Research on Smart Contracts of Accounts Receivable Financing in Supply Chain Finance Based on Blockchain Technology

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Abstract. The blockchain technology in digital currency has received extensive attention again with the continuous promotion of digital currency. The decentralization of blockchain has had a severe impact on the traditional supply chain financial model. Although the credit of core enterprises is introduced as guarantee when banks build a financing platform, there are still credit risks and operational risks. The basic reason is that smart contracts based on blockchain are not complete. How to improve financing efficiency and scales while stabilizing or reducing financing risk has always been the concern of financing providers. This paper has referenced the shortcomings of smart contracts and analyzed the financing platforms based on blockchain where smart contracts built by banks. The framework model of smart contracts in SCF has been reconstructed in this paper to ensure the supply chain finance more consistent with the financial scenes and more tally with the business logic. The correctness of smart contracts in supply chain financial accounts receivable has been verified by analyzing practical application cases and establishing BBV complex network model. This research aims to solve financing trust problems by optimizing and reshaping the preset logic, execution, node verification and node judgment of smart contracts, so that the financing economy can be recycled.

Keywords: blockchain · smart contract · supply chain finance · financing risks · circular economy

1 Introduction

Supply chain finance is a financing mode that banks combine core enterprises with upstream, middle and downstream enterprises to reduce risks through mechanism redesign. It is also a trade driven financial service [1]. The advantage of supply chain finance is that banks can give bank credit to financing enterprises in the supply chain, which enhances their commercial credit in disguised form. Supply chain finance can

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not only reduces the financing difficulties of small and medium-sized enterprises, but also improves the competitiveness of the supply chain. Blockchain technology was first proposed in 2008 by Nakamoto Tsung [2], but it has not been clearly defined. So Yong Yuan made a detailed description and explanation of the basic principles, core technologies, applications, and problems of blocks in the blockchain [3]. Blockchain technology has the characteristics of decentralization, information transparency, identity security, data authenticity and unmodifiable. Smart contract technology is a sub-technology of blockchain technology. The smart contract first proposed in 1995 is complementary to BCT. The concept of smart contract was defined by Nick Szabo as a set of commitments specified in digital form, including agreements on which contract participants can implement these commitments [4].

Supply chain finance can be divided into three types: receivable financing, prepayment financing and storage mortgage and pledge financing. There are different problems in different financing modes. The risk of non-material asset mortgage is greater in the receivable financing mode, such as the pledge of patent rights. The value of intellectual property itself changes quickly. It is different from the material assets that can be auctioned when disposing of intellectual property, so it is difficult to alleviate the business struggling. The whole financing process relies more on core enterprises in the prepayment financing mode, which causes much unfairness. The downstream enterprises exchange the financing amount for the future delivery right, which requires that the upstream enterprises must have good anti-risk ability and the market value of goods is relatively stable. In addition, there is a risk of time difference between the ownership handover of goods and actual handover of goods. The third-party warehousing company plays a very important role in the financing mode of storage mortgage and pledge. Whether the warehousing company implements the procedures fairly, comprehensively accepts the goods, and strictly preserves and supervises the goods or not determines the quality of financing. Many of these uncertainties will cause risks which are difficult to quantify. Besides, there are many problems such as multiple documents and complex processes, resulting in increased costs through the whole financing business process. Meanwhile, general supply chain finance relies on human operation, which is easy to lead to operational risks.

The smart contract technology in the blockchain can greatly reduce the operational risks, information asymmetry risks and ownership risks in supply chain finance. Smart contracts can realize the self-compensation of supply chain finance through the compilation of preset logic, and use the sales funds of financing enterprises to repay loans through contract accounts. However, the irreversibility of blockchain not only ensures the authenticity of information, but also limits the further development of smart contracts. Once the contract is executed incorrectly, all financing funds cannot be recovered quickly, which is easy to cause bad debts, capital chain breakage and other risks. It will also aggravate the distrust between enterprises and commercial banks.Although prior studies have combined blockchain and supply chain finance, detailed content of smart contracts in supply chain finance is lacking. Smart contracts play an important role in supply chain finance, but few people describe its specific implementation principles. Only a few studies, such as Haiwu He has described the specific structure of smart

contracts in detail from the aspects of contract subject, loading method, execution environment, verification method and scalability [5]. Although smart contracts can be applied to financial services, it is easily to be found that the current researches and application of smart contracts in supply chain finance have some problems, such as unclear process and operation.

Therefore, this paper will describe in detail how smart contracts are applied to account receivable financing in supply chain finance, and propose a new definition by comparing the differences, characteristics and limitations between general smart contracts and smart contracts in supply chain finance. At the same time, this paper studies and designs the execution, verification and judgment of smart contracts of accounts receivable financing in supply chain finance under the premise of preset logic. This design is conducive to optimizing the stability of smart contracts and enhancing trust to a certain extent. Finally, the feasibility analysis has been carried out by analyzing cases and establishing BBV complex network model. The empirical results show that this design makes the whole financing platform more stable, enhances the trust between participants in financing activities and is conducive to commercial banks providing more financial services for enterprises in the supply chain. The improvement of smart contracts helps to improve the capital flow of enterprises, and also meets the demands of commercial banks for long-term development so as to achieve economic stability, circulation and sustainable development.

2 Literature Review

The research of supply chain finance can be divided into two categories, one is the profitability of financing, the other is the mode of financing. This paper will focus on the receivable model. Receivable financing is aim to solve the fund flow difficulties caused by upstream enterprises providing credit sales to downstream enterprises. For general accounts receivable financing, the core enterprise provides guarantee for the upstream enterprise to apply for bank-financing. Concretely, the upstream enterprise transfers the accounts receivable issued by the core enterprise to the bank for financing, and the core enterprise returns the funds to the bank before the bill expires. The advantage of receivables financing is that the bank can easily control the operational capacity of core enterprise. No matter which enterprise the bill is split and transferred to, the bank only needs to find the core enterprise for repayment because the bill is issued by the core enterprise [6]. Receivables financing can also be subdivided into factoring financing, reverse factoring financing, factoring pool financing, financial leasing, bill pool financing, financing under export credit insurance, etc. Yanhai Li et al. established a multi cycle inventory control model which was based on the determined demand and capital constraints in order to analyze the impact of different discount rates on the total financing cost in factoring financing (sale of accounts receivable). They found that different discount rates had a significant impact on the decision-making of enterprises, but the study ignored the quality of accounts receivable and the credit risk of buyers [7]. Ruzhen Yan et al. considered the impact of equity financing model, debt financing model and commercial credit financing model on the financing proportion, order volume and profit of financing units in the market with linear demand. Different model combinations

will cause diversity in financing proportion, order volume and profit of financing units, but the result need to be based on certain credit assumptions [8]. An very important factor is risk no matter the research is based on profitability of financing or mode of financing, so Chinese banks tend to pay much attention to risk control in their supply chain financial business. On the contrary, the problems of information flow and capital flow in supply chain management have been ignored. Actually, there are two key problems in carrying supply chain finance—— risks and necessity. Z Wang et al. developed an adoption model of supply chain finance [9], and verified the feasibility of three types of financing one by one. The results show that capital perceived pressure and inventory turnover period are the important factors affecting the use of supply chain finance. Wuttke DA et al. have shown that imitation and normative pressure will urge suppliers to adopt the supply chain finance [10]. Generally, enterprises will only adopt supply chain finance when the buyer's expected interest is much higher than normal interest.

As a relatively new technology, blockchain technology is expected to be applied to supply chain finance to solve the above problems due to its decentralization, information transparency, identity security, data authenticity and tamperability. The core technologies of blockchain include asymmetric encryption technology, distributed ledger technology, smart contract technology and consensus mechanism, as shown in Fig. 1. In order to study BCT better, the architecture of blockchain and its technology has been described by Qifeng Shao et al. from the perspective of databases [11]. Smart contract technology can automatically complete repayment and avoid adverse selection risks. Time stamp and digital signature record the flow of financing funds in detail, and can avoid default. The distributed ledger and consensus theory allow all node enterprises in the supply chain to supervise the financing enterprises, so that joint fraud can be avoided. Asymmetric encryption technology and cryptographic algorithm maintain the information security and capital security of the transaction subject. In addition, the participation of all companies not only reduces the cost of risk control, but also increases the cost of default in disguised form. The "intelligent" operation also reduces a large number of operational risks.

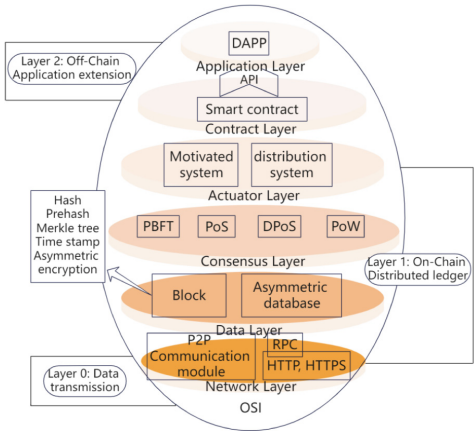

Fig. 1. Composition of blockchain Technology

3 Smart Contracts of Accounts Receivable Financing in Supply Chain Finance

According to the characteristics of accounts receivable financing mode in supply chain finance and the definition of smart contract, this paper gives the definition of smart contract of accounts receivable financing mode in supply chain finance. The framework of the smart contract has been constructed as well. And the characteristics and working principles of the new smart contract are described in detail. In addition, this paper describes the characteristics and working principles of the new smart contract in detail to fill the research gap.

3.1 New Definition of Smart Contract in Supply Chain Finance

In supply chain finance, the smart contracts retain the features of automatic contract execution, self-verification, status response, condition response and distributed nodes. The smart contract acts as the credit collection between the contract executor and the financing parties. Smart contracts are a program that can automatically perform repayment in supply chain finance [12]. Therefore, this paper defines smart contracts in supply chain finance as a set of financing credits triggered by preset logic. The preset logic should be determined by the system and supply chain nodes (other companies, institutions and organizations). The smart contract needs to complete the information exchange and store it in the data block.

3.2 Characteristics of Smart Contracts in Supply Chain Finance

(1) Easy-identifiable codes.

The essence of smart contract are still some codes, which depend on the programming language. The writing of the codes determines whether the smart contract can accurately execute the contract content or not. The codes should be clear, concise and easy to identify, so as to avoid the problem that smart contracts cannot recognize them [13]. The design of smart contracts is similar to the simple‘ If then’ judgment [14], so the execution of the system depends on simple logic. The programming language of smart contracts in supply chain finance is machine language, and involves more complex transaction modes. Therefore, programming needs to be practical-oriented, rather than re-adjusting the financing process after design. The financial business-oriented design ensures that the smart contract system can handle more emergencies during the implementation process.

(2) Legal adaptability.

Smart contracts also need to meet the requirements of legal supervision when the contents of smart contracts are consistent with the contents of traditional contracts. The premise of the effectiveness of the traditional contract is to comply with the law but it cannot make sure the smart contracts are also comply with the law even the contents of smart contracts are the same meanings as traditional contracts. Much information such as the amount, subject, transaction mode, pledge and credit level of financing involve a large number of privacy issues. The information transparency advocated by blockchain technology itself is contrary to the privacy issue [15]. Smart contracts will inevitably

face this problem when implementing procedures. There is a certain conflict between decentralization and supervision [16]. Therefore, the programming design must have professional legal personnel participated in order to avoid legal conflicts while taking into account privacy and information transparency.

(3) Callback mechanism.

'Callback mechanism' is the first improvement of smart contracts in this paper. The return of funds is a serious problem in the supply chain finance accounts receivable model. Unlike pledge financing, which has corresponding collateral, and is also different from the credit standing of large enterprises in prepayment financing, receivables financing is the acceptance bill issued by downstream enterprises. Once the bill is circulated, the credit standing of the acceptance subject will become worse and worse, and the cashing problem will arise. Therefore, a callback mechanism must be set for smart contracts under the supply chain finance receivables financing mode. Solidity is an Ethereum language with a unique advanced feature [17] - event callback mechanism. The node will send a callback notification to the software development kit after the event is successfully executed. Then smart contracts will execute the callback function. Similarly, the callback mechanism can also be used for post-loan tracking of financing providers. Once the contract conforms to the preset logic, it will be automatically executed and all transaction information will be recorded in the log. Once the smart contract conforms to the preset logic, it will record all transaction information in the log. This design makes it easy to find financing records. The financing provider can call out the records in time and broadcast the default to the entire network when the financing party defaults.

(4) Double judgment.

'Double judgment' is the second improvement of smart contracts in this paper. In order to ensure that the smart contract can operate according to the expected logic and does not conflict with the design concept of the smart contract itself, the smart contract should be changed from a single judgment to a double judgment composed of multiple systems and supply nodes. The accounts receivable model in supply chain finance judged by the smart contract alone will meet some problems such as execution deviation caused by complex business structure, conflict between privacy and information transparency, and difficulty in capital return. Therefore, other supply chain node enterprises need to be added for auxiliary processing, as shown in Fig. 2.

(5) Terminable.

The smart contract program must be terminable and no infinite loop after triggering conditions [18].

(6) Response uniqueness.

The trigger of each smart contract has a unique number in SCF. As shown in Fig. 3, the smart contract system is prone to execute wrong events if other events also meet the trigger conditions.

3.3 Main Components of Smart Contracts of Accounts Receivable Model in Supply Chain Finance

(1) Preset logic.

The preset logic is given first in smart contracts of BCT, including triggering conditions and response rules. The preset logic can be simply understood as the trigger

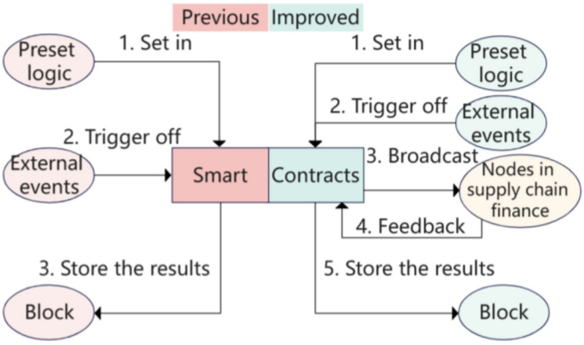

Fig. 2. Double judgement in the smart contract of accounts receivable model in supply chain finance

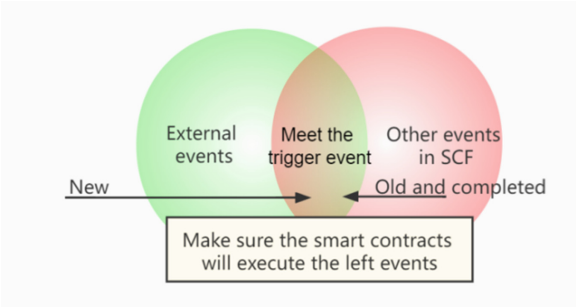

Fig. 3. Response uniqueness in the smart contract

condition of smart contract. According to the preset logic, the system will process the event when an external event is entered into it, as shown in Fig. 4.

(2) Composition of smart contracts.

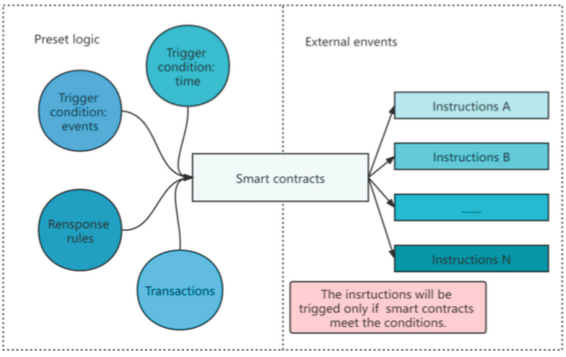

Fig. 4. Preset logic in smart contracts of accounts receivable model

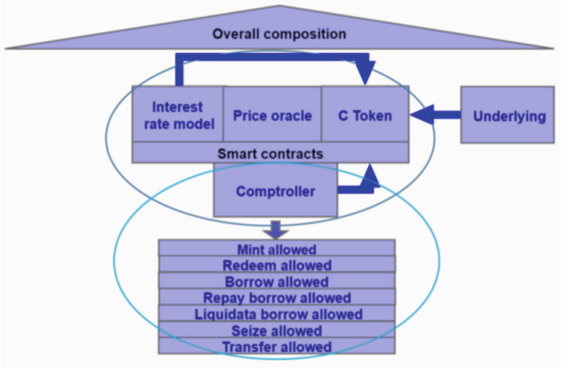

Fig. 5. Composition of smart contracts

The design of smart contract generally includes interest rate abstract contracts, comptroller contracts, the price oracle and the Token core logic contract as shown in Fig. 5.

Interest rate contract is the main sub-contract of smart contracts applied to finance. The smart contract adopts the blockchain interest rate in order to facilitate identification, such as the simple linear interest rate, which is called as white paper interest rate model. It was written as $y = kx + b$, as shown in Table 1. In addition, there are other interest rate models that adapt to different financing scales, such as inflection point interest rate. The interest rate can be selected according to actual business [19]. Comptroller contracts are used to store business data, verify logic and check business. Mint, redeem, borrow, replay borrow, liquidate borrow, seize, transfer and other function commands have been included in them. The price oracle is a link between the real world and the digital world, which can write external information into the blockchain. The oracle can separate the blockchain from the real world and avoid smart contracts from reading the information of the external Internet in case the information in the block chain is inaccurate. The token core logic contract is not only related to interest rate abstract contracts and comptroller contracts, but also related to underlying. Token core logic contract can be simply understood as the circulation of virtual currency. Token should be connected with the digital currency or directly replaced by the digital currency issued by the central bank in reality.

3.4 The Combination of Supply Chain Finance Accounts Receivable Financing Mode and Smart Contract

According to the working principle of smart contract and the characteristics of supply chain finance accounts receivable financing mode, the combination of smart contract technology and supply chain finance accounts receivable financing mode is shown in Fig. 6. Under the accounts receivable financing mode, enterprises in the upstream of the supply chain are in a weak position and need to rely on core enterprises for financing. Smart contracts will directly transfer the accounts receivable token issued by the bank to the upstream enterprise after the core enterprise guarantees to the bank. At this time, the

Table 1. Block rate value

Theoretical value	Actual value
k = multiplier per year	k' = multiplier per year / block per year = k/ 2102400
b = base per year	b' = base per year/ block per year = b/ 2102400
x = utilization rate	x' = borrows/(cash + borrows- reserves)

* All smart contracts need to pass Ethereum test. The smart contract needs to calculate the interest rate according to the speed of block generation as the time unit. The generation time of blocks in Ethereum is 15 s, so a year is 4* 60* 24* 365 = 2102400.

enterprises that obtain the accounts receivable token become the first-level distributors in the whole supply chain. On the one hand, the accounts receivable token makes up for the shortage of funds to a certain extent, greatly shortens the period of accounts receivable, and enables enterprises to invest in reproduction faster. On the other hand, the accounts receivable pass can be split many times, and the surplus financing funds can be transferred to the secondary distributors for refinancing. The endorsement is the bank and the guarantee is the core enterprise and the primary distributor. The financing income will be allocated to banks, core enterprises and first-tier distributors in a certain proportion. In addition, if the whole supply chain is too short or the number of enterprises cooperated with the first-tier distributors is small, the surplus financing funds will also be put into the financing pool by smart contacts, waiting for the enterprises in need to claim. Banks, do not need to make accounts and to review the credit of the financing unit again. Smart contracts have strengthen the cohesion with weak and core enterprises in the whole supply chain.

During the whole process of on-chain, the smart contract has completed three tasks. First of all, smart contracts convert accounts receivable bills into tokens to facilitate digital splitting. Secondly, smart contracts complete the transfer of accounts receivable tokens, which have the ownership of goods and funds. Smart contracts also upload them to the entire blockchain system to complete the filing; Finally, the repayment of the financing amount will be completed immediately from the smart contract account in order to avoid bad debts.

In this mode, the main body providing financing has changed from a single bank to all enterprises in the supply chain. Neighboring upstream and downstream enterprises know each other's business capabilities well so that the financing risk is much lower. In addition, the rest bills can be put into the bill pool to provide financing for enterprises in need. Bills can be circulated better, and the pressure on cash flow of enterprises has been relieved. The bill is credible because it is uniformly endorsed by the bank. The digital operation makes each bill has the digital signature of the provider. The smart contract will complete the splitting and transfer of notes, and the additional financing income will also be deposited into the contract account, which greatly reduces the operational risk.

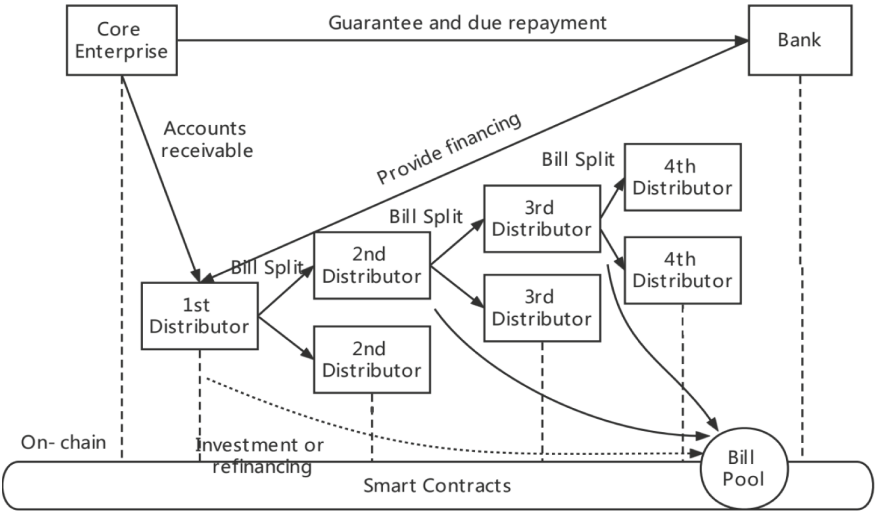

Fig. 6. The combination of supply chain finance accounts receivable financing mode and smart contract

3.5 Workflow of Smart Contracts of Accounts Receivable Financing Mode

The preset logic can be written as 'the broadcast message of the smart contract system triggered by uploading the contract,' if the manufacturer and the buyer upload the purchase and sale agreement, which is regarded as a trigger point, as shown in Fig. 7. The improvement of the preset logic of smart contract of accounts receivable financing model is the bank's confirmation. Generally, in the actual business operation process, the bank extends credit to the core enterprise. The core enterprise opens and lends accounts receivable according to its own considerations, then confirms with the bank, and finally settles the interest. For blockchain-based business operations, banks will once again take the initiative to consider the reputation of financing entities, as the cost of checking information has been reduced and the information is true and reliable. The guarantee role of the core enterprise has declined and the operation of lending is decided by the bank. Finally, the interest income of one or both parties will be settled. The advantage of this design is to ensure the main position of financial institutions in lending, and promote the trade cooperation between core enterprises and SMEs (Small and medium-sized enterprises, SMEs). SMEs do not have pressure of capital flow and loans, and core enterprises do not need to bear guarantee risk.

(1) The execution of smart contracts of accounts receivable financing mode in supply chain finance.

The execution flow chart of smart contracts is shown in Fig. 8 after the preset logic is finished.

Step1: The purchase and sale agreements (contracts) signed between enterprises should be uploaded to the blockchain system firstly. The blockchain system transmits the information to the smart contract system, which then broadcasts the information to the nodes in the supply chain. The nodes in the supply chain will judge the information

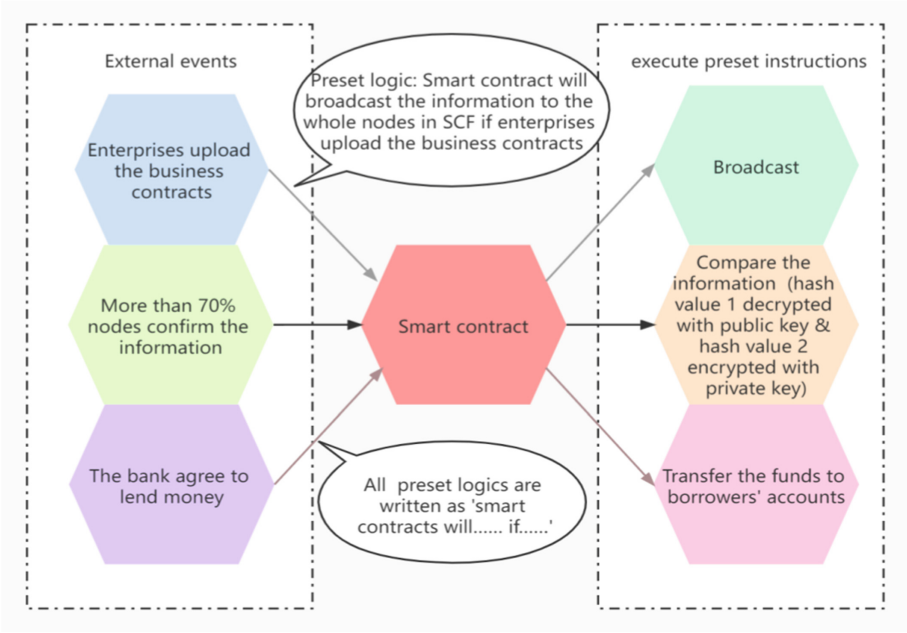

Fig. 7. The preset logic of smart contracts of accounts receivable financing mode in supply chain finance

for the first round with two reasons, one is the authenticity of the information, the other is that the nodes need to acknowledge the existence of information. The error will be passed to the smart contract system when the information is wrong, and the smart contract will notify the blockchain system to terminate the contract. Also, the blockchain system will pass the error to enterprises.

Step2: When the information is correct, the smart contract will compare the information confirmed by the supply chain nodes with the information transmitted by the blockchain for the second round. If the information cannot be matched, it will feedback to the blockchain system, terminate the smart contract, and notify the enterprises.

Step3: After receiving the financing request, the bank will query the enterprise information such as order information, financing amount, and the usage of funds from the blockchain system and decide whether to make a loan. The smart contract system will feedback to the blockchain system, terminate the smart contract, and inform the enterprises if the bank disagrees.

Step4: When the bank agrees to lend, the smart contract will transfer the funds from the bank contract accounts to financing enterprise contract accounts. It will inform the blockchain system that business has occurred, and the business will be recorded in the distributed ledger. Meanwhile, it will start to implement the terms of smart contracts.

Step5: The smart contract system will automatically and repeatedly determine whether the repayment date is due or not during the execution of contracts. This model is bank-centered, which only linked to lending and collection. Therefore, the setting of the smart contract system in the bank determines whether the repayment date is due.

Step6: When the repayment date arrives, the smart contract system will transfer the funds from financing enterprise accounts to the bank accounts, inform the bank and the blockchain system, record it into a distributed ledger, and mark the credit rating score.

Step7: If the funds in the enterprise accounts are insufficient, the smart contract system will inform the bank. The bank will contact the financing enterprises to discuss whether the money can be postponed or processed by stages or not. This paper designed a negotiation process between banks and financing enterprises with potential value but still with the risk of financing default due to the competition between banks in real life. In the processing schemes selected by the bank, delay, installment or compensation can be given. When the bank agrees to postpone, the blockchain system will terminate the smart contracts and create new smart contracts.

Step8: When the bank chooses to pay compensation, smart contracts will implement the default clause presented at the beginning by transferring the ownership of other fixed assets in the financing enterprises (every flow of enterprises is recorded in the distributed ledger, including procurement cost, depreciation cost, etc.) to the bank accounts.

(2) The verification of smart contracts of accounts receivable financing mode in supply chain finance.

Still, smart contracts have preset logic. The system will broadcast it to other nodes in the supply chain for the first time when an external event is entered into the smart contract. Only other nodes pass the verification, the next process will be conducted. The successful response can be set to 70%, because it is hard to guarantee the nodes can

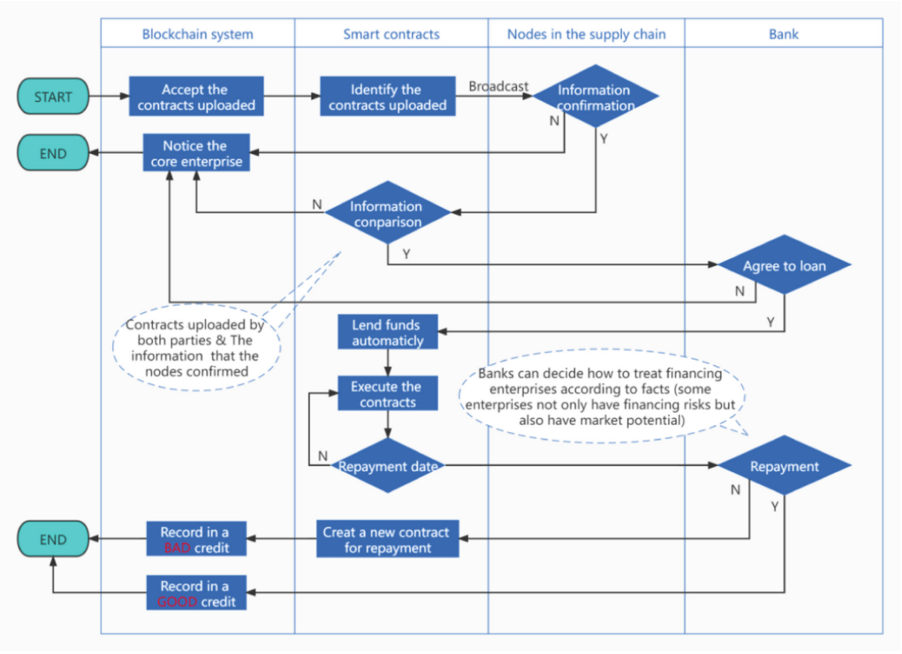

Fig. 8. The execution of smart contracts of accounts receivable financing mode in supply chain finance

respond 100%. Each node has a node scoring system. The event will be stored on the node system and be processed once every short period when the node receives the event. The smart contract system will compare the uploaded information originally with the contract set information that multiple nodes have verified. The event will be included in the block if the private key of the contract participants matches the account as shown in Fig. 9.

(3) The judgment of smart contracts of accounts receivable financing mode in supply chain finance.

The usual transaction process of the smart contract is: transaction proposal (trigger transaction) → other nodes respond → content execution (triggering condition) → record [20]. In short, the system will automatically trigger the transaction, and other nodes will get the message when uploading the contract to the system. The system will execute the content according to the preset logic. For example, the contract will be triggered again, executed, and the whole transaction will be recorded when a breach of contract or both sides is clear. The smart contract system will process a breach of contract according to the preset logic in the transaction process. In other words, smart contracts will make compensation according to the liability for breach of contracts if someone violates the treaty in the contracts.

The state machine in the smart contract system will judge whether the contract is completed or not when the transaction process is completed, making both sides clear. The contract transactions will be removed from the current block (contracts need to be executed) by the system, and the completed contracts block will be created if contracts

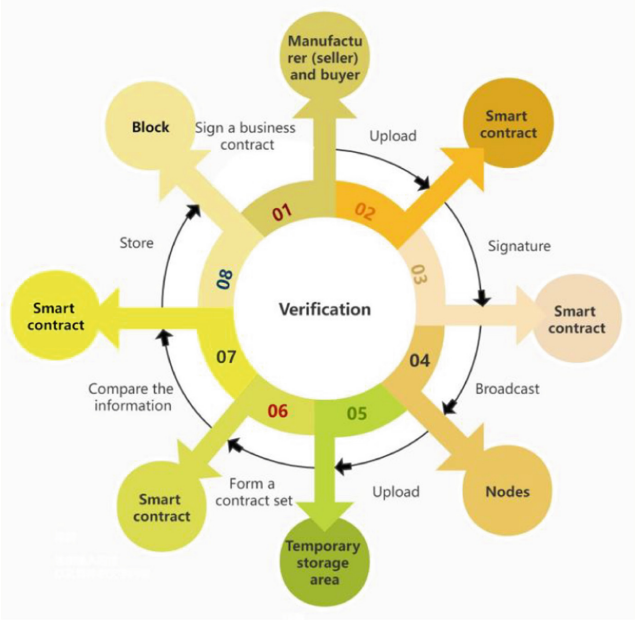

Fig. 9. The verification of smart contracts of accounts receivable financing mode in supply chain finance

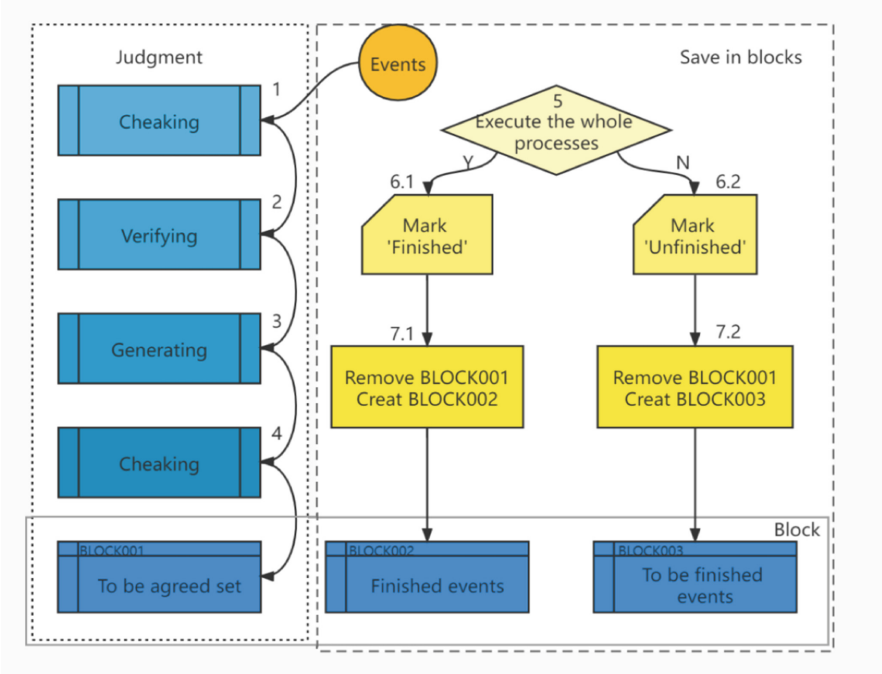

Fig. 10. The judgment of smart contracts of accounts receivable financing mode in supply chain finance

are completed. If the state machine judges the contract has not been executed, smart contract system will mark the contract as a state 'unfinished' and save it to the latest block for completion.The specific process is shown in Fig. 10.

4 Feasibility Analysis

4.1 BBV Model Analysis

In order to verify the feasibility of adding decision nodes, this paper uses BBV complex network model to verify. A large number of complex systems in nature can be described by networks. A typical network is composed of many nodes and edges, where nodes are used to represent different individuals in the real system, while edges are used to represent the relationship between individuals. Generally speaking, when a new node is generated in the network, it will inevitably generate a new edge with the original node and generate a new weight value, which represents the relationship between the new node and the old node. It can also be considered as the influence between nodes. There is a problem is that the edge increases while the weight value do not change with the continuous increase of nodes. The BBV model takes into account the dynamic changes of nodes and edges, that is, the addition of new nodes and edges will affect the weights of the original nodes and edges. For example, when new enterprise A enters the competitive market, it will affect the influence of old enterprise B on C. The newly added decision

node in smart contracts and the original decision node will generate new edges. Their relationship includes verifying the authenticity of events, broadcasting events, etc. The point weight represents the credibility level of the node.

Suppose that there are m0 decision nodes in the original fully coupling network, and the weight value of the edge is w0. The network has m edges if a new decision node n is added. The new decision node will only select the added edge according to the weight of the node in the original network, and the probability of the old node being selected is

$$\Pi(k_i) = \frac{k_i}{\sum_j k_j} \tag{1}$$

where i and j represent nodes, and k represents the weight of nodes. The larger the weight of the original node, the easier it is to be selected. The node weight will change with time t. Similarly, the addition of a new node may not have a relationship with all the old nodes at the same time. Therefore, the increase of new nodes also needs to consider the priority connection. The probability of the new node considering the priority connection is

$$\Pi(k_I) = \frac{k_I}{\sum_J k_J} \tag{2}$$

The new node may not be connected with all the old nodes. Assuming that it is connected with M $(M \geq m_0)$ nodes, the connection probability is

$$\Pi(k) = \frac{M}{m_0 + t} \tag{3}$$

The new edge weight value is W_0 when a new node is added to the smart contract network. The weight value Wij of the neighboring edge with which new node is related will also be adjusted to $Wij + \Delta Wij$, and

$$\Delta W_{ij} = \delta \frac{W_{ij}}{k_i} \tag{4}$$

ΔWij represents the strength value. The increase of strength value is related to the weight ratio. The new weight of the node is

$$K_i = k_i + W_0 + \delta \tag{5}$$

Suppose that the probability of new nodes joining the network to obtain information is p. At time t, the distribution of the point weight Ki of node i to t, Ki is continuously changing, then

$$\begin{aligned} \frac{dk_i}{dt} &= p[m\frac{k_i}{\sum_j k_j}(W_0 + \delta) + \sum m\frac{k_I}{\sum_J k_J} \cdot \delta\frac{W_{IJ}}{K_I}] \\ &+(1-p)\frac{M}{m_0 + t}[m\frac{k_i}{\sum_j k_j}(W_0 + \delta) + \sum m\frac{k_I}{\sum_J k_J} \cdot \delta\frac{W_{IJ}}{K_I}] \end{aligned} \tag{6}$$

When the new node can obtain all network information, that is $M = m_0 + t$. The point weight at this time is only related to W_0 and δ. The exceptional case is $M = m_0$

which represents new node do not consider the priority connection. At this time, the change of point weight can be approximately regarded as

$$\sum\nolimits_J K_J = \overline{K}_J M \approx \frac{2m(1+\delta)t}{t+m_0} M \tag{7}$$

So

$$\frac{dk_i}{dt} = p\frac{2\delta+1}{2\delta+2}\frac{k_i(t)}{t} + (1-p)\frac{m}{m_0+t} \tag{8}$$

Let $m_0 = 1$

$$\frac{p(2\delta+1)k_i(t) + (1-p)m(2\delta+2)}{(2\delta+2)t} \tag{9}$$

It can find that *Ki(t)* is similar to power-law distribution *Ki-α*. The rate of change is

$$\alpha = p\frac{2\delta+1}{2\delta+2} \tag{10}$$

$$\delta = 1 + \frac{1}{\alpha} = 1 + \frac{2\delta+2}{p(2\delta+1)} \geq 2 \tag{11}$$

At this time, the whole network is similar to scale-free network and has strong fault-tolerance ability. The smart contracts network will be the most stable when $\delta \approx 2.6$. That means the probability of new nodes getting information can be maintained at 70%. In the smart contracts network, the less information can be obtained by adding new nodes, the more nodes should be set up to ensure the security of the network. Financial platforms are trading systems which involve a large amount of funds and personal information. More nodes should be set up when a new node cannot reach at least 70% information.

4.2 Case Analysis

Firstly, the design of smart contracts is similar to the simple 'If then' judgment, so the execution of the system depends on simple logic. The disadvantage of smart contracts applied in accounts receivable financing mode is that the programming language is machine language, not human language. The programming needs to be deduced from the possible problems in actual operation to ensure the smart contract system can deal with more emergencies in the execution process. The smart contract in accounts receivable financing mode mentioned in this paper is a frame structure designed from two key points of capital flow and interests of banks. Due to mutual distrust among people, smart contracts in accounts receivable financing mode need security. Thus many judgment nodes have been added to the framework to ensure authenticity.

FISCO ensures the correctness of all data by adding a large number of nodes [21]. The development of the entire blockchain platform is decided by all members at a meeting, and the daily operation is maintained by the presidium, whose members include Shenzhen Financial Technology Association, WeBank, etc. as shown in Fig. 11. Tencent is responsible for the supervision, and the open source working group is composed of

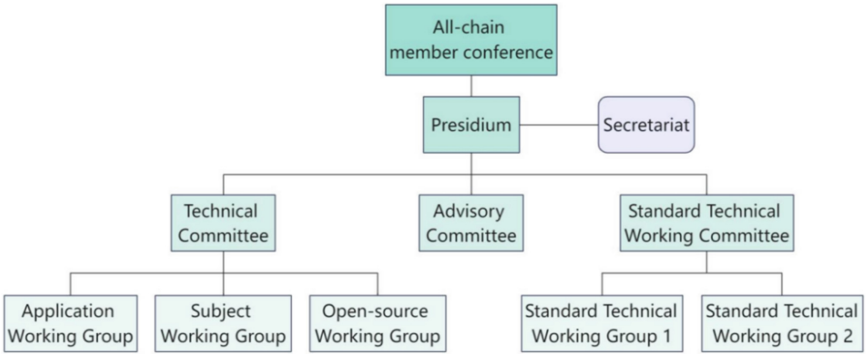

Fig. 11. FISCO composed of multiple nodes

Huawei and other technology companies. All the records of financial business will be guaranteed by different large enterprises, such as Lenovo, ZTE, etc. Customer relationship management between banks is connected by KYC, avoiding repeated fraud and data leakage. The committee management reduces the cost of trust and friction.

Secondly, the model proposed in this paper considers the other nodes in the supply chain and ensures the dominant position of banks to decide whether to lend or not during the financing process. The combination of supply chain finance and smart contract technology should eliminate the risk of information asymmetry as much as possible, rather than destroy the existing market order and financing process. Smart contracts in supply chain finance have more supply chain nodes to judge events. It is impossible to determine the authenticity of the original information recorded, although distributed ledgers have the characteristics that cannot be modified. The cost of information fraud in the short chain is low, so the purpose of broadcasting to other supply chain nodes is to notify and supervise. The node can report the falseness of the event by setting the anti-contract and there is a penalty for false reporting, which can increase the cost of enterprise default, improve the authenticity of the system, and ensure the purity of the system.

Supply chain nodes include enterprises with different functions, such as tax bureau, judicial institutions, banking regulatory bureaus, logistics regulators, etc. On the one hand, the more members involved in supply chain finance, the more conducive it is to avoid 51% confrontation [22]. On the other hand, it also prevents banks and third-party logistics companies from bad behavior. Xiaodong Chen, CEO of WaykiChain, put forward the concept of cross domain consensus on the issue of original information. Only the guarantee of the third-party platform can make the information world and the physical world reach a consensus. Therefore, the node needs to set up a national regulatory authority to further confirm the original information and ensure that the information transmitted by the smart contract is correct.

Thirdly, the fast transfer accounts between SMEs, core enterprises, and banks can be completed through the preset logic of smart contracts in SCF. The funds in the account earned by financing enterprises will be used for repayment at the first time in the case of financing risks. The preset logic also permits the negotiation between banks and the

financing enterprises when the financing enterprises can not repay. It gives human more operation space, rather than purely mechanical execution without human nature and social complexity.

Chinese banks such as Zheshang Bank and China Merchants Bank, will open external accounts and contract accounts when using blockchain technology. External accounts are used for general transactions, while contract accounts can be used for repayment. The advantage of the contract account is that it is only controlled by the smart contract and is not subject to external intervention. The financing funds of small enterprises can be repaid with sales revenue, which truly realizes self-liquidating finance.

5 Conclusion

There are still many financing risks in accounts receivable financing based on blockchain technology because the network is unstable due to the irreversible nature of smart contracts. This paper found and verified that reshaping the information transmission process of smart contracts and adding network nodes can effectively reduce risks. Improving participants' trust in accounts receivable financing based on blockchain technology can make the capital flow more stably.

First of all, a different definition of smart contracts in supply chain finance was proposed in this paper, and the corresponding framework structure was established from the perspective of banks to avoid many supervision problems [23]. Secondly, this paper redesigns the flow of smart contracts to return error information. Only by ensuring the elimination of the non-terminable nature of smart contracts can the entire financing system be more secure, so as to enhance the trust between participants and realize the circulation of funds. Then, on the basis of reconstructing the information return, the paper specifically describes the working process of the entire smart contract in accounts receivable financing which fills in the research gap of the smart contract in specific financing. It can also help researchers have a detailed understanding of the working process of smart contracts in accounts receivable financing. Finally, this paper uses the BBV model to verify that it is necessary to increase more supply chain nodes to maintain the network balance and enhance the anti-risk capability of the financing platform when enterprises newly joined the blockchain platform obtain information less than 70%.

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