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APPLICATION OF BLOCKCHAIN TECHNOLOGY IN THE LOGISTICS OF COOPERATING ENTERPRISES

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Purpose: The objective of the study was to indicate the opportunities that the implementation of blockchain technology brings for companies in the TSL sector. Based on our own research, it was shown that the implementation of blockchain technology solutions can lead to time and cost savings in the procedure of documentation exchanged between cooperating companies.
Design/methodology/approach: The main research objective was to attempt to evaluate the initial implementation of blockchain technology into the customer service process at a selected logistics operator (the criteria for evaluating the process were the time and cost of document processing). The research hypothesis was that: the use of blockchain technology will reduce the time and costs of document processing in the logistic process in the supply chain. The research method was the diagnostic survey method. The research techniques were an interview and a survey, and the research tools were an interview questionnaire and a survey questionnaire. A purposive selection method - snowballing - was used for the research. This means that a large supply chain logistics operator was selected for the research. This operator identified smaller TSL operators who were its subcontractors or potential subcontractors for the study. The sample size among subcontractors was 54 companies.
Findings: The introduction to the article presents the relevance of blockchain technology for logistics processes implemented in supply chains from a theoretical point of view. The second section presents the research methodology. Appendices 3 presents the author's research results indicating blockchain as a technology to improve logistics processes in the supply chain by speeding up and reducing the cost of document procedures.
Research limitations/implications: The feasibility of implementing blockchain technology only with a logistics operator operating supply chain and with subcontractors of the TSL sector was investigated.

Keywords: Blockchain, logistics, cooperating enterprises.

1. Introduction

The genesis of blockchain technology was developed in 1991, by Stuart Haber and Scott Stornett, and called a document meaning system using cryptographically encrypted block chains with timestamps. Today, blockchain is understood as a decentralised data storage structure where the history of data cannot be changed. The basic unit is a block, which consists of a header and input data. This header has a stored hash function (hash). The hash function, interchangeably referred to as a mixing or hash function, ensures that each subsequent block stores information about the hashed value from the previous block. This association allows data to be stored only at the time a block is created and is unmodifiable once it has been publicly disseminated. Each subsequent block is created in succession and has a timestamp in the aforementioned header. Thanks to the hash function, any unique set of security keys can be generated for any digital data. Thus, blockchain documents are regarded as secure and collision-free (Kurowski, 2021).

The basis of blockchain technology is asymmetric cryptography, which differs from symmetric encryption in that, in classical symmetric cryptography, in order to send an encrypted message or data, both the sender and the receiver must have the same secret key. Asymmetric cryptography relies on each party having two types of keys. One of these keys is the private key and the other is the public key. The public one is known to every user on the network, while the private one is kept secret. When we encrypt data with the private key, then any user can decrypt the data. Using the public key of a particular user, the data can be decrypted. This encryption is characterised by a high degree of security. Blockchain as a distributed database is an uneditable digital ledger that cannot be defaced, forged or altered. The data is stored in a network of computers that operate on a single-measure system. With every transaction goes an acceptance from intermediaries or other parties. This mutual authorisation scheme is called proof of work (Szczerbowski, 2018). Blockchain technology enables so-called smart contracts with (smart contracts). Nick Szabo defines smart contracts as the conclusion of electronic transactions, underpinned by contracts that guarantee security between unknown entities on the network. Smart contracts can be concluded in a number of programming languages including JAVA, Solidity or Chain Code (Baloch, 2019).

According to the World Economic Forum, blockchain technology will generate 10 per cent of the world's gross domestic product by 2025, and Gartner reports that blockchain-based systems will generate $176 billion in value added to the economy by 2025. The wave of deployments so far has mainly been in industries such as banking and finance, transport and logistics, and the food and beverage sector. An analysis of deployments according to statista.com for 2018-2025 is shown in Figure 1.

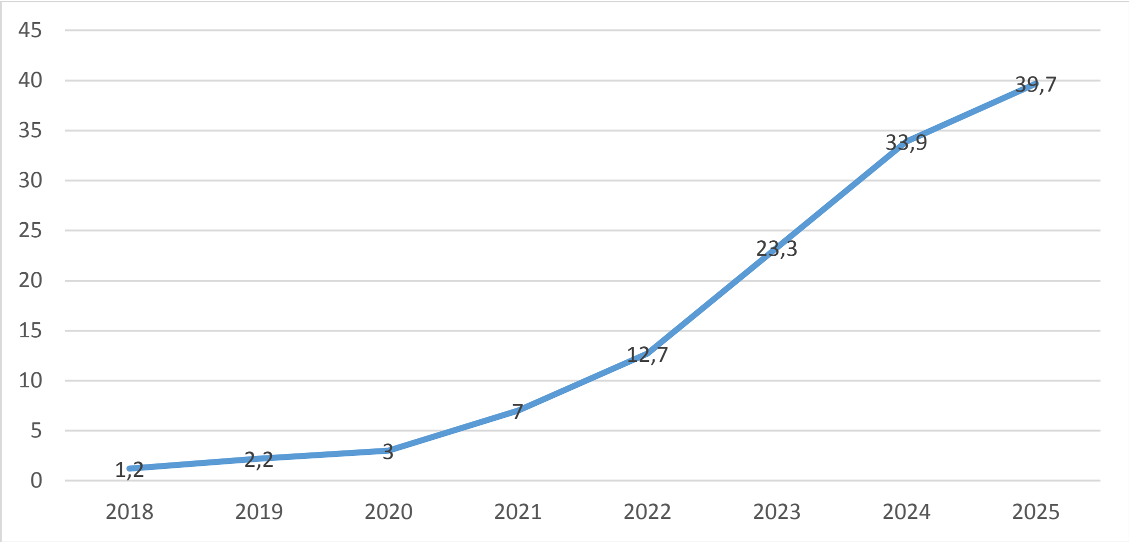

Figure1. Projected value of the blockchain technology market by 2025 in billions of dollars.
Source: own compilation based on data from https://www.statista.com.

Blockchain technology has begun to be used in supply chain logistics to guarantee the origin of materials and component products, (the technology enables the attribution/recognition of property rights) (Konnst, 2021).

Over time, blockchain technology has begun to complement the functionality of the Autonomic Logistics Informations System (ALIS).

ALIS had already based autonomous data information on the use of operational research, barcodes, RFID, image recognition. Autonomous vehicles, augmented reality, picking by voice, digitisation of databases as well as documents have also found their way into ALIS systems. ALIS systems use Electronic Data Interchange (EDI). EDI is an automated, purely electronic process of document exchange between the various parties in the supply chain. The basis of this system is the exchange of globally standardised documents/data between operators, regardless of the type of hardware, operating system, e-mail client, application from which the data is retrieved and the type of connection between operators. EDI has been in use since the 1960s. The transfer of open text files via file transfer (FTP/SFTP) from the sender's folder to the recipient's folder was not secure. Blockchain Data Interchange (BDI) is a modern variation of Electronic Data Interchange (EDI), based on Public Blockchain technology, enabling agile, encrypted, auditable and cost-effective Peer-2-Peer exchange of electronic business messages without any third-party systems or intermediaries. BDI relies on industry-standard message formats and plug-ins for ERP/IT systems to connect and streamline all business-to-business processes. BDI is key to the further development of ALIS (Fraga-Lamas, Fernández-Caramés, 2019). An integral part of the ALIS system is the Global Positioning System GPS. Due to its versatility, GPS is applicable to all modes of transport. Thanks to telematic solutions, it can be used to track shipments in real time and additionally collect information on their condition in order to optimise the movement of the fleet (Gołębska, Sławińska, Szymczak, 2013). The intelligent interaction of sensors that enable devices to independently identify, collect and process data within a single electrical or computer network is the Internet of Things (IoT) (Bai, Dallasega, Orzes, Sarkis,2020). The aforementioned technologies counted among the tools of Industry 4.0 unsupported by analytical algorithms and central supercomputers can lead to simple system overloads (Piątek, 2023). Therefore, a tool for collecting raw or already analyzed data, and supporting data decomposition and re-analysis - that is, BIG DATA technology - may be necessary for the smooth operation of these systems (Gupta, Modgil, Gunasekaran, Bag, 2020). Thanks to this technology, large amounts of data can be processed, analyzed, enriched, verified. Access as well as transmission of digital data is carried out by means of computer networks and the data is placed in the so-called Cloud. A modern ALIS (with BDI) is designed to collect internal (from the enterprise) as well as external (from the supply chain) information, while using analytical subsystems that filter information noise. A modern ALIS can autonomously extract BDI-confirmed information, make and execute logistics decisions. The Accenture research company has filed a patent application with the US Patent and Trademark Office in 2020. Accenture's ALIS-based solution using blockchain, IoT and Big Date aims to intelligently manage the logistics network (Stawiarska, Szwajca, Matusek, Wolniak, 2021; Stawiarska, 2019). Future Automated Logistics Information Systems will spin up other Industry 4.0 technologies such as artificial intelligence, autonomous vehicles, drones, aerial machines, robots, 3D printing, automated warehouses, smart buildings creating smart factories. Each of their actions/transactions will require time-stamped, digitally signed NODs to act as notaries of the transaction. In view of the above, the ideal solution seems to be the successive implementation of blockchain registries into ALIS. Sooner or later, blockchain will record all transactions/events currently recorded in ALIS (Tapscott, Tapscott, 2019). The current ALIS system has been accused of e.g.: high operating costs, time-consuming maintenance and slowing down processes due to system overload (Harris, 2021; Szopa, 2021). Blockchain running on a cloud-based external network will reduce the hardware requirements of ALIS, making the system accessible from browsers or dedicated applications on cell phones. Table 1 compares ALIS equipped with blockchain and without this technology.

Table 1.
Comparison of ALIS with blockchain and ALIS without blockchain by selected domains

Domeny dotyczące danych	ALIS with blockchain	ALIS without blockchain
General common ledger	YES	YES
Data non-repudiation	YES	NO
Finality of the transaction	YES	NO
Automation of task execution and decision making	YES	YES
Saving time on operations	YES	YES
Reducing risk on operations	YES	NO
Transparency of transactions	YES	NO
Reliability in data access	YES	NO

Source: own study.

The use of blockchain is a solution to numerous problems related to the course of logistics processes implemented with the circulation of documents. Blockchain makes it possible to track goods and assets throughout the logistics supply chain from the manufacturer of components to the manufacturer of the final product. The registration of documents through the blockchain system (thanks to the timestamp function) makes it possible to identify the moments of manufacture, transfer of goods to the next link in the supply chain. Blockchain and other Industry 4.0 tools are already recommended in process reference models. Implementing blockchain into modern customer service systems is becoming a necessity due to the need to increase process efficiency and service quality (Kotler, Kartajaya, Setiawan, 2017). Reference processes for logistical customer service have been developed. The process diagrams reflect customer service in practice. In the beginning, they assumed the course of processes without automation with the use of standard manual technologies such as fax, Internet, e-mail, traditional mail and smartphones. The next solutions relied mostly, on automated systems such as ALIS based on ERP subsystems, WMS, TMS, RFID with Electronic Date Interchange EDI between cooperating companies. The third generation of reference customer service processes involves the use of BDI, IoT Big Data. Figure 2 shows reference opportunities to use blockchain in supply chain logistics.

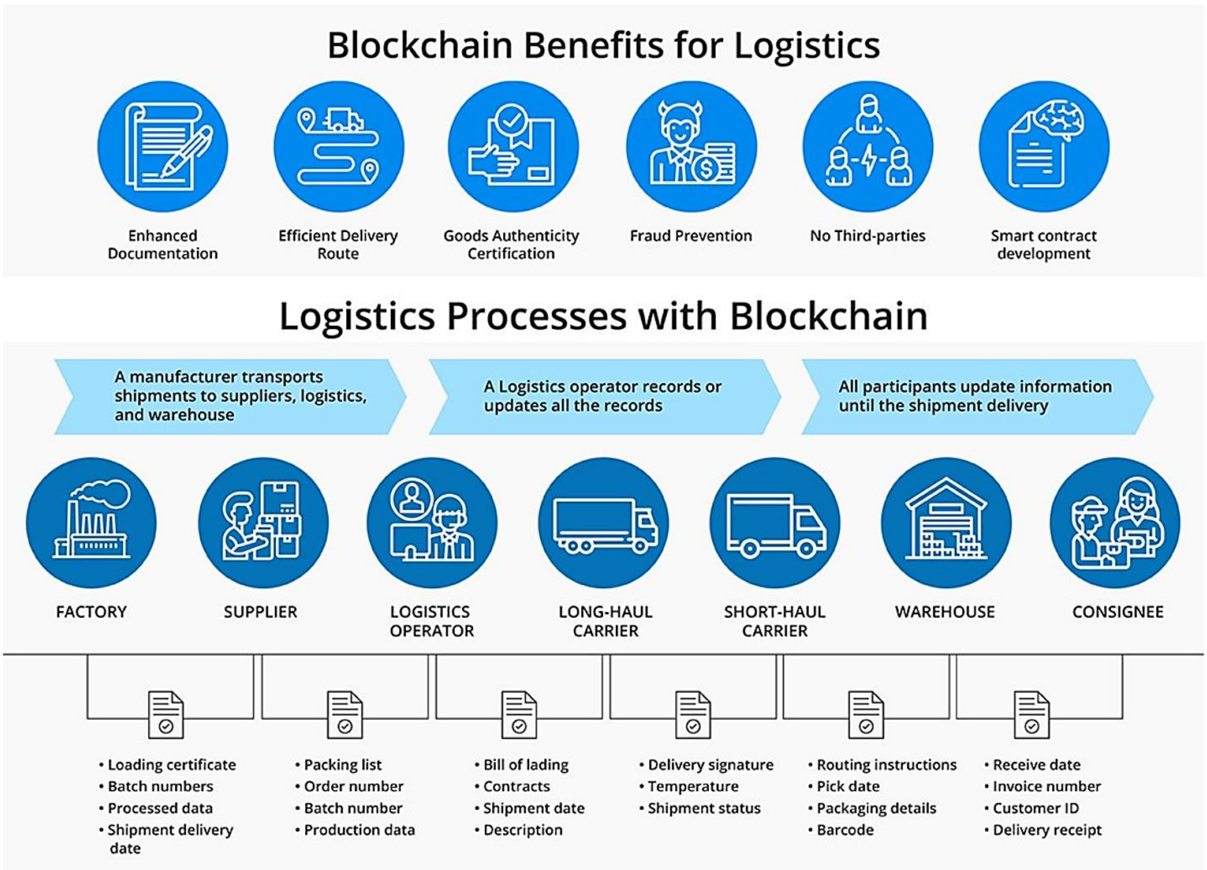

Figure 2. Reference opportunities to use blockchain in supply chain logistics.

Source: https://blockchain.oodles.io/blog/blockchain-development-for-advanced-logistics-solutions/

Logistics operators began to diversify their services, providing facilities such as customs clearance, order processing, packaging, labeling, after-sales support and returns logistics. As a result, reference models for customer service in the supply chain have evolved.

In the first models, the chain integrator communicated with the links of procurement, distribution as well as subcontractors of logistics operations using standard information channels. Access to data as well as a workflow center was administered by the logistics operator. A customer wanting information on the specifications or status of a shipment sent an inquiry to the operator, who responded using conventional communication channels. The flow of capital took place without financial analysis and verification of new customers. The phenomenon of limited trust usually resulted in various types of prepayments. Data was stored in paper form as well as on computer disks in the form of scans. Data was susceptible to destruction, deletion, forgery, or illegal use. The whole process prolonged, expensive and not environmentally friendly.

Currently, processes based on ALIS and using EDI for communication are proposed. Systems like ERP, TMS, WMS are bundled in ALIS (Galankashia, Helmi, 2014). Automation is at a very high level. The customer has access to the operator's portal, where he can request information via chat using bots or a form. ALIS with the help of stored data and ready analyses from the systems: ERP, WMS, TMS transmits reports to customers. The system verifies customers financially, so payment occurs after the operation is completed and is automatically posted (using automatic debits) after the order is completed. The logistics operator owns the automated information system, so it determines what information is sent between supply chain participants. The logistics operator is responsible for data security. The customer has access to product information and order status in real time, as well as to product documentation and specifications. The added value of such a solution can be the speed of processes and the reduced number of people needed to handle processes. In contrast, the complexity of centralized handling has drawbacks, such as the incompatibility of systems belonging to individual members of the supply chain (this forces at times traditional data processing). The incompatibility of systems can also be quite a problem, especially when working with smaller entities. Lack of access from the supplier or customer level to most functions can also disrupt the entire process. Failure of a processing computer can make or break an automated customer service process.

The customer service process using blockchain technology was then presented. The new ALIS uses Industry 4.0 solutions, i.e: IoT using mobile networks, preferably 5G. The customer's ERP generates the order, and the manufacturer's BDI system generates the smart contract. The system, from ready analysis, prepares material orders to upstream suppliers/or starts the production process. Thanks to the phenomenon of deitermediation, the entire process passes without additional intermediaries. Payment is made instantly with digital currency convertible to any payment type. Accounting as well as tax settlement is done automatically. The role of the logistics operator is reduced to controlling processes and renting infrastructure such as, transportation infrastructure and warehouse infrastructure. Document circulation is based on blockchain, where smart contract records can create a document for any system. Work on a document can be done by multiple entities at the same time. Blockchain technology, through compatibility with all systems at the same time, creates documents, which improves the customs and tax process as well as controlling the customer service process. The customer has direct access to product information and the transportation process, and with the help of process programmability can be automatically notified of changes in shipment location, temperature, unloading and delivery. The entire logistics chain is analyzed automatically. The history of the logistics process as well as the product is stored in the blockchain and is non-editable. The system, thanks to the fact that it is distributed, does not overload, because as the participants in the process increase, the computing power increases. The advantages of the system are the transparency of the transaction as well as the product, speed and scalability. Implementation of blockchain technology into ALIS Autonomous Logistics Information Systems means replacing EDI with BDI solution in dealing with supply chain partners (Szopa, 2021).

Blockchain is a technology that provides logisticians with a trustworthy platform to monitor shipment status, location, events, receipts, delivery times (Hastig, Sodhi, 2020). It also allows updating any changes, such as supplier creditability, payment terms, pricing, quality standards, service specifications, delivery requirements and conflict resolution procedures. The updated data is shared with multiple stakeholders in the supply chain (Chod et al., 2020; Kumar et al., 2020; Niu et al., 2021). The main drawback of the technology is its dependence on internet access, making it unable to operate offline (Ahmed, Khan, 2020; Walasek, 2014). Implementing blockchain technology into ALIS Autonomous Logistics Information Systems means replacing EDI with a BDI solution for dealing with supply chain partners. The implementation involves a great deal of complexity and numerous technological resolutions (Eckerd et al., 2021). Implementation decisions, include the selection of a trust anchor, the process of modifying a smart contract, the development of a dispute resolution policy, the mode of payment, and procedures for implementation and extension to other companies. There is a lack of guidance on the choice of architecture for blockchain implementation in TSK companies (Chod et al., 2020). Large logistics companies developing Blockchain platforms specifically for their own use are setting up technology start-ups creating applications for general use in the logistics industry (Cao et al., 2022). Then companies extend the use of the developed platforms to other entities when the proof of concept has been successful internally. When implementing blockchain technology into logistics processes, the financial aspect is taken into account, the advantages and disadvantages of blockchain-based solutions are analyzed, as well as the long-term impact on the competitiveness of the company. The backbone of a BCT system for a logistics operator has been outlined by few researchers (Wan et al., 2018; Sinil et al., 2023).

There are standard tools for smaller businesses as well as the possibility to prepare a blockchain network in-house. In order to effectively implement the technology for a particular business, it is necessary to conduct an internal audit in a particular company, as well as an external audit, where various determinants will be taken into account, i.e.: market analysis, existing technology in the company, level of knowledge and capabilities of employees.

The phasing of blockchain implementation is shown in Table 2, which takes into account the market, the type of business and the technological solutions possessed and possible to implement - as factors determining the stages of implementation.

Table 2.
Staged process of implementing blockchain technology

Etaps	I	II	III	IV
Factors	**Begiing**	Implementation	Statrtup	Usge
Market	Analysis market	Identification of cooperating entities (that will potentially use BDI)	Determining the scale of action (mobilization of cooperating entities to launch BDI)	Mobilization of new users/customers
Type of business	Analysis logistics processes	Modeling of logistics processes using blockchain in the logistics supply chain	Process reengineering through application blockchain and other Industry 4.0 solutions	Continuous process optimization
Technology	Analysis of existing ALIS technology	Developing a platform or adding to existing solutions	Launch of the platform pilot project	Further scaling by sharing technology with supply chain partners
Duration	1 month	3-4 months	4-6 months	from 1 year to now

Source: Own study.

By implementing a blockchain application from the Ethereum public network, the user agrees to interact with other participants by communicating with the application. Acceptance of the Baseline Protocol (the key blockchain application protocol) will enable confidential and complex collaboration between enterprises without leaving sensitive data on the blockchain. Users can operate the applications on computers, cell phones or other mobile devices. An application with a user interface is written in a front-end programming language (e.g. HTML/JavaScript). Data processing in the blockchain is carried out using back-end languages. After sending data for analysis and accepting it, the application launches smart contracts to formalize operations. Not all enterprises like to keep their data on a public network. For users with sufficient programming knowledge, the Ethereum Geth solution is recommended to build a private blockchain network. For transactions that require payment, an application is needed to settle for approved transactions. Creating contracts and transferring funds between addresses requires operating ETHER payment means (Dhillon et al., 2018).

2. Research methodology

The main problem in the operation of logistics companies in the implementation of customer service processes is the use of outdated technological solutions that prevent the efficient flow of data as well as the sending and storage of documents. The use of outdated technologies currently generates high labor time and costs in logistic customer service. The hardware resources of the ALIS system are also under strain, resulting in a decrease in the quality of customer service.

The main research objective was an attempt to evaluate the pilot implementation of blockchain technology into the customer service process at a selected logistics operator (the criteria for evaluating the process were the time and cost of document processing). The research hypothesis was that: the use of blockchain technology will reduce the time and cost of documents relevant to the service process.

The research method was a diagnostic survey. The research techniques were an interview and a survey, and the research tools were an interview questionnaire and a survey questionnaire. The study used the snowball sampling method. This means that a large logistics operator servicing supply chains was selected for the study. This operator indicated smaller entities from the TSL sector for research, which are its subcontractors or potential subcontractors. The sample size among subcontractors was 54 companies. The survey was sent to 4655 companies, but only 54 completed surveys were returned. The subject of the research in which the interviews were conducted was the logistics operator Swiss Logistics Company - Simplified Logistics Transport (with 150 branches in 15 countries, employing over 15,000 people). The interviews were conducted in one of the branches located in Switzerland, in the federal state of Aargau in the town of Oftringen (this particular branch was in the process of implementing blockchain technology). The interview was conducted with one of the senior managers responsible for servicing subcontractors and regular employees who have direct contact with subcontractors. Subcontractors dealing mainly with forwarding and transport services were surveyed using the survey method. The surveyed subcontractors came from many European countries. The research carried out therefore has a European dimension. The research was conducted at the turn of 2021/2022.

3. Re-engineering the customer service process in a selected logistics company using blockchain - Research findings

The surveyed branch of the logistics operator is located in Switzerland. For years, Switzerland has had an efficient, publicly available automatic EDI document exchange system called eXite (used by some 20,000 companies, generating more than 400 million transactions annually) (Cegner). Nevertheless, the surveyed operator is piloting a BDI implementation. An assessment of existing customer service processes is shown in Tables 3-5.

Table 3.
Number of employees at the logistics operator's branch, number of documents exchanged with TSL service subcontractors

Employment level at the logistics operator's company		
All employees	Employees delegated to handle logistics documents processed with TSL subcontractors	Percentage of the number of employees of logistics documents processed with subcontractors of the TSL sector
100	18	18%

Source: own study based on primary research.

Table 4.
Number of hours per month required to process documents exchanged with TSL service subcontractors

Operations related to document procedure	Number of people	Number of hours (h)	Number of man-hours (h)
Manual operation	18	21	378
Manual operation inputs/outputs	4	168	672
Additional service	3	84	252
Handling analysis	2	84	168
Error handling	3	42	126
Planning support	3	4	20
Accounting services	3	16	54
Total	18		2120

Source: own study based on primary research.

In the surveyed company, a full-time monthly position is 160 hours. The cost of an employee, per hour of work at the level of specialist in logistics is a gross cost of about CHF 50/hour (https://www.aplikuj.pl/…). 2120 labor hours requires approximately 13.25 employees and costs about CHF 106,000.

To the calculated labor costs of specialists should be added the labor costs of a manager (160 hours and 8000CHF), making a total of 2280 hours and 114 000CHF (allocated for the procedure of documents).

Table 5.
The sum of relevant data in the procedure of documents exchanged with subcontractors of TSL services without the use of blockchain

Total operations per month	3780 operations
Total documents per month	18 900 pages
Dimension of employment in service on a monthly basis	2280 hours (2120+16)
Required employment costs per month	114 000 CHF (10 600+8000CHF)

Source: own study based on primary research.

With the use of blockchain technology, the staffing level for subcontractor logistics dropped from 18 people to 4 (or 5 counting the manager), and costs to about CHF 36,000 (counting the manager). Similar calculations can be arrived at using a blockchain implementation simulation calculator (https://altab.pl/cennik).

Analyzing the possibilities of blockchain technology, based on the experience of a company that is in the process of implementing blockchain, and referring to the Altab implementation calculator, it is possible to prepare a summary of the savings of procedural documents related to the handling of subcontractors of TSL services (Table 6).

Table 6.
Evaluation of the procedure of documents (exchanged with subcontractors of TSL services) by the logistics operator before and after the implementation of blockchain technology

Process evaluation criteria	Before implementing blockchain	After blockchain implementation	Decrease in %
Number of man-hours necessary for operation	2120 hours	800 hours	62
Employment in the company	100 persons	87 persons	13
Employment in service	18	5	72
Monthly costs of employing service staff	114000 CHF	36000 CHF	72
Costs of processing one document in CHF	6,03	1,9	70

Source: own study based on primary research

According to the survey, conducted among TSL subcontractor companies, 40% are micro-enterprises, employ 10 people. 20% of the surveyed enterprises employ from 10-50 people. 15% of the surveyed companies employ from 50-100 people, and 25% employ more than 100 people. At 57% of respondents, the number of logistics operations requiring the issuance of documents reaches 1000, 25% of respondents generate from 1000 to 10000 documents. 31% of respondents send documents to logistics operator (by e-mail - 90% of respondents; by snail mail - 26% of respondents; by cell phone - 26% of respondents; by fax - 11% of respondents), 67% partially use EDI, 2% declare full documentation automation using BDI.

From the survey of respondents/subcontractors in the TSL sector, average ratings - related to the service of logistics operators). The results obtained were confirmed in the calculator (Table 7) (https://altab.pl/cennik).

Table 7.
Averaged evaluation of operations over documents processed at subcontractors (before and after implementation of blockchain technology)

Process evaluation criteria	Before implementing blockchain	After blockchain implementation	Decrease in %
Averaged monthly number of man-hours required to operate	210 hours	80 hours	61
Average employment in the surveyed companies	28 persons	26 persons	8
Averaged monthly employment costs for process personnel	10500 CHF	4000 CHF	62
Averaged cost of processing one document in CHF	5,03	1,1	54

Source: Own compilation based on primary research, Declared costs converted to Swiss currency.

4. Discussion - Cognitive conclusions of the study and recommendations for companies wishing to implement blockchain

The literature cited below shows that document processing using modern blockchain technology translates into a reduction in the costs and time of the logistics process in the supply chain. Multitasking of the logistics operator in the supply chain, makes it extremely important to satisfy the need for information and authorization of documents (Forslund, Jonsson, 2008). In logistics industry, it is essential to promptly deliver the right information to the right entity at the right time (Custon et al., 2006). If this need is not met, it may not be possible to move to the next stage of the logistics process. It is within the competence of the logistics operator to have knowledge of the flow of information in the supply chain. Ideally, the focus should be on the dynamics of information flow, the veracity and certainty of information (where entities such as the TSL service sub-supplier, component suppliers, customers and clients have the same reliable information. All of these entities could automatically exchange information on delivery, production, quality, financial settlement, warehouse operations, transportation, orders, etc. if they have blockchain (Klöckner et al., 2022; Hastig, Sodhi, 2020; Casey, Wong, 2017). Blockchain can give the best results if it is adopted by all participants in the supply chain. However, logistics companies are concerned about the lack of clarity in the laws governing smart contracts. There are also no clear technical guidelines and decision-making plans to guide companies, both before and during blockchain implementation (Stawiarska, 2016). There should be a clear definition of the various stages and milestones on the road to successful blockchain implementation (as has been done in the UK see Status of cryptocurrencies and smart contracts" - November 2019). Countries such as Argentina, Australia, Brazil, Canada, most countries in Europe, Japan, Saudi Arabia, South Africa, South Korea and the United Arab Emirates have taken steps to legalize cryptocurrencies and blockchain applications (Hammond, Ehret, 2022).

The presented assessments of document processing show that the use of modern blockchain technologies translates into cost and time reduction, as shown in Table 5 and 6.

The surveyed logistics operator switching to BDI is currently implementing processes through a hybrid procedure (i.e., using EDI and BDI). Logistics operator declares that about 20% of the companies working with him are also implementing BDI. Over time, more contractors will join the blockchain platform.

The company, through the use of the blockchain platform in its dealings with stakeholders, wants to achieve higher competitiveness in the logistics services market. The interview shows that the logistics operator, after the partial implementation of blockchain technology, has achieved benefits having the following dimensions: financial, improved efficiency of the service process, increased security, improved transparency, increased quality of service.

The financial savings are:

- enterprise-wide employment decreased by 13%,
- employment of employees in document handling decreased by 72%,
- reduced IT maintenance costs by using network infrastructure,
- faster payments resulting from the elimination of intermediaries in the process (improved liquidity),
- elimination of payment bottlenecks due to the due and irrevocable fulfillment of the smart contract.

Improving the efficiency of the service process involving:

- minimization of manual work related to document procedure,
- reducing the time (by 95%) required to generate, send and check a document (simultaneous work of multiple internal users on the same document in real time, i.e.: accounting, payment, document generation and transmission, authentication of receipt and handling of analysis and checking for possible errors),
- timely information to all external document stakeholders and the ability for multiple external users to work on the same document simultaneously in real time,
- higher susceptibility to development and integration with other systems in the future, which will certainly still appear in Industry 4.0 or 5.0. Backward compatibility with traditional solutions also affects the efficiency of handling process.

The increased security consists of:

- an increase in the security of transactions between users resulting from distributed authentication, where no single entity can tamper with a record,
- the impossibility of retroactive editing, which secures timeliness and gives time certainty,
- resistance of the system to double spending (it consists in the fact that one commodity or service is assigned to a specific entity, thus eliminating the risk of double posting in the system),

- storing and securing data in the cloud embedded on distributed block records, which prevents loss, falsification, and possible abuse will be transparent to all users.

Improving transparency by:

- enabling online tracking of shipment status,
- preventing manipulation in service offerings, improving competitiveness,
- making all meaningful data available while keeping subjects anonymous by pledging shortcut functions,
- storing data for later multivariate analysis. Good quality, error-free data provides analysts with support for supply chain management,
- smart contracts promote trust-building, accountability and transparency in collaboration.

Improved customer service quality through:

- reduced response times and more effective decision-making,
- real-time customization and analysis of customer needs,
- insightful analysis of timing, cost, quality, efficiency, reliability of customer service,
- continuous data collection, resulting in information on all important customer service parameters,
- eliminating errors due to human factors.

According to the survey, about 33 percent of surveyed respondents/subcontractors in the TSL sector are small companies with up to 10 employees. These entities often do not have adequate knowledge as well as human resources for blockchain implementation.

5. Summary

In the article feasibility of implementing blockchain technology with a logistics operator operating supply chain and with subcontractors of the TSL sector was investigated. No research has been carried out in companies cooperating in the supply chain, i.e. suppliers, clients and customers of final goods. Therefore, it can be concluded that the hypothesis (the use of blockchain technology will reduce the time and costs of document processing in the logistic process in the supply chain) was only partially confirmed. The truth of the hypothesis was confirmed only at the stages of the logistics process, where actions are taken on documents exchanged between the logistics operator and its subcontractors. Other stages of the logistics process will be the subject of further research.

Companies implementing blockchain in supply chains confirm the truth of the hypothesis put forward in this article (by presenting the functions and capabilities of blockchain on their information portals - zobacz IBM Blockchain Services for Supply Chain Solution Brief).

For companies cooperating in the supply chain, (i.e. suppliers, clients, subcontractors of the TSL sector) it is possible to implement free open source solutions. An example of such a solution is IBM Cloud. In the IBM Cloud service, there is also an extension to a paid version in case the company's demand increases without the need for a new implementation of another solution. IBM Cloud also gives access to more than 170 off-the-shelf solutions, from data, artificial intelligence, Internet of Things and blockchain technologies. It allows you to analyze up to 1000 documents per month using 5GB of transfer. With a user-friendly interface and tools, as well as ready-made plug-and-play solutions, almost any intermediate user has a chance to successfully join the blockchain community. According to IBM, the implementation of blockchain results in savings in time and costs of logistics processes generated for all supply chain partners.

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