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SPECIAL SECTION ON HEALTHCARE INFORMATION TECHNOLOGY FOR THE EXTREME AND REMOTE ENVIRONMENTS

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Big Production Enterprise Supply Chain Endogenous Risk Management Based on Blockchain

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ABSTRACT In view of the influence of information's ''incompleteness'' and ''asymmetry'' to supply chain operation efficiency, we make big production enterprise as the object and apply blockchain to its supply chain endogenous risk management, to research the specific operation mechanism and application value. In the operation process of big production enterprise supply chain, because of the information's asymmetry, the fraud problem will produce among the business subjects; blockchain is a decentralized distributed accounting and data storage technology, and with blockchain technology, we can resolve the business subjects' fraud problem and can provide more accurate decision information basis for each business section, and realize group decision. This paper has described the system structure and intelligent contract operation mechanism under consensus authentication of blockchain applying in big production enterprise supply chain and analyzed by the case. In view of the limitation of classical blockchain technology applying in big production enterprise supply chain, we constructed the corresponding blockchain data storage mechanism and data access mechanism. Analyzed the economic value of this paper researching from the aspects of response speed, supply accuracy, cooperation integrity, business interaction economic cost, supply quality, and supply price. This paper research will provide ideas and model structure for developing supply chain area's blockchain system and will promote the application research development of blockchain in specific area.

INDEX TERMS Blockchain, big production enterprise, supply chain, endogenous risk management.

I. INTRODUCTION

Supply chain is a complex system, since 21st it has achieved rapid development, with the development and popularization application of information technology and network technology, the supply chain has broken through the traditional linear single chain model and turned to nonlinear network chain model, the supply chain's operation efficiency is not only relative to the core enterprise's profit, but also is relative to the whole supply chain all relevant enterprises' profit. Supply chain risk is the potential threat in operation of supply chain, the sources are the existence of each uncertain factor, because of the correlations of the business process and profit among supply chain enterprises, leading to the correlations among supply chain risks. Classified according to the causes of supply chain risk, the supply chain risk can be divided as endogenous risk and exogenous risk, the endogenous risk includes moral risk, information delivery risk, production organization and procurement risk, logistic risk etc., and the exogenous risk includes market demand risk, policy and legal risk, accidental disaster risk etc. For the supply chain endogenous risk, the causes mainly come from the interaction game and cooperation based on profit among each enterprise inside supply chain, and come from the information's incomplete and asymmetry inside supply chain, at the same time, as a spontaneous organized virtual organization, the supply chain also lack of the corresponding supervision and restriction mechanism. For the supply chain exogenous risk, the enterprises inside supply chain do not own controllable ability to exogenous risk, but whether we can effectively realize the risk early warning, is the key of avoiding exogenous risk.

Compared with other types of supply chain, the supply chain structure make big production enterprise as the core is relative more stable, each business subject (such as supplier,

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production enterprise, distributor, retailer, big customer etc.) of supply chain is relative more fixed, and has the necessity and characteristics of long-term cooperation, so the supply chain risk management of making big production enterprise as the core has more realistic, meanwhile in view of the uncontrollability of supply chain exogenous risk, this paper make big production enterprise as the research object to analyze its endogenous risk management mechanism, and analyze the management mechanism produced economic value. In this paper following discussion, unless otherwise specified, ''risk management'' refers to ''endogenous risk management''.

For a big production enterprise, its supply chain endogenous risk can be divided into two parts: the credit risk caused by the information asymmetry among the enterprises inside the supply chain, and the risk caused by information acquisition's incomplete inside the supply chain.

In the big production enterprise supply chain, because upstream and downstream enterprises are different profit groups respectively, these profit groups are business cooperation and profit sharing relations in transaction process, so different enterprises will plunder profit each other with their information advantage. Meanwhile, because the cooperation basis among different enterprises is credit, the fraud will destroy cooperation, that conversely restricts the implementation extension of fraud behaviors. Therefore, in supply chain, different enterprises as profit subjects will game between ''integrity cooperation'' and ''fraud cooperation'', obviously, the game's primary cause is the information's ''asymmetry'' between both sides.

In big production enterprise supply chain, if the upstream enterprise cannot accurately obtain downstream business' demands in time and quantity, it will not well provide services for downstream enterprises, eventually resulting in ''bullwhip effect'', the largest problem of ''bullwhip effect'' is excess supply, each section material's (product's) overstock, supply is not in time, manpower's and material resources' excessive consumption. In view of the supply chain's endogenous risk, the scholars proposed JIT theory, MRP model, by the supplier to manage production enterprise inventory etc theories and methods, but in the practical application these theories' and methods' adaptability is inadequate to supply chain's dynamic diversification. Although in modern management system, there are credit basis between different enterprises, but due to lack of credit supervision, and the ''incomplete'' of the whole supply chain information acquisition has not completely resolved, the supply chain endogenous risk issues are still very prominent.

The sources of the supply chain information's ''incomplete'' and ''asymmetry'' are lack of the management mechanism for information openness and transparency in the supply chain system, and lack of the transaction behaviors' supervision mechanism in supply chain, the whole supply chain efficiency is split into the total of different enterprises' (nodes') efficiency, different enterprise (node) does not care about other enterprises' (nodes') efficiency, and cannot interfere with other enterprises' (nodes') efficiency, this ''each for the camp'' supply chain management mode will eventually lead to overall supply chain's resources waste and inefficiency. In real life, the production enterprise raw materials and inventory pile up, fund default, and the condition of not satisfying the enterprises and customers demand, are the indisputable facts, not only harming the profits of the consumers, but also leading to the supplier's credit deficiency in the long run.

Therefore, in supply chain, the information's completeness and symmetry is the basis of improving supply chain operation efficiency, and is the premise of maintaining supply chain good operation order. At present, in the supply chain that making big production enterprise as the core, only the business correlation different upstream and downstream subjects have constructed their information interaction relations, while the subjects who have not business interaction relations have not any connections, and even one subject cannot understand other no interaction relation subjects' information, once some a section's (some a supply business') information transmission or interaction deviated from the facts, it will lead to a subsequent supply chain information transmission deviation, and the deviation will even gradually enlarge, resulting in the supply chain overall operation efficiency depress.

In view of the ''asymmetry'' and ''incompleteness'' of supply chain information, the scholars have done a lot of research on supply chain risk management, and produced the corresponding research results.

From the perspective of supply chain information's ''asymmetry'', the corresponding research direction can be divided into three categories: transmission mechanism and characteristics analysis for supply chain risk, construction for supply chain risk evaluation model, research for supply chain risk management mechanism and method.

A. SUPPLY CHAIN RISK TRANSMISSION MECHANISM AND CHARACTERISTICS

Such as Pfohl *et al.* [1] described the correlation relations among supply chain risks with interpretive structural modeling. Xu *et al.* [2] proposed supply chain members would adopt different pricing strategies under different risk preference degree. Dai *et al.* [3] analyzed the influence of risk aversion to optimal order quantity. Zhao *et al.* [4] proposed dynamics model for supply chain risk diffusion, described the supply chain risk diffusion mechanism, and made the agricultural product supply chain network as object to analyze the risk diffusion characteristics. Wang [5] analyzed the supply chain enterprise's moral risk and the corresponding risk conduction mechanism.

B. SUPPLY CHAIN RISK EVALUATION MODEL

Such as Berenji and Anantharaman [6] used Fuzzy Analytic Network Process and Fuzzy TOPSIS to construct supply chain risk evaluation model. Yan *et al.* [7] constructed agricultural supply chain's risk evaluation model.

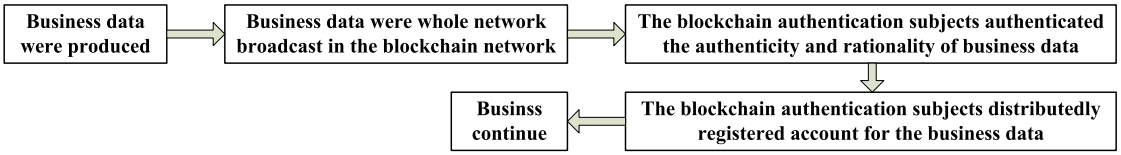

FIGURE 1. The blockchain work principle.

C. SUPPLY CHAIN RISK MANAGEMENT MECHANISM AND METHOD RESEARCH

Such as Ghadge *et al.* [8] listed the different risk management methods of supply chain. Wang and Wang [9] researched supply chain contract mechanism design problems in the condition of bilateral cost information asymmetric. Peng *et al.* [10] researched supply chain risk sharing contract and model in the uncertain condition of raw materials and products production, and market demand. Dong and Liu [11] constructed supply chain risk management model based on information leading. On the basis of the influence of external market diversification to contract fairness, Shen *et al.* [12] used the principal-agent theory, at the same time on the basis of considering the supplier and manufacturer product quality failure, to construct secondary supply chain product quality control game model under bilateral moral risk. Zhang *et al.* [13] constructed a flexible supply chain coordination model with time in advance, by the purchaser and supplier together making the decision for delivery time in advance, flexible cost, and optimal order quantity.

From the perspective of supply chain information's ''incompleteness'', the corresponding research direction can be divided into three categories: credit characteristics analysis, evaluation model construction, supply chain credit mechanism.

1) CREDIT CHARACTERISTICS ANALYSIS

Liu *et al.* [14] analyzed credit transaction's evolutionary game process in supply chain. Yang [15] researched the credit risk between enterprises in the supply chain.

2) EVALUATION MODEL CONSTRUCTION

Hu *et al.* [16] proposed the credit risk evaluation model of small and medium-sized enterprises in the perspective of supply chain finance.

3) SUPPLY CHAIN CREDIT MECHANISM

Qin *et al.* [17] proposed the supply chain coordination mechanism of considering commercial credit in VMI model. Lou *et al.* [18] researched manufacturer investment emission reduction technology's supply chain incentive mechanism under asymmetric information. In view of the inventory control and collaboration management problems in decentralized supply chain, Zeng and Luo [19] achieved the optimal joint coordination strategy of the members of the parties in the supply chain.

Integrating the existing research results on the supply chain risk (information's ''incompleteness'' and ''asymmetry''), the research results for supply chain risk characteristics and influence are more mature, although experts and scholars proposed supply chain risk management mechanism from different perspectives, but the existing management mechanism research mainly from the perspective of institutions, humanities, and profit constraints to carry on, the research contents focused on the supply chain some a section or some an aspect risk management (such as moral risk, information transmission risk, production organization and procurement risk, logistic risk, etc.), and made the hypothesis of supply chain subject being ''rational person'' as the premise to carry on, such management mechanism has incompleteness and no timeliness to the supply chain risk management, is unable to completely cure the supply chain risk.

If we construct a corresponding network system, all the business subjects in the supply chain can release their own business supply and demand information, and can supervise and constraint mutually in the network system, will improve each business subject's credit and operation efficiency from management perspective, and if the management mode can be realized with technology, the management object realization will be more objectivity and reliability.

Blockchain was proposed by Satoshi Nakamoto in January 9, 2009 with bitcoin, is a decentralized distributed account technology. In blockchain, using hash algorithm, digital signature, time stamp, consensus authentication mechanism etc technology to achieve business activity non repudiation proof [20]. Therefore, this paper proposed applying blockchain technology to modern supply network chain, the business subjects who entered blockchain constituted multi authentication centers under being authorized, for authenticating the network chain business contents' authenticity and accuracy, realizing each section in the supply network chain collective maintenance in the aspect of credit and operation quality, realizing supply network chain work and pull together, data sharing and operation transparency, realizing the business subject fair competition in supply network chain, and improving supply network chain response accuracy and response speed on the basis of not influencing supply network chain original operation mode.

II. THE BLOCKCHAIN WORK PRINCIPLE AND APPLICATION RESEARCH PROGRESS

The blockchain work principle as shown in Figure 1.

In Figure 1, we omitted the technology realization part of blockchain consensus authentication, at same time the work principle is different from the bitcoin blockchain classic discussion, bitcoin blockchain focused on information's

authenticity proof, in this paper the supply chain endogenous risk management need supply chain authentication nodes' analysis and decision, so the authentication subjects not only needed authenticate business activity data's authenticity and subject's identity, but also needed group authenticate (decide) the business activity data's rationality.

Since blockchain technology was proposed, it had achieved high attention from each country's government, academic circles and industry circles, in addition, in USA, European Union, Japan and South Korea etc countries the blockchain has also got rapid development in applications and researches. In China, in December 15, 2016 the State Council issued ''the National 13th Five-Year Informatization Plan'', which included blockchain technology into the strategic frontier technologies.

In the industry circles the applications of blockchain technology can be divided into three levels as blockchain 1.0-digital currency, blockchain 2.0-intelligent contract and digital asset, blockchain 3.0-different area applications, at present the whole world blockchain applications are at the level of blockchain 2.0.

The research results of blockchain in academic circles can be roughly divided into three categories: principle analysis and application discussion, value analysis, application system construction.

A. PRINCIPLE ANALYSIS AND APPLICATION DISCUSSION

Steven [21] analyzed the principle and service characteristics of bitcoin blockchain. He and Huang [22] analyzed the essence of blockchain and its influence to financial industry.

B. VALUE ANALYSIS

Meijer and Carlo [23] discussed the application value of blockchain in different fields including intelligent contract. Yang and Pan [24] proposed blockchain's applications will influence the existing laws and regulations.

C. TECHNOLOGY AND APPLICATION SYSTEM CONSTRUCTION

Zhu and Fu [25] designed multi center authentication architecture on the basis of blockchain work principle, and made the supply chain in which coal enterprise is the core as an example to construct the corresponding authentication model and accounting mechanism. Ziegeldorf *et al.* [26] and Fromknecht *et al.* [27] proposed the technology products based on blockchain. Wang *et al.* [28] constructed the data security sharing network system. Tsai *et al.* [29] designed the system structure of a blockchain, and researched the application development method of the blockchain.

Colligating the existing blockchain application research results we can see, at present blockchain technology and its application value has already achieved wide affirmation, but the mature and can be spread used products are not much. Although we can find the research results that blockchain in supply chain management (such as [25]), but we have not found the perfect research results of blockchain in supply chain risk management mechanism and protocol.

III. BIG PRODUCTION ENTERPRISE SUPPLY CHAIN RISK MANAGEMENT SYSTEM BASED ON BLOCKCHAIN

This paper discusses the application system of blockchain in big production enterprise supply chain from five aspects: big production enterprise supply chain system structure based on blockchain, intelligent contract operation mechanism under consensus authentication, case analysis, data storage mechanism, data access mechanism. Among them, the construction of data storage mechanism is for improving data storage efficiency and privacy protection, the construction of data access mechanism is for improving supply chain data management and application efficiency. In information era, the supply chain which make the same type of production enterprise as the core usually interrelate and form the supply network chain. For blockchain hash algorithm, digital signature, time stamp technology and other classic information security technology, readers can achieve by referring to the relevant references.

A. BIG PRODUCTION ENTERPRISE SUPPLY CHAIN SYSTEM STRUCTURE BASED ON BLOCKCHAIN

Blockchain uses P2P network broadcast technology, at the same time requires the network nodes have a certain computing power and storage capacity, consensus authentication mechanism requires sufficient authentication nodes, which is the required hardware environment for blockchain technology application. For the supply network chain mode structure that make big production enterprise as the core, the business subjects of the supply chain system include upstream suppliers, production enterprises, downstream distributors, retailers and customers, etc. All the business subjects of the big production enterprise supply network chain based on blockchain will affiliate the blockchain network, which will resolve the problem of each section separating each other and even breaking in traditional supply chain, and will realize integrity and agility of the supply chain. In the supply network chain that make big production enterprise as the core, the business subjects can be enterprises, business group or customer group, these subjects' computers can reach a certain scale, can by interconnection to provide high information computing power and storage capacity (also can by network cloud platform to realize information computing or storage task). The big production enterprise supply network chain based on blockchain rely on industrial private network or Internet to construct, at the same time require only the business subjects in the supply network chain affiliate the blockchain network by authorization, which can avoid the interference to system operation from the users who are not relevant to the system, can reduce the risk of malicious users jointly forging supply chain information. Thus, under supervision mechanism and competitive environment, each business subject will be more inclined to provide real information and participate in the supply chain operation supervision for its own profit,

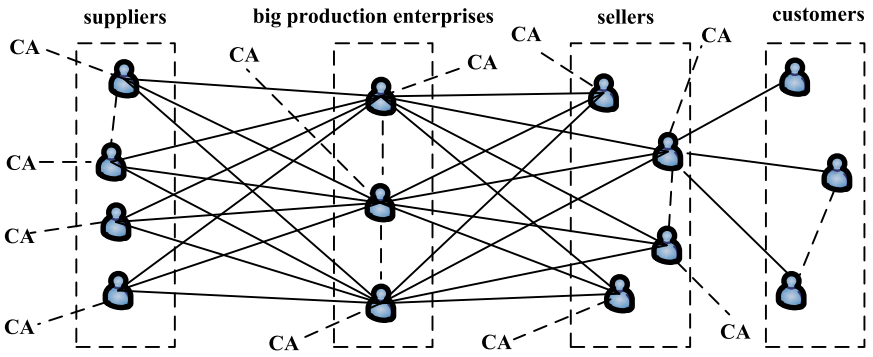

FIGURE 2. The system structure of big production enterprise supply chain based on blockchain.

and will strive for maintaining the overall efficiency of supply chain.

The system structure of big production enterprise supply chain based on blockchain as shown in Figure 2.

In Figure 2, CA represents ''Authentication Center'', by the suppliers, big production enterprises, sellers (distributors, retailers) respectively as independent authentication center to authenticate the authenticity and rationality of supply chain information (compared with the other business subjects, the customers have greater randomness and instability, so this paper does not consider to make ''customers'' as the authentication centers, but the customers can share all the business data in blockchain). In the supply chain based on blockchain, all the business subjects share the whole supply chain data, reducing the risk of information's ''asymmetry'' and ''incompleteness'', ensuring the supply chain information cannot be destroyed, improving the supply chain's operation efficiency and information's response speed.

B. INTELLIGENT CONTRACT OPERATION MECHANISM UNDER CONSENSUS AUTHENTICATION

Consensus authentication is the process for the whole network blockchain nodes' accordance consensus on block information, while intelligent contract refers to an automatic execution protocol that originally need be finished by manual operation, and the generation of blockchain promotes the application research development of intelligent contract. The rationality of supply chain information (such as material quantity, material price, supply mode, supply time, etc.) need be authenticated by the characteristics of demand and supply etc for the whole supply chain, need be achieved with the actual situation combination supply chain authentication subjects' overall analysis, this point is different from bitcoin blockchain system. So, in this paper, the supply chain management system consensus authentication process based on blockchain need be realized by each authentication node's intelligent analysis and calculation, which belongs to intelligent contract operation management based on consensus authentication, and different from the consensus authentication for the information's existence proof in bitcoin blockchain.

Making some a section's demander's demand information release, rationality authentication, final supplier selection etc process as an example to research, so, basing on blockchain, the supply chain's intelligent contract operation process under consensus authentication (in here, we omitted the description on the relative information security technology implementation details) is:

a) Some a business section's demand information in supply chain is broadcast in the whole blockchain network by the information producing demand subject.
b) The authentication subjects who receive the information authenticate the information authenticity. If some an authentication subject queried about the information authenticity, this authentication subject would broadcast in the whole blockchain network, and the other authentication subjects would response and re-authentication, until all the authentication subjects uniformly confirmed the information authenticity.
c) Each authentication subject analyzes the rationality of the received demand information with the supply chain each section requirements, supply characteristics etc, and proposes respective analysis method (randomly selecting one from the predetermined analysis methods) and analysis result (referring to the demand information combination which formed by adjusting the demander's demand information), and broadcasting in the whole network.
d) The authentication subjects in the supply chain network do distributed accounting for each authentication subject's analysis method and analysis result.
e) In view of different analysis results, the supply chain's each authentication subject votes by ballot, and vetoes the low support rate (we can set a threshold in advance) analysis results. Then for the high support rate analysis results to have the second round votes by ballot, calculating the average of the first round and the second round voting results and vetoing the low support rate analysis results. Again for the high support rate analysis results to have the third round votes by ballot, calculating the average of the second round and the third round voting results and vetoing the low support rate analysis results. So continue until obtaining the

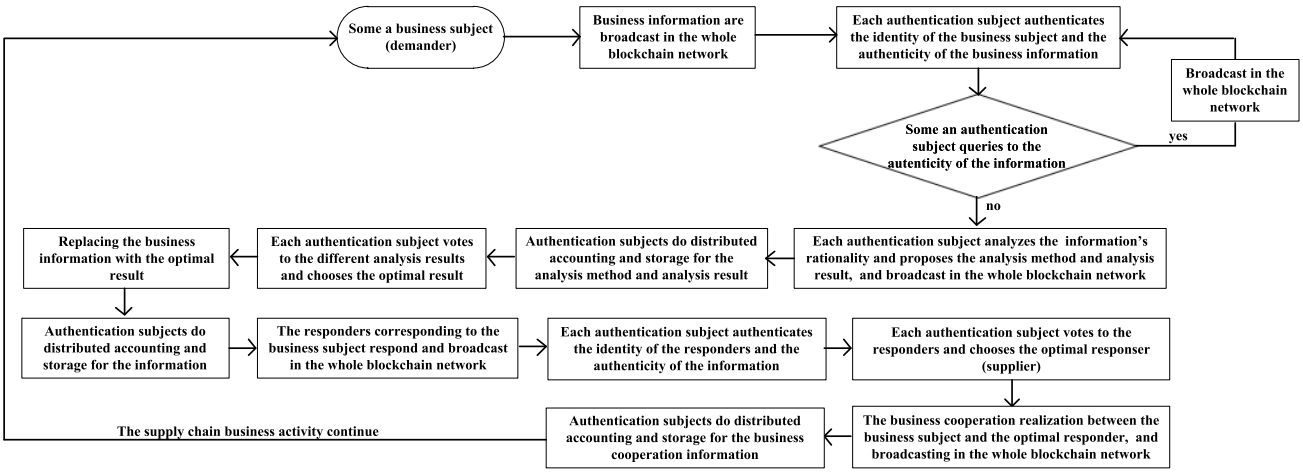

FIGURE 3. The supply chain intelligent contract operation mechanism under consensus authentication based on blockchain.

optimal analysis result, and replacing the information producing subject's sender demand information with the optimal analysis result, and broadcasting in the whole network.

f) The authentication subjects in the supply chain network do distributed accounting and storage for the demand information.

g) The information producing subject, the corresponding information responders (in general they are multiple, referring to the suppliers corresponding to the information producing subject) respond to the demand information, the authentication subjects in blockchain network authenticate the information authenticity referring to the way of step a)-b).

h) In view of different responders the supply chain each authentication subject votes by ballot, and vetoes the low support rate (we can set a threshold in advance) responders. Then for the high support rate responders to have the second round votes by ballot, calculating the average of the first round and the second round voting results and vetoing the low support rate responders. Again for the high support rate responders to have the third round votes by ballot, calculating the average of the second round and the third round voting results and vetoing the low support rate responders. So continue until obtaining the optimal responder, and the optimal responder (supplier) would cooperate with the demand information producing subject (demander), and broadcasting in the whole network.

i) The authentication subjects in the supply chain network do distributed accounting and storage for the two (the demander and the optimal responder) parties' cooperation information.

j) The supply chain business process and intelligent contract operation process continue.

The supply chain intelligent contract operation mechanism under consensus authentication based on blockchain as shown in Figure 3.

With Figure 3 we can see, the information transmission and the identity of information producing subject of the supply chain each section all can be authenticated by the authentication subjects (in here, the customers only have the authority of sharing the blockchain data according to the authorization, and have not authentication authority), for the rationality of the business information and the choice of the business subject, we adopted the form of group decision analysis, that resolve the management and decision risks from supply chain information's ''incompleteness'' and ''asymmetry''.

C. CASE ANALYSIS

Making the medicine industry as the case to analyze, the suppliers for the pharmaceutical factory supply raw materials to pharmaceutical factory, then the pharmaceutical factory produces and sales drugs to medicine companies, next the medicine companies sale the drugs to the hospitals, in the end the hospitals sale the drugs to the patients. In the whole supply chain, the pharmaceutical factory as the core (a number of pharmaceutical factories can also be combined to form a pharmaceutical group company). The quality of the suppliers' raw materials directly influences the quality of drugs, so the medicine companies and the hospitals also need participate in the selection of the pharmaceutical factory to the suppliers. For the medicine company and the hospital which have a fixed business relationship, the hospital will formulate drug procurement requirement plan according to the pre turnover statistics, and the raw materials' suppliers and the pharmaceutical factory will also actively participate in each section's procurement plan for achieving a stable and friendly business relation with the medicine companies and the hospitals, for adjusting their supply and production behaviors. The suppliers, pharmaceutical factory, medicine companies, and the hospitals can by affiliating the supply (network) chain based on the blockchain to participate in the decision of the supply chain each section, even the patients can also affiliate the corresponding network to understand the whole production process or logistics process of the drugs (we can set the

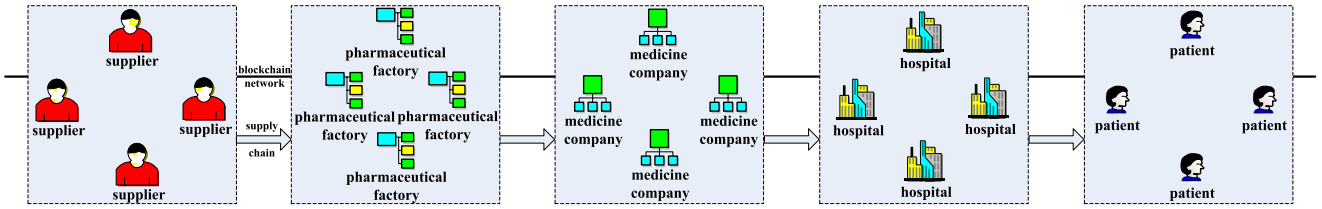

FIGURE 4. The pharmaceutical factory supply chain topology structure based on blockchain.

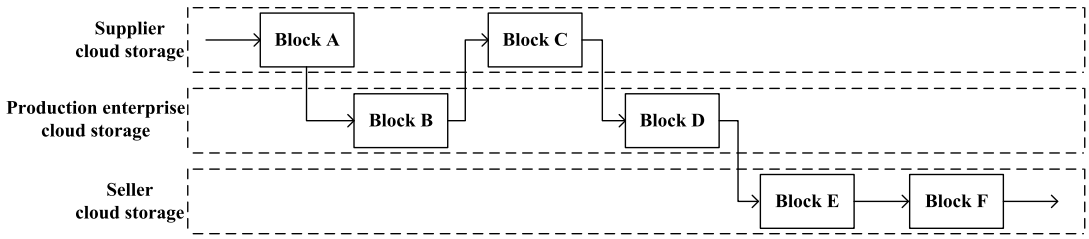

FIGURE 5. The supply chain business data storage structure based on blockchain subsection.

blockchain function structure according to the supply chain business concrete characteristics). The pharmaceutical factory supply chain topology structure based on blockchain is shown in Figure 4.

D. DATA STORAGE MECHANISM

In blockchain, the structure of block is composed with block header and block body, and the hash values of business data are hashed in pairs gradually and form Merkel tree structure. The leaf nodes are the initial hash values of business data, and the tree body of Merkel tree are stored in block body, and the tree root is stored in block header. Business data are constructed mapping relation with the leaf nodes of Merkel tree, and business data can be stored in block body, also can be stored in other storage space apart from blockchain. In this paper research, we make business data and its hash value Merkel tree structure as a logical whole, and do not consider the problem of business data are stored in block or not. Therefore, the block structure of blockchain in this paper refers to the block logical structure containing business data hash value and the corresponding mapping relation business data.

The classic blockchain use distributed accounting and storage technology, all the data are fully shared by each authentication center, ensuring the data cannot be tampered, but the mode of each authentication center (node) storing blockchain account will also result in the waste of storage space. Basing on this, this paper colligates the demand of the supply chain to data authenticity and saving storage space, proposing the subsection storage model of the blockchain, that is, for the blockchain constructing subsections, by some blocks constituting a subsection, each subsection of the blockchain is shared by some authentication centers, different subsections of the blockchain are constructed logical connections. So, although each authentication center does not completely store all the subsections of the blockchain, but can achieve all the blockchain data with the logic connections of the subsections. On the one hand the subsection storage can resolve data storage space problem, on the other hand can effectively realize the classification management of data access, and resolve the privacy leakage problem of the supply chain business subjects.

In this paper supply chain structure based on blockchain, by each business' data constituting a block, the same type of business subjects storing this type of business' block data, because in blockchain the subsequent block containing all the previous blocks' business data hash function value, so the data authenticity and non-tampering has not changed. The subsection storage structure of blockchain can be shown in Figure 5.

With Figure 5 we can see, the data storage structure of blockchain is different from single production enterprise supply chain structure, this is because in Figure 5 we described the business process of supply network chain. In the supply network chain, the supply chains of different production enterprises are logical parallel, rather than serial. In the traditional information system, the supply chains of different production enterprises are parallel, usually have not correlation with each other. While in the blockchain system, the different business data of the supply chain business subjects are correlated with hash function pointer and formed a whole, and data interaction. Figure 5 does not represent all the supply chain business data storage structure based on blockchain subsection, and only is the figure for illustration, in fact the supply chain structure of different production enterprises may be also different, and the business subject structure in the supply chain is far more complex than Figure 5, but the data storage mechanism in Figure 5 has the same guidance significance for the storage of complex supply chain structure's business data. In Figure 5 the same type of business' different subjects share the same type of subsection data, and with the time goes on, the capacity of blockchain data will

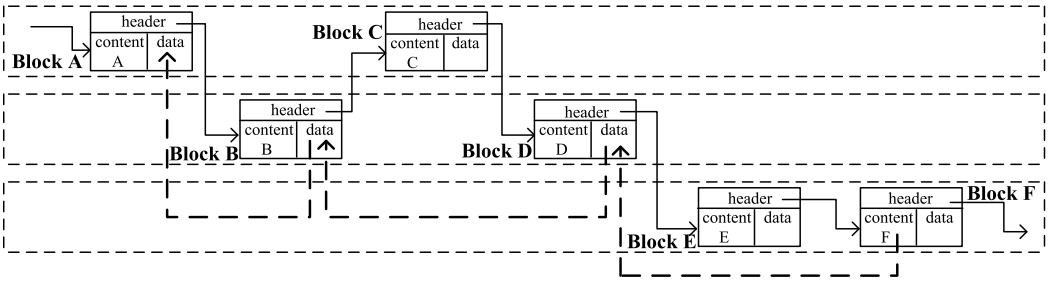

FIGURE 6. The supply network chain data access mechanism based on blockchain.

rapidly increase, each business subject need realize block data storage with its cloud platform or renting other cloud platform.

E. DATA ACCESS MECHANISM

Blockchain's undeniable proof mechanism has resolved the supply chain business fraud problem caused by the information's ''asymmetry'', and the basis of resolving supply chain information's ''incompleteness'' is obtaining the other business subjects' related business information, although the blockchain has stored all the business information of the supply chain, but how to obtain the information determines the efficiency of accessing the blockchain data.

Basing on this, this paper proposes the supply chain authentication subjects can possess the whole blockchain data's access authorities. For the general users, it is necessary to access the authorization scope's data under the authorization from the blockchain system, it can be the data access for a part of block, or the data access for some a keyword. Because each block and each block's data in the whole blockchain are connected by hash function pointers, so, the access users who affiliate the blockchain can rapidly traverse the whole blockchain under the authorization from the blockchain system. Therefore, for improving access efficiency, we can construct information content for the blockchain's each block, and the block information content formulated by business categories and substances, with the continuous production of the block, the subsequent block will copy the previous block's information content and add new block information to content, so the access users can rapidly produce data virtual connections according to the retrieval requirements and with the last block's content as an entrance, with the virtual connections the access users can quickly and accurately achieve the requirement information, obviously the extended order of the virtual connections is contrary to the produced time series of the blockchain. The supply network chain data access mechanism based on blockchain as shown in Figure 6.

In Figure 6, ''content B'' of the block B contains the substance of ''content A'' of the block A, at the same time adds the information of block B to ''content A'', the dashed line is the connection path for access users' data access, from Figure 6 we can see the direction of the virtual connection is contrary to the blockchain produced time series. In Figure 6, the blocks that connected by the dashed line are not the whole blockchain, that is because from ''content F'' can know not all blocks contain the information that the access users demand. In Figure 6 the supply network chain data access structure based on blockchain is not the uniform path for the supply chain's all data access users, in here the description only for illustrating the access users' data access mechanism that constructed in this paper. In Figure 6, access users need achieve blockchain system access authorization before data access, for avoiding access users exceed their authorities to access the blockchain data, which is different from the classical blockchain.

IV. THE VALUE ANALYSIS OF BIG PRODUCTION ENTERPRISE SUPPLY CHAIN RISK MANAGEMENT BASED ON BLOCKCHAIN

In this paper, the purposes of applying blockchain technology to big production enterprise supply chain is to eliminate the supply chain risks that brought by the supply chain information's ''asymmetry'' and ''incompleteness'', to improve the supply chain response speed and decision accuracy, to realize the objectivity and fairness of the supply chain business, to promote the transition of supply chain business from simple monopoly linear supply mode to complex supply network chain mode, and to make the supply chain business asymptotically trend to perfect competition mode. Therefore, the terminal purpose of this paper research is to improve the economic profit of the big production enterprises, integrity cooperation business subjects, and the customers in the supply chain system.

The application of blockchain technology in big production enterprise supply chain will influence big production enterprise at the aspects of supply chain business response speed (V), supply accuracy (A), the integrity of cooperation (I), the economic cost of business interaction (C), supply quality (Q), supply price (P), etc. While among these influence aspects, some are interrelated, such as V and A, V and I, and so on. For research convenience, this paper has constructed a multiple linear regression model among big production enterprise profit (Y_E) and each influence aspects, supposing the multiple linear regression model structure is:

$$Y_E = \alpha V + \beta A + \gamma I + \frac{\lambda}{C} + \omega Q + \frac{\varphi}{P} + \varepsilon_E$$

(thereinto, $\alpha, \beta, \gamma, \lambda, \omega, \varphi \geq 0$, ε_E is disturbance term, and the values of V, A, I, C, Q, P are prescribed in advance).

In this multiple linear regression model, V, A, I, Q is positive correlation to Y_E, while C, P is negative correlation to Y_E. The application of blockchain in big production enterprise supply chain will improve the supply chain business response speed, improve each section supply accuracy (that is referring to resolve the excess supply caused by bullwhip effect), contributing big production enterprise to choose good faith supply chain business cooperation partners, reduce the manpower, material resources and capital costs from repeated negotiations, improve the transparency and supervision intensity of the supply chain, improve supply quality and reduce supply price in the supply chain. Therefore, through this model analysis we can know, the application of blockchain in big production enterprise supply chain will improve the profit of big production enterprise.

In the market competition environment, the supply chain's supply price reduction will result in the reduction of the production enterprise products' selling price, the improvement of each section supply quality will urge the customers achieve higher quality products and services, so the profit of the customers will also increase. Blockchain technology will eliminate or reduce the supply chain information's ''asymmetry'' and ''incompleteness'', and good faith and higher quality partners affiliate the supply chain, that maintain the social fairness and good market order. Application of blockchain technology in enterprise supply chain make the customers can be changed from the blind receivers to the supervisors in the process of supply chain production and circulation, improve the competition among the production enterprises, and maintain the customers' profit, at the same time, contributing the production enterprise to find the supply chain's weak sections, timely adjust their own production structure. The application of this paper research results will realize the overall management of the supply chain business subjects to the supply chain, and will improve the supply chain's operation efficiency.

V. CONCLUSION

Aiming the endogenous risk that caused by the supply chain information's ''asymmetry'' and ''incompleteness'', this paper analyzed the causes and consequences of risk, aiming at the lack of research on this field in academic circles, proposed the ideas of applying blockchain technology in supply chain risk management. Combined the principle of blockchain and the application research status of blockchain in academic circles and industry circles, made big production enterprise as the object to construct the system structure, intelligent contract operation mechanism under consensus authentication, case, data storage mechanism, and data access mechanism of blockchain technology applying in supply chain endogenous risk management, and by constructing model to analyze the economic value of blockchain applying in big production enterprise supply chain. With this paper analysis we can know, the application of blockchain technology in big production enterprise supply chain endogenous risk management is reasonable and feasible. This paper research was proposed in the situation of blockchain technology rapid development and application, provided the measures of resolving supply chain endogenous risk under the precondition of not changing the supply chain original business operation mode and mechanism, has a certain prospective and practical significance.

The research content of this paper is the construction of the supply chain endogenous risk management mechanism and its economic value analysis, the research idea maybe not feasible to the other type of supply chain (such as to the supply chain in which each section business subjects are flexible, the applicability of this paper research result is not strong), in addition, there still facing many difficulties in the process of blockchain technology applying in big production enterprise endogenous risk management, specific performance in:

A. THE FEASIBILITY OF TECHNOLOGY APPLICATION

There are an acceptance process for the application of any a new technology in the concrete environment, for the supply chain that make big production enterprise as the core, to convince managers and specific users to learn and use blockchain technology products will need use the existing blockchain product operation efficiency and the concrete feasibility and necessity program to do.

B. THE FEASIBILITY OF APPLICATION SCENARIO CONSTRUCTION

The big production enterprise supply network chain system based on blockchain involve many entity enterprises, and in prophase need the corresponding technical team and soft hardware equipment support, and the difficulty of coordinating all parties' profit and constructing the corresponding application system is also great.

C. THE APPROPRIATE SERVICE SUPPORT

The simply application of blockchain in the supply chain system cannot effectively solve the supply chain endogenous risk problem, and the data storage and data access modes are also the key of influencing the risks, constructing reasonable authentication center system and data storage, data access system is the guarantee of resolving the endogenous risks of the supply chain system based on blockchain.

At present, blockchain technology is still at the stage of testing and analysis discussion, and yet hasn't entered into the period of large-scale product development and application in each field, there still need a certain time and all directions' efforts for blockchain applying in big production enterprise supply chain, but it is a future development trend for blockchain applying in the supply chain endogenous risk management. Henceforth, we will start out the simulation system development on the basis of the existing mechanism research, and propose the detailed implementation program.

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