ORIGINAL ARTICLE
DOI: https://doi.org/10.30932/1992-3252-2022-20-4-6

World of Transport and Transportation, 2022,
Vol. 20, Iss. 4 (101), pp. 217–228

Blockchain Technology in Supply Chains of Transport Hubs in the People's Republic of China

Bingzhang LI

Bingzhang Li
Don State Technical University, Rostov-on-Don / Jinan, Shandong Province, People's Republic of China.
✉ *runa666.6@mail.ru.*

ABSTRACT

Efficient cargo transportation at major transport hubs its management is critical to global trade. Existing systems for organising cargo transportation do not provide traceability, transparency, information security and immutability of data stored and exchanged during various operational processes. Consequently, this negatively affects the performance of transport hubs.

The use of digital applications of information and communication technology (ICT) in the transport industry can lead to highly automated processes and more cost-effective solutions. Cargo transportation requires the use of real-time data exchange between the various stakeholders involved in the process. Traditional ICT-based logistics systems use a centralised architecture to allocate and process data and services. However, centralised logistics systems cannot provide secure real-time data access, operational visibility, and trust between participating organisations.

Automating various functions of transport hubs with the help of the Internet of Things (IoT) and cloud computing can adequately improve the performance of transport hub operations. These operations include automation of the vehicle interface, container yards, intra-port logistics, and the terminal reception area.

The objective of the research is to increase the efficiency of organisational and functional activities of transport hubs through digitalisation. Significant are the methods of applying an integrated approach that combines confirmation of feasibility of participation of a port facility in servicing the cargo traffic in terms of delivery «just in time» and of economic feasibility of participation of the facility in the channel of cargo flows to save operating costs. Possibilities for improving the process are considered from the point of view of integration of information exchange between different participants using end-to-end technologies in transport hubs, namely, the blockchain concept, to optimise operations by integrating and exchanging information between participants in the transportation process.

Keywords: *cargo transportation, blockchain, intelligent transport systems, Internet of things, smart contract, end-to-end technologies, transport hub.*

For citation: *Li Bingzhang. Blockchain Technology in Supply Chains of Transport Hubs in the People's Republic of China. World of Transport and Transportation, 2022, Vol. 20, Iss. 4 (101), pp. 217–228. DOI: https://doi.org/10.30932/1992-3252-2022-20-4-6.*

The text of the article originally written in Russian is published in the first part of the issue.
Текст статьи на русском языке публикуется в первой части данного выпуска.

INTRODUCTION

The transition of the People's Republic of China to a consumption-driven economy, coupled with improved accessibility of interior regions, has turned the transport industry's focus away from outward orientation towards meeting the needs of new domestic markets. In such a large and diverse market, many transport companies have succeeded by experimenting and finding their niche. The complexity of the market results in the fact that the largest operators with streamlined processes and more adaptable and scalable business models are in an even better position [1].

As domestic consumer markets grow, and investment expands into new interior regions, China's transport and logistics infrastructure is facing new challenges and attracting new attention from businesses and government authorities. High economic growth in China, while stimulating demand for logistics services, also creates problems for logistics operators.

As the service sector and high-tech industries develop in the country, companies will need stronger logistical support to improve their efficiency. In turn, this will require better management practices, greater use of information technology and systems capable of integrating and controlling movement of goods and materials in supply chains both within and outside the country. Particular attention is paid to the operations of transport hubs, where material flows are processed when moving from one mode of transport to another.

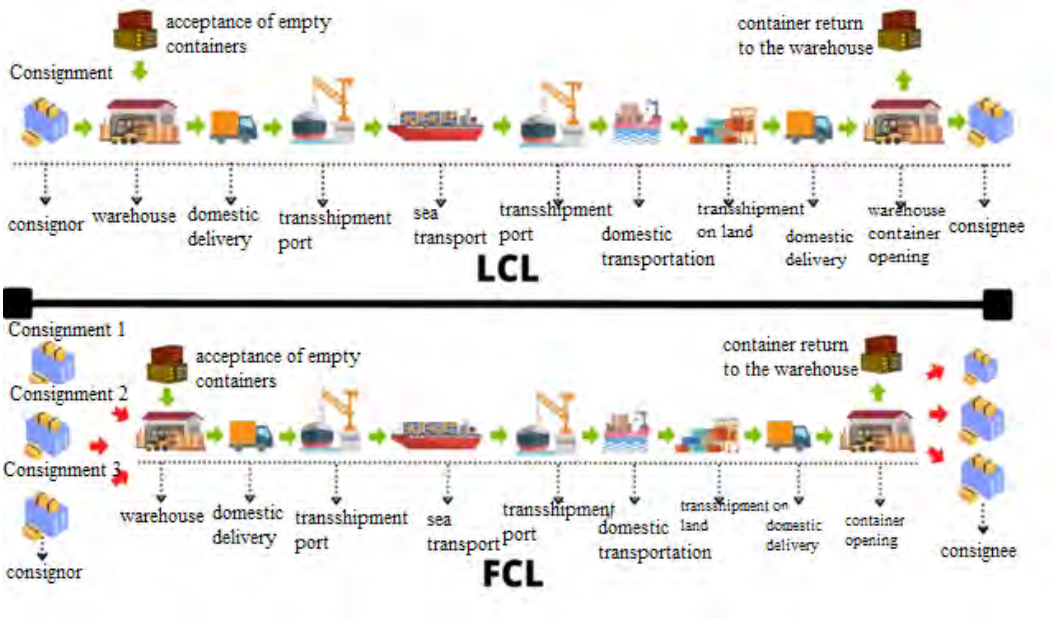
The port infrastructure of China's major transport hubs suffers from several shortcomings in terms of efficiency and maintenance [2]. First, mainland berths average 22 to 27 crane movements per hour, compared to 30 movements per hour in Hong Kong. Secondly, bottlenecks often occur as containers are slowly reloaded from the port to other modes of transport, often requiring at least two crane movements for each operation. Bureaucracy is the third problem hindering efficiency. Shipping companies must obtain permits from customs, the State Administration of Quality Supervision, Inspection and Quarantine, the State Administration of Foreign Exchange and other government agencies. Fourth, cargo loss in China is higher than in Hong Kong or Singapore due to theft and damage. Finally, shipping is still a relatively restricted sector since foreign companies are only allowed to have a minority stake in Chinese port facilities.

Since neither the shortage of barges nor the congestion of waterways are serious problems, the government of the PRC is striving to modernise the infrastructure of water transport. Currently, there are more than 1,200 ports in China offering berths for 33,000 ships, including 800 deep water berths capable of handling 10,000 tonne ships. A significant increase in container transshipment capacity is planned for 2025. The PRC authorities have entered negotiations with international shipping companies and committed themselves to develop regulations requiring shipping lines to provide information on freight rates. These are all signs of increased transparency in the industry.

The PRC government is also taking advantage of foreign interest in building ports. The Shanghai Port Authority has already begun implementing a 20-year, $14,5 billion project that provides for construction of 52 berths along a 13-kilometer embankment for the ships with a draft of at least 15 meters at Yangshan Deep Water Port. The container terminal on the mainland is being designed by Hamburg Port Consulting, a subsidiary of the German Group, Hamburger Hafen und Lagerhaus-AG [2].

The vision of the Shanghai port is to become a global hub operator, and its main strategy is to further develop the port while expanding to the world. The Shanghai port has focused on two aspects of the development strategy, hardware and software ones, and this will make the port more competitive. To do this, it is necessary to focus on operational and management aspects such as IT communications, EDI system, port marketing, internalisation policy to attract potential users of the port. A transport hub is a junction of two or more modes of transport, the technological interaction of which is ensured by an appropriate set of devices and means, as well as by organisational measures [3].

Today, the supply chain network is well integrated with information technologies such as enterprise resource planning (ERP), RFID, GPS, sensor technology, video technology, and barcode technology. However, in most cases, these technologies work separately and are not interconnected. To overcome the aforementioned problems, operation of the transport hub can be



Pic. 1. Types of import-export operations in the transport hub [performed by the author].

radically improved through digitalisation and, in particular, through introduction of a blockchain technology.

The fast-growing pace of world trade requires cost-effective, fast, and highly reliable port operations and cargo transportation management systems. The use of digital applications of information and communication technologies (ICT) in the transport industry can potentially result in highly automated processes and more cost-effective solutions [4].

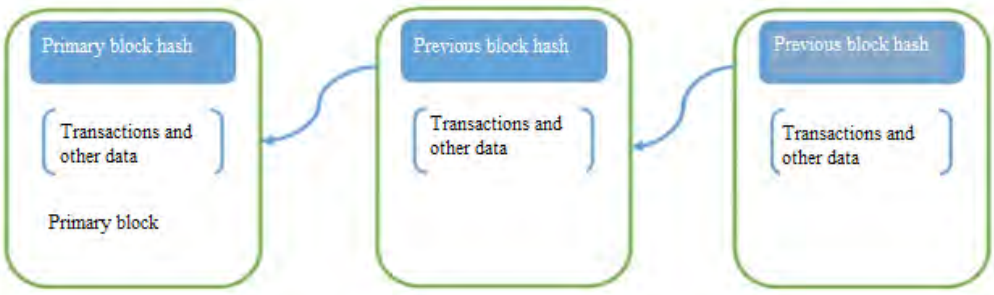
Cargo transportation at transport hubs requires the use of real-time data exchange between various stakeholders involved in the process. This is important, especially during transportation in intermodal transport hubs, for more efficient use of resources and infrastructure. Traditional ICT-based port logistics systems use a centralised architecture for hosting and processing data. However, centralised logistics systems cannot provide secure real-time data access, responsiveness, traceability, and trust between participating organisations.

Close coordination of stakeholders involved in the logistics chain of the transport hub contributes to rationalisation of cargo planning processes. Therefore, it can provide efficiency by reducing the total turnaround time of a vehicle in a transport hub. Effective cargo transportation planning and decision making also requires a secure and transparent flow of information between various stakeholders. These operations include automation of the vehicle interface, container yards, intra-port logistics.

With the growth of international trade and development of the economy, the volume of container transportation in China's ports is growing rapidly. FCL and LCL are two terms that are used in the field of import-export operations in sea cargo transportation. If a consignee has a large consignment of goods that will take up a whole container, then he books FCL. The abbreviation stands for «Full Container Load». FCL belongs to one consignee. Even with partial loading and belonging to one customer, the cargo will be considered FCL [4].

If the volume of the consignment cannot fill the entire container, the consignee books only a space in the common container. In such a container, goods of other consignees are transported, who pay not for the entire container, but only for a space. This is called LCL delivery – an English abbreviation that stands for «Less-Than Container Load». LCL is cheaper than FCL. It makes sense to book LCL when delivering small loads and consignments of goods. LCL business processes in most ports in China continue to be complex and inefficient.

Blockchain is a data structure that represents a ledger entry or transaction record. Each transaction is digitally signed to ensure its authenticity. This ensures the integrity of the



Pic. 2. Blockchain data structure [performed by the author].

ledger and existing transactions [5; 6]. These digital ledger entries are then distributed across multiple computers or servers, each acting as a node. These additional nodes and layers of infrastructure serve to provide consensus on the state of the transaction at any given second; they all have copies of the entire existing authenticated ledger distributed among them.

Blockchain uses cryptography to ensure that if any changes are made to a block, users can instantly notice those changes [7]. This property makes the blockchain an ideal data structure for storing records.

As the name suggests, blockchain consists of a chain of blocks. Each block consists of transaction record data and related information contained in each transaction. Each transaction has a timestamp associated with when it was written to the block chain. Subsequent blocks require the identifier (or hash) of the previous block, and this is the link that links all the blocks together (Pic. 2).

The advantages of blockchain over existing systems are obvious. Blockchain generates a single source of data through decentralisation compared to existing systems, which are mostly centralised. In addition, the blockchain provides an increased level of security since the data are immutable. In existing systems, data are mostly verified externally (for example, through an audit), while in a blockchain, external verification is not required. The data on the blockchain have a date and time stamp that serves as proof of confirmation. All these transactions are stored online in blocks. This technology is used in cryptocurrencies. For example, in the Bitcoin Satoshi blockchain, blocks contain information about transactions in Bitcoin [8]. The block indicates who and to whom sends bitcoins.

As the blockchain keeps track of movement of all bitcoins since their creation, it is possible to check through the ledger who exactly owns this or that bitcoin at any given time. This ownership mechanism that helps keep track of bitcoins is called the current «state» of the blockchain. A transaction only happens when it is added to a block. As new blocks are added, the state of the blockchain is updated. Since all transactions are updated in the blockchain, the user can access the blockchain at any time and see which transactions have been made [9; 10].

Blockchain is a revolutionary new technology that facilitates peer-to-peer (P2P) value transfer without the need for a centralised intermediary [11]. Blockchain technology paired with smart contracts is a reliable method for automating business rules within an efficient and trusted mechanism. A smart contract is a self-executing piece of code that runs on a blockchain platform. Predefined rules between participating organisations are translated into smart contract functions to establish trust.

There are three popular types of blockchain: public, federated and completely private [12]:

• *Public blockchain* is the most common form of blockchain. In it, anyone and everyone has the ability to confirm or view any transaction that occurs on the network, upload the code and run a public node on their local device, confirming transactions on the network and participating in the consensus process. This entitles a person to participate in the process that determines which blocks are added to the chain and what the current shape and size of the blockchain is.

Several modern public Blockchain protocols based on Proof of Work consensus algorithms are open source. This implies that anyone can take part in them without permission. Bitcoin,

Ethereum, Monero, etc., can be quoted as examples there-of.

• *Completely private blockchain*. The consensus mechanism is centralised in the hands of an organisation, that is assigned a task to verify and add all transactions to the blockchain. A network based on a private blockchain therefore does not need to use mechanisms such as « Proof of Work» or «Proof of Stake», which are difficult to be implemented and expensive.

• *Federated blockchains* are mainly used in the banking sector. They are a kind of private blockchains that are controlled not by a single node, but by several pre-defined nodes. The consensus process in federated blockchains is different from the consensus process in public blockchains. Here the consensus is controlled by a pre-selected set of nodes. The right to read the blockchain can be public or restricted to participants. Such blockchains are also known as private permissioned blockchains.

In the context of the supply chain, transparency refers to the information available to companies participating in the supply chain. For the supply chain to be transparent, it is important that the origin of a product or service can be traced from the beginning to the end of its life cycle. Thus, transparency and traceability are interrelated.

Blockchain technologies provide increased transparency in the supply chain, but more importantly, they create an immutable and distributed type of record of custody due to the nature of the protocol, which is well suited for traceability applications. However, there are problems that need to be overcome. An issue how the technology will be developed and managed is among them.

• *Permissioned blockchain* is a distributed ledger that is not public. Only users with permissions can access it. Users can only perform certain actions granted to them by general ledger administrators and must identify themselves via certificates or other digital means. Both public and permissioned blockchains have their constraints and benefits. It is necessary to ensure compatibility of permissioned and public blockchains, which will require standards and agreements.

Another major problem is associated with regulations and legislation. A complex array of regulations, maritime law and commercial codes govern property and ownership rights on the world's shipping lanes and in their multiple jurisdictions.

Of various proposed benefits of blockchain discussed earlier, one major benefit refers to the form of smart contracts. A smart contract can be understood as a set of algorithms and programs within digital environment that can be partially or completely executed or enforced upon the occurrence of certain conditions. In the blockchain context, smart contracts have pre-written logic; stored and replicated on a distributed storage platform; are executed/ triggered by a network of computers and may result in an update of the ledger. In general, they work on the basis of « if–then» statements, which are executed and checked by many computers to ensure validity. The main function of the blockchain is to provide users with a distributed reliable storage. Similarly, the main function of a smart contract is to provide users with distributed reliable computing.

A smart contract consists of a computer code that is used to automate the «if–then» parts of a traditional contract. The advantage of a computer code within a blockchain is that the likelihood of manipulation is very low since there are fewer potential disputes. The code is reproducible on many computers and is run by those computers that have come to an agreement on the results of executing the code.

Smart contracts provide the following benefits:

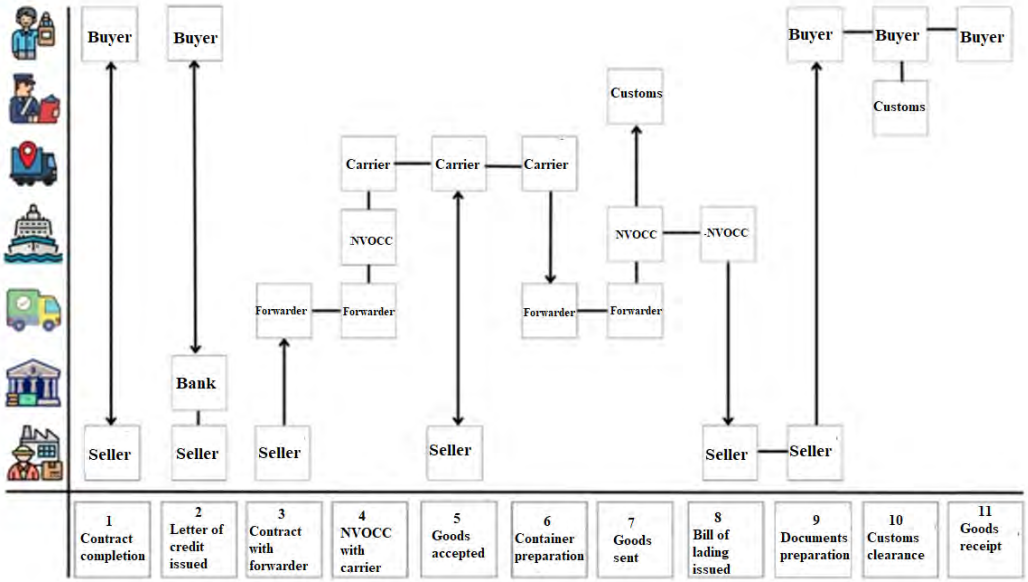
• *Self-executing conditions:* «if–then» clauses create a self-executing contract. This reduces the need for interaction between process participants. If a certain set of conditions is met, the seller gets paid. If the conditions are not met, then one of the parties automatically receives a penalty.

• *Security*: the smart contract is encrypted and distributed between nodes. This ensures that it will not be lost or changed.

• *Speed and cost*: due to automation, the process is very fast. For example, the seller does not have to wait for payment if everything is correct. As soon as the conditions in the smart contract are met, the payment process starts automatically. It also helps eliminate middlemen, which saves costs.

Despite the great advantages, smart contracts also have disadvantages:

• *Human factor*: People are involved in coding and programming, which means that there



Pic. 3. The currently adopted process of transportation of containers As-Is [performed by the author].

may be possible loopholes in the codes. This makes the smart contract susceptible to hacker attacks.

• *Legislative complexity*: smart contracts are currently not subject to legal regulation. However, the rapid rise in prices for cryptocurrencies has led to the fact that many countries have begun to regulate the crypto-currency industry. Smart contracts are legal documents that will be executed on a digital platform. They are currently outside the legal and regulatory framework, and the parties may conclude them based on their own understanding. If smart contracts become regulated and will require regulatory approval, then the effectiveness of smart contracts will be lost.

• *Contractual terms*: smart contracts are mostly useful for «if–then» execution. Many contracts are specifically written with clauses to create a channel for arbitration. For example, the force majeure clause is found in most shipping contracts.

We have considered various supply chain challenges in transport hubs and how various blockchain applications such as smart contracts can be useful in bringing transparency and traceability to current supply chains. Three main problems for shippers in the supply chains of transport hubs were identified: barriers to trade, technology adoption in the maritime industry, and inefficient contracting practices. They cause shippers to face unnecessary delays and costs due to paperwork overload.

RESULTS

As-Is – Delivery Process

The current process of shipment of goods and the importance of documentation are shown in Pic. 3.

1. Here is the interaction of the buyer and the seller in the sale and purchase of goods:

• The seller and the buyer enter into an agreement for the sale of goods. This happens through traditional paper contracts. Contracts are signed physically, so they are exchanged by courier or express mail.

• In most cases, when the transaction is of high value and when the buyer and seller do not know each other, the seller asks the buyer to provide a letter of credit (LOC) from the buyer's bank. LOC is a document from a bank that guarantees payment.

2. The buyer and seller interact with their banks to issue and confirm LOC:

• The buyer requests LOC from his bank. When the buyer requests LOC, he also specifies the conditions under which the payment must be made. For example, on what day and time the seller should ship the goods, or from which port the goods should be shipped. In accordance with these instructions, the bank issues the payment.

• The issuing bank then sends a copy of the letter to the seller's bank, along with a list of documents that will be required from the seller for payment.

• When the negotiating bank confirms LOC status, it then informs the seller. The seller needs to carefully study the terms of LOC since payment is made based on LOC.

3. After the contracts are signed and LOC is approved, the seller prepares to ship the goods:

• The seller starts preparing the goods in accordance with the agreed conditions (e.g., the type of packaging, the appearance of the product, etc). These points are usually specified in the original contract.

• In parallel, the seller is also looking for a freight forwarder to help the buyer deliver the goods. The seller usually sends a request for a freight quote, which can be sent by e-mail, by phone or in an online form. The freight quote request will contain all the information needed to transport the goods.

• Based on the information provided, the freight forwarder prepares a freight quotation, breaking down the individual elements of the freight, including margins. They comprise:

– Information about the route: where and from where the goods are sent.

– Method of transportation and equipment.

– Details of the shipment, including dimensions, weight, and a description of the goods, such as whether they are dangerous.

• After the seller accepts an offer from a certain forwarder, he provides him with the following documents:

– Commercial invoice: suppliers selling goods to importers issue a commercial invoice. Like other invoices, it is proof of sale and includes the same information as a standard invoice. Its difference is that it also includes information about the cargo required for customs clearance.

– Certificate of origin: in most countries, this document is required for customs clearance, calculation of possible duties, as well as for preliminary reporting of cargo.

– Material Safety Data Sheet. This is a declaration for dangerous goods.

– A letter of instruction from the consignor. It contains shipper/consignee information, routing information, Incoterms, etc.

4. After the freight forwarder receives the contract and relevant documents from the seller, he proceeds to book capacity with the trucking company and with the NVOCC (Non-Vessel Operating Common Carrier). NVOCC is an aggregator that collects containers from multiple freight forwarders (FF) or shippers and then book capacity.

• FF sends a request for quotation to several trucking companies and NVOCCs. FF may enter into a contract with a trucking company/NVOCC based on a long-term contract in the spot market. The trucking companies and NVOCC then review the terms and conditions and accept or reject the request accordingly. This is usually done via email.

• NVOCC provides FF with a booking confirmation that includes the booking reference, equipment size and quantity, transportation plan, loading route with arrival time at port, etc. This confirmation is sent by email.

• FF then sends the information to the seller via email.

5. After the seller has received the information from FF, the shipper prepares the goods for acceptance by the carrier.

The delivery man arrives at the seller's facility to pick up the goods. It also collects the following documents:

• Container Weight Declaration: The document will include shipper's data, consignee's data, container type, commodity, total product weight and type of cargo.

• Booking confirmation that FF should have provided to the seller.

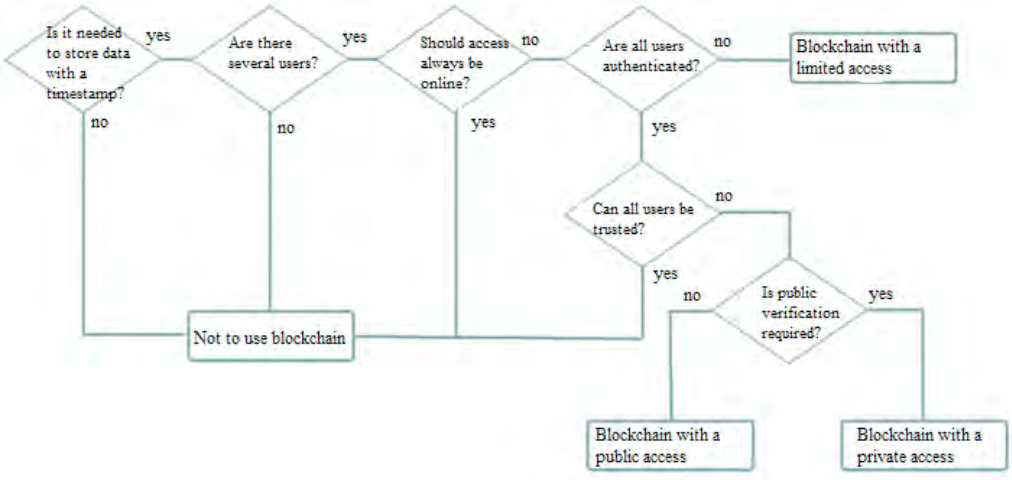
6. After the goods are taken from the seller's warehouse, the carrier takes the goods to the FF warehouse. Then the freight forwarder starts preparing containers, which are sent to the port for loading. The freight forwarder consolidates volumes from different clients and prepares containers with a full load. This allows increasing capacity and minimising costs:

• FF also ensures the completeness of the packing list containing information such as shipper/consignee, equipment/skids/cranes, packing details, cargo description and HAZMAT.

• The carrier collects the containers for delivery to the port along with the packing list. Packing list and booking confirmation are required by the carrier to obtain permission to enter the port.

7. Then the carrier arrives at the port and receives an entry permit, presenting the relevant documents. However, FF has more work to do at this stage:

• FF liaises with customs to clear goods. This is a difficult task, as customs checks all documents



Pic. 4. Structure for deciding on the need for a blockchain [performed by the author].

and makes sure that the declarations are correct. If there are any discrepancies, the goods are not loaded onto the ship and if they remain in the port, it causes a demurrage cost.

• FF also liaises with NVOCC for Bill of Lading. The Bill of Lading (BOL) is an important document that contains full details of the goods, their shipment, condition, etc. This document serves as proof that the goods have been cleared through customs and shipped on the specified date and time. Any discrepancy in the BOL means that the buyer will not be able to take possession of the goods.

• NVOCC issues a draft BOL and sends it to FF, who checks all the details and corrects errors if any.

8. After completion of all formalities and approval by FF of a draft BOL, the containers are loaded onto the vessel and sent on a voyage:

• NVOCC issues 3 original copies of BOL to FF.

• These are paper copies delivered to the seller in person or via FF courier service. This process takes time depending on the location of the seller.

9. After receiving copies of BOL, the seller keeps one copy:

• He sends the second copy to the bank to receive payment. BOL contains all the important information required to receive payment, such as time of departure of the goods, the quantity, the port of departure, etc.

• The third copy is sent to the buyer, who needs it to receive the cargo at the port of destination. This copy is usually sent via courier or express mail.

10. Once the buyer receives BOL, he prepares all the necessary documents that he will need to obtain ownership of the goods. After the cargo arrives at the port of destination, the importer must submit the following documents to receive the cargo:

• Bill of lading: The bill of lading is one of the main import documents for customs clearance of imports. The bill of lading is a measure of the «country's total outgoing remittances» regulated by the Reserve Bank and the Customs Department. The bill of exchange must be submitted within thirty days after arrival of the goods into the customs territory. After the import customs formalities are completed, a «pass order» is issued for such an invoice. Once the importer or his authorised customs agent receives an «export order» from the appropriate customs officer, the imported goods can be removed from customs.

• Commercial invoice.

• Bill of lading.

• Import license.

• Insurance certificate.

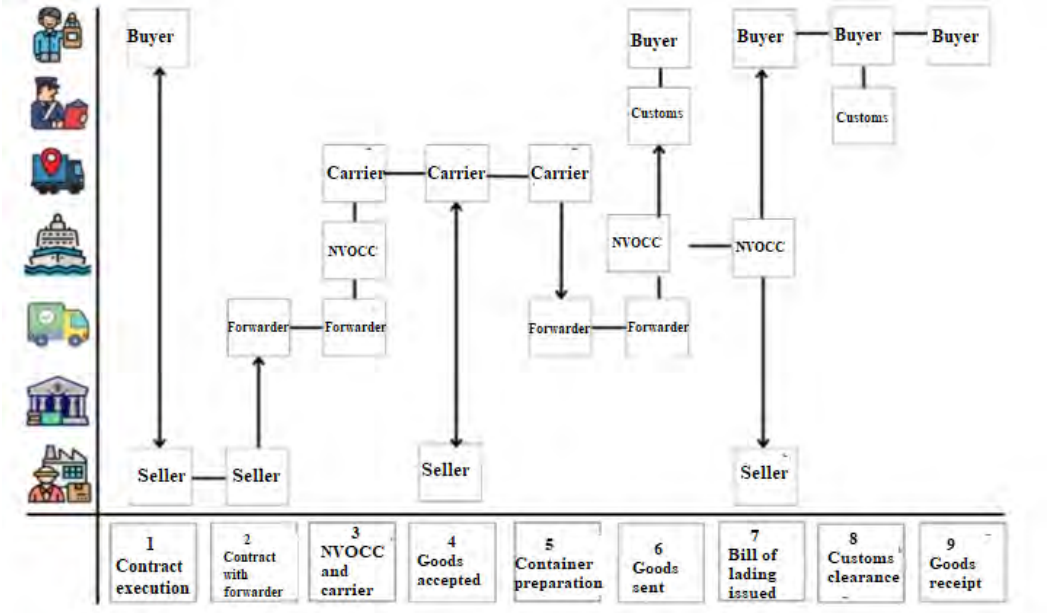
• Purchase order.

• Credit sheet.

• Any other tax documents.

11. If all documents are correct, the goods are released from the port and the buyer takes possession of them. However, if there are any discrepancies in the documents, the goods are not released, and the buyer bears additional costs in the form of demurrage.

The As-Is delivery process has many constraints that make it cumbersome and costly.



Pic. 5. To-Be process of transporting containers [performed by the author].

This is extensive documentation that is required at every stage. As a rule, contracts with high value and high risk are executed on paper to maintain legal status. Besides, all documents submitted for customs clearance are usually printed on paper. Paying fines for shortcomings in work is a serious problem. In most cases, the shipper or carrier does not pay for deficiencies in service. Contracts, as a rule, are free verbal agreements transferred to paper [13].

Another aspect that creates barriers is the need for a bank guarantee. Generally, the buyer is expected to provide the seller with a letter of credit (LOC) as a guarantee that the seller will be paid after certain conditions are met. The banks of both sides are involved in this process, and the seller does not ship the goods until he is satisfied with received LOC. This is especially true for small buyers [14].

The problem is that LOC only describes some general terms, such as port of shipment, time of shipment, quantity of shipment, etc., however, as a rule, there is no condition in it that speaks of the quality of the goods received. Thus, even if the supplier ships defective goods, he will receive payment from the bank in any case, if LOC conditions are met.

As-Is container shipping is inefficient and costly. And it is the blockchain as a tool that can help solve many of the problems of this process and make it more efficient. The diagram shown in Pic. 4 explains why the blockchain might be suitable for re-engineering an existing process.

Based on the diagram above, we have determined that for our existing model, we need a private permissioned blockchain. Below are the facts for deciding on the type of blockchain we need:

• We will need timestamped data and there will be multiple participants such as seller, buyer, forwarder, and customs.

• We do not have a single trusted third party.

• All participants are known but not trusted.

• We do not need an external audit.

The first step towards blockchain implementation is that the buyer, seller, freight forwarder, NVOCC, and customs all join the blockchain. It will be a private permissioned blockchain where different parties have different access rights. For example, customs cannot view information about the cost of goods [15].

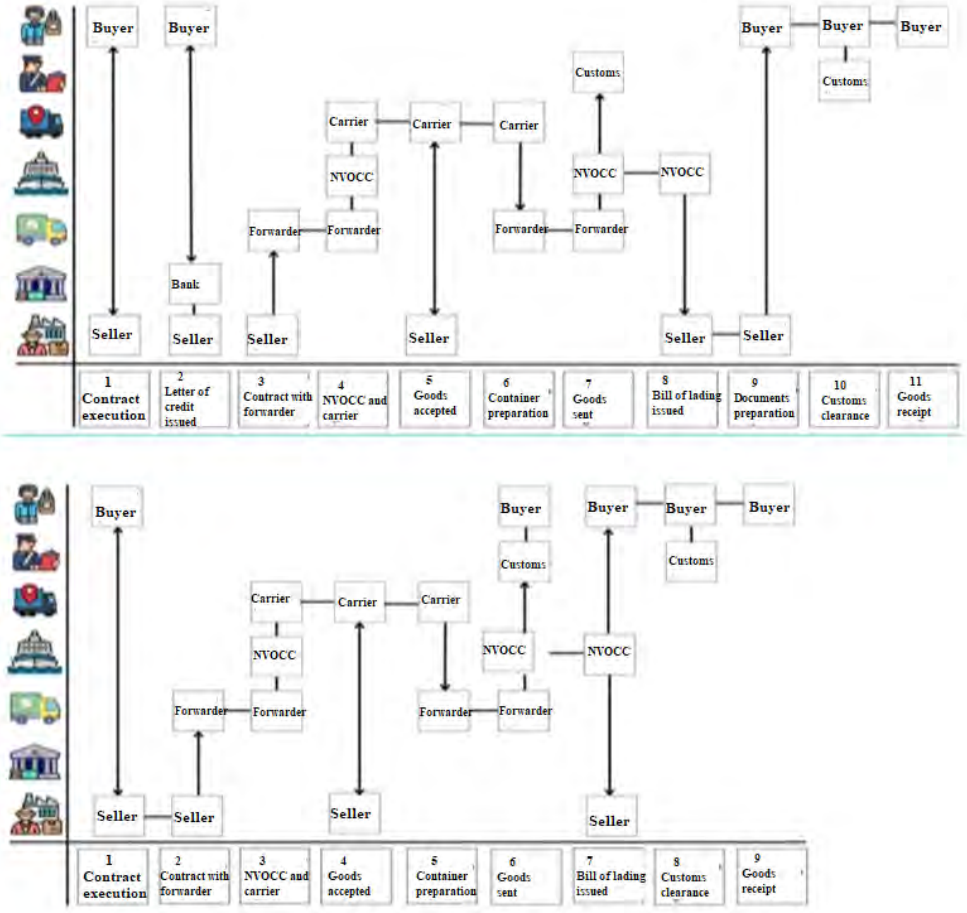
To-Be – Delivery Process

To-Be process consists of the following steps:

1. Buyer and seller enter into an agreement as follows:

• The contract is executed as a smart contract through the blockchain.

• A bank may not be required as a party to a blockchain-enabled platform. A smart contract is a self-executing contract based on certain if-then clauses. Money can be stored in



Pic. 6. Process As-Is and To-Be [performed by the author].

cryptocurrency. If all the conditions in the contract are met, the seller receives the money, otherwise the money is held within the dispute.

2. The seller concludes an agreement with a forwarder (FF).

3. After finishing work on the contract with FF, he signs a contract with NVOCC and a trucking company. All information is transmitted through the blockchain.

4. The carrier receives all the necessary information from the seller. Details such as collection time, details, etc., are sent to the driver of the vehicle. The carrier may or may not join the blockchain. The shipper is usually a subcontractor and does not need to upload any special documents, so the process will not be affected if the shipper is not on the blockchain.

5. The carrier then delivers the goods to the FF warehouse, where the container is prepared for shipment.

6. The information is then transmitted to NVOCC/sending partner via the blockchain. This information is required by NVOCC to prepare the bill of lading. FF no longer needs to have physical copies of documents to submit at the port. All necessary information, such as commercial invoice, packaging data, bill of materials, etc., is transmitted to customs electronically via blockchain by the freight forwarder or seller:

• The blockchain process does not require production of physical documents. This will save FF time as he will be able to check the documents at customs electronically.

• After the carrier picks up the cargo from the supplier, it goes directly to the port. Customs has all the necessary information through the blockchain. The only document the carrier may need is an entry permit.

• When the cargo is in the port, the customs officer can conduct a physical inspection of the

goods based on the information provided by the shipper via the blockchain.

7. After customs clearance, NVOCC is preparing the shipment. The bill of lading is generated electronically and transmitted to the customs of the seller and the buyer via the blockchain. There is no more need for a physical copy.

8. When the cargo arrives at the destination port, the buyer does not need to collect all the documents. All documents are transmitted to the port authorities and customs via the blockchain. Customs officers control goods against documents uploaded via the blockchain.

9. After the control, the buyer takes possession of the goods.

Comparing both processes, As-Is and To-Be, in Pic. 6, we can see possible improvements. The number of steps in the process has been reduced from 11 to 9, indicating an increase in efficiency. Another important point is that the bank is no longer a participant in the process. Thus, the number of intermediaries is reduced.

In steps 1 and 2 of To-Be process, we use smart contracts between buyer, seller, and forwarder instead of traditional paper contracts. This makes the process more efficient and dynamic. This will help to minimise inefficient contracting practices.

In step 7 of To-Be process, we note that the bill of lading (BOL) is now transferred over the blockchain to both the seller and the buyer. This is a key improvement. Usually, BOL is emailed to the buyer or seller. Thus, there is a risk that BOL may be lost. If the buyer fails to present BOL at customs, he risks receiving a penalty for cargo demurrage in the port. In the blockchain process, such risks will be minimised.

In general, using blockchain, we see that data move faster along the chain, the use of paper documentation is limited, and the contracting practices become more efficient. In addition, since there is mutual trust between different participants, no external validation of the data is required [16].

Incorporating blockchain into the delivery process can have many benefits. The need for physical documentation is greatly reduced. The seller and the buyer can save a lot of time otherwise lost due to paperwork. All documentation is transmitted electronically to partners such as the freight forwarder, NVOCC and, most importantly, customs. Customs officers receive documents in electronic form for each shipment.

A significant advantage of the blockchain here is that the customs can trust the transmitted data. The data uploaded to the blockchain will be date- and time-stamped. Also, if customs or any of the parties want to edit the documents or change the timestamp, they will have to get the approval of the majority of the participants in the system. Thus, neither the customs officer nor other parties can easily make changes. Changes will be kept. In existing systems, we can achieve this level of permissions, but the system remains centralised. The difference that blockchain brings to the system is decentralisation and the fact that all parties must agree before changes can be made.

The report (2017) by the Global Supply Chain Subcommittee of the Customs Operations Advisory Committee (COAC) has assessed the applicability of blockchain for trade operations. The group proposed 14 blockchain use cases [17]. These included ideas such as collection and tracking of licenses, permits and licenses from partner government agencies, reporting on certificates of origin and qualification of products under free trade agreements, carnets TIR, and tracking movement of bonds.

In addition, using the blockchain, we can initiate payments based on performance. Shippers and carriers usually don't get paid for poor service from either party. This issue can be solved with the help of smart contracts. Since smart contracts use an «if–then» clause to make payments, either party can punish the other party based on the shortcoming in the service provided [18].

CONCLUSION

The suggested model for applying blockchain technology to transport hub supply chains requires all parties involved to adopt the blockchain. This can be a difficult task, especially when it comes to customs. First, the customs of each country must implement the blockchain and accept documents received through it. This may involve multiple approvals and will take time. Secondly, the customs office of the country of destination must also be linked to the customs office of the country of origin to ensure a smooth flow of information. This raises the question of compatibility.

Currently, different blockchains are incompatible, which means that a blockchain that uses bitcoin as a currency cannot trade with an Ethereum blockchain that uses Ethereum. He will have to convert bitcoin into fiat currency (fiat currency is a currency declared legal tender by the government but not backed by a commodity), and then buy ethers with this fiat currency.

Blockchain can act as an aid to and improve the existing process in the transportation industry. Thanks to the immutable nature of the blockchain, it has the potential to build trust between the participants in the transportation process, such as customs, shippers, freight forwarders, etc. Since knowledge of the capabilities of information technology is an important point in the design of an integrated information management system for a transport hub, the study refers also to technologies available for tracking cargo and vehicles, communication and management of the transportation system.

REFERENCES

1. Marvin, R. Blockchain in 2017: The Year of Smart Contracts. PCMag, December 12, 2016. [Electronic resource]: https://www.pcmag.com/news/blockchain-in-2017-the-year-of-smart-contracts. Last accessed 21.08.2022.

2. Hyung-Geun, Kim. The Role of logistics industry in China national economy – An Input-Output analysis. *Chinese Studies*, 2013, Vol. 45, pp. 281–302. DOI: 10.14378/KACS.2013.45.45.281.

3. Yi, Lin; Xiaojun, Duan; Chengli, Zhao; Li, Da Xu. Complex Systems and Complexity. In: Systems Science, 1st ed. CRC Press, 2013, 38 p. eBook ISBN 9780429112812. DOI: https://doi.org/10.1201/b13095-11.

4. Eremina, L., Mamoiko, A., Bingzhang Li. Use of blockchain technology in planning and management of transport systems. *E3S Web Conf., Key Trends in Transportation Innovation (KTTI-2019),* 2020, Vol. 157, Article Number 04014, 8 p. DOI: https://doi.org/10.1051/e3sconf/202015704014.

5. Li, Bingzhang, Zirianov, V. Blockchain in agricultural supply chain management. Blockchain in agricultural supply chain management. E3S Web of Conferences, January 2021, Vol. 273 (4), pp. 08029. DOI: 10.1051/e3sconf/202127308029.

6. Nozdrev, S. China in the system of world finance. *World Economy and International Relations,* 2016, Vol. 60, Iss. 10, pp. 29–40. DOI: https://doi.org/10.20542/0131-2227-2016-60-10-29-40.

7. Weber, I., Xu, X., Riveret, R. [*et al*]. Untrusted Business Process Monitoring and Execution Using Blockchain. 14th International Conference on Business Process Management (BPM 2016). Springer International Publishing, Business Process Management, 2016, pp. 329–347. DOI: https://doi.org/10.1007/978-3-319-45348-4_19.

8. Khamenehmohammadi, T. Cross Case Analysis in Shipping and Logistic Industry Supply Chains: Blockchain Qualities in Stakeholder Value Proposition. Theses Dissertation. Ottawa, Carleton University, 2021, 130 p. [Electronic resource]: https://curve.carleton.ca/2d36dc9e-531f-41ff-ae40–2e267e09a18d. DOI: https://doi.org/10.22215/etd/2021-14483.

9. Bauk, Sanja. Blockchain conceptual framework in shipping and port management. Conference lecture. Universitat Politècnica de Catalunya. *Iniciativa Digital Politècnica,* 2022. [Electronic resource]: https://upcommons.upc.edu/handle/2117/369103. DOI: http://dx.doi.org/10.5821/mt.10848.

10. Zhang, Z., Figliozzi, M. A. A Survey of China's Logistics Industry and the Impacts of Transport Delays on Importers and Exporters. *Transport Reviews,* 2010, Vol. 30, 26 p. DOI: https://doi.org/10.1080/01441640902843232.

11. Yu, Nannan; De Jong, M.; Storm, S.; Mi, Jianing. The growth impact of transport infrastructure investment: A regional analysis for China (1978–2008). *Policy and Society,* 2012, Vol. 31, pp. 25–38. DOI: https://doi.org/10.1016/j.polsoc.2012.01.004.

12. Chen, Lurong; De Lombaerde, P. China moving up the value chain: What can be learned from the Asian NICs? *International Area Studies Review*, 2013, Vol. 16, Iss. 4, pp. 407–430. DOI: 10.1177/2233865913507441.

13. Zhang, Junping; Wang, Kunfeng; Lin, Wei-Hua; Xu, Xin; Chen, Cheng. Data-Driven Intelligent Transportation Systems: A Survey. *IEEE Transactions on Intelligent Transportation Systems,* 2011, Vol. 12, pp. 1624–1639. DOI: 10.1109/TITS.2011.2158001.

14. Luan, Xin; Cheng, Lin; Yu, Weiwei; Zhou, Jie. Multimodal Coupling Coordination Analyses at the Comprehensive Transportation Level. *Journal of Transportation Systems Engineering and Information Technology*, 2019, Vol. 3, pp. 27–33. DOI: 10.16097/j.cnki.1009-6744.2019.03.005.

15. Yeung, H. W.-C. Rethinking the East Asian developmental state in its historical context: finance, geopolitics and bureaucracy. *Area Development and Policy,* 2016, Iss. 2 (1), pp. 1–23. DOI: 10.1080/23792949.2016.1264868.

16. Junjie, Hong; Zhaofang, Chu; Qiang, Wang. Transport infrastructure and regional economic growth: Evidence from China. *Transportation,* 2011, Vol. 38, pp. 737–752. DOI: https://doi.org/10.1007/s11116-011-9349-6.

17. Li, Bingzhang; Eremina, L. V. Development of the transport corridor «The New Silk Road» in China. Materials of the International Conference «Scientific research of the SCO countries: synergy and integration» – Reports in English. Part 2. Beijing, PRC, December 12, 2018, pp. 208–215. ISBN 978-5-905695-84-1. [Электронный ресурс]: https://elib.pnzgu.ru/files/eb/2ybU3sAQlUFy.pdf. Last accessed 21.08.2022.

18. Eremina, L., Mamoiko, A., Semchugova, E., Shatalova, E., Volohov, A., Li, Bingzhang. Innovative Use of Blockchain Technology in the Logistics Industry. In N. Lomakin (Ed.). Conference: Finance, Entrepreneurship and Technologies in Digital Economy. *European Proceedings of Social and Behavioural Sciences*, 2021, Vol. 103, pp. 629–638. DOI: https://doi.org/10.15405/epsbs.2021.03.79. ●

Information about the author:

Li, Bingzhang, *Ph.D. student at Don State Technical University, Rostov-on-Don / Jinan, Shandong Province, China, runa666.6@mail.ru.*

Article received 02.08.2022, approved 07.09.2022, accepted 18.09.2022.