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Research Article

Big Data Logistics Service Supply Chain Innovation Model Based on Artificial Intelligence and Blockchain

Xin Zhang ,[1] Xiaomin Shi,[1] and Wenan Pan[2]

[1]*Business College, Jiaxing University, Jiaxing 314001, Zhejiang, China*
[2]*School of Business Administration, Zhejiang Gongshang University, Hangzhou 310035, Zhejiang, China*

Correspondence should be addressed to Xin Zhang; zhangxin@zjxu.edu.cn

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Blockchain technology is widely used in various fields according to its programmable advantages. Such technology has several typical characteristics, such as openness, automation, independence, security, sharing, and modularity. The logistics system is greatly beneficial from such characteristics. Therefore, blockchain technology can provide core technical support for the construction of logistics supply chain system. In this paper, we focus on the current demands of "blockchain + logistics" business system and reduce half risks in the supply chain through decentralization and detrusting of blockchain technology. Finally, experimental results show that it has a certain practical significance for the adjustment of the strategic layout and sound development of supply chain logistics.

1. Introduction

As an organizational form of movable finance, supply chain finance has natural business relationship and social capital. It takes all the cooperative enterprises in the supply chain as a whole, takes the core enterprise as the focus, and takes the real trade as the premise [1]. At the same time, as a complex and diversified business development form, it gradually unifies logistics, capital flow, information flow, and commercial flow with the development and promotion of domestic and foreign economic markets. Among them, the main role of logistics activities is to maintain the flow of materials in the supply chain, from the producer to the owner, and to transport materials from A to B [2]. At the same time, based on the characteristics of logistics itself, a series of available data are generated in the process of material circulation, and if these data are reasonably used to become effective information, then some uncontrollable risks in supply chain finance will become controllable risks [3].

At present, a new round of technology and industrial change is sweeping the world, a series of emerging technologies are being put into use or tested by many enterprises [4–6]. The digital economy is subtly changing the way of life of human beings and is also changing the world economic development model. Since Satoshi Nakamoto proposed the concept of Bitcoin in 2008, blockchain technology has entered the vision of various countries, and it is considered to have strong application space. Especially after 2016, domestic and foreign financial institutions have been focusing on the application innovation of blockchain technology for economic empowerment, while the International Monetary Fund has put its vision on exploring the application of blockchain in cross-border payment, digital currency, and other fields" [7].

China is currently in a critical period of economic transformation, and under the leadership of the Belt and Road policy and supply-side reform, the digital economy has become a hot direction for technology application during the transformation period, and the characteristics of supply chain finance business determine the necessity of combining with blockchain technology [8]. As the most important component of supply chain finance, logistics can be used as an important credential to support supply chain financial services through the optimization and innovation of the enterprise itself and the interaction system between the enterprise and the enterprise, which can effectively solve the problem of data authenticity in the management of supply chain finance and provide the basis of credit management for the demanders of financing services [9].

At present, the cost of logistics activities and supply chain finance is extensive with big data, whereas it is necessary to monitor and analyze the dynamic data [10]. In the researches and applications of blockchain, the risk control mechanism contains various aspects. For example, the distributed ledger, the function of irreversible change to ensure the real and effective data on the chain, the automatic execution of smart contract to reduce the cost of enterprise operation and to improve the efficiency of supply chain financial services. More importantly, data silos and low quality in the supply chain financial industry today can be solved by risk control [11]. Therefore, blockchain technology can not only reconstruct the logistics management system but also bring innovative opportunities to the cross-border integration of supply chain financial management in the field of risk control [12].

2. Related Work

Literature [13] proposed that freight logistics is an important part of China's transportation strengthening strategy, and its development must be integrated with information technology, while blockchain technology as a new technology combination can better connect online and offline supply chain activities, solve the problem of integrity building among transaction subjects through blockchain's smart contract, and improve the supervision ability of logistics market through distributed storage. Gligor et al. [14] pointed out that one of the advantages of blockchain technology is to return the value of data to the data creators themselves and to let SMEs, which accounts for the largest share of supply chain management and do the vertical application of blockchain. Blockchain technology establishes the whole process smart contract of tax refund at the port of departure, which ensures that the bank automatically credits the tax refund to the enterprise's preset account, thus greatly improving the efficiency of tax refund; another important role of blockchain is that it can shield the confidential data of data providers according to the encryption algorithm so that the data assets form clear boundaries in an invisible way and provide different data to subject with different business needs. In this way, the data assets form a clear boundary, providing different business needs to different subjects with different dimensions of data, which not only ensures the security of data but also achieves the role of data sharing and use. Khan et al. [15] believe that the logistics supply chain industry has developed to an intelligent stage, and the logistics supply chain information management has become a bridge between enterprises and businesses. In the enterprise business information system, the information of warehousing, distribution, and transportation is stored in the distributed ledger of blockchain, and enterprises can query through predefined data fields; each bookkeeping process is endorsed in the consensus node, can only be queried and used, and cannot be changed or deleted, which ensures the authenticity of data and nonrepudiation of responsibility; according to the mechanism of smart contract, the logistics and transportation processes are carried out through the online predefined process, and then the smart contract will automatically start to get executed. Through the application of Jingdong blockchain technology, Bo and Meifang [16] pointed out that the anticounterfeiting and traceability of goods is the focus of the layout of the giant and head enterprises in the direction of supply chain, and the focus of Jingdong blockchain is to build an enterprise-level blockchain alliance to help the government, brand owners, logistics providers, and financial institutions to establish a blockchain technology platform, and the application direction will never be limited to the logistics field but will also be applied to trade financing in the future. The application direction will not be limited to the logistics field but will also be applied to trade financing in the future so that both sides and banks can share information openly and transparently, and the application in the financial field will significantly reduce the cost of payment and settlement. Liu et al. [18] considered that the logistics field is a typical landing point of blockchain technology application, and the author proposed through the analysis of the blockchain technology application of Jingdong, Tencent, Huawei, Maersk, Wal-Mart, SF, and other enterprises based on the premise that the contemporary supply chain is getting longer and longer, the supply chain network is getting more and more complex, and each commodity has gone through the process of heavy logistics and commercial flow when it reaches the hands of users [19]. Information interoperability and data sharing in supply chain network, supply chain subject, and external environment create more value market space for outstanding enterprises at the forefront of technology: application of blockchain technology smart contract to fill the traditional model, because electronic bills can be counted and changed without official seal. The application of blockchain technology smart contract fills the loophole that electronic bills cannot be stamped and can be changed, ensures the authenticity of each bill, reduces the cost of passing paper bills, and makes business communication more effective [20].

3. Blockchain Architecture

Blockchain consists of six layers of architecture and diagram is shown in Figure 1.

The bottom layer is the data layer, which is the foundation of blockchain technology. This layer encapsulates the chain structure of the underlying data blocks and defines how blockchain data is stored. Blockchain account security transactions are based on a variety of algorithms and technologies such as asymmetric public and private key data encryption, timestamps, digital signatures, and Hash functions, which are the lowest level of algorithmic technologies in the entire blockchain technology. Most of these technologies are the basis for finance, cryptography, and other disciplines. Blockchain, however, formally and cleverly combines these technologies together to ensure safe and

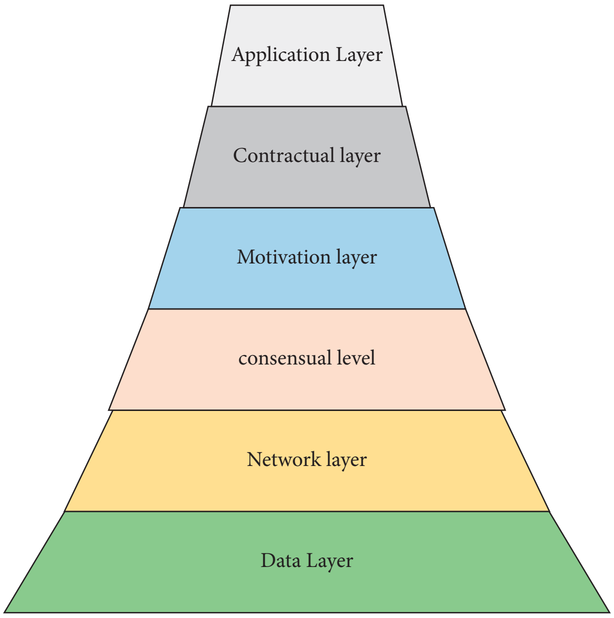

Figure 1: Blockchain architecture diagram.

reliable operation of transactions in a decentralized environment.

The formal definition of the logistics service smart contract blockchain model and the logical framework of the logistics service smart contract blockchain model. The model realizes the functions of logistics service transaction matching, smart contract generation, data transmission and encryption, and consensus and storage and provides the hardware and software basis for the design of smart contract algorithm based on the logistics service ant colony. From the architecture diagram, we can see that this model is suitable for multi-node logistics service transactions; the consensus mechanism and consensus algorithm of the consensus module are used to reach a network-wide consensus. After consensus is reached, the smart contract is written into the logistics service blockchain and executed automatically. The blockchain model of smart contract for the logistics service transaction ant colony is shown in Figure 2. This model realizes the decentralized logistics service transaction in multinode users and stores the logistics service transaction data and smart contracts in the public logistics service blockchain after encryption, which realizes the high security and open transparency of logistics service transaction data and contract contents and even prevents the possibility of malicious calculation and data alteration. Moreover, all nodes can trace the complete logistics service transaction information and service process and realize the trust transaction without the supervision of third-party institutions.

Therefore, we can start from protecting the security of logistics data, ensure the efficient operation of the logistics system, and finally achieve the goal that in the supply chain financial activities, financial institutions can supervise the order standardization process and financial standardization process in the logistics platform online in a comprehensive and real-time manner. The purpose of credit management is to optimize the service mode of supply chain finance according to the process from point to line and then to the surface, as shown in Figure 3.

4. Ant Colony Algorithm

The traditional ant colony algorithm for solving the path planning of mobile robots has the advantages of the shortcoming of slow convergence, which has received wide attention from scholars. In the literature [14], authors have proposed ways to reduce the total energy consumed in the path planning process. In order to solve the problem of slow convergence of the traditional ant colony algorithm, improvement strategies are proposed in terms of algorithm structure, parameter optimization, and planning path characteristics. The process of optimal path search in the traditional ant colony algorithm is as follows:

(1) Pheromone initialization stage. Suppose there are M nodes and N ants, give the initial value of pheromone to all paths, set the pheromone concentration of all sections to $\tau_{T_{ij}}(0) = c$ (c is a constant)

(2) Path selection phase. Ant k ($k = 1, 2, 3, 4, 5, \ldots, n$), the current ant is at node i, and the next node is chosen to pass by following the rule of the following equations:

$$p_i^k(t)\big] = j = \begin{cases} \operatorname{argmax}\left(\tau_{r_i}^{a}(t)\right]\eta_{T_{i\omega}}^{\beta}(t)\big]\big\}, & q, q_0 \\ s, & q > q_0 \end{cases}, \quad (1)$$

$$P_{is}^{t}(t)\big] = n, \quad (2)$$

$$\eta_{T_j}(t) = \frac{1}{W_{T_{ij}}}, \quad (3)$$

where $P_{is}^{t}(t)$ represents the set of all nodes that ant k can visit next, which are connected to node i and not passed by the ant. $\eta_{T_{i\omega}}^{\beta}(t)$ is the heuristic function of the road segment T when the number of selected generations is t, as in equation (3). $\tau_{r_i}^{a}(t)$ is the pheromone concentration of the road segment T at the tth iteration. α is the information heuristic factor, characterizing the strength of the pheromone action, the larger the value, the faster the convergence. B is the expectation heuristic factor, which is the mechanism that affects the search ability of the ant colony

(3) The pheromone concentration is updated locally. When the ant colony achieves the next iteration, the pheromone is updated. The update is carried out according to the following equation:

$$\tau_{r_{\bar{v}}}(t+1) = (1-\rho)\tau_{\tau_j}(t) + \rho\Delta\tau_{r_{\bar{v}}}(t), \quad (4)$$

where p is the local pheromone evaporation coefficient. p has a value between 0 and 1. The larger the value, the faster the pheromone evaporation rate on the path and the slower the convergence rate. $\Delta\tau_{r_{\bar{v}}}(t)$

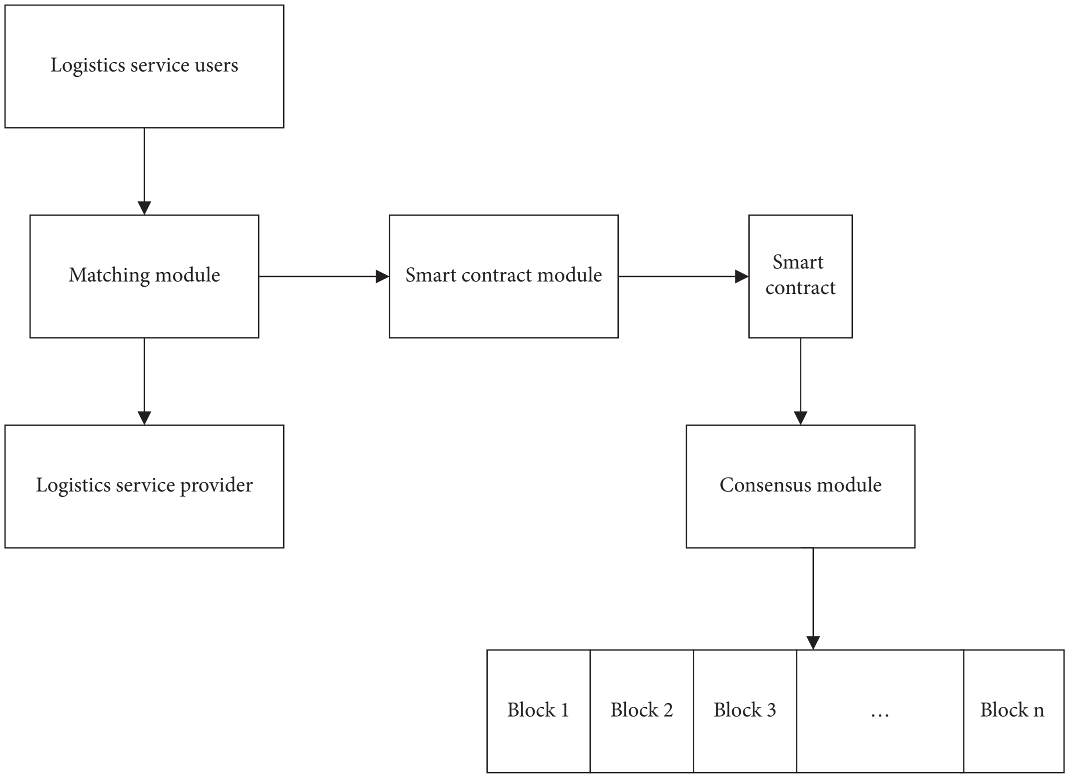

Figure 2: Blockchain model of smart contract for logistics service transactions.

is the number of pheromones released on the path after the ant achieves one search. If the ant does not select the path T, the value of $\Delta\tau_{r_{\bar{v}}}(t)$ is 0; otherwise, it is Q/W. Q is a given parameter, and W is the sum of the weighted function values of all intersections on the path

(4) The overall update phase of pheromone concentration is within the barrier environment. Each overall search is updated once, and equations (5) and (6) are also updated:

$$\tau_{r_{ij}}(t+1) = \tau_{T_{ij}}(t) + \mu\Delta\tau_{r_{ij}}(t), \tag{5}$$

$$\Delta\tau_{\tilde{r}_{j}}(t)| = \begin{cases} \left(\dfrac{1}{W_{\text{despowi}}}\right), \\ 0 \end{cases} \tag{6}$$

where μ is the global pheromone update coefficient, which is positively correlated with the overall environmental search ability. When section T_{ij} is not on the globally optimal path, $\Delta\tau_{\tilde{r}_{j}}(t)$ is 0; otherwise, $1/W_{\text{despowi}}$ is the sum of the pitchfork values of the globally optimal path and the turn intersection function

(5) Global optimal solution update phase. The global optimal solution of the whole colony is obtained by updating the taboo table each time, and the current optimal path is updated or not by comparing the previous optimal paths, and the results are repeatedly compared until the end of the selected generation

The mechanism of the improved ACO is that the genetic algorithm is responsible for the first search and the ant colony algorithm is responsible for the second search. When the genetic algorithm finishes the search, the result is an array of optimal solutions. In order to prevent all ants from gathering on the better path derived from the genetic algorithm, resulting in insufficient search range and local optimum, the initial pheromone C is assigned to all free grids; that is, all possible paths in the gridded environment have the initial pheromone concentration, and the pheromone concentration of the road in the improved initial state is the initial pheromone with the additional information assigned according to the better solution, as in equation (7), where $\tau_{ij}(GA)$ and C are constants.

$$\tau_{ij} = C + \tau_{ij}(GA). \tag{7}$$

After the two algorithms have successively explored the obstacle environment in a round-robin search, the pheromone is updated in the way shown in the following equation:

$$\tau_{ij}(t+n) = (1-\rho)\tau_{ij}(t) + \Delta\tau_{ij}, \tag{8}$$

$$\Delta\tau_{ij} = \sum_{i=1}^{w}\Delta\tau_{ij}^{l}. \tag{9}$$

Since free grids in the raster can form path nodes directly, while obstacle grids can block path formation, the initial population of feasible solutions is formed using a node search method based on orientation and randomness, as in equations (9) and (10). Paths that do not cross obstacles are

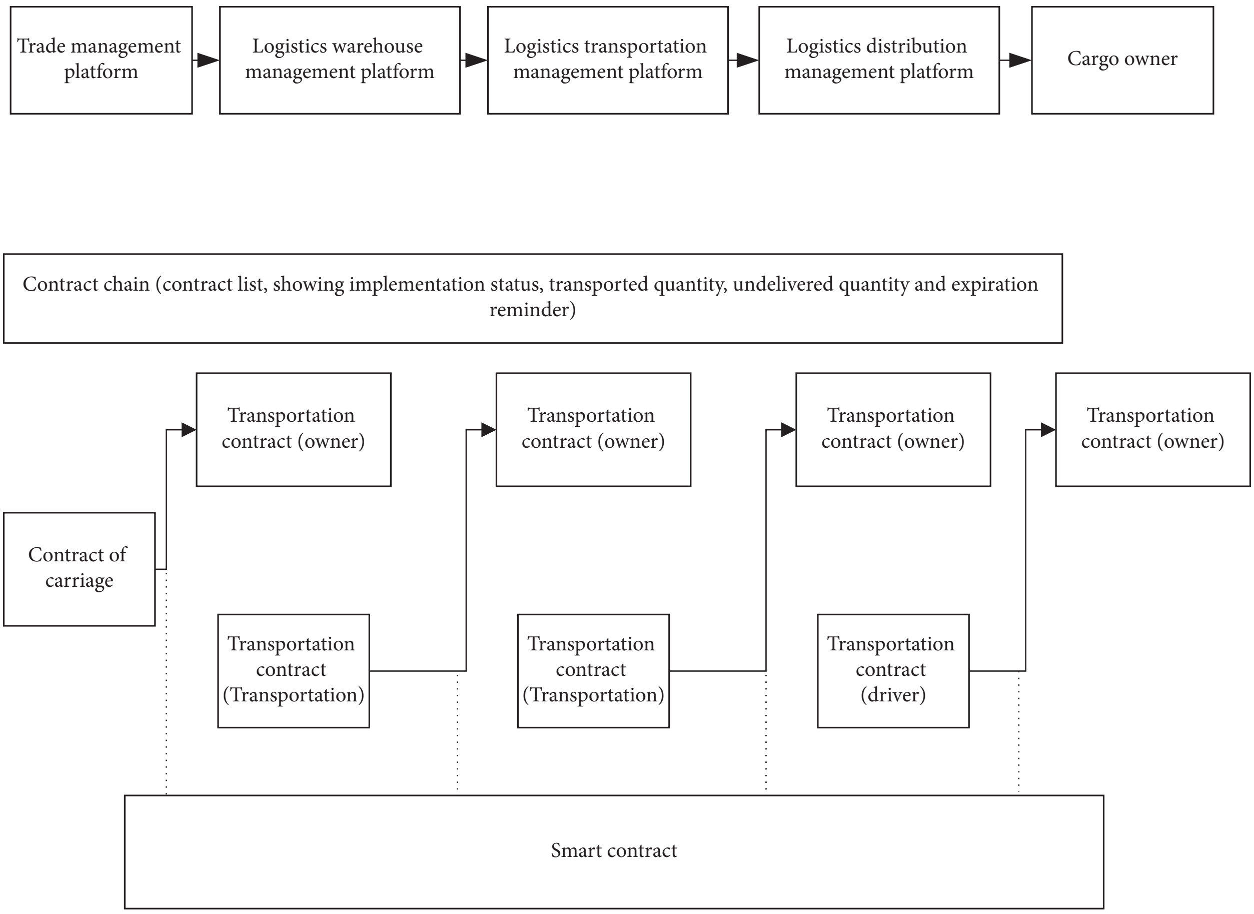

Figure 3: Financial services model.

considered valid; otherwise, path nodes are reselected; if the generated path node is close to the end point, node generation is stopped and the current path is saved.

$$\begin{cases} x_{c+1} = \left(x_7 - x_c\right) * \text{random} + x_c \\ y_{c+1} = \left(y_T - y_c\right) * \text{random} + y_c \end{cases}, \quad (10)$$

$$\begin{cases} x_{c+1} = N * \text{random} \\ y_{c+1} = \left(y_T - y_c\right) * \text{random} + y_c \end{cases}, \quad (11)$$

where x_{c+1} is the horizontal coordinate of the potential node, x_c is the horizontal coordinate of the current node, y_{c+1} is the potential node vertical coordinate, y_c is the current node vertical coordinate, x_r and y_r are the target point horizontal and vertical coordinates, respectively, N is the number of grid columns, and random is the random number, which takes the value between 0 and 1. This path generation method can overcome the obstacle grid blocking to generate effective paths, which makes the gene pool of the population richer and more diverse under the path selection method and is conducive to filtering out the real optimal solution and further providing the shortest path for the ant colony algorithm. Figure 4 shows the flow of the improved ACO based on the genetic algorithm mechanism.

5. Results

As shown in Figure 5, China's supply chain finance market is huge and has great potential for development, and there are two main types of main bodies guiding the rapid development of supply chain finance: first, bank supply chain finance represented by major banks, relying on the resources of core enterprises to provide funds for the supply chain; second, e-commerce enterprises such as Alibaba and Jingdong, which have the advantages of capital flow, information flow, and logistics in the physical supply chain.

According to the data of Foresight Industry Research Institute, 40% of domestic small and medium-sized enterprises have credit difficulties or are unable to obtain external financing from the formal financial system. The problem is not only the reason to limit their own development but also the core problem that stalls the whole supply chain industry to drive forward. According to the banker's questionnaire, the demand for SME loans reached 50% and above in 2013–2019, but the banks' approval in this area is below 50%. Some SMEs have to keep innovating their business models in the case of immediate loan demand, but this method has little effect and can be said to be insufficient in terms of business efficiency improvement." Therefore, as a financing market with great potential for development, the

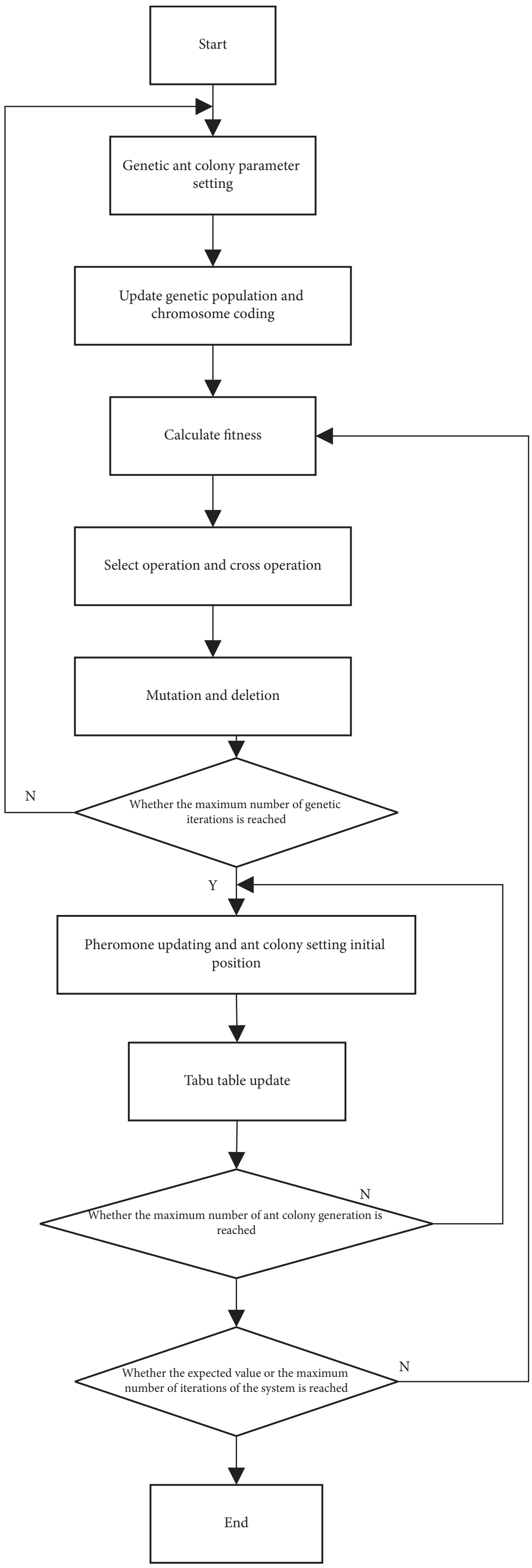

Figure 4: Improved genetic algorithm mechanism.

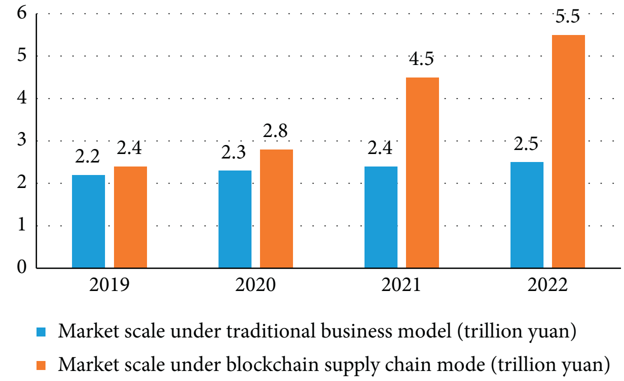

Figure 5: China supply chain finance market size and incremental assessment, 2019–2022.

combination of supply chain finance and financial technology is a fundamental and necessary means to improve the efficiency of the industry [21–23].

The concept of logistics was gradually introduced in the process of socio-economic development. Logistics originated in the U.S. military system in the 1930s and was gradually introduced to industry and commerce. The English word for logistics is physical distribution (PD for short), which includes activities such as warehousing, handling, and transportation. The concept was introduced from Japan to China in the 1980s, but it was not until the beginning of the twenty-first century that it was taken seriously and widely used in China. American scholars once proposed that in the process of the gradual development of information technology and enterprise management technology, the production and sales chain can be compressed less and cost-effective, and logistics as the last link of enterprise cost control is the third source of profit for enterprises.

China's overall freight volume and express business volume rose year by year, see Figure 6 and Figure 7. At present, China's logistics industry has developed into operational integration, management informatization [24–26], resource socialization, system integration, and four streams integration. With the expansion of the volume of logistics business and the diversity of models, there are also some problems: (1) China's logistics industry started later than other countries, and there is a obvious shortage in the application of technology; the system is not perfect leading to a cumbersome and time-consuming transport process, wasting a lot of human, material, and financial resources; (2) the logistics system structure is insufficient; most logistics companies currently have only one or two services, and it is difficult to find the ability to have a full range; (3) the lack of logistics information technology applications, systems, and information exchange platform system is not complete; data cannot be shared and exchanged, resulting in a large part of the data not being able to be converted for effective use of resources in the era, which makes large data a great waste nowadays

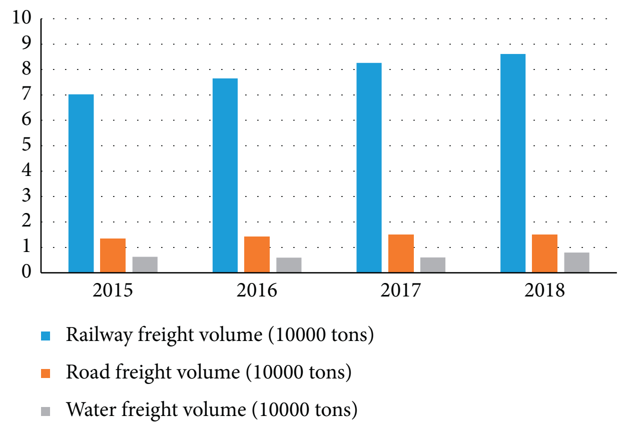

Figure 6: China's freight volume statistics, 2015–2018.

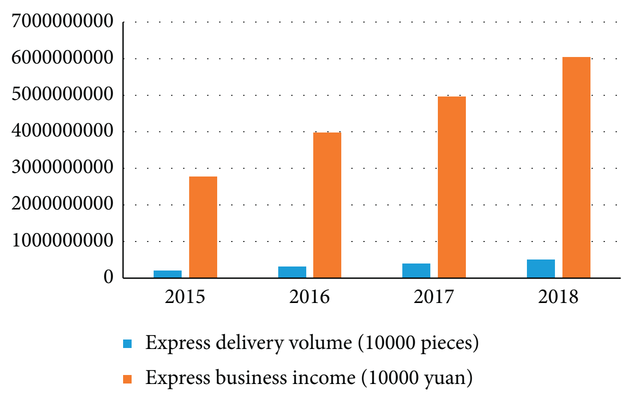

Figure 7: China express volume statistics, 2015–2018.

The group decision weight values were sorted and ranked to summarize the degree of influence of the indicator layer. Collating the above data, the influence weights of each factor in the A-B-C layer are ranked and shown in Table 1 below:

From the results in Table 1, we know that in the logistics platform management system with blockchain technology as the underlying support technology, the weight value of credit risk accounts for a relatively large amount, which is followed by supply chain risk, and operational risk is often the last factor considered by enterprises. It confirms the analysis in Section 3 of this paper that in logistics, the fundamental factor affecting business development is the lack of data sharing due to trust issues; and in supply chain finance, fictitious trade, self-insured self-financing, and financing money transfer are also caused by incomplete credit audit mechanism, transaction information and data, and improper management of logistics enterprises, which will inevitably lead to the generation of supply chain risk once there is a problem in the flow of funds in a certain loop. Thus, the supply chain risk is generated. Therefore, at present, the main technical grip of China in the supply chain market is to solve the trust problem [27–30].

In the case of the same parameters, 200 iterations of the improved ACO and the traditional ACO were conducted.

From Figure 8, it can be seen that our method has a smooth rise and fall of the algorithm curve with increasing number of iterations and stabilizes earlier than the other three algorithms for the exact same parameters.

In this paper, the samples are matched for transactions based on Table 1 and other data samples using the ant colony algorithm and the improved ACO, and the experiments are repeated and their averages are taken. The time required for the experiments with the traditional and improved ant colony algorithms is shown in Figure 9. As the number of matching transactions increases, the time taken by our method to perform matching transactions is shorter than the time taken by the traditional ant colony algorithm to perform matching transactions. Therefore, the improved algorithm has better performance in terms of time consumption.

Figure 10 shows the change curves of the global optimal mean of three objective functions: (1) the overall satisfaction function, (2) the matching evaluation function, and (3) the optimal matching evaluation function under the comparison experiments of the improved ant colony algorithm, particle swarm algorithm, and PDN-AFS algorithm. From Figure 10, it can be seen that the global optimal mean of such three objective functions of the improved AFS algorithm has a decreasing trend compared with the traditional AFS algorithm. The improved algorithm can obtain better results for the average of the three objective function type global optimums. The selection process is also more stable. Therefore,

Table 1: Ranking of indicator weights in A-B-C layer.

Floor a	Floor B	Peer weight	Global weight	Floor C	Peer weight	Conclusion value (global weight)	Sort
Blockchain + logistics supply chain	Credit risks	0.558	0.558	Credit audit + transaction information and number	0.332	0.187	2
	Operational risk	0.185	0.185	Employee + technical safety management	0.352	0.174	3
	Supply chain risk	0.257	0.257	Supply chain rupture + supply chain risk transmission	0.5	0.128	4

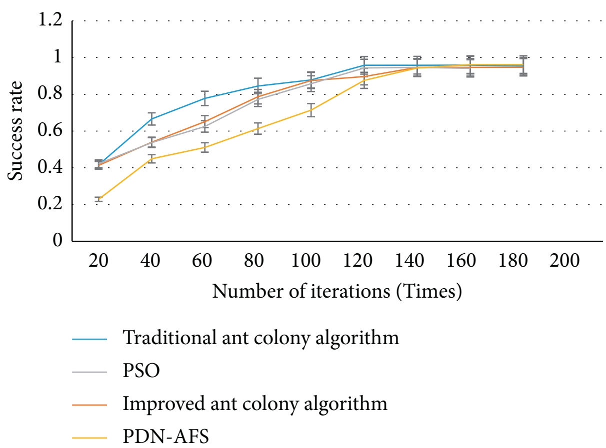

Figure 8: Performance comparison chart of four algorithms.

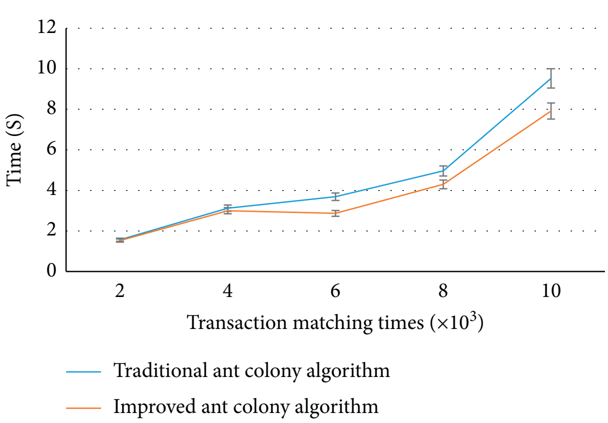

Figure 9: Execution transaction matching time chart.

the improved algorithm is effective in finding global optimum solutions during the process of iteration.

Figure 11 shows the change curves of satisfaction values based on the improved ACO, the traditional algorithm, the basic particle swarm algorithm, and the PDN-AFS algorithm in a certain transaction matching. It can be seen that the improved ant colony algorithm can achieve the best performance, and the curve fluctuates less.

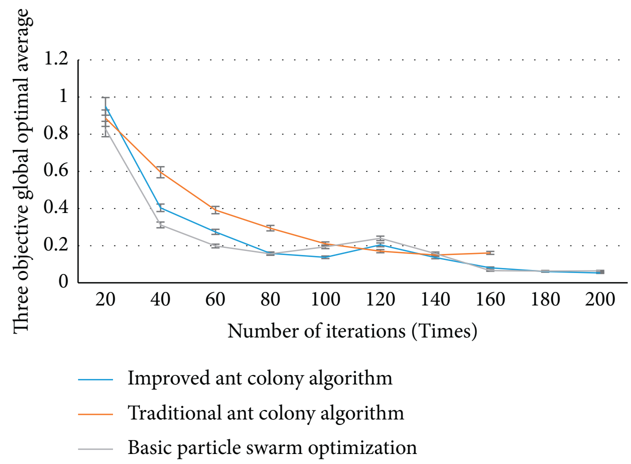

Figure 10: Variation curve of the global optimal mean of the three objectives.

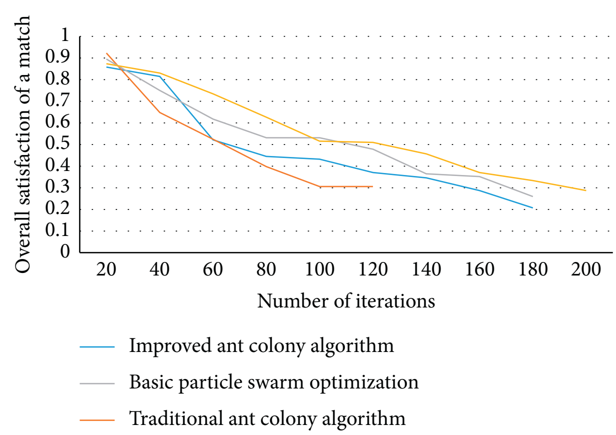

Figure 11: Matching overall satisfaction change curve.

6. Conclusion

At present, blockchain technology can improve the service capability of the whole supply chain, making the process visible. It can not only break the original solidified development model of logistics enterprises but also reform the business model and crediting method for financial institutions. So the problem of capital flow in financing enterprises can be solved effectively to reduce the risk with 50% on supply chain industry. Furthermore, the distributed ledger, smart contract, and data corroboration on the chain function are discovered to solve the credit problem of blockchain technology in practice.

Data Availability

Data sharing is not applicable to this article as no datasets were generated or analysed during the current study.

Conflicts of Interest

The authors declare that there are no conflicts of interest with any financial organizations regarding the material reported in this manuscript.

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