Evaluation of Cross-border E-commerce Economic and Trade Data Management Device Based on Blockchain Technology

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Abstract

In the era of digital economy, trade data and goods transaction data in the field of international trade have become increasingly important. In the digital era, the transfer of international trade-related data from the physical world to the digital world through the application of advanced Blockchain Technology (BT) is an important means to promote the development of international trade in the digital era. This paper aimed to analyze Cross-Border E-Commerce (CBEC) economic and trade Data Management (DM) devices based on BT. This paper discussed the application of blockchain in CBEC trade, and proposed a blockchain security algorithm. Based on this, an experimental analysis of CBEC economy and trade DM was carried out. The experimental results of this paper showed that in the logistics costs of CBEC companies, the logistics costs of CBEC companies under the trade DM device based on BT accounted for 20%-30% of the total costs. The logistics cost of CBEC companies under the trade DM device based on traditional technology accounted for 30%-40% of the total cost; in the comparison of the favorable rate of CBEC companies' products, the favorable rate of Company A's products under the trade DM device based on BT was 98.2%, and that of Company B was 98.6%. Under the trade DM device based on traditional technology, the favorable rate of Company C's products was 90.8%, and that of Company D was 91.1%. To sum up, based on the BT trade DM, the company's logistics costs would be greatly reduced and its product quality control was in place.

Keywords: Cross-border E-commerce, Blockchain technology, Trade data, Management devices

1 Introduction

First of all, from the current development of CBEC, before 2014, China's CBEC transactions were small and showed a slow growth trend. It was not until 2014 that the volume of CBEC transactions in China increased significantly. Secondly, from the perspective of the current economic development environment, China's economic environment has entered a new normal stage. As an important way and carrier for China to promote economic growth and export trade development, CBEC industry plays a vital role in it. Thirdly, from the perspective of the current international trade development situation, with the arrival of the digital era and the increasingly frequent international trade activities, the traditional paper document records can no longer meet the needs of the current international trade activities in the digital era. Finally, from the perspective of many problems and challenges faced by current international trade, some problems arising from the traditional model have been difficult to solve and cope with.

From the current application and research development of international trade BT, on the one hand, its application value is relatively wide; on the other hand, it is also faced with problems and challenges such as technology, capital and talent. Therefore, it can be said that in order to promote the rapid development of CBEC economy and the sustained growth of commodity export trade in the digital era, many specific contradictions and problems need to be solved. Based on this situation, the first is to solve many problems in the economic and trade data records in the traditional CBEC industry; secondly, corresponding solutions are proposed for relevant problems; finally, it is necessary to promote the research and development and application research of BT in international trade economy and commodity export.

Based on the existing research results, scholars have carried out relevant research on CBEC. Shuzhong Ma used BizArk's CBEC hosting service database to analyze the prosperity and risk level of China's export e-commerce, and drew the following conclusions: The overall development was stable; the convenience of logistics was relatively stable, but the convenience of customs fluctuated greatly; cheaper and more effective marketing technologies and channels were gradually used; there was a significant improvement in the degree of risk [1]. Qiuyan Fan put forward some new opportunities and challenges on how to seek and develop new customers on China's CBEC platform. The goal of the project was to let small and medium-sized companies understand the unique e-commerce ecosystem in China, so as to provide appropriate strategies for e-commerce in China [2].

The rise of CBEC has greatly changed the relationship between enterprises and consumers. Although CBEC has emerged for less than a decade, many scholars have raised some major issues in this field. Through sorting out the

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DOI: https://doi.org/10.70003/160792642025012601012

literature on CBEC, Bidyut B. Hazarika found its existing problems and shortcomings, which was expected to have certain reference value for future research [3]. Jian Mou mainly discussed the product description in CBEC and the impact of consumers on shopping intention from a psychological perspective. He proposed the research model of purchase intention in CBEC and tested the research model using the structural formula modeling technology based on covariance [4]. However, these scholars' research on CBEC lacked some technical argumentation. Through research, it was found that BT was better for CBEC. In this regard, relevant literature on BT was consulted.

Some scholars also have some research on BT. Xiaoheng Zhang analyzed the energy distribution of blockchain research in China's e-commerce field from the aspectsl of subject distribution, research level, source journals, writer distribution, research institutions, fund projects, etc., and in-depth analyzed the research hotspots and frontiers of blockchain e-commerce in China's academic community from the dimensions of keyword social network [5]. Lu Jiang first analyzed the business model of the current mainstream Internet CBEC platform, and pointed out its characteristics and defects; secondly, the feasibility of the blockchain business model of the CBEC platform was discussed theoretically; finally, based on empirical analysis, the application of BT in CBEC was integrated, analyzed and summarized [6].

In addition, Omar Alqaryouti gave a blockchain-based architecture, which aimed to simplify the e-commerce transaction process through BT. This framework could help expand e-commerce, and manage the transaction modes of all parties concerned, so as to establish a level of mutual trust among all stakeholders [7]. However, these scholars did not analyze the CBEC economy and trade DM device based on BT, and they only discussed it from a shallow level.

In order to solve some problems in the economic and trade data of the traditional CBEC industry, this paper proposed a blockchain security algorithm. Through the analysis of the application of BT in CBEC trade, the simulation experiment of CBEC economy and trade DM was designed. According to the experimental results, CBEC companies under trade DM based on BT could well control logistics costs, cross-border payment costs and product quality. Voting systems, healthcare data management, supply chain management, food safety and traceability, and intellectual property protection. These are but a handful of uses for traceable blockchain technology that go beyond cross-border optimization.

2 Application Methods of BT in CBEC Economy

2.1 Application of Blockchain in CBEC Trade

First, based on BT, in the CBEC economy, the production, logistics, payment and other links of goods can be optimized and simplified [8-9]. By taking customs as an important link in CBEC economic trade, the customs clearance method used is to complete the "list release" of import and export goods by the customs [10-11]. However, the traditional way of collecting import tariff and import value-added tax is not very reasonable. Custom import tariffs and value-added taxes are deemed unfair due to unequal burden, harm to developing countries, higher consumer prices, administrative complexities, retaliation, and inconsistent regulations. Countries are pursuing alternatives like free trade agreements, tariff cuts, and simplified tax systems to ensure fairness, reduce trade barriers, and foster economic growth. In some cases, this method has a great impact on the national tax. Progressive taxation is a method that impacts income tax significantly by redistributing income. It entails higher tax rates for higher-income individuals to support government programs, while lower-income individuals face lower tax rates to reduce their tax burden. In addition, the imposition of tariffs in CBEC trade would cause some governments to impose high tariffs on foreign trade goods [12-13].

CBEC features a wide variety of goods, diverse demand, and large price fluctuations, making traditional customs clearance inefficient and supervision difficult. BT, with customs as the central node, can effectively solve these issues by transmitting information between nodes in the trade link. This eliminates redundant work by both sides during data exchange, reducing enterprise costs and providing faster access to goods information. Additionally, the use of BT can significantly improve import and export transaction efficiency. The effectiveness of import and export transactions is significantly boosted by blockchain technology, which provides increased transparency, traceability, security, faster operations, and effective collaboration. Figure 1 shows CBEC based on blockchain.

BT is characterized by decentralization, openness and transparency. Blockchain's decentralization, openness, and transparency allow for safe peer-to-peer transactions and information exchange, promoting responsibility, innovation, and trust. BT has the potential to eliminate middlemen in a variety of sectors, including finance, supply chain, healthcare, and more. For example, when CBEC enterprises need to complete import orders, they only need to submit the documents to the customs department, instead of publishing the goods information on the Internet; through BT, risk problems caused by data sharing can be avoided. Blockchain technology can reduce the risks connected with data sharing and assure ethical and secure practises by putting in place preventive measures such data privacy/security, anonymization/pseudonymization, consent processes, regulatory compliance, and continuous monitoring/auditing. Therefore, the application of BT in CBEC trade can not only effectively solve the above problems, but also effectively reduce costs and improve efficiency. Finally, the application of BT can also bring more advantages and opportunities to CBEC enterprises [14-15].

2.2 Blockchain Security Technology

(1) Asymmetric encryption algorithm

The progress of network technology has made information transmission easier, yet it has also resulted in increased information leakage and theft, particularly in BT, which involves vast amounts of data storage. Therefore, the need for data encryption technology is on the rise. Encryption algorithms have two kinds: symmetric and asymmetric. Asymmetric encryption provides a highly confidential and adaptable process by giving the other party the public key for encryption. However, it requires more complex algorithms and processing methods than symmetric encryption. Figure 2 shows the entire process flow of asymmetric encryption for information transmission.

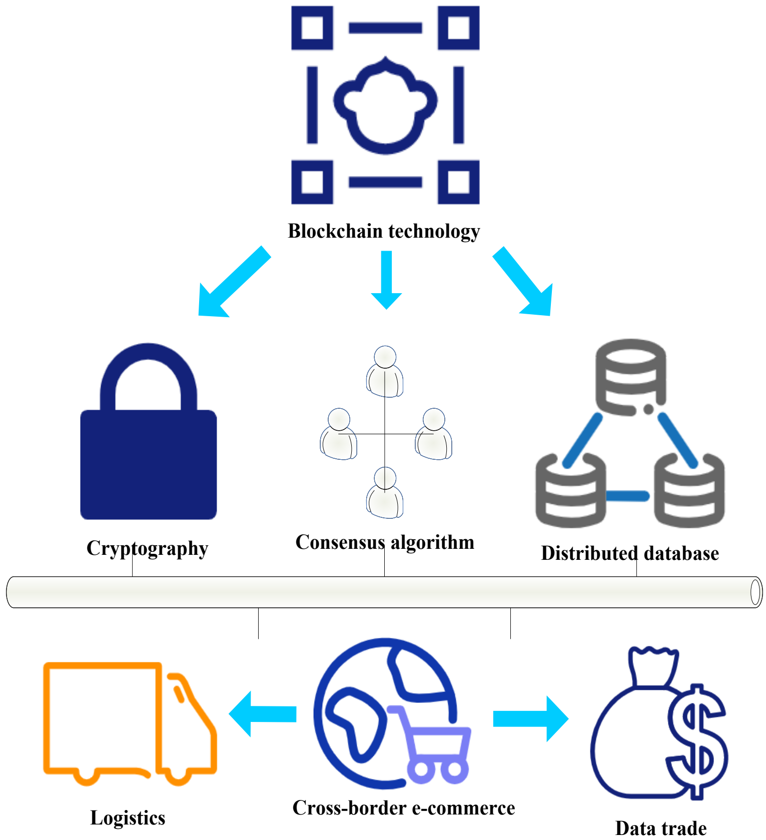


Figure 1. CBEC based on blockchain

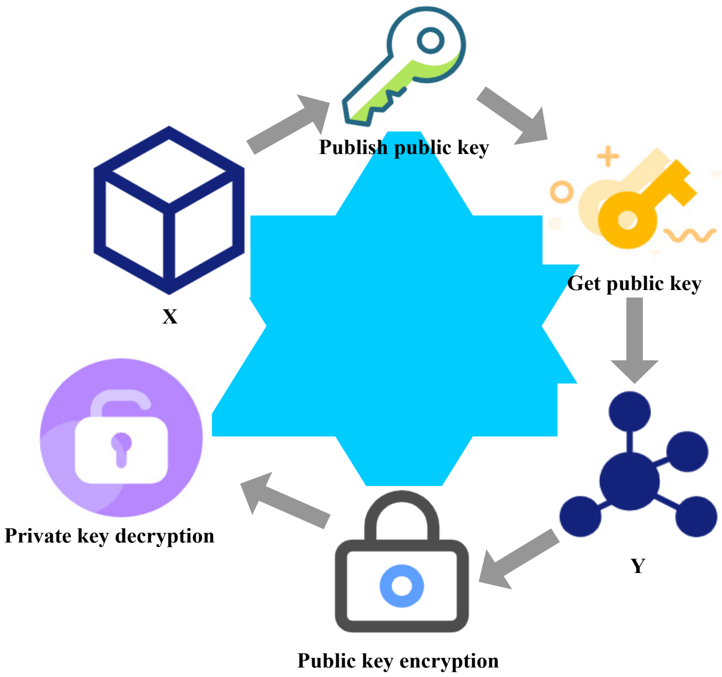


Figure 2. Flow of information transmission by asymmetric encryption algorithm

It is assumed that X and Y have two nodes that can communicate with each other, Y would use asymmetric encryption algorithm to transmit information to X. X node shares its public key with Y node; node Y uses the newly obtained public key to encrypt the information to be transmitted, so that it can become secret information and be transmitted to node X; the X node receives the encrypted information sent by the Y node; X nodes use the private key of X node to decrypt the ciphertext, thus turning the information into a clear text. Node X performs the following operations in order to decrypt the ciphertext: get the encrypted ciphertext, get the private key, decrypt the ciphertext, and get the decrypted message. Observe that depending on the encryption algorithm, the steps may change. The confidentiality of the private key must be maintained.

At this time, node X and node Y communicate according to the encryption algorithm. It is assumed that the key pair of node X has been generated through the above procedure. Node Y uses message z as the public key (M, r) of node X, and the private key is (M, f).

Y converts z into an integer m smaller than M, which adopts the format of protocol with X node;

Formula 1 is used to encrypt m;

$$m^{r} = v(\bmod M) \tag{1}$$

Y node sends v to X node after calculating v; After X node obtains v, Formula 2 is used to decrypt v;

$$v^{f} = m(\bmod M) \tag{2}$$

The X node uses the generated m to recover the information z.

In the fields of information encryption, login authentication, digital signature and digital certificate, asymmetric encryption algorithm based on BT has been widely used. Blockchain technology uses asymmetric encryption to guarantee secure data transfer and validation, safeguarding data privacy, confirming message integrity, and promoting confidence in a decentralised network [16-17]. Of course, it also plays a huge role in e-commerce.

(2) Tamper resistance

It is assumed that in the master-slave multi-link model, the number of nodes participating in the block generation is M; the number of Byzantine nodes is g; $M > 2g$. Decentralized networks' integrity, security, and resilience are crucially dependent on the Byzantine node. These nodes support the reliability and efficiency of blockchain and other distributed systems by upholding consensus rules, validating transactions, and enduring Byzantine flaws. As everyone knows, no matter the verification block or the record block, and no matter what consensus algorithm is used, the newly generated block would not be activated until it becomes the parent block. For the blockchain network to preserve sequential ordering, ensure consensus, maintain chain integrity, and increase security and immutability, a newly generated block must first become the parent block before it can be activated. It is like that Bitcoin needs six confirmations to ensure that a transaction is irreversible.

Under the above circumstances, the probability of the Byzantine node becoming a legal block is the ratio of the number of Byzantine nodes to the number of nodes in the whole system, as shown in Formula 3.

$$Q_1 = \frac{g}{M} \tag{3}$$

The Byzantine node must create a child block to become the parent block and activate its contents. To identify and reduce Byzantine behaviour, blockchain networks use methods like reputation systems, sanctions, and additional consensus protocols. The security and integrity of the block generation process are guaranteed by reducing the number and impact of Byzantine nodes. If a normal node creates the child block, the system won't recognize the parent block or its data. This rule applies to both slave and master chains.

Since the height of the blockchain is infinite, it is assumed that its height is J. According to the above conditions, the possibility that the blocks generated by Byzantine nodes are legal blocks can be obtained from Formula 4.

$$Q_2 = Q_1^{J} \tag{4}$$

It is assumed that there is a Byzantine node of X in a slave node group, and X node wants to modify the data of the linked block. From the characteristics of blockchain, it can be seen that each block has its own digital signature. In asymmetric cryptographic algorithms, to modify a digital signature or data in a block, a corresponding private key is required. Therefore, X can only modify the block Y_X generated by itself.

It is assumed that there are M nodes in the master-slave multi-chain model system; there are m nodes in the slave chain node group to which X belongs; the block header information of Y_X is stored on Y_B of the main chain; the height of the Y_X in the subordinate chain is J_X; the current height of the slave chain is J_1; the height of Y_B main chain is J_B; the current height of the main chain is J_2. A primary blockchain serves as the "master chain" in the master-slave multi-chain concept, which also consists of numerous secondary blockchains. Through the use of a communication protocol, data exchange and synchronization, in a unified blockchain architecture, are scalable and flexible for various use cases. Since the main chain is stored on all nodes, node X must modify the number of blocks num if it wants to modify Y_X, as shown in Formula 5:

$$num = (J_1 - J_X) \times m + (J_2 - J_B) \times M \tag{5}$$

It can be seen from Formula 5 that even if Node X wants to change the height of the block, there is not much difference between its height and that of the block, which would cause great losses. Therefore, even if Byzantium wants to tamper with the block data, the price it would pay is far higher than the profit it would get. With the increasing height of the blockchain, the possibility of tampering is not high because the cost associated with it increases significantly. Therefore, the data stored in the blockchain cannot be tampered with.

3 Evaluation of Experimental Results of CBEC Economy and Trade DM Device

3.1 Data Source

At present, the CBEC industry presents the following five characteristics: The scale of CBEC is constantly expanding, accounting for a large proportion of China's import and export; key markets for CBEC; the distribution of CBEC in commodities and regions is relatively concentrated; the main business of CBEC is export, and the export of CBEC would continue to grow rapidly; B2B (Business-to-Business) is the main form of CBEC. Major CBEC markets include China, the US, and the EU. Fashion, beauty, electronics, and health are the focus of the CBEC. Concentration by region: North America, Europe, and Asia-Pacific. Conduct current study to gain a complete grasp. The cross-border model of B2C (Business to Consumer) is gradually emerging and has the trend of expansion. At the same time, the government has increased its support for CBEC, which fully demonstrates the huge role of CBEC in the development and provides an internal impetus for the development of CBEC in the future [18-19]. In the current development trend of CBEC, major network companies and transnational e-commerce companies have participated in the development of BT and actively discussed its application in the field of CBEC.

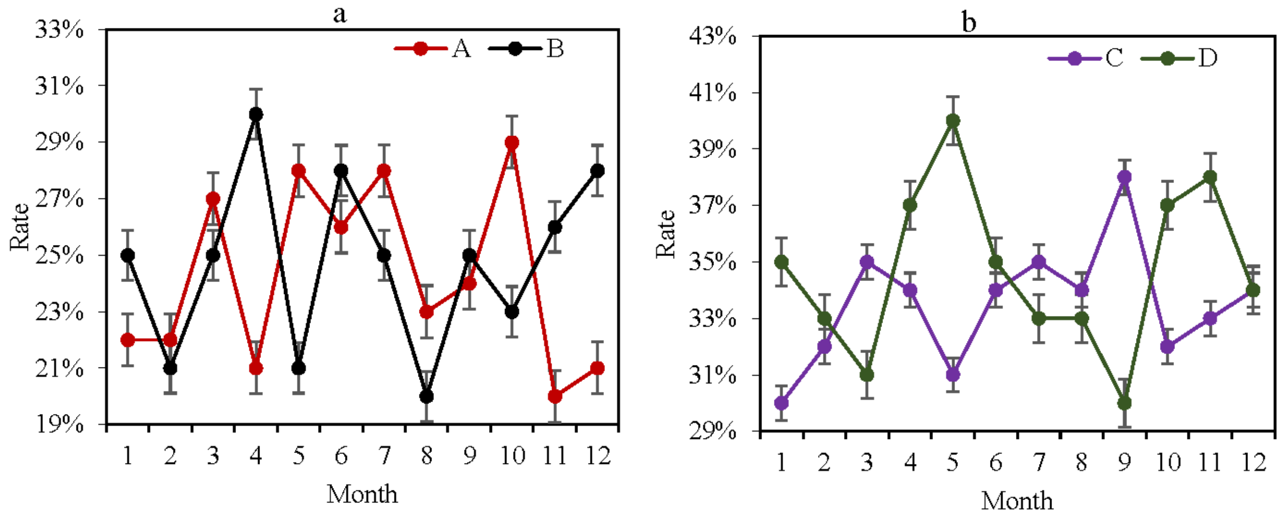
In order to better explore the role of trade DM devices based on BT in CBEC, this paper took four CBEC companies as examples (A, B, C, and D) to analyze their trade data in 2020 and the problems they encounter. Devices for Trade Data Management (TDM) are crucial for CBEC operations because they facilitate effective data gathering, customs compliance, secure transfer, integration, analytics, and risk management. Transparency is increased, trade is made easier, and cross-border e-commerce transactions are made easily and securely. Among them, Companies A and B adopted trade DM devices based on BT, and Companies C and D adopted trade DM devices based on traditional technology. The key advantages of BT-based trade DM devices are improved market reach, efficiency, transparency, and traceability. These advantages add up to more transactions per unit of trading activities. Table 1 showed the 12-month transaction volume data of four CBEC companies. It could be seen from the table that the transaction volume of CBEC companies based on BT was much higher than that of CBEC companies based on traditional technology.

Table 1. Transaction volume of four e-commerce companies (10000 yuan)

	A	B	C	D
1	590	563	368	346
2	573	577	361	353
3	552	573	347	311
4	552	571	358	352
5	551	570	353	347
6	578	555	344	303
7	550	568	385	308
8	590	594	351	311
9	600	581	378	305
10	599	570	354	355
11	568	551	393	363
12	573	600	393	381

3.2 Application of BT in Cross-border Logistics

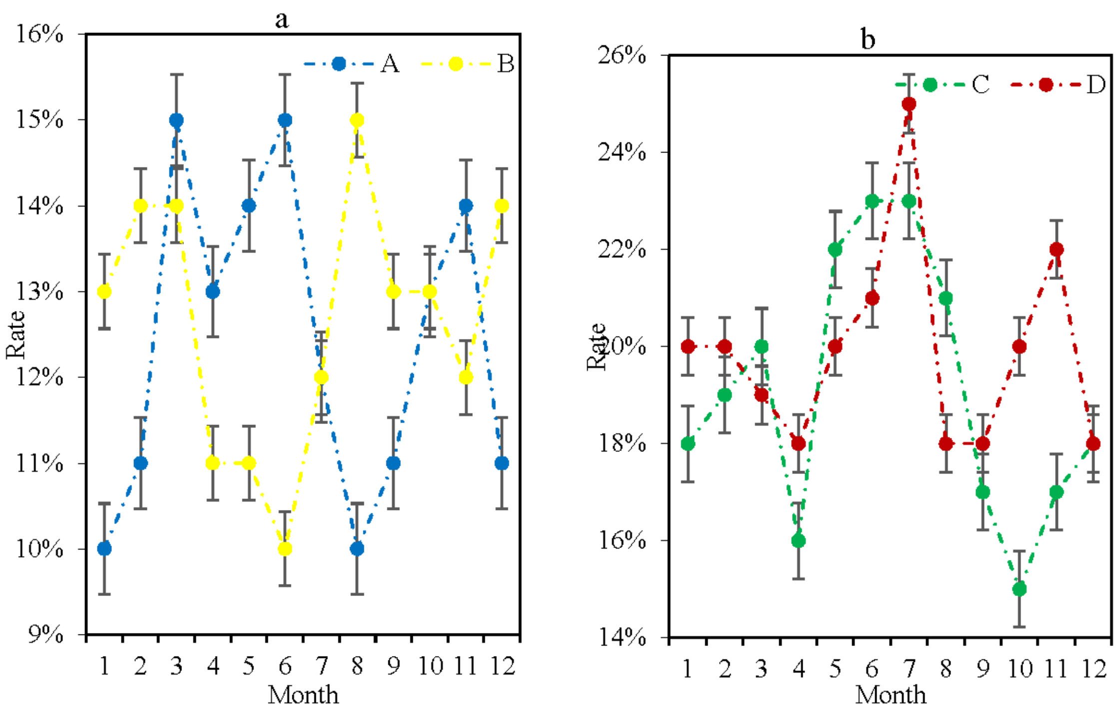
Blockchain is a distributed accounting technology, which can realize real-time monitoring of logistics and goods, and also facilitate the accountability of goods. Every node in the blockchain has the right of accounting. Therefore, in the process of goods transportation, all agents can record all logistics information through blockchain, so that the whole process of goods from shipment to receipt can be recorded in real time and also the openness and transparency of information can be ensured. When the goods are lost or lost, the relevant department shall confirm the responsibility based on this information. Customers can check the distribution of goods. Once they find that the goods are inconsistent with the goods they ordered, they can communicate with the logistics company in time and propose corresponding rectification or return, which greatly reduces the logistics cost. Figure 3 showed the comparison of logistics costs of four CBEC companies. Through streamlined procedures, transparency, optimised inventory, fewer middlemen, improved payments, and less conflicts and fraud, blockchain in CBEC lowers logistical costs. Cost savings vary by scale, sector, and degree of blockchain use. Figure 3(a) was based on BT, and Figure 3(b) was based on traditional technology. Among them, the logistics costs of Companies A and B under the trade DM device based on BT accounted for 20%-30% of the total cost, and the logistics costs of Companies C and D under the trade DM device based on traditional technology accounted for 30%-40% of the total cost.



(a) Based on BT (b) Based on traditional technology

Figure 3. Comparison of logistics costs of four CBEC companies

Figure 4 showed the comparison of the return rates of four CBEC companies. Figure 4(a) was based on BT, and Figure 4(b) was based on traditional technology. Among them, the return rate of Companies A and B under the trade DM device based on BT was 0.1~0.15. The annual average return rate of Company A was 0.124, and that of Company B was 0.127; under the trade DM device based on traditional technology, the return rate of Companies C and D was 0.15~0.25. The annual average return rate of Company C was 0.191, and that of Company D was 0.199.

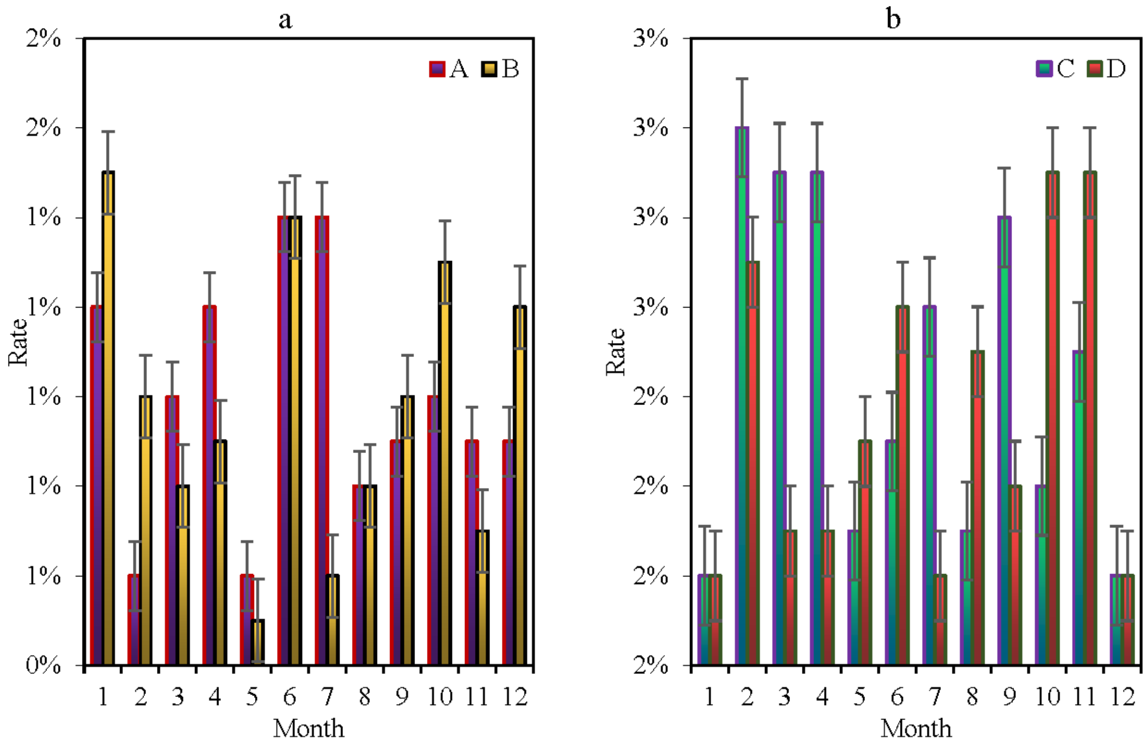


(a) Based on BT (b) Based on traditional technology

Figure 4. Comparison of return rates of four CBEC companies

3.3 Application of BT in Cross-border Payment

Blockchain's point-to-point transmission technology enables direct CBEC transactions, increasing transaction efficiency and reducing costs. Hierarchical agency structures in cross-border payment lead to high costs, as banks in all links charge fees. This structure can also result in the exposure of customers' personal information due to a lack of technology and management. The cross-border payment system with hierarchical agents has caused the traditional cross-border payment fees to remain high, while the use of point-to-point transmission and distributed BT is a very effective solution. High fees associated with middlemen can be reduced, enabling reasonably priced transactions, by utilising point-to-point transmission and distributed blockchain technology. The decentralised and distributed nature of blockchain further improves the security and privacy of client data, reducing the dangers of exposure and unauthorised access. Figure 5 showed the proportion of cross-border payment fees of four CBEC companies. Figure 5(a) was based on BT, and Figure 5(b) was based on traditional technology. The cross-border payment fees of Companies A and B under the trade DM device based on BT accounted for 0.5%-1.5% of the total fees. The annual average cross-border payment fee of Company A accounted for 0.99%, and the annual average cross-border payment fee of Company B accounted for 0.98%; under the trade DM device based on traditional technology, the cross-border payment costs of Companies C and D accounted for 2%-3% of the total costs. The annual average cross-border payment fee of Company C accounted for 2.45%, and the annual average cross-border payment fee of Company D accounted for 2.36%.

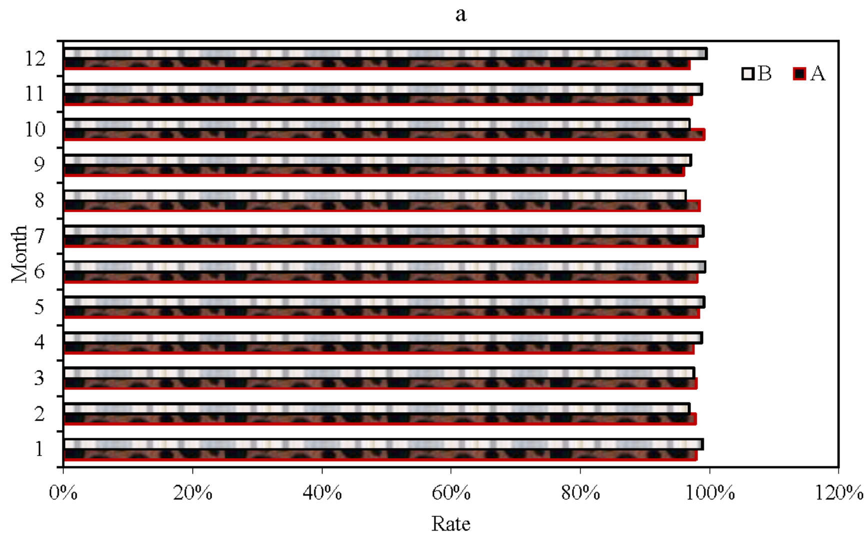


(a) Based on BT (b) Based on traditional technology

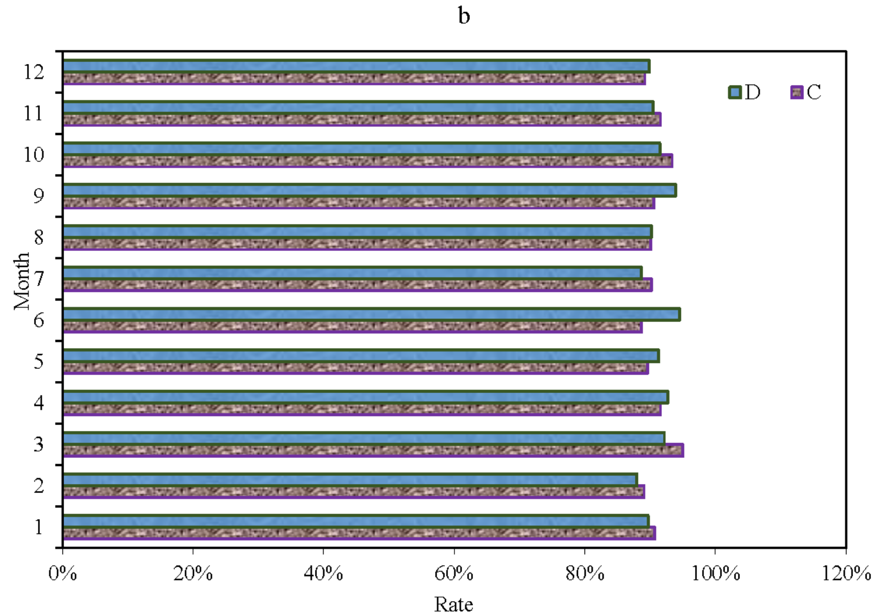
Figure 5. Proportion of cross-border payment fees of four CBEC companies

3.5 Application of BT in Cross-border Product Quality

The quality problems of cross-border products are mainly reflected by the favorable rate of customers. The comparison of favorable rates for CBEC enterprises utilizing various technologies reveals that implementing cutting-edge technology can have a good impact on product quality, customer satisfaction, and trust. As a result, the CBEC sector gains a competitive edge, enhances brand recognition, and becomes more long-term sustainable. Figure 6 showed the comparison of product favorable rate of four CBEC companies. Figure 6(a) was based on BT, and Figure 6(b) was based on traditional technology. Among them, under the trade DM device based on BT, the favorable rate of Company A and Company B's products was between 96% and 100%. The average annual favorable rate of Company A's products was 98.2%, and that of Company B's products was 98.6%; under the trade DM device based on traditional technology, the favorable rate of products of Companies C and D was between 88% and 95%. The average annual favorable rate of Company C's products was 90.8%, and that of Company D's products was 91.1%.



(a) Based on BT



(b) Based on traditional technology

Figure 6. Comparison of product favorable rate of four CBEC companies

4 Conclusions

Compared with traditional cross-border procurement methods, CBEC is characterized by multilateralism, directness, miniaturization and high frequency. Its information collection, storage and integration are key issues in the entire supply chain. The potential dangers of online transactions, such as the theft of credit card information and privacy infringement, would affect consumers' shopping desire. Among them, online payment equipment and express service are very important. With trust alone, customers can complete or cancel orders, and a safe and sound online payment and delivery system can help customers achieve this. The application of BT in the CBEC field can improve the reliability and security of its services, thus enhancing consumers' purchasing desire. The characteristics of the blockchain, such as decentralization, data tamper ability and traceability, make the blockchain become a reliable machine and establish mutual trust between individuals and individuals in business. The data generated by the timestamp is generated in the current block, which can ensure the traceability and anti-tamper of the transaction data. On the basis of supply chain technology, a large number of diverse data can be obtained, thus meeting the requirements of traceability of supply information, process certification, mutual trust between supply and demand sides, and real information communication. The CBEC platform based on BT can track the whole process. Products, logistics, regulations, orders, etc. are clear and easy to check, so as to strengthen users' trust in the platform.

Acknowledgements

Major project in humanities and social sciences of Anhui Provincial Department of Education; Award Number: Sk2021ZD0107; Grant Recipient: Jie Cao; Key Project of Humanities and Social Sciences Research in Anhui Universities (2022AH052643).

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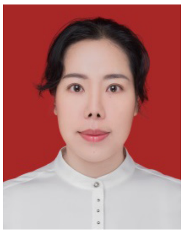
Biography



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