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Research Article

Cross-Border E-Commerce Business Model Based on Big Data and Blockchain

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In the context of the rapid development of Internet technology, the integration of the world economy has been strengthened. The continuous innovation of technology and foreign trade business forms has promoted the rapid development of cross-border e-commerce (CBE). Based on the research on the development status of CBE, this paper analyzes the reasons for the above problems in the development of CBE and discusses the innovation of CBE business models based on blockchain. Its purpose is to study the CBE business model based on big data and blockchain. This paper proposes to build a CBE framework system based on blockchain. It also uses blockchain technology (BT) to provide solutions to the problems of trust, customs supervision, cross-border payment, cross-border logistics, and cross-border data flow encountered in CBE. According to experimental statistics, China's CBE exports were 7.29 trillion yuan, an increase of 40.1%, and imports were 3.76 trillion yuan, an increase of 16.5%.

1. Introduction

In the context of economic globalization and the gradual popularization of Internet coverage in the world, foreign trade is changing from "trade diversification" to "global buying, global selling, global payment, and global transportation." The main body of trade has changed from traditional trading enterprises to small and medium-sized enterprises and individuals. The characteristics of transactions have changed from "big in and large out, low frequency" to "small batch, high frequency," and the trade supply chain has changed from nonpersonalized, large scale to a flexible supply chain that is personalized and fragmented, and meets customer needs. The form of trade has changed from traditional offline trade to CBE. CBE transactions involve a large amount of document information. In addition to the need to share such information between trade multilaterals, it also needs to be submitted to regulatory authorities. At present, trade information is scattered in separate systems, and the information lacks transparency. Although each country has specified its own EDI data exchange format standard plan, the transmission speed of information is low. Data format conversion costs are high, and it is not easy to form mutual trust.

While CBE is booming, it is also accompanied by some problems. Foremost among them are issues of trust, information opacity, and high costs. Because CBE transactions involve multiple national governments, complex supply chains, and long logistics times, it is difficult to trace the source of product quality problems and accountability is difficult. BT can decentralize, realize information sharing, trace and track commodities, and improve the trust foundation of CBE. The research of blockchain in the field of CBE application provides a way to promote blockchain to improve business in traditional business fields and provide a way to unify supervision and break the crisis of trust. CBE platform is based on blockchain, information is shared, and platform data can be obtained through technical means, to achieve product traceability, logistics tracking, quality control, and trust in cross-border payment, and through big data analysis, to achieve risk early warning and the credibility evaluation of cross-border enterprises.

The innovation of this paper is that (1) it promotes research on the application of blockchain in CBE and its implementation in practical application scenarios; (2) in the CBE industry, the application of BT can change the existing business model of CBE; it allows all participants to have an equal dialogue, reduce intermediate transaction links, reduce costs, and improve corporate profits; (3) it promotes the change of trade type. Blockchain-based CBE can keep in touch with end consumers, transforming the traditional model of relying on large-value imports and exports into a small-value transaction model and promoting the development of CBE.

2. Related Work

Teresa Ballestar research segmentation is based on customers' commercial activities and roles in the social network of the website [1]. In the absence of any clear regulatory policies, Indian e-commerce businesses appear to be enjoying a free market and growing rapidly. The Tyagi study found that India's leading e-commerce companies are growing in a policy vacuum, allowing 100% foreign direct investment under a "market model" [2]. With the popularization of the Internet and smartphones, Internet-based e-commerce has developed rapidly with its unique advantages. Hu research finds traditional and improved business-to-customer (B2C) e-commerce [3]. Although existing research links the emergence and development of e-commerce to various aspects, it does not address technology and platform acceptance from a legitimacy-building perspective. In Kwak's research, legitimacy is divided into market legitimacy, relational legitimacy, and social legitimacy. He also explores the link between legitimacy and acceptance of each. While Alibaba's intellectual property weaknesses are exposed, Alibaba's continued efforts to establish legitimacy have fueled the platform's growth [4]. The Monroe study aims to describe this growth and explore the factors that influence the magnitude and timing of the growth. From 2000 to 2015, the average annual growth rate of B2B e-commerce in the USA exceeded 10%. After a slow start in previous years, growth was strong between 2003 and 2005 [5]. PJW survey explores e-commerce logistics business models from unstructured big data [6]. E-commerce plays an increasingly important role in transforming the mode of economic development, promoting industrial upgrading, and promoting the modernization of circulation. On the one hand, e-commerce has broken the time and space barriers of trade. On the other hand, it provides rich information resources and unlimited business opportunities for enterprises. Sun M's research found that e-commerce has become a trend leading Vietnam's economic development. In recent years, the online cosmetics industry has gradually emerged in the Vietnamese market. However, due to the unique characteristics of cosmetics such as the largest number of bottles, the requirements for logistics and distribution are higher to ensure the integrity of the product. Meanwhile, in the context of e-commerce, customers are paying more and more attention to the quality of logistics services [7]. Yang proposed a blockchain-based big data sharing and transaction framework. This framework utilizes the idea of decentralization and openness of blockchain to build a big data trading platform for multiple users [8]. Although his research has been greatly applied to the distributed secure storage of big data in the blockchain, there is still a problem of high cost.

3. Algorithm Design of BBE Supply Chain Framework

The architecture diagram of the prototype system of large-scale cross-border supply chain based on blockchain is shown in Figure 1. It includes foreground, interface layer, service layer, network layer, core layer, and storage layer.

As shown in Figure 1, it solves the pain points faced by the supply chain industry, such as lack of trust, poor information flow, low degree of automation, data fraud, difficulty in accountability, and difficulty in connecting and collaborating with a large number of existing block supply chain systems [9, 10].

3.1. Blockchain-Based Product Information Traceability Framework. This facilitates suppliers' information control over product production, transportation, and warehousing [11, 12]. Aiming at different entities and business operation processes in the supply chain, and taking into account the various data involved in product information traceability, a multi-level blockchain-based product (BBP) information traceability framework is proposed, as shown in Figure 2.

As shown in Figure 2, on-chain and off-chain data and services are connected through a multi-level blockchain [13, 14]. The information encryption model provides a solution for users to disclose data externally. Users can encrypt data according to the degree of privacy of the data. The information anchoring model is used to ensure the global consistency of multi-chain data. The key distribution model is used in many aspects such as user management accounts, external transactions, and enterprise management [15, 16]. The product traceability label is used for users to perform online and offline verification and information traceability of product information.

3.2. Framework of E-Commerce Supply Chain Based on Blockchain. This section proposes a blockchain-based e-commerce (BBE) supply chain framework (PIT-EC). Under this framework, it proposes a multi-chain structure to store product, transaction, and logistics information [17, 18]. At the same time, the framework provides a reliable, easily monitored, and tamper-proof solution to the problem of traceability of product information. The BBE supply chain framework is shown in Figure 3.

As shown in Figure 3, according to different data characteristics such as data volume, data update speed, and data encryption degree, data items are grouped into different sets [19, 20].

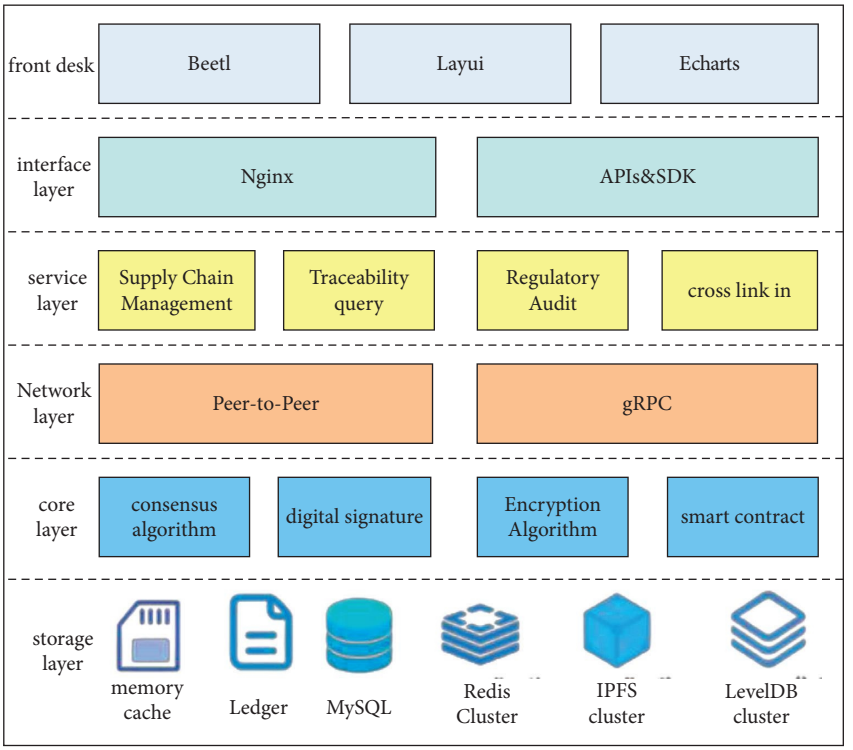

Figure 1: System structure diagram.

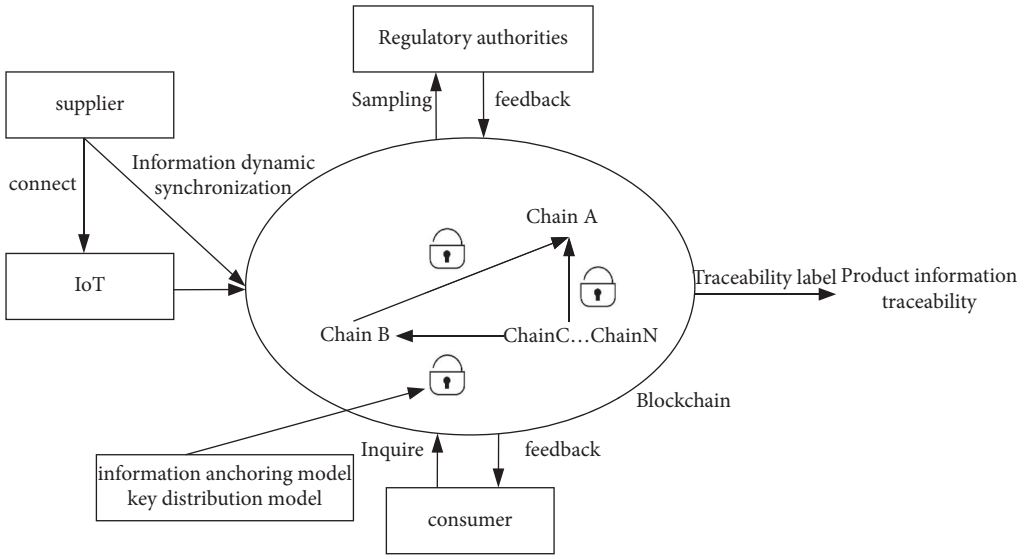

Figure 2: BBP traceability framework.

3.3. Key Distribution Based on Hierarchical Wallet

3.3.1. Initial Key Distribution. The entities of the initial key distribution scheme are as follows:

$$(Pk, PK) \longrightarrow (Ck_i, CK_i), \quad i = 1, 2, \ldots, \tag{1}$$

where P is the parent key and C is the next level key generated by P and PC.

It is recommended to use an encrypted pseudo-random number generator (CSPRNG).

$$\begin{aligned} E &= \mathrm{CSPRNG}(N), \\ N &= 1.158 * 10^{77}, \\ \mathrm{check\_sum} &= \mathrm{SHA256}(E, 4). \end{aligned} \tag{2}$$

Collections are defined as follows:

$$\mathrm{Set}_i = \mathrm{divide}(E \oplus \mathrm{check\_sum}), \quad i = 1, 2, \ldots, 11. \tag{3}$$

It maps these sets to Dict and generates a seed, and seeds are defined as follows:

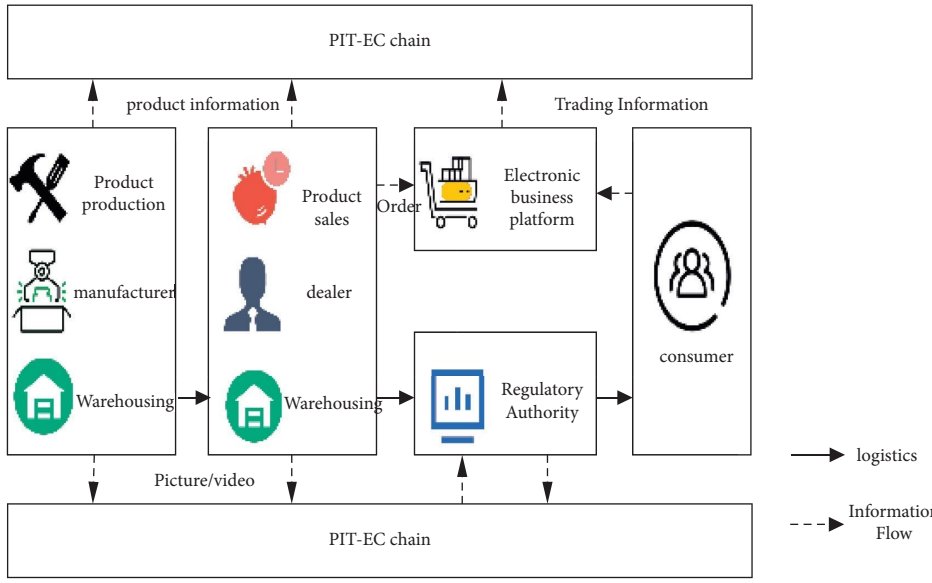

Figure 3: BBE supply chain framework.

$$\text{seed} = \text{PBKDF2}(\text{match}(\text{Set}, \text{Dict})), \quad i = 1, 2, \ldots, 11. \tag{4}$$

The master private key obtained by calculation is the initial key (Ik).

$$\begin{aligned} Ik &= \text{left}(\text{HMAC} - \text{SHA512}(\text{seed}), 256), \\ \text{Mcc} &= \text{right}(\text{HMAC} - \text{SHA512}(\text{seed}), 256). \end{aligned} \tag{5}$$

3.3.2. Function Key Distribution. In the key distribution scheme based on ECC, the function key has a strong correlation with the initial key, so that the initial key has all the functions of the account. The initial key is used to generate the secondary key, which has the highest privilege. The specific calculation process is as follows:

The user uses the ECC algorithm to calculate the public key of the initial key, as follows:

$$IK = \text{IKG}. \tag{6}$$

It combines the public key (IK), and the index number refers to the level of functional authority.

$$\begin{aligned} Sk &= \text{left}(\text{HMAC} - \text{SHA512}(IK\Delta\text{Mcc}\Delta n), 256), \\ \text{Mcc} &= \text{right}(\text{HMAC} - \text{SHA512}(IK\Delta\text{Mcc}\Delta n), 256). \end{aligned} \tag{7}$$

The calculation process is as follows:

$$\begin{aligned} SK &= SkG, \\ Fk &= \text{left}\left(\text{HMAC} - \text{SHA512}\left(\frac{\text{Sk}\Delta\text{Mcc}\Delta\text{Function}}{\text{level}}\right), 256\right), \\ \text{Mcc}_{\text{function}} &= \text{right}\left(\text{SK}_{\text{account}}\Delta\text{Mcc}_{\text{account}}\Delta\frac{\text{Function}}{\text{level}}, 256\right). \end{aligned} \tag{8}$$

The initial key is used to generate the secondary key, which has the highest privilege. For other keys, according to the depth of the organizational structure, the breadth of the business, and the size of the supervision power, repeat the above steps 2 and 3 to generate keys at all levels in turn.

3.3.3. Key Recall Mechanism. It then obtains the initial key, i.e., the private key, according to the above method. Initial keys play an important role in key management. ID (x) is defined as follows:

$$\begin{aligned} \text{ID}(x) &= \text{Hash}\left(\left(\begin{array}{c}\text{Hash}(\text{registration number}, \text{registered address}, \text{legal}) \\ \text{representative}\end{array}\right)\oplus\text{user\_defind\_word}\right), \\ \text{IDK} &= \text{ID}(x) * G. \end{aligned} \tag{9}$$

It maps the initial key (Ik) to an elliptic curve, randomly generates integers $r \in (1, n-1)$, and then computes

$$P = E_p(IK),$$
$$C_1 = P + rI\ DK\ , \quad (10)$$
$$C_2 = rG.$$

The data that need to be digitally signed are as follows: Dacaccount = addr, Usernp, $C1$, $C2$, IDK.

3.3.4. Anti-Counterfeiting Traceability Label Model. It provides anti-counterfeiting traceability label solutions that link products with real product information. The anti-counterfeiting traceability label scheme is shown in Figure 4.

As shown in Figure 4, each product line has a unique code. Each code corresponds to multiple batches of products.

4. Blockchain-Based CBE Model

In order to demonstrate the advanced nature of the proposed method, experimental verification is carried out, and the experimental environment is shown in Table 1.

As shown in Table 1, it will be divided into four aspects: whether there is a risk of centralization, whether it supports data-based asset operations, whether it supports smart contracts, and whether it is efficient.

4.1. Construction of CBE Model Framework Based on Blockchain. China's trade form and market environment are different from those of overseas. To ensure that CBE maintains a healthy development in the world, the establishment of a trade ecological environment must ensure mutual recognition and uniform standards. The operation model of the traditional CBE model is shown in Figure 5.

As shown in Figure 5, the information sharing and collaboration technology of blockchain use decentralization and consensus to enhance trust. It provides a technical foundation for the establishment of a benign trade ecological environment and can ensure the vigorous development of CBE ecology. The traditional cross-border model is built in a centralized way, and its collaboration model is based on the CBE platform as the central node. Figure 6 shows the cooperation mode of the participants of the CBE alliance based on blockchain.

As shown in Figure 6, the CBE model based on the blockchain can be built into a multi-coordinated platform by using the decentralization, distributed storage, and anti-tampering features of the blockchain. The parties located on the blockchain platform form a community of interest alliance according to their roles and functions. It participates in the data consensus on the CBE platform and can realize the sharing of the underlying data. In this way, the functional positioning of each participant can be changed, which is conducive to multi-party collaboration, and maintains and promotes the orderly development of CBE.

4.2. Characteristics of the CBE Model Based on Blockchain. The CBE model based on blockchain can promote the diversified collaboration of transaction entities. The supply chain that forms a multi-centralized CBE is very long. It involves commodity producers, buyers, warehousing, logistics, CBE platforms, customs (inspection and quarantine and customs clearance), import and export traders, domestic and foreign consumers, banks, insurance companies and third-party payment institutions, and so on. The position of the participants of CBE in the transaction center reflects the advantages they occupy in the transaction to a certain extent. The centralized value of the blockchain can ensure that the CBE platform is not controlled by any single party, and can take into account the interests of multiple parties in operation.

The corporate qualifications, commodity supply chain information, user data, and related business data of traditional CBE are stored in a centralized platform. It is difficult for regulators and consumers to obtain the true picture of a business. Enterprises generally do not share the business data of CBE. Third-party credit assessment agencies do not have enough data to analyze the credit situation of enterprises. The cross-border credit reporting platform based on blockchain is shown in Figure 7.

As shown in Figure 7, after using blockchain, the qualification information, user data, supply chain information, and operation data of the CBE business are stored on the blockchain, which can be real and effective data to give credit rating to each participant of the CBE business under the condition of privacy protection, and the rating can be easily queried by the public. This can protect the honestly operating enterprises and law-abiding consumers, enhance consumers' trust in the CBE business, and also combat nonhonest enterprises, ensure the interests of honest enterprises, and reduce the cost of credit acquisition.

4.3. Application Scenarios of Blockchain in CBE. Blockchain is the underlying data technology. In view of the particularity of CBE, BT can be applied to trace the origin of CBE products, CBE orders, and smart contracts for insurance business, and protect the privacy data of transaction parties. The various scenarios are discussed in detail below.

4.3.1. Product Traceability of CBE. The categories of goods in CBE are becoming more and more diverse. However, because the supply chain of CBE is long and complex, it is difficult to effectively track the quality and origin of products using traditional methods. If the commodity category is food, once a problem occurs, it will have a great impact on cross-border trading countries and traders, so commodity traceability is necessary in CBE.

The blockchain traceability of cross-border commodities uses the data immutability feature of BT. It automatically and directly collects all data of commodities from production to circulation basins through IoT devices and automatically records them on the blockchain to form sharable distributed ledger data. At present, major CBE platforms are trying to use BT to achieve their commodity traceability needs, such as Alibaba's overseas shopping traceability system, Jingdong blockchain anti-counterfeiting traceability platform, and opening up with cross-border logistics systems. The results of the comparative analysis between this method and the existing scheme are shown in Table 2.

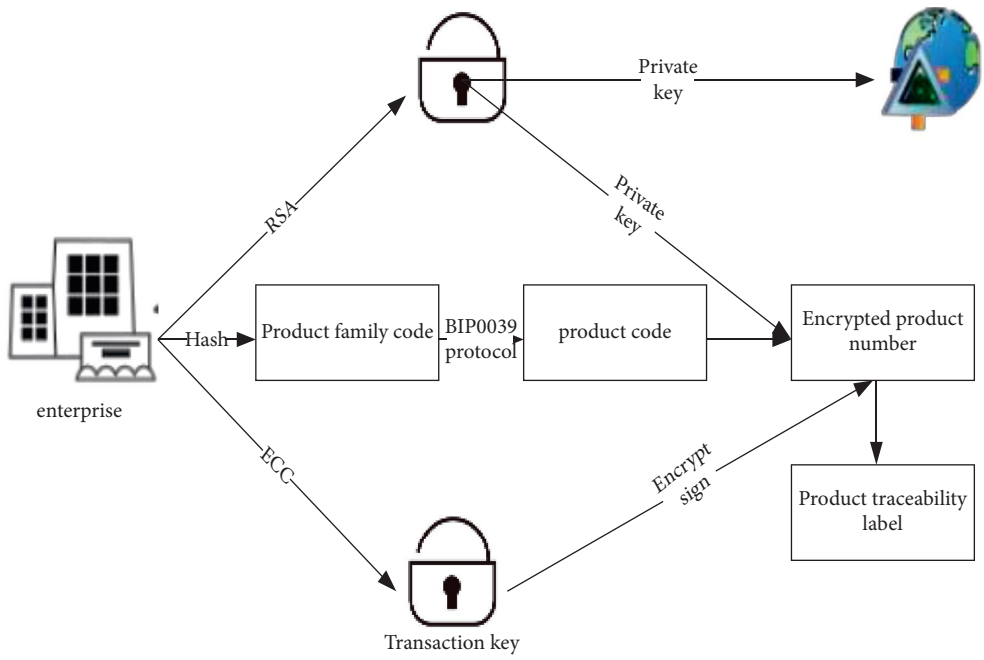

Figure 4: Anti-counterfeiting traceability label scheme.

Table 1: Description of the experimental environment.

Configuration item	Describe
Physical server	CPU: Intel (*R*) Xeon (*R*) Gold 6146 CPU @ 3.20 GHz Operating system: CentOS Linux release 7.6.1810 (core) RAM: 16 GB
Blockchain network	CPU: E5-2680 v4 @ 2.40 GHz RAM: 8 GB Blockchain type: Hyperledger Fabric v2.0 Consensus mechanism: raft Number of consensus nodes: 3

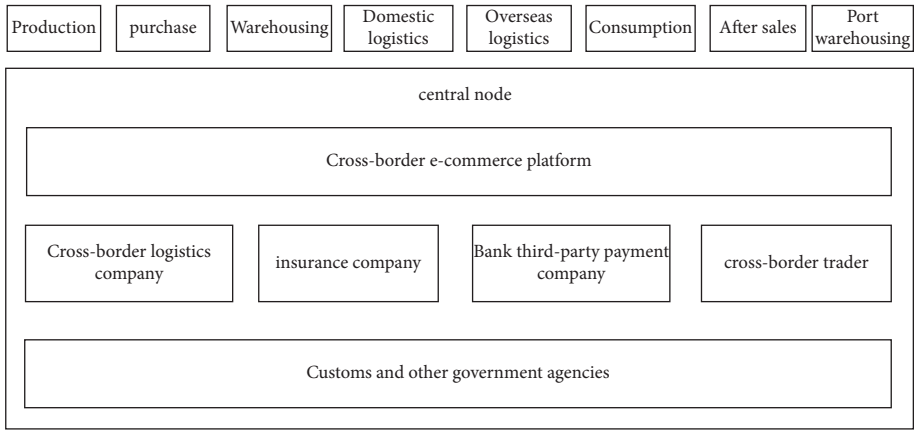

Figure 5: Traditional CBE process and collaboration methods.

As shown in Table 2, the method in this paper connects the blockchain network based on the cross-chain interoperability model and uses the whole-process trusted closed-loop mechanism of cross-chain transactions to ensure the security and trustworthiness of cross-chain transaction execution. It avoids the risk of centralization while ensuring the efficient execution of transactions and can effectively adapt to smart contracts and data-based blockchains. It has the advantages of no centralization risk, supports data-based cross-chain interoperability, supports smart contracts, and operates efficiently, meeting the application needs of supply chain scenarios.

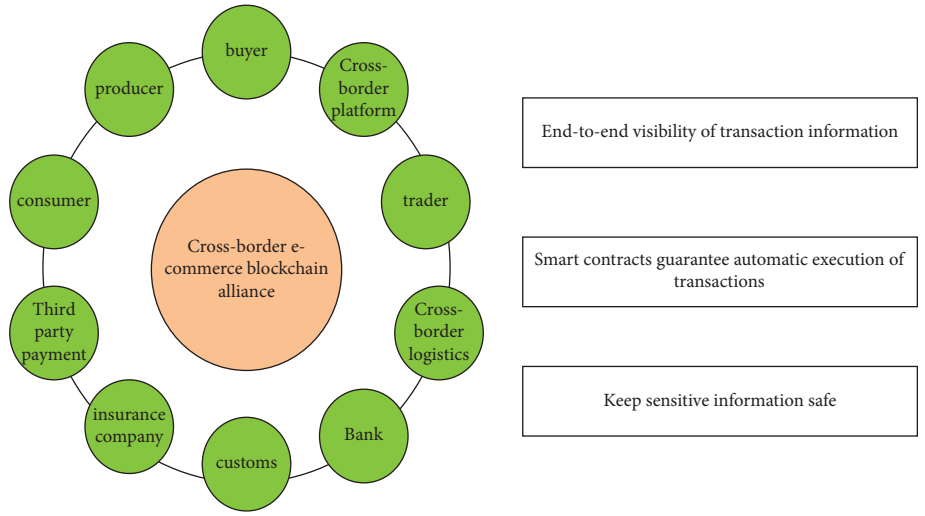

Figure 6: Collaboration method of CBE alliance participants based on blockchain.

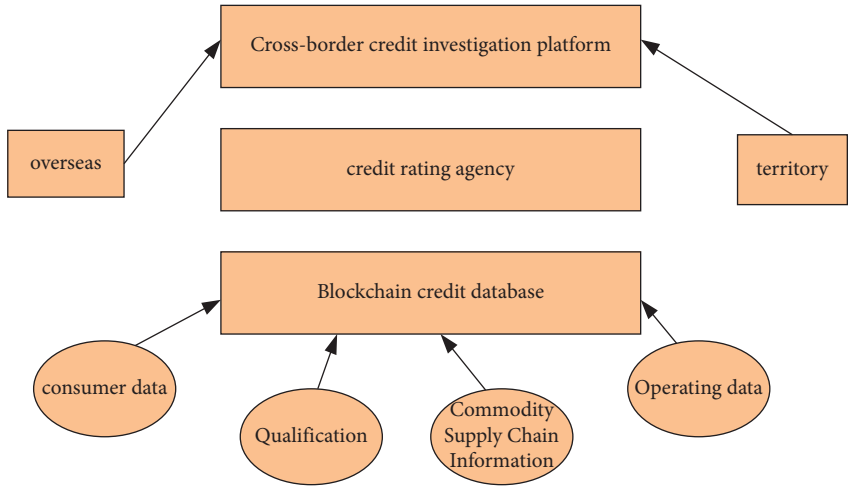

Figure 7: Blockchain-based cross-border credit reporting platform.

Table 2: Comparison between the method in this paper and the existing scheme.

Supply chain scenario requirements	Notary mode	Relay/side chain	Hash lock	Distributed private key control	The method of this paper
No centralization risk	×	✓	✓	✓	✓
Data type	✓	✓	×	×	✓
Interoperability across chains	✓	✓	×	×	✓
Support smart contracts	✓	×	✓	✓	✓

4.3.2. Cross-Border Secure Transactions on Cross-Border Platforms. Blockchain smart contracts define transaction rules in the contract code in advance. Once the conditions are met, the rules are automatically executed. First, it can improve work efficiency, and second, it can solve the occurrence of contract execution disputes. CBE B2B trade often buys insurance for goods. Using smart contracts, once a claim condition occurs, the claim procedure will be executed automatically, without the need for both parties to intervene. In addition, the process of receiving payments for CBE platform transactions can also be protected by the use of smart contracts, so that when the terms of the transaction are met, the money is automatically transferred to the seller's account; otherwise, it is returned in the same direction.

4.3.3. Application of Blockchain in CBE Supply Chain. The supply chain of CBE includes product procurement, production, manufacturing, sales, logistics, warehousing, and other links. The supply chain is long, and the scenarios are complex. It introduces blockchain, 5G, and IoT technologies to provide a full range of services for CBE. The combination of blockchain and cross-border logistics can bring logistics and supply chain participants onto a

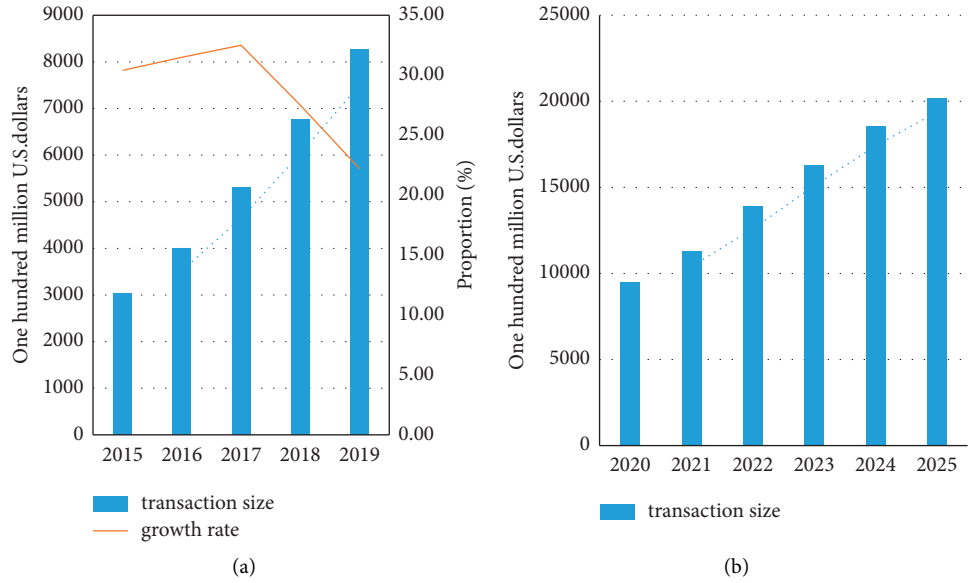

Figure 8: Global B2C cross-border transaction scale and transaction scale forecast. (a) Global B2C cross-border transaction scale. (b) Global B2C CBE transaction scale forecast.

decentralized blockchain platform, opening up the information flow between domestic logistics companies, international transport, and overseas logistics companies, so that buyers, sellers, insurance companies, and other interested parties can quickly and accurately locate the logistics trajectory of goods on the platform and quickly determine liability when losses are caused by logistics problems.

The combination of blockchain and cross-border supply chain finance takes advantage of the decentralization, openness, transparency, and immutability of BT. It integrates the transaction data of upstream and downstream enterprises of CBE and forms a complete transaction record to prove the authenticity of accounts receivable. At the same time, the smart contract is used to stipulate the payment path, and the four-flow integration and relatively closed operation of business flow, information flow, logistics, and information flow are realized. At the same time, it can also obtain better financial support from the bank.

5. Characteristics Analysis of CBE Based on Blockchain

5.1. Development Characteristics of CBE. With the development and innovation of ICT such as the Internet, the global e-commerce business has developed rapidly. The number of people participating in online shopping is gradually increasing, and especially under the global outbreak of the new crown epidemic in 2020, more users choose to shop online. Under the current global macro environment, global CBE shows the following trends.

5.1.1. More Consumers Choose Online Global Shopping and the Market Size of the Global CBE Industry Continues to Increase. The transaction scale of the global CBE industry continued to grow. In a report released in January 2021, it was pointed out that despite the impact of the epidemic in 2020, the scale of global CBE B2C transactions could reach US$3.4 trillion. The global B2C cross-border transaction scale and transaction scale forecast are shown in Figure 8.

As shown in Figure 8, the number of CBE participants increased from 309 million in 2014 to 900 million in 2020. By 2020, the global epidemic reduced CBE, but the global CBE scale will exceed USD 1 trillion in 2020, with an average annual growth rate of up to 30%, and achieve high growth. In 2019, with the development of 5G, the Internet infrastructure will become more and more perfect, global logistics network construction will gradually mature, and CBE will show a high growth trend. Based on the current growth, the survey results predict that the global CBE B2C cross-border transaction scale will maintain a growth of 10% to 20% in the next few years, affected by the increasing number of new crown epidemics translated with http://www.DeepL.com/Translator (free version).

5.1.2. CBE Platform, Amazon, Is Still in the Leading Position. According to the data of the Qianzhan Industry Research Institute, the market share of CBE platforms and the categories of platforms used for online shopping are shown in Figure 9.

As shown in Figure 9, when choosing CBE transactions, 24% of cross-border consumers use the Amazon platform and 16% use AliExpress (Alibaba's CBE platform). 14% of users choose eBay, which is positioned as a CBE platform.

5.1.3. Affected by Global Logistics Conditions and Technologies, the Development of Global CBE Varies Greatly. According to data, consumers in the Middle East who use CBE for overseas shopping account for 70% of online shopping compared to other regions. Less than 50% of CBE consumers in Asia Pacific and North America are the

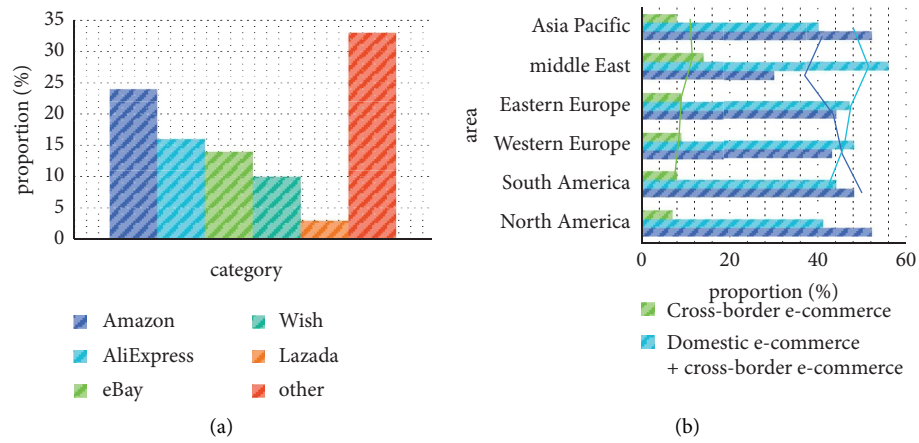

Figure 9: (a) Market share of CBE platforms and (b) types of platforms used by global consumers for online shopping.

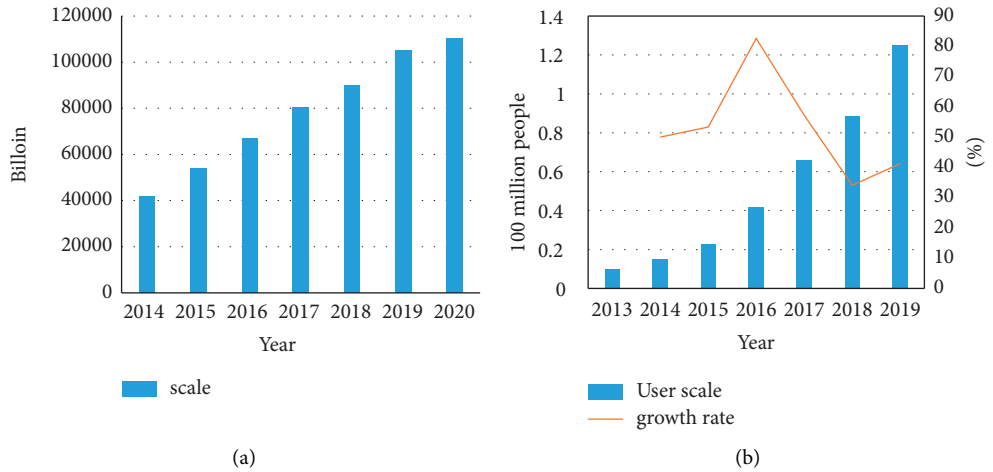

Figure 10: Scale of China's CBE transactions and the number and growth rate of imported CBE users. (a) Scale of CBE transactions in China. (b) Number and growth rate of imported CBE users.

proportion of e-commerce usage preferences in various regions drawn according to the data.

Taking the EU economy as an example, the growth of CBE is also uneven, with Ireland at the bottom with 85%, accounting for only about 2%. In addition, due to cultural influences, Australian cross-border shoppers are more likely to purchase products primarily from the UK and the USA, and over 63% of Canadian users use CBE, with the majority of purchases coming from China and the USA. CBE growth in South America, Brazil, and Argentina has matured since 2018. The total retail sales of CBE account for about 3% of e-commerce.

5.2. Development and Trend of CBE. From the overall point of view of the above national policies, the state is also regulating supervision and protecting intellectual property rights while supporting the development of CBE. It has promoted the standardized development of CBE development through national-level policies. After years of development, the CBE industry generally presents the following trends.

5.2.1. China's CBE Has Entered a Period of Steady Growth and Its Scale Is on the Rise. CBE in China has grown rapidly in the past few years. Figure 10 shows the scale of China's CBE transactions, the number, and growth rate of imported CBE users.

As shown in Figure 10, 2020 is affected by the new crown pneumonia epidemic. According to statistics, China's CBE exports were 7.29 trillion yuan, an increase of 40.1%, and imports were 3.76 trillion yuan, an increase of 16.5%.

5.2.2. Cross-Border Exports Occupy the Dominant Position of China's CBE. This paper analyzes the data of China's CBE import and export from 2014 to 2019. The scale and growth rate of China's CBE exports and China's CBE imports are shown in Figure 11.

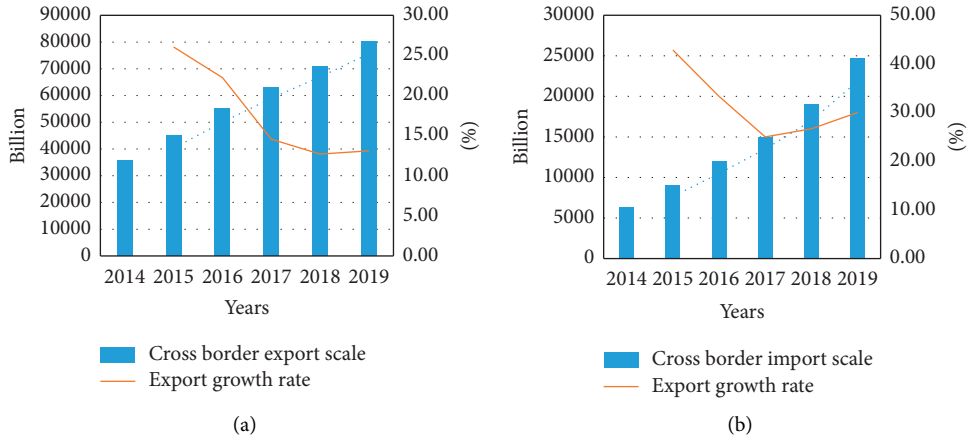

Figure 11: Scale and growth rate of China's CBE import and export; the total number of imported CBE users in China in 2019 was 125 million. It increased by 41.24% year-on-year in 2018 (the number of CBE users in 2018 was 88.5 million). (a) Scale and growth of CBE export transactions. (b) Scale and growth of CBE import transactions.

6. Conclusion

With the maturity of BT and the in-depth research on the combination of CBE, it will definitely promote the development of the CBE industry and realize the unification of CBE logistics, information flow, and capital flow. This has prompted a change in corporate behavior and finally realized the transformation of the CBE industry driven by BT. CBE is a new form of cross-border trade in the Internet era. With the emergence of new business models such as overseas shopping and live streaming, its business environment has become more complex. Its scope is also wider, and the problems it faces will become more and more complex. Only solving the problems of trust, logistics, payment, goods quality, and supervision of CBE cannot fully meet the needs of CBE development. Especially after the epidemic, the CBE model will also expose more and more problems and risks.

In addition, although blockchain technology can solve the problems encountered in CBE to a certain extent, the development of the technology is still immature, such as the high latency of its consensus algorithm, computational costs, encryption technology, cross-chain communication technology, and taking up a lot of storage space to store the same data which have not been effectively solved. Therefore, in the combination of research and CBE, the application of BT is still limited. Based on the existing CBE model, future research can combine BT with increasingly mature and perfect 5G technology. This makes CBE as convenient as e-commerce. In addition, we should also pay attention to the new trends in the development of BT and the relevant policy trends of blockchain token transactions in countries around the world. This is in order to introduce more convenient and low-cost tokens into CBE transactions faster and realize the ability of blockchain value flow transmission.

Data Availability

No data were used to support this study.

Conflicts of Interest

There are no potential conflicts of interest in this study.

Acknowledgments

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