Innovative system architecture design based on blockchain technology

Ziwei Qian*, Yayun Liu, Chi Wang

Southeast University, Nanjing, China

*zqian0111@gmail.com

Abstract. For the innovation chain, the financing problem on the innovation chain, the tracking and evaluation of the effect of government support policies, the innovation trust problem, the innovation landing problem, the intellectual property problem and the talent gathering problem have always troubled the start-up enterprises. Based on the existing innovation chain, this paper designs the architecture and public chain information of blockchain technology in the innovation chain, and uses game theory to analyze and compare the existing innovation system with the innovation system based on blockchain technology. Through the way of "blockchain + time stamp", it effectively reduces the communication cost and time cost of start-ups, solves the problem of non-cooperation between various innovation subjects, improves the operation efficiency of the innovation chain and reduces the cost of entrepreneurship.

Keywords: blockchain,decentralization,game theory, innovation system, innovation structure

1 Introduction

Innovation chain is a series of functional activities, such as the generation of new ideas, new inventions, the design and development of new products, new production processes, new marketing strategies and the development and diffusion of new markets. Innovation, as a systematic behavior, requires mutual trust and cooperation among participants, especially for start-ups. How to eliminate the problem of trust between start-ups and the government and better realize technological innovation through organizational innovation and institutional innovation is an important topic.

The innovation system of a start-up enterprise can be defined as a system composed of heterogeneous entities such as scientific research institutions such as universities and research institutes, financial institutions, scientific and technological intermediaries, and enterprises. With the start-up enterprise as the core, the system provides innovative knowledge and innovative ideas through the innovation system constructed by research institutions such as universities and research institutes. Financial institutions and science and technology intermediaries provide capital and industrial support for the industrialization of the results for the start-up enterprises. As far as the existing innovation system of start-ups is concerned, it does have the

C. Chen et al. (eds.), *Proceedings of the 3rd International Conference on Digital Economy and Computer Application (DECA 2023)*, Atlantis Highlights in Computer Sciences 17,
https://doi.org/10.2991/978-94-6463-304-7_43

advantages of perfect main body of each element and good operation of the innovation sub-network, but there are problems of cooperation and trust among innovation entities, which will lead to inadequate provision of innovation data by a single innovation entity and insufficient information sharing among innovation entities, thus affecting the innovation effect. As a result, it is difficult for start-ups to obtain financing, increasing the difficulty for start-ups to obtain information and recruit talent.

Therefore, this paper introduces blockchain technology into the innovative system design of start-ups. A blockchain is a data chain formed by many blocks arranged together in chronological order. Information factors are entered in each block, and the information flow is recorded in a chain structure. The blockchain relies on computer encryption algorithms to encrypt the information in each block to ensure the security of its information. In the whole blockchain system, multiple servers can be connected to store the data chain. These servers are the nodes of the blockchain system, and the information on the blockchain will be saved in each node and can realize information sharing. When one part of the server is damaged, the other servers can also store and update data to ensure that the blockchain information is not lost. Based on the above characteristics, blockchain technology has a high degree of trust and security, and introducing blockchain technology into the innovation system of start-ups can solve the pain points of start-ups.

2 Literature review

2.1 Literature on innovation chain

In 2004 America's Council on Competitiveness argued that innovation had shifted from a mechanical and linear process to an ecosystem of interacting elements. Iansiti and Levin (2004) proposed that an innovation system is a whole formed by the interaction between enterprises located in different links but closely connected with innovation entities [1]. In essence, Mercan et al. (2011) proposed that the internal innovation system is a process of cooperation and symbiosis among various participants, but at different stages of development, each innovation subject exhibits different symbiosis modes and evolutionary characteristics [2]. Ander(2016) believes that the innovation system is actually a collection of multilateral cooperation among various innovation entities, so if the alliance goals need to be concretely demonstrated, the Internet of Things and communication will become the most important factors affecting the innovation system[3].

From the perspective of the composition of innovation system, innovation subject and its local natural, social and economic environment constitute a complex network. Kapoor(2016) compared innovation system with complex network. From the perspective of complex network, the innovation body in the innovation system consists of customer, core enterprise, upstream component supplier and downstream complementary component supplier, and the close collaboration of these four elements together forms a complex network [4]. The complex network provides the symbiosis conditions for the members of each innovation alliance in the innovation

ecosystem, and provides the necessary conditions for each innovation body to build the system and the possibility of flexible partner selection.

From the perspective of the characteristics of innovation system, most researches at home and abroad focus on the complexity, embeddedness, dynamics and openness of innovation ecosystem. Leten et al. (2013) show that tacit knowledge transfer and sharing can help innovation systems build uncertain functions, because it determines the value of ecosystem partners and the occupancy potential of their partners, and has a positive impact on promoting the development of the main enterprises in the innovation system [5]. Stefano et al. (2013) studied the innovation ecosystem from the perspective of intellectual property rights among alliance members, and explained the different capabilities displayed by the main enterprises in coordinating the innovation system from the perspective of system complexity, so as to ensure that they can benefit from the activities of their suppliers, supplementors and users [6]. In addition, openness and dynamic development, two important features in innovation systems, are mainly caused by synchronization. Jason (2014) adds a biological firefly model to the system to make the innovation system realize organizational characteristics like an ecosystem. The results show that, like diffusion, the innovation system can be organized in the same way. Synchronization works better in denser systems and reflects the openness and complexity of the system [7]. Zahra (2011) further revealed the dynamic relationship of mutual benefit between the innovation ecosystem and environment and entrepreneurship through research, and verified that the coordination of minority group members provides positive help for group synchronization within a certain range, and is conducive to coordinating the organization in the innovation system and makes it more likely to converge to the optimal configuration of the dynamic coordination organization [8].

2.2 Literature on blockchain

On November 1, 2008, a computer programmer named Satoshi Nakamoto detailed the basic framework of the Bitcoin system. In January 2009, Bitcoin was officially born as the world's first cryptocurrency. But at that time, as the underlying technology, blockchain technology was not paid attention to. It wasn't until 2014 that people really started taking blockchain technology seriously. Davidson et al. (2016) define blockchain as an Internet of value that includes a lot of open source software, cryptography, Internet, and incentives. It is expected to exchange things of value through powerful intermediaries and to send an encrypted and destroyed email through a trusted third party. [9] Tapscott (2016) explained that due to the development of computer technology and the diffusion of blockchain technology, the development of open source community and global network are ready for the future [10].

As a highly inclusive technology, blockchain can use some of its characteristics to make everyone's life better, such as the financial inclusion proposed by Swan (2017) [11], although it is still not accepted by the traditional financial system. In fact, as M-Pesa has demonstrated, blockchain may make payment and investment tools accessible to everyone, so as Chen (2017) said, everyone may become our partner in the blockchain [12]. On the other hand, as Sutherland (2017) et al pointed out,

blockchain-based solutions can often solve the problem of scarcity and abundance in the market by improving transparency, empowering blockchain public keys, and strengthening the right to use natural resources [13]. Blockchain technology can be used to solve some problems that a traditional centralized society cannot solve. From a historical perspective, trust has been the most important in the history of centralized power, such as clean and efficient government decision-making, and it is also a prerequisite for economic prosperity. However, as Davidson (2016) et al pointed out, building trust is often costly [9]. In addition, Seidel (2018) stated that blockchain technology can maintain trust even though it subverts traditional organizational theories [14]. Blockchain thus opens up a new community governance model in the form of "Internet governance," which sees the innovation process as a collective action problem that can be solved through governance, rather than a problem that can be centrally managed by the government. Thus, as Potts (2018) suggests, the economic problem in innovation can in fact be seen as a multilateral contract problem rather than a market failure choice problem, and therefore the traditional innovation system is challenged [15]. Audretsh and Feldman (1996) propose that systemic innovation is associated with the rapid diffusion of trust and ideas and knowledge, which may be affected by blockchain [16], as shown in Marsal-Llacuna's "Life in the Future" (2017). Blockchain-enabled networks are assumed to be distributed and participatory environments, enabling cooperative networks with the following principles: virtual and physical cooperation facilitated by smart contracts; A universal and decentralized network that allows for bottom-up participation and citizen contributions without the need for a central authority, including the collective implementation of new citizan-centered governance models, including blockchain-enabled policy codes, planning codes, and regulations codes [17]. In this context, Van Valkenburgh (2015) et al. proposed that blockchain public keys play an important role in collaborative networks. Collaborators are rewarded for the value they create and enhanced for their effective contribution to the community [18].

2.3 Literature on game theory

Game theory was originally developed in mathematics. The famous mathematician John von Neumann (1928) studied the existence of mixed strategy equilibrium in two-person zero-sum game [19], and game theory, as a formal scientific research theory, formally stepped on the scientific stage. From this perspective, the field of game theory is actually quite sparse. In 1944, however, he co-edited with Oskar Morgenstern Theory of Games and Economic Behavior, the first study of economic problems using game theory. In 1950, in a mathematical discussion, Merrill Flood and Melvin Dresher presented the famous "Prisoner's dilemma", a typical two-person non-zero-sum game, in which the rationality of the players was first discussed within the framework of game theory [20]. In the same year, John Nash proposed the famous "Nash equilibrium", which explained the universality of optimal strategy combination in multi-player games from the theoretical level, and these studies laid the foundation for the application of game theory to a wider range of disciplines [21].

Therefore, game theory has been widely used in many fields such as economy and industry in recent years. Molinero et al. divided cooperative game theory into two categories: simple game and influence game. Simple game is regarded as a game between a single individual, while influence game is a game in which one type of player influences another type of player through certain means, and then conducted in-depth analysis of society and social network [22].

2.4 Literature review

The above domestic and foreign relevant literature research results have laid the theoretical foundation of innovation system and blockchain, and provided the source of ideas, which can be referred to the research ideas and research methods. In the relevant literature, the literature on the integration of blockchain and innovation system is mostly limited to a certain aspect of innovation system, and relatively few studies from multiple angles, aspects and factors, while there are still gaps in the research in many aspects.

From the perspective of innovation system, many domestic and foreign researches only focus on innovation system itself instead of combining innovation system with other technologies. At the same time, due to the emphasis on the law of innovation system itself, domestic and foreign researches cannot provide a more effective solution to the problems faced by innovation systems in various countries at the present stage.

From the perspective of blockchain, although many scholars have designed solutions based on blockchain technology for a certain part of the innovation system, these solutions are too close to the technology and to some extent ignore some characteristics of the innovation system itself. And these studies are often not comprehensive enough, still in the initial stage, there is still a lot of room for follow-up research.

3 Game analysis of open innovation system based on blockchain

3.1 Game theory analysis of open innovation system without blockchain

In order to analyze the sharing of innovation resources in the open innovation system, the following assumptions are made according to the game theory:

(1) There are N+1 innovation entities in the open regional innovation system, among which one innovation entity is far stronger than other innovation entities and has more decision-making and innovation capabilities in this field. The other N innovation subjects have weak innovation ability and can only decide whether to participate in innovation according to their own situation. At this point, the government is in a leading position and can influence the decision-making of innovation entities.

(2) The players in the game are independent entities that can independently calculate costs and benefits. All parties involved are rational, able to make rational decisions and can analyze the actions of other participants.

The Prisoner's Dilemma model can explain the problem when the innovation resources are shared between the secondary innovation agents in two systems（Table 1). Secondary innovator A and secondary innovator B constitute a pair of game players, and both of them can independently choose whether to participate in the game. Suppose that A and b respectively represent the benefits of secondary innovator a and secondary innovator B when innovation resources are not shared, while a' and b' respectively represent the benefits of secondary innovator A and secondary innovator B when innovation resources are shared. c and c’ respectively represent the cost of secondary innovation subject A and secondary innovation subject B when they participate in innovation resource sharing. Because the distribution of innovation resources in the region is not uniform and relatively scarce, it is necessary to establish an innovation resource sharing platform to solve the problem. If both parties can participate in the sharing, the benefits they can receive are (a+a' , b+b'). However, if either party chooses not to share, the other party will have to bear the cost brought by the sharing, thus damaging its own interests. Therefore, if either party does not participate in the sharing, the other party will not participate in the sharing. To sum up, for any innovation subject, not participating in sharing is the optimal strategy. The combination of these "no participation in sharing" strategies thus forms a "prisoner's dilemma" Nash equilibrium. The final equilibrium result is that each secondary innovation entity will treat the sharing protocol negatively, which leads to the failure of the sharing protocol.

Table 1. The game between secondary innovation subjects

	Secondary innovation subject B		
Secondary innovation subject A		Participate in sharing	Not participate in sharing
	Participate in sharing	(a+a’,b+b’)	(a-c,b)
	Not participate in sharing	(a,b-c’)	(a,b)

When the main innovation body and the secondary innovation body share the innovation resources, the "smart pig game" can explain the problem(Table 2). When innovation resources are shared between the main innovation subject and the secondary innovation subject, the main innovation subject can be regarded as the big pig in the "smart pig game", while the secondary innovation subject is the little pig in the "smart pig game". According to the "smart pig game" model, if both sides do not participate in the sharing of innovation resources, the status quo will remain. If both parties participate in the sharing, the main innovator gets the main benefit and the secondary innovator gets the secondary benefit. If the main innovation body participates in the sharing, the secondary innovation body does not participate in the sharing. At this time, the main innovation body shares part of its innovation resources, and the secondary innovation body can develop rapidly. If the secondary innovator shares its innovation resources and the main innovator does not share its innovation resources, then the main innovator benefits while the secondary innovator suffers. In

this game, the main innovation entities tend not to share their own innovation resources in order to avoid their own interests being damaged.

Table 2. Game between primary innovation subject and secondary innovation subject

	Secondary innovation subject		
Primary innovation subject		Participate in sharing	Not participate in sharing
	Participate in sharing	5, 1	4, 4
	Not participate in sharing	9, -1	0, 0

From the above analysis, it can be seen that without government intervention, the cooperation between major innovation entities and minor innovation entities cannot be maintained. Therefore, the innovation ability of open regional innovation system depends not only on each innovation subject, but also on the attitude of the government in the region. Therefore, the game between the government and the major innovation entities is inevitable. There are two strategies they can adopt: one is to actively promote and the other is to negatively promote the sharing of innovation resources among innovation entities in the regional innovation system(Table 3); the other is to actively participate and negatively participate in the sharing of innovation resources among innovation entities in the regional innovation system. If c1 represents the cost invested by the government to promote the sharing of innovation resources in the regional innovation system, c2 represents the cost invested by the major innovation entities to participate in the sharing of resources. r1 represents the achievements and benefits brought by the successful sharing of innovation resources in the regional innovation system, and r1' represents the benefits brought by the slow progress of innovation resource sharing in the regional innovation system. r2 represents the benefits obtained by major innovation entities not participating in innovation resource sharing, and r2' represents the benefits obtained by major innovation entities participating in innovation resource sharing. When major innovation entities share their innovation resources, their own innovation competitiveness will be affected to some extent, so r1>r2'. If the government encourages the sharing of innovation resources and invests funds in the construction of the sharing platform, and the main innovation entities also actively participate in the cooperation and sharing, the game result is (r1-c1,r2-c2). If the government treats innovation negatively and the main innovator actively participates in innovation, the game result is (r1',r2'-c2). If the government treats innovation negatively, and the main innovator also treats innovation negatively, then the game result is (0, r2). If the government actively encourages innovation but the main innovator treats it negatively, then innovation develops slowly and the game result is (r1'-c1,r2').

Table 3. Game between primary innovation subject and government

	Primary innovation subject

Government within innovation system		Participate in sharing	Not participate in sharing
	Participate in sharing	（r1-c1,r2-c2）	（r1’-c1,r2’）
	Not participate in sharing	（r1’,r2’-c2）	（0， r2）

At this time, the operating efficiency of the innovation system is heavily dependent on the attitude of the local government. In this case, the cooperation among various innovation entities in the innovation system cannot be long-term, and it will cause harm to the innovation system itself.

3.2 Game theory analysis of innovation system based on blockchain technology

In order to analyze the sharing of innovation resources in the open innovation system, the following assumptions are made according to the game theory:

(1) There are N+1 innovation entities in the open regional innovation system, among which one innovation entity is far stronger than other innovation entities and has more decision-making and innovation capabilities in this field. The other N innovation subjects have weak innovation ability and can only decide whether to participate in innovation according to their own situation. At this point, the government is in a leading position and can influence the decision-making of innovation entities.

(2) The players in the game are independent entities that can independently calculate costs and benefits. All parties involved are rational, able to make rational decisions and can analyze the actions of other participants.

(3) If it does not participate in the sharing, the notary on the blockchain will punish the defaulting individual, and the harm brought by the punishment to each innovation entity will be far more than the income of each innovation entity when it refuses to share innovation resources, and part of the income from the punishment will be compensated to the innovation entity damaged by participating in the sharing.

When the innovation resources are shared between the secondary innovator in two systems, the secondary innovator A and the secondary innovator B constitute a pair of game players (Table 4), and they can both choose independently whether to participate in the game. Suppose that A and b respectively represent the benefits when the innovation resources of the secondary innovator A and the secondary innovator B are not shared. And a 'and b' respectively represent the income of secondary innovation subject A and secondary innovation subject B when innovation resources are shared. c and c 'respectively represent the cost of secondary innovation subject A and secondary innovation subject B when they participate in innovation resource sharing. Because the distribution of innovation resources in the region is not uniform and relatively scarce, it is necessary to establish an innovation resource sharing platform to solve the problem. If both parties can participate in the sharing, the benefits they can receive are (a+a ', b+b'). However, if either party chooses not to

share, the other party will have to bear the cost brought by the sharing, thus damaging its own interests. At this time, the blockchain notary will punish the party that refuses to share innovation resources. d and d 'indicate the impact of the punishment on the two innovation subjects, and the impact of the punishment on them will be far greater than the income obtained when one party participates in the sharing and the other party does not participate in the sharing. e and e' indicate that the blockchain notary will compensate each innovation subject for the loss of interests caused by the sharing. The compensation will be greater than the cost to both parties involved in the sharing. At this time, both parties will choose to participate in sharing in order to ensure their own interests.

Table 4. The game between secondary innovation subjects

	Secondary innovation subject B		
Secondary innovation subject A		Participate in sharing	Not participate in sharing
	Participate in sharing	（a+a’,b+b’）	(a-c+e,b-d’)
	Not participate in sharing	(a-d,b-c’+e’)	(a-d,b-d’)

When the main innovation body and the secondary innovation body share the innovation resources, the "smart pig game" can explain the problem (Table 5). When innovation resources are shared between the main innovation subject and the secondary innovation subject, the main innovation subject can be regarded as the big pig in the "smart pig game", while the secondary innovation subject is the little pig in the "smart pig game". However, at this time, the open innovation system with blockchain technology as the core will subsidize the innovation subjects who voluntarily participate in the sharing, and punish the innovation subjects who refuse to share. Grants and penalties are slightly higher than shared costs. At this time, according to the "smart pig game" model, if both sides do not participate in the sharing of innovation resources, the status quo will remain. If both parties participate in the sharing, the main innovator gets the main benefit and the secondary innovator gets the secondary benefit. If the main innovation body participates in the sharing, the secondary innovation body does not participate in the sharing. At this time, the main innovation body shares part of its innovation resources, and the secondary innovation body can develop rapidly. If the secondary innovator shares its innovation resources and the main innovator does not share its innovation resources, then the main innovator benefits while the secondary innovator suffers. At this time, each innovation subject will actively participate in the sharing of innovation resources.

Table 5. Game between primary innovation subject and secondary innovation subject

	Secondary innovation subject		
Primary innovation subject		Participate in sharing	Not participate in sharing

	Participate in sharing	7，3	4，2
	Not participate in sharing	5，1	0，-2

In this case, regardless of whether there is government intervention, the major innovator and each minor innovator will choose to share all their own innovation resources, so the cooperation in the open regional innovation system based on blockchain technology is relatively stable.

To sum up, the application of blockchain technology to the innovation system of start-ups can well solve the trust problem between the various entities of start-ups, so as to achieve information sharing, reduce the cost of market information acquisition, attract talents, and expand financing.

4 Construction of an open innovation system based on blockchain

4.1 Functional analysis of open innovation system based on blockchain

The requirement analysis of the system is based on the requirement analysis of the definition and function of the system before the construction of the software system, and the system development after accurately grasping the system positioning. In response to the needs of each body of the system, this paper establishes the following functions of the startup's blockchain-based innovation system.

(1) Innovative financing functions

In the early days of start-ups, many often face problems such as difficulties in financing and obtaining government subsidies. In the open regional innovation system based on blockchain technology, startups can easily get in touch with investment institutions and angel investors, and show them their achievements and prospects to obtain investment, and startups can obtain government financial subsidies and other funds through smart government blocks.

(2) Innovation policy support and regulatory functions

The growth and expansion of start-ups cannot be separated from government support and supervision. The government will introduce many preferential policies for startups, but these preferential policies often cannot be enjoyed by all startups for a variety of reasons, but in the open innovation system with blockchain technology as the core, startups can inquire and apply for innovation support through the intelligent government module. At the same time, many large enterprises often take actions to suppress start-ups for the purpose of monopolizing the market, and some start-ups will appear financial fraud and other situations. In the traditional innovation system, these behaviors are difficult to find, and in the open innovation system with blockchain technology as the core, the government can investigate the operation and financial situation of start-ups through blockchain technology, and also find and be alert to the behavior of large enterprises.

(3) Innovation subjects information sharing functions

In the traditional innovation system, each innovation body often chooses to refuse to share all its own innovation resources for the consideration of protecting itself. In the open innovation system with blockchain technology as the core, each innovation subject is punished for refusing to share innovation resources, so at this time, each innovation subject chooses to share innovation resources for the consideration of protecting themselves. At the same time, smart contracts will regulate the sharing protocol to avoid the occurrence of the big bully the small, and ensure that each innovation subject can benefit from the sharing.

(4) Innovation achievements patent protection functions

Intellectual property protection is one of the guarantees for the normal operation of the innovation system, and intellectual property protection has always been a difficult point in the innovation system. In an open regional innovation system with blockchain technology as the core, innovation achievements and patents can be effectively protected. When the suspected infringing product appears, the infringed person can apply to the regulator to temporarily stop the sale of the product and investigate the product. If the infringement is confirmed, the regulator will report it to the local police, file a lawsuit in court and punish it according to the smart contract.

(5) Innovation achievements transformation functions

In the traditional innovation system, the transformation of innovation results is often a big problem that troubles the innovation system because each innovation subject refuses to share the innovation results. However, in the open regional innovation system with blockchain technology as the core (see Figure 1), start-ups can quickly find the resources and intellectual property they need through the system, and obtain the right to use knowledge through talks and other forms, so as to maximize the efficiency and conversion rate of innovation achievements.

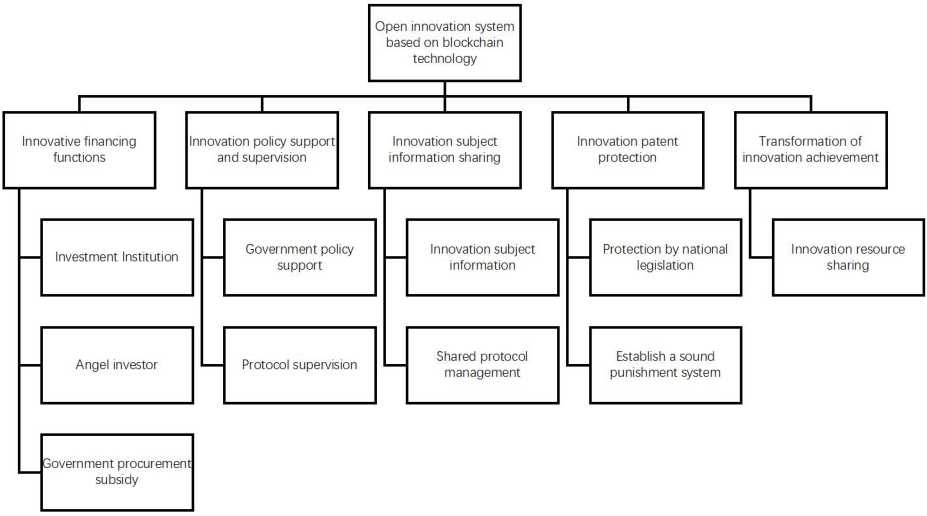

Fig. 1. An open innovation system based on blockchain technology

4.2 System architecture design of open system based on blockchain

Blockchain technology integrates point-to-point network communication protocols, public database technology, distributed consistent protocols, modern cryptography algorithms, and various programming and scripting languages to achieve data storage, exchange, and processing functions. Build trust in a decentralized and distributed environment to initiate and maintain transactions of all kinds without any threat. In the blockchain network, all nodes are equal to each other, all data is saved to get the same record, and the corresponding functions are realized in a distributed manner. To ensure the credibility of the system, all newly created transactions must be verified again before they can be linked. The blockchain consists of a chronologically linked block of data generated in a cryptographic manner, ensuring that the data is traceable and transparent. The incentive mechanism encourages the nodes in the network to actively account according to the consistency protocol to achieve efficient consensus.

Based on the existing innovation chain, the system architecture and public chain information of blockchain technology in the innovation chain are designed, in which the blockchain consists of five parts, distributed as financial block, intelligent government, academic network, citizen network, industrial block and legal block (as shown in Figure 2). The architecture of each chain has a total of 5 layers: application layer, contract layer, consensus layer, network layer and public chain information. The public chain information is how each block is linked, as shown in Table 6.

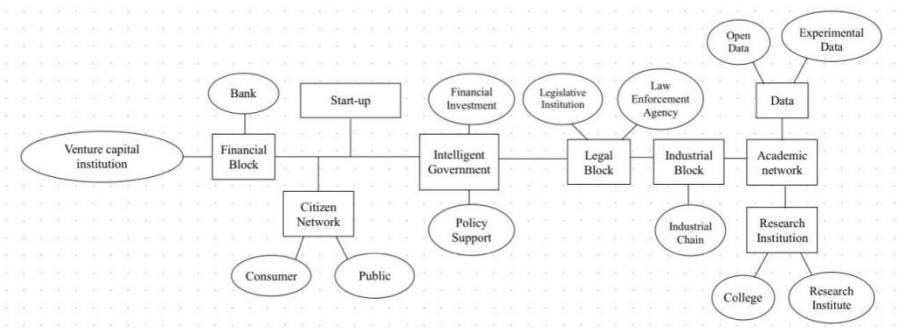

Fig. 2. Innovation chain structure based on blockchain technology

Table 6. Public chain information

Party A (inviting party)	Party B (accepting party)	Third Party (contract drafting and storing)	Judicial Party (providing legal aid)
Launch date	Signing date	Contract initiation date	Two-party subject inspection
Sponsor (Company)	Signatory (Company)	Validity period of the contract	Reasonableness inspection
Invitation content	Contract content	Performance term	Compliance capability material inspection

Cost	Breach clause	Breach liability	Legal representative authorized verification
Breach clause	Signature of legal representative	Third party guarantee	Limitation of legal action
Performance method		Dispute resolution method	Legal aid
Signature of legal representative			Retention of title

Blockchain-based innovation chains can be defined as a chain of digital signatures (as shown in Figure 2), with each participant passing the chain to the next participant by digitally signing the hash value of the previous operation and the public key of the next participant, which is added to the end of the chain. Participants can validate the chain by signing it.

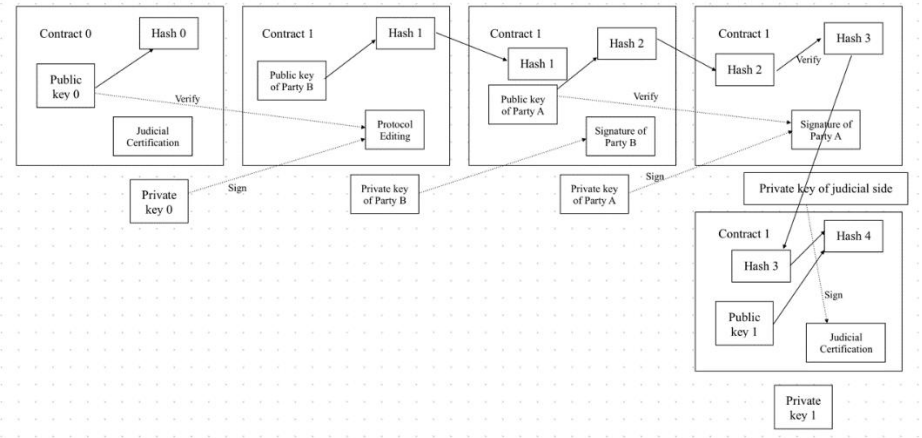

Fig. 3. Matching offer realization process

The total layers of blockchain technology in the innovation chain are application layer, contract layer, consensus layer, network layer, data layer and time stamp.

1. Application layer

Start-ups obtain real results through the application layer through financing, obtaining government funding, purchasing intellectual property and transforming innovation results.

2. Contract layer

This layer contains all kinds of code, algorithms, smart contracts and so on. The script encapsulated in this layer specifies the matching method (Figure 3), penalty contract, transaction contract signing method and related details in the process. Smart contracts consist of the following four types of contracts:

Contract Signing Contract: A contract with respect to the specifications and requirements for signing a contract.

Contract Query Contracts: How to query contracts for existing contracts.

Contract Enforcement Contract: A contract that monitors the performance of a contract.

Default penalty contract: establishes normative penalties for different breaches of contract.

Matching contracts: Ensure that startups can directly find the innovation resources they need.

3. Network layer

Through p2p network protocol, the data transfer is distributed among different nodes. This demonstrates the decentralization of an open innovation system based on blockchain technology, while a single point of data corruption does not affect the entire chain. And each node keeps consistent blockchain data, guaranteeing its immutability.

4. Data layer

The data layer, the lowest layer of an open innovation system based on blockchain technology, stores the data uploaded by each node. The storage adopts hash encryption technology.

5. Consensus layer

Consensus algorithms such as proof-of-work algorithms are used to determine which newly generated blocks join the main chain. At the same time, through the consensus algorithm, an agreement can be reached in the multi-party transaction and the parties can fully implement the agreement.

6. Time stamp

The time stamp is the total number of seconds from 00:00 00 GMT on January 1, 1970 to the present. The signature and transaction timestamp is a series of characters that record the completion time of the specific transaction and the specific time when the agreement was signed and entered into force. In the innovative system with blockchain technology as the core, it represents the specific time of each transaction and each agreement. At the completion of each transaction and the signing of the agreement, the accounting node adds a time stamp to the block header of each transaction contract and agreement and connects them by order. A timestamp is a transaction certificate that proves its existence, completeness, and verifiability at a certain point in time.

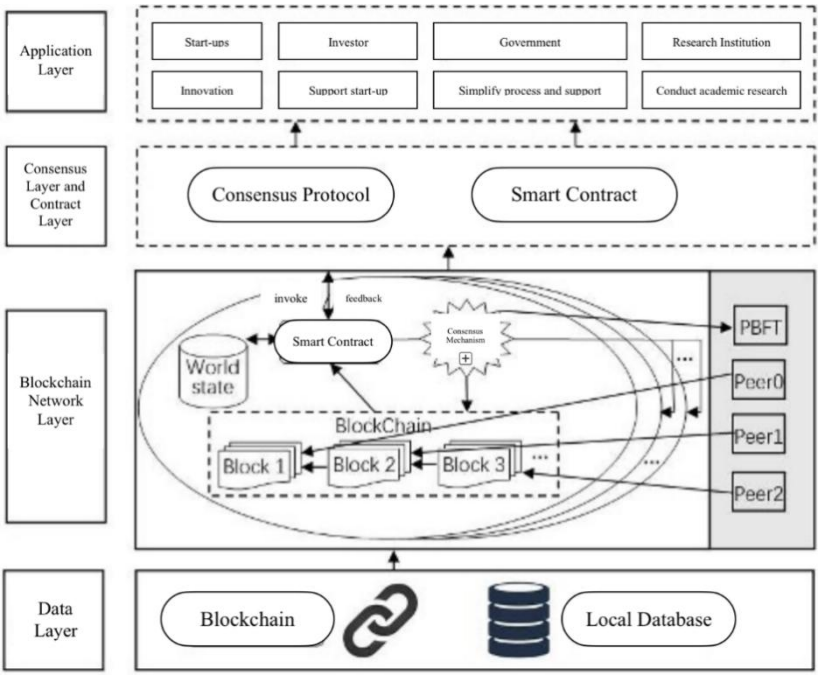

Fig. 4. Open innovation system architecture based on blockchain technology

4.3 Module analysis of innovation system based on blockchain

(1) Start-up module

As the innovation body of the system, the start-up enterprise plays a crucial role in the innovation system. An open regional innovation system based on blockchain technology (see Figure 4) will greatly reduce the difficulty of cross-regional innovation and make it easier for investment institutions such as angel investors to invest in companies through blockchain trade. Start-up enterprises can attract individuals with innovative strength to participate in innovative production activities by attracting talents; Secondly, start-ups can attract innovative individuals and informal organizations to participate in innovation through open and semi-open platforms on the Internet, and incorporate innovative results into the innovation system through cooperation or patent transfer, so as to improve the total innovation output of enterprises.

(2) Smart government module

Blockchain technology has the potential to form the government into a government network, which is not only conducive to the coordination of government work, but also help the government play its functions more efficiently. At the same time, government networks can more easily coordinate the work of local governments, while reducing trade and investment barriers between different places. Many governments are experimenting with smart government systems, including e-ids, e-passports, and more. Going a step further, citizens' data may be stored on a

blockchain platform in the future. Start-ups can more easily obtain business qualifications from the government.

(3) Academic network module

Blockchain technology can connect global research institutes and universities to the same network, transforming global academic institutions into nodes of teachers and students. Academic networks can benefit greatly from blockchain technology, firstly, the review, revision and publication of academic works, secondly, the efficient acquisition of intellectual property and experimental data, and finally, the establishment of academic reward mechanisms. Blockchain technology can also overcome a number of drawbacks of online courses such as the possibility of false knowledge, or the inability to identify the source of knowledge and content. In the academic network module, start-ups can obtain patents and other intellectual property rights they need more easily.

(4) Industrial network module

Blockchain technology can revolutionize existing industries such as aviation, insurance, entertainment, energy, and real estate, or in other words, it will also change the functions of traditional industries such as retail, auditing, and supply chain management. Combining business with blockchain technology will allow these industries to gain a comparative advantage. When the core business of these industries is linear. Transaction costs in these industries will drop dramatically, and intellectual property and payments will become more accessible and transparent. For example, when blockchain technology is used on a large scale in the energy industry, for both parties in the energy market, blockchain technology gives them a relatively transparent and fair trading environment, which will attract more and more relevant parties to join the energy transaction. When an industrial network is built, start-ups can greatly improve the conversion rate of their results and can more easily mass-produce their results for success in the market.

(5) Financial network module

In the open regional innovation system, financial institutions such as banks and investment institutions can be organized into financial networks. Existing financial institutions often make their investments or loans based on the creditworthiness of customers. They measure a number of factors that cost a lot of money, such as reputation. In fact, these indicators are difficult to accumulate, record, and use. However, the characteristics of efficient value transfer and better risk management of blockchain technology will, to some extent, improve the efficiency of financial institutions in the financial and social system, and at the same time, blockchain also allows startups to seek funds from the world, and venture investors will also become an important part of the open innovation system.

(6) Legal service module

The law block contains legislative, civic, educational, and law enforcement agencies. In other words, the cooperation of various participants in the open regional innovation system may find the imperfections of social norms, which also promotes the perfection of social institutions to a certain extent. Because of the decentralized nature of the blockchain itself, it can break the centralized and hierarchical governance structure. This reduces the decision-making process from top to bottom,

and also reduces the occurrence of bureaucracy to a certain extent. In case of legal disputes between the start-up and other large enterprises or other entities, the start-up can seek help through the legal service module so that the start-up can protect its own interests through law.

4.4 Innovation process analysis of open system based on blockchain

Unlike the traditional open regional innovation system, the regional innovation system based on blockchain technology will greatly reduce the burden of start-ups in the region. At the beginning of the innovation, start-up will put forward needs, and the system will classify these needs into purchase needs and investment needs. At this time, if there are other innovative entities that can provide innovative resources needed by start-ups, and are willing to provide such innovative resources to the market. The blockchain system then recommends each other to both parties at the same time. If no agreement is reached, the match ends. Both parties can choose to initiate a match again or abandon the match. If the two sides reach an agreement, the transaction demand will be initiated by the startup in the blockchain, and the authenticity of the data will be checked by the nodes. If the inspection fails, the transaction is void. If the data is verified and correct, each transaction subject will digitally sign and release the data, and then submit the data to the regulator for supervision. After one or more such transactions, startups will have access to a variety of necessary innovation resources such as capital and scientific research results, and then they can transform these innovation resources and finally complete innovation (as shown in Figure 5).

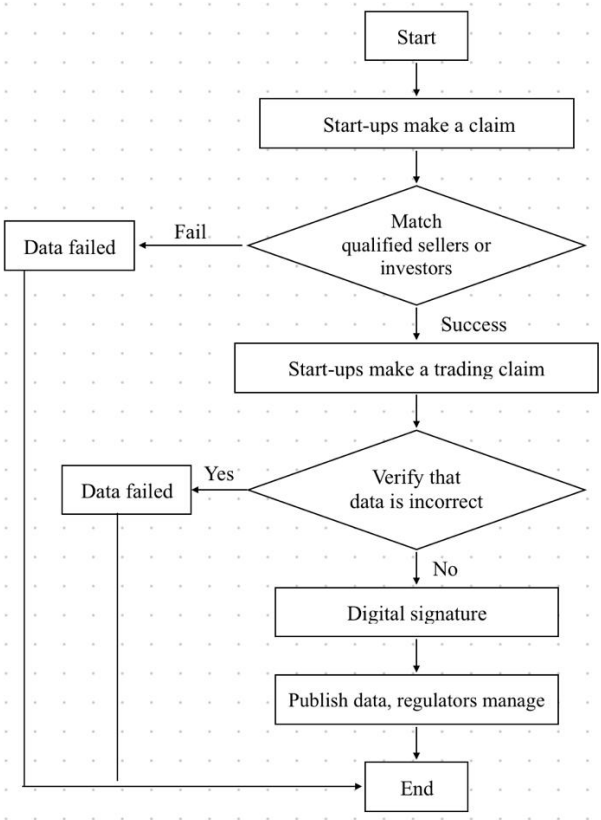

Fig. 5. Innovation process

5 Conclusion

Start-ups in the traditional innovation chain always face various problems such as innovation landing, intellectual property, innovation trust, talent gathering, financing, etc. The "blockchain + timestamp" approach effectively reduces the cost of communication and time for start-ups and solves the problem of non-cooperation among innovation subjects, improving the efficiency of innovation chain operations and reducing cost of entrepreneurship. This study is limited by technological determinism, as it reflects on key findings from the blockchain-related literature, pointing to the emergence of new forms of blockchain-based innovation governance. Unfortunately, they ignore the complexity of human interaction and social organization. In this respect, blockchain is very similar to the development of the Internet, which years later transformed into an oligopolistic structure, dominated by a few but powerful Internet companies such as Google. In general, future research should solve the following limitations: (1) institutional perspectives; (2) design

principles; (3) governance; (4) regulation; (5) collaboration; (6) human, social, cultural, and organizational aspects.

Reference

1. IANSITI M, LEVIEN R. Strategy as ecology[J].Harvard Business Review, 2004,82(3):68-81.
2. MERCAN B, GOKTAS D. Components of innovation ecosystems: A cross country Study [J]. International Research Journal of Finance and Economics, 2011, 76(76): 102-112.
3. ADNER R. Navigating the leadership challenges of innovation ecosystems [J]. MIT Sloan Management Review. 2016, 58(1): 141-146.
4. ADNER R, KAPOOR R. Innovation ecosystems and the pace of substitution: Re-examining technology S-curves [J]. Strategic Management Journal, 2016, 37(4): 625-648.
5. LETEN B, VANHAVERBEKE W, ROIJAKKERS N, et al. IP models to orchestrate innovation ecosystems: IMEC, a public research institute in nano-electronics [J]. California Management Review, 2013, 55(4): 51-64.
6. BRUSONI S, PRENCIPE A. The organization of innovation in ecosystems: Problem framing, problem solving, and patterns of coupling [J]. Advances in Strategic Management, 2013, 30(1): 167-194.
7. DAVIS J P. The emergence and coordination of synchrony in organizational ecosystems [J]. Advances in Strategic Management, 2013, 30: 197-237.
8. XU G, WU Y, MINSHALL T, et al. Exploring innovation ecosystems across science, technology, and business: A case of 3D printing in China [J].
9. Davidson, S., De Filippi, P. and Potts, J. (2016), "Disrupting governance: the new institutional economics of distributed ledger technology", July, doi: 10.2139/ssrn.2811995, available at: SSRN: https://ssrn.com/abstract=2811995.
10. Tapscott, D. and Tapscott, A. (2016), Blockchain Revolution: How the Technology behind Bitcoin is Changing Money, Business, and the World, Penguin.
11. Swan, M. (2017), "Anticipating the economic benefits of blockchain", Technology Innovation Management Review, Vol. 7 No. 10, pp. 6-13.
12. Chen, Y. (2017), "Blockchain tokens and the potential democratization of entrepreneurship and innovation".
13. Sutherland, W.J., Barnard, P., Broad, S., Clout, M., Connor, B., Cote, I.M., ... and Fox, M. (2017), "A 2017 horizon scan of emerging issues for global conservation and biological diversity", Trends in Ecology and Evolution, Vol. 32 No. 1, pp. 31-40.
14. Seidel, M.D.L. (2018), "Questioning centralised organisations in a time of distributed trust", Journal of Management Inquiry, Vol. 27 No. 1, pp. 40-44
15. Potts, J. (2018), "Governing the innovation commons", Journal of Institutional Economics, Vol. 14 No. 6, pp. 1025-1047.
16. Audretsch, D.B. and Feldman, M.P., (1996), "R&D spillovers and the geography of innovation and production", The American Economic Review, Vol. 86 No. 3, pp. 630-640
17. Marsal-Llacuna, M.L. (2017), "Future living framework: is blockchain the next enabling network?", Technological Forecasting and Social Change, Vol. 128, pp. 226-234.
18. Van Valkenburgh, P., Dietz, J., De Filippi, P., Shadab, H., Xethalis, G. and Bollier, D. (2015), "Distributed collaborative organisations: distributed networks & regulatory frameworks", Coincenter. org, 7.

19. NEUMANN J. Zur Theorie der Gesellschaftspiele[J]. Mathematische Annalen, 1928,100: 295-320.
20. MOLINERO X, RIQUELME F. Influence decision models: From cooperative game theory to social network analysis[J]. Computer Science Review, 2021,39: 100343.
21. NASH J F. Equilibrium points in N-Person games[J]. Proc Natl Acad Sci U S a, 1950,36(1): 48-49.
22. PALAFOX-ALCANTAR P G, HUNT D V L, ROGERS C D F. The complementary use of game theory for the circular economy: A review of waste management decision-making methods in civil engineering[J]. Waste Management, 2020,102: 598-612.