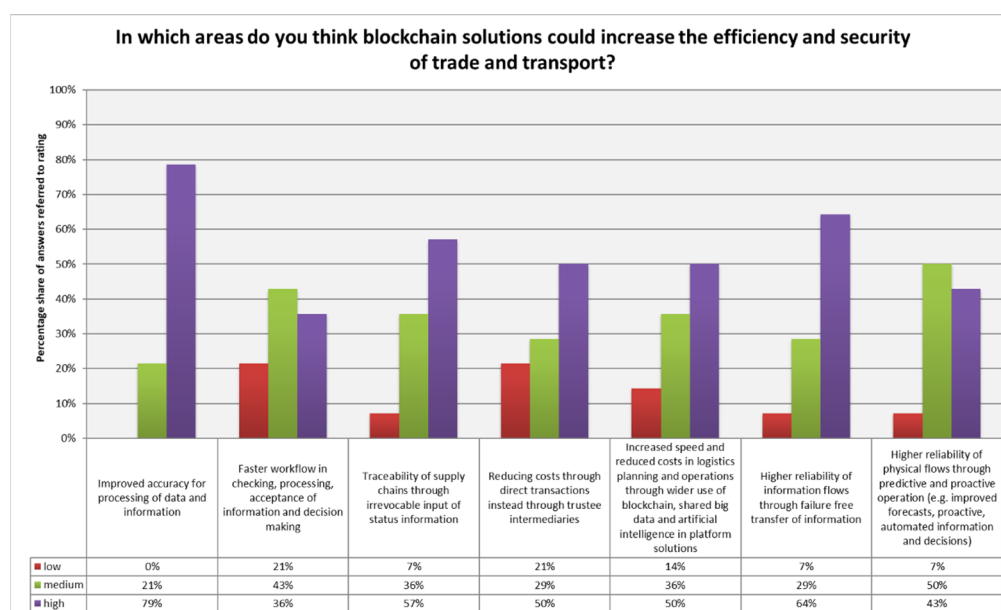


Figure 6. Opportunities for trade and transport through blockchain (source: own elaboration).

Furthermore, two areas can be highlighted where the “medium” rating outweighs the other ratings within the same area. These are “*higher reliability of physical flows through predictive and proactive operation*” with 50% and “*faster workflow in checking, processing, acceptance of information and decision making*” with 43%. However, the latter area is closely followed with a 36% share of answers received in the rating of “high” and 21% of participants reflecting this area with a “low” impact on the other side, thus turning this area into an arguable discussion point with no clear consensus compared to the other six areas of this question. This shows that some respondents doubt that blockchain will facilitate the workflows.

Concerning the question “Have you already tested blockchain solutions in your own company? If so, for which application?”, seven respondents answered “No”, three answered “No, but we want to try”, and four with “Yes”. That shows that the actual interest to apply blockchain solutions is 50/50. Companies which already tested blockchain include German Railways, Russian Railways, and a Chinese platform operator using an

own designed Smart Container Global Tracing System. All the systems are in a testing or upgrading phase.

Finally, the open question “What would have to be done so that blockchain technology can also facilitate trade and transport on the New Silk Route?” was raised in the survey. As fields of actions, the following aspects were recommended by the respondents of the survey (wording in italic):

Governance and Business Model

- *“Co-operation*
- *Organizational structure which can be agreed with all the participants and strong IT platform.*
- *Push trust and compliance*
- *Finding champions (shippers, railway companies, logistics service providers and freight forwarders) to introduce/develop blockchain solutions on the New Silk Route.*
- *It’s a wide topic with several scenarios, linked to trading company, logistics, customs, CIQ China Inspection and Quarantine, insurance company, bank, etc.*
- *Enterprises must learn to share data for better end-to-end supply chain performance.”*

Knowledge and Competencies

- *“Improvement of competencies for blockchain technologies Incorporation at companies and government level (customs and border services, tax administration, sanitary control and etc.)*
- *Knowledge about Blockchain technology and its use has to be improved”*

Standardization

- *“Standardization*
- *Harmonization/standardization of dataflows of involved parties”*

Regulatory Framework

- *“Legal implications must be considered*
- *Bureaucracy should be cut and customs law liberalized.”*

“Blockchain technology is still being developed. The more applications there are, the more trust this technology will gain. Using blockchain technology is not only a simple implementation of the tool but changes the communication and co-operation model in supply chain—and therefore it requires more time.” (one respondent of the survey)

Due to the used ordinal scales, it is not possible to test hypotheses. However, it is possible to apply the basic methods of descriptive statistics and the study of the Spearman’s rho correlation. It should be stated that the most frequent answer in the questions regarding the challenges related to the implementation of blockchain solutions on the New Silk Road was the answer “Medium”. The median for the responses was also the same (assuming that the responses could be ranked in ascending order: “Not Existing”, “Low”, “Medium”, “High”). In questions about the opportunities brought by the implementation of blockchain solutions, the most common answer was “High”, and the median was also the same (assuming the same ranking of answers as in the case of questions related to challenges). An important observation is also the relationship between knowledge and experience concerning blockchain of responders and their assessment of the challenges and opportunities offered by the implementation of blockchain solutions on the New Silk Road. The analysis with the Spearman’s rho showed that there is a statistically significant negative correlation ($\rho = -0.66$, $p\text{-Value} = 0.009$ assuming $\alpha = 0.05$) between the self-assessment of the respondent’s knowledge, experience, and challenges posed by the implementation of blockchain solutions on the New Silk Road. This means that respondents with more knowledge and experience see fewer challenges and consider the implementation of Blockchain solutions on the New Silk Road more realistic. No other statistically significant relationships were found.

It can be summarized that blockchain solutions are seen as a potential tool for improving the conditions for trading along the New Silk Road through more secure and efficient documentation and transaction processes, especially because of the high complexity of

countries and parties involved. For the success of blockchain, some essential preconditions must be ensured.

5. Platform Governance and Business Models

Concerning the type of access to the DLT, one can distinguish between “open” and “closed” networks (For a detailed explanation of DLT’s see [28–30]). Publicly available and permissionless DLT’s are the most decentralized form with the least control by one actor. This kind of DLT is considered as the most secure format, but requires highest computing power and is comparably slow (for example, Bitcoin). Another type of public DLT’s are those that are public but permissioned. They are still open as everybody can view the content, but writing transactions are allowed for authorized users only. An example in the application of transport could be the registration and monitoring of transport vehicles and equipment (automobiles, wagons, containers, etc.) in the future (see also [4]) (p. 12).

In supply chains the stakeholders have a vital interest to protect their commercial data and to keep competitive advantages. This is an argument to prefer a closed type of blockchain. On the other hand, the benefits from blockchain can only be disclosed if the platform is open for possibly all parties involved in a certain supply chain. On the New Silk Road, a variety and high number of different private and administrative parties are involved. This calls for an authorization scheme to read and write, namely a closed, permissioned blockchain. These blockchain solutions are private systems in which only authorized users are granted access to join, view, and publish data. Permissioned users can securely record transactions and exchange information between one another.

It is obvious that the installation and maintenance of a blockchain platform needs administration. This administration can be assured by a single organization (private permissioned type) or by a set of parties (consortium type).

The experiences with “TradeLens” (See <https://www.tradelens.com/>, accessed on 25 March 2021) as one of the first operating blockchain platforms in overseas trade show that successful operation is possible only if acceptance and participation of a wider market share can be achieved. Strict neutrality and a non-discriminatory practice are preconditions. TradeLens is a closed, permissioned blockchain platform. Permissioned blockchains are private ecosystems whereby only authorized users are granted access to join, view, and publish data. Permissionless blockchains are open ecosystems that let any user access and interact with the network. Cryptocurrencies typically run on permissionless blockchains so they are distributed, transparent, and able to offer nearly total anonymity [31]. Having started as a partnership between Maersk and IBM, TradeLens was confronted with a great deal of hesitance from other shipping lines to use the platform. Only after revision of the partnership model, so that Maersk had no more control than other ocean carrier members over the platform governance, could the platform experience more acceptance by other industry leaders to join (see [4] (p. 25)).

For trades along the New Silk Road, permissioned blockchains should be the preferred solution since trade data are sensitive and need to be accessible by authorized users only. For the platform administration, several options are feasible.

In principle blockchain solutions can be managed by:

- IT-infrastructure providers and application developers

open, user neutral platforms
“Blockchain as a Service”

Example: Hyperledger (See <https://www.hyperledger.org/use/fabric>, accessed on 25 March 2021), VeChain (See <https://www.vechain.com/product/toolchain>, accessed on 25 March 2021)

- Financial institutions, banks

example: Corda (See <https://www.corda.net/>, accessed on 25 March 2021)

- Transportation and logistics systems providers

Shipping Lines, Railway companies, Intermodal operators

Example: TradeLens (See <https://www.tradelens.com/>, accessed on 25 March 2021)

- Logistics platform operators
(ports, logistics parks)

To ensure neutrality, the IT-infrastructure providers and application developers are widely accepted by market participants. Nevertheless, transport operators are the main beneficiaries and drivers of the process.

Concerning the New Silk Road, a consortium of participating railway companies seems to be the most feasible solution to “order” a blockchain platform which is implemented by an IT company. First initiatives to establish blockchain technology exist:

Example DB Cargo Eurasia

The Deutsche Bahn DB (German railways) has been operating on the New Silk Road for more than 12 years. Since 2018, DB Cargo Eurasia GmbH is the DB-owned operator on the Trans-Eurasian corridor. It offers up to nine train departures every week connecting Germany with Russia and China.

Within the Seven Railways Agreement, the partners Chinese Railways (CR), Kazakh Railways (KTZ), Mongolian Railways (UBTZ), Russian Railways (RZD), White Russian Railways (BC), Polish Railways (PKP), and German Railways (DB) have been meeting and discussing joint blockchain solutions for the trade and traffic concerning this route since 2016. The main objectives are the improved tracking and tracing of containers, safer and easier exchange of data, and organizing paperless international rail transportation (see [32,33]).

The innovative IT-solution DB Cargo Eurasia is working together with DB Systel which developed the digital platform, known as joint enabling network (JEN). This platform connects customers, rail operators, customs, and other parties involved in the trade and allows for an accelerated digitalization of processes. It can be intelligently linked with innovations such as blockchain technology and artificial intelligence (AI). It provides a forgery prove, reliable, traceable, and immutable transfer and storage of information and transactions, as well as auditing proof archiving. As the single point of truth, the platform JEN forms the basis for horizontally and vertically integrated value-adding chains. The ecosystem of this platform offers microservices and intuitive micro user interfaces, which can be customized [34]. The principal configuration is shown in Figure 7.

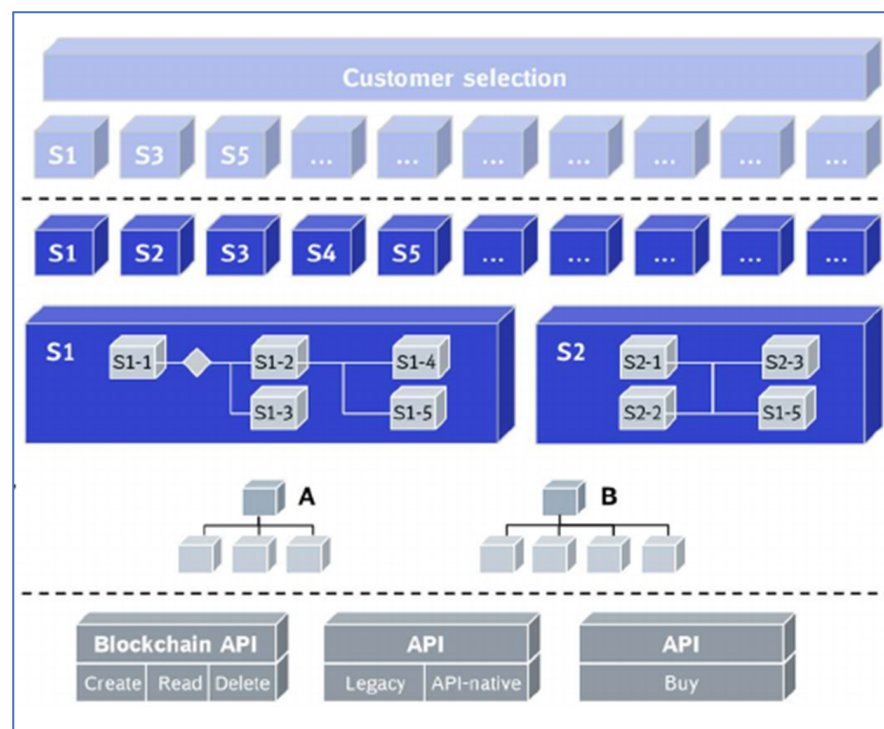


Figure 7. Scheme of joined enabling network (JEN). (Source: [34]).

The challenge is how to integrate trade-focused platforms (e.g., the IBM Food Trust Blockchain Platform) with logistics-focused platforms (e.g., railway or shipping platforms). Interfaces and common standards are needed.

Another challenge is cost recovery for the installation and administration of the blockchain platform on the one hand and to keep costs user-friendly on the other hand. The platform operator shall establish a scheme for generating income, for instance through registration (“entrance fee”) and participation fees (“pay as you use”), and eventually also additional fees for premium services and consultancy.

6. Policy Implications

Unlike many innovations in technology, which are often incremental and transform the way activities are organized at the margins, blockchains challenge the notion of a central entity that controls the process and is a repository of all the main data. It also questions the way the fundamental role of the regulator is positioned within the supply chain. As demonstrated in this article, the early pilots indicate ways in which the traditional teething problems of transboundary logistics can be addressed. By offering a mechanism to track all transactions, a new type of contract mechanism is introduced which enables the entire system to be more resilient to human and natural shocks in the supply chain. The challenge for policy makers is how to introduce the appropriate regulation that does not suffocate innovation.

A recent study gives the following recommendations for policy makers concerning regulations on the use of the distributed ledger technology:

- Make regulations more flexible to accommodate the use of blockchain and other distributed ledger technologies
- Use regulatory sandboxes to promote innovation while minimizing risks
- Actively engage with transport industry initiatives around distributed ledger technologies
- Require some level of open data access for transport applications of distributed ledger technology
- Make transport policies machine-readable
- Run pilot projects to identify use cases for distributed ledger technologies in the public sector [4] (pp. 7–8)

Insofar, as blockchain technology is used in international trade, international trade agreements are applicable, either through bilateral or multilateral free trade agreements (FTAs) and/or by WTO agreements. Even if slowly, international cooperation on digital trade is deepening. Under the framework of the World Trade Organization, countries have reached agreements on electronic signatures, paperless trading, transparency, electronic transmission, tax exemptions, and other related issues. The member states of the WTO are working on new agreements on digital trade and e-commerce. For different models and outlook see [35].

By the end of 2019, 199 cooperation documents have been signed between 137 countries and 30 international organizations with China under the framework of the Belt and Road Initiative [36]. The New Silk Road covering many different states with different political and economic systems is a vivid field of international co-operation which should include harmonized rules on e-commerce and digital services.

7. Conclusions and Future Outlook

The New Silk Road has proved to be a reliable and dynamic alternative intermodal transport connection between Asia and Europe within international supply chains, especially for time sensitive and higher value goods. Due to the complexity of partners and countries, different railways systems and regulations involved a call for an efficient and secure transfer and processing of data. A survey among main transport operations working on this market shows that slow operation at interfaces as border crossings and terminals is the main challenge along this route. The most important reasons for that are the lack of capacities and slow commercial procedures. Among the operators, blockchain is seen

as an opportunity to improve accuracy for processing data and information, to increase reliability of information flows through failure-free transfer of information, and to improve traceability of supply chains. Up to now, there is no blockchain application implemented on this trade route (New Silk Road). One result of the survey is that 50% of the respondents are interested in, or are in the process of testing/implementing, blockchain solutions. For a wider application of blockchain solutions, business models are required which are preferably private and permissioned but accepted widely by the various partners along this route. Standardization and harmonized rules and regulations are needed which call for increased co-operation and concerted actions of policy makers in the different countries in the future.

Author Contributions: Conceptualization, B.A., N.W.; methodology, C.W., N.W., M.A.; validation, B.A.; formal analysis, C.W., M.A.; data curation, B.A., C.W., N.W., M.A.; writing—original draft preparation, B.A., C.W., N.W., M.A.; writing—review and editing, B.A., C.W., N.W.; visualization, C.W., M.A.; supervision, B.A., N.W.; project administration, N.W. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: All participants of the survey have been informed with the questionnaire that the survey results will be processed in strict confidence and used for publication in an anonymous manner only. An ethical review and approval were waived for this study, due to the fact that no human data were processed.

Data Availability Statement: The data are not publicly available but can be obtained from the authors on request for scientific purposes.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. OECD. *Is There a Role for Blockchain in Responsible Supply Chains?* OECD Publishing: Paris, France, 2019.
2. Nelson, P. *Primer on Blockchain*; USAID: Washington, DC, USA, 2018.
3. Peters, G.W.; Panayi, E. Understanding modern banking ledgers through blockchain technologies: Future of transaction processing and smart contracts on the internet of money. *SSRN Electron. J.* **2015**, 1–33. [CrossRef]
4. International Transport Forum. *Forging Links—Unlocking Transport with Blockchain?* OECD: Paris, France, 2021.
5. Gurtu, A.; Johnny, J. Potential of blockchain technology in supply chain management: A literature review. *Int. J. Phys. Distr. Log. Man.* **2019**, 49, 881–900. [CrossRef]
6. Jovic, M.; Tijan, E.; Zgaljic, D.; Aksentijevic, S. Improving Maritime Transport Sustainability Using Blockchain-Based Information Exchange. 2020. Available online: <https://www.mdpi.com/2071-1050/12/21/8866/pdf> (accessed on 4 July 2021).
7. Dietrich, F.; Ge, Y.; Turgut, A.; Louw, L.; Palm, D. Review and analysis of blockchain projects in supply chain management. *Procedia Comput. Sci.* **2021**, 180, 724–733. [CrossRef]
8. Gonzales, A. Blockchain in Supply Chain Management. 2012. Available online: <https://talkinglogistics.com/2019/12/02/blockchain-supply-chain-management/> (accessed on 26 March 2021).
9. Reinhold, S.; de Raad, N.; Nehl, M.; Kleeberger, J.; Müller, M. Cannabis-Lieferkette Mit Blockchain Sicher dokumentieren. 2021. Available online: https://www.ecv.de/beitrag/pharmind/Cannabis-Lieferkette_mit_Blockchain_sicher_dokumentieren (accessed on 27 March 2021).
10. Fraunhofer-Institut für Angewandte Informationstechnik FIT. *Chancen und Herausforderungen von DLT (Blockchain) in Mobilität und Logistik*; Bundesministerium für Verkehr und Digitale Infrastruktur: Berlin, Germany, 2019.
11. Buchhorn-Roth, M. Secure Data Exchange across Supply Chains—Blockchain and EDI. 2016. Available online: <https://combined-transport.eu/blockchain-edi-for-supply-chains> (accessed on 26 March 2021).
12. O'Dwyer, D.; Malone, K. Bitcoin mining and its energy footprint. In Proceedings of the 25th IET Irish Signals & Systems Conference, Limerick, Ireland, 26–27 June 2014. Available online: http://karlodwyer.com/publications/pdf/bitcoin_KJOD_2014.pdf (accessed on 7 June 2021).
13. Vranken, H.P. Sustainability of bitcoin and blockchain. *Curr. Opin. Environ. Sustain.* **2017**, 28, 1–9. [CrossRef]
14. Sedlmeier, J.; Buhl, H.U.; Fridgen, G.; Keller, R. The Energy Consumption of Blockchain Technology: Beyond Myth. *Bus. Inf. Syst. Eng.* **2020**, 62, 599–608. [CrossRef]
15. Fu, Y.; Zhu, J. Operation Mechanisms for Intelligent Logistics System: A Blockchain Perspective. *JIEEE Express* **2019**, 7, 144202–144213. [CrossRef]
16. Dujak, D.; Saijter, D. Blockchain Applications in Supply Chains. In *SMART Supply Network. EcoProduction (Environmental Issues in Logistics and Manufacturing)*; Springer International Publishing AG: Cham, Switzerland, 2019; pp. 21–46.

17. IBM. Walmart, JD.com, IBM and Tsinghua University Launch a Blockchain Food Safety Alliance in China. 2017. Available online: <https://www-03.ibm.com/press/us/en/pressrelease/53487.wss> (accessed on 19 April 2021).
18. Tian, F. An agri-food supply chain traceability for China based on RFID & blockchain technology. In Proceedings of the 13th International Conference on Service Systems and Service Management (ICSSSM), Kunming, China, 24–26 June 2016. Available online: <https://ieeexplore.ieee.org/document/7538424> (accessed on 27 March 2021).
19. IBM. Maersk and IBM to Form Joint Venture Applying Blockchain to Improve Global Trade and Digitize Supply Chains. 2018. Available online: <http://www-03.ibm.com/press/us/en/pressrelease/53602.wss> (accessed on 19 April 2021).
20. van Kralingen, B. IBM, Maersk Joint Blockchain Venture to Enhance Global Trade. 2018. Available online: <https://www.ibm.com/blogs/think/2018/01/maersk-blockchain/> (accessed on 19 April 2021).
21. Kumar, A.; Abhishek, K.; Ghalib, M.R.; Nerurkar, P.; Bhirud, S.; Alnumay, W.; Kumar, S.A.; Chatterjee, P.; Ghosh, U. Securing logistics system and supply chain using Blockchain. *Appl. Stoch. Models Bus. Ind.* **2020**, *37*, 413–428. [CrossRef]
22. Rejeb, A.; Rejeb, K. Block chain and Supply Chain Sustainability. *LogForum* **2020**, *16*, 363–372. [CrossRef]
23. Mann, S.; Potdar, V.; Gajavilli, R.S.; Chandan, A. Blockchain Technology for Supply Chain Traceability, Transparency and Data Provenance. In Proceedings of the 2018 International Conference on Blockchain Technology and Application (ICBTA 2018), Xi'an, China, 10–12 December 2018; Association for Computer Machinery: New York, NY, USA, 2018; pp. 22–28. [CrossRef]
24. Venkatesh, V.G.; Kang, K.; Wang, B.; Zhong, R.Y.; Zhang, A. System architecture for blockchain based transparency of supply chain social sustainability. *Robot. Comput. Integr. Manuf.* **2020**, *63*. [CrossRef]
25. Shojib, M.; Lim, M.K.; Wang, C. An integrated framework to prioritize blockchain-based supply chain success factors. *Ind. Man. Data Syst.* **2020**, *120*, 2103–2131. [CrossRef]
26. Hackius, N.; Petersen, M. *Blockchain in Logistics and Supply Chain: Trick or Treat*; Epubli GmbH: Berlin, Germany, 2017; pp. 3–18.
27. Ye, J. Regional Orientated Global Logistics Networks Redesign with Respect to the Belt and Road Initiative (BRI). Ph.D. Thesis, Universität Bremen, Bremen, Germany, 2020. [CrossRef]
28. Hileman, G.; Rauchs, M. *Global Blockchain Benchmarking Study*; University of Cambridge: Cambridge, UK, 2017.
29. OECD. *Blockchain Primer*; OECD: Paris, France, 2018.
30. OECD. Blockchain and Distributed Ledger Technology. 2021. Available online: <http://www.oecd.org/finance/blockchain/> (accessed on 6 April 2021).
31. Tradelens. Trade Made Easy. 2020. Available online: <https://tour.tradelens.com/blockchain> (accessed on 29 March 2021).
32. DB Cargo AG. 7 Bahnen-Agreement: Für Schnelleren und Kostengünstigeren Containerverkehr Zwischen Asien und Europa. 2020. Available online: https://www.linkedin.com/posts/db-cargo-ag_dbinternationalaffairs-dbcargoeurasia-echtermachergeist-activity-6687022209422245888-cMzn (accessed on 27 March 2021).
33. DB Cargo Eurasia GmbH. Rail Networks. 2020. Available online: <https://eurasia.dbcargo.com/de/> (accessed on 27 March 2021).
34. DB Systel. *Joint Enabling Network—The Digital Solution for Your Services (Internal Presentation)*; DB AG: Berlin, Germany, 2020.
35. Gao, H. Data regulation in trade agreements: Different models and options ahead. In *Adapting to the Digital Trade Era: Challenges and Opportunities*; WTO Chairs Programme; World Trade Organization: Geneva, Switzerland, 2021; pp. 323–336.
36. Wang, X. Building an e-Silk Road. 2021. Available online: <https://eng.yidaiyilu.gov.cn/qwyw/rdxw/167554.htm> (accessed on 24 April 2021).