

Visualization Analysis of Smart Contract Technology Based on Citespace

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Abstract. As an emerging technology, smart contract has attracted more and more attention. In order to deeply analyze the research status and development trend in the field of smart contract at home and abroad, we take the core journals of CNKI and ScienceNet database in recent ten years as the research object, and adopt the CiteSpace software to construct the knowledge maps for these literatures. We analyze author co-occurrence, keyword co-occurrence and keyword emergence respectively. The results show that the research on smart contract is constantly increasing at home and abroad, however the domestic research on smart contract is far behind foreign countries. The research hotspots of smart contract mainly lie in blockchain, Ethereum, privacy, security, consensus mechanism and so on. The future development frontier mainly focus on the fields of underlying architecture, application and security.

Keywords: smart contract; blockchain; CiteSpace; visual analysis; knowledge graph

1 Introduction

With the development and popularity of Bitcoin^[1], the research and application of blockchain technology has been gradually valued by many scholars. Blockchain provides a programmable environment for smart contract. With the development of blockchain, smart contract has also been widely used. Smart contract is a programmable computer program, whose essence is some pre-defined rules and terms that can be automatically executed based on the blockchain^[2]. The characteristic of smart contract is that once deployed to the blockchain, it can only be accessed and cannot be changed. Smart contract can be executed automatically without a third party. So currently, researchers use smart contract to solve various types of computer problems.

In order to promote the research and development of smart contract technology, it is necessary to understand the research hotspots and development trends of smart contract technology, so as to help researchers plan their research ideas and framework. In this paper, we adopt the knowledge graph visualization software Citespace of the research literature to deeply analyze the research literature of smart contract technology in the past 10 years at home and abroad and form the visualization function. We select the key research directions to measure and analyze

the research of smart contract and summarize and conclude it. Based on the comparison of domestic and international research developments, we analyze the current status of researches and predict the future development trends, these provide a reference for future research development of domestic smart contract^[3].

2 Data sources and research methods

2.1 Data sources

The data used in this study come from the literature of smart contract research in domestic CNKI and foreign web of science, and the time span of the literature is 2012-2022. The subject term retrieved in CNKI is set as smart contract, and a total of 4486 articles are detected. The journals are set as the core journals, which ensured the authority of this research to a certain extent. A total of 815 articles are retrieved by manually screening out the literature with low relevance. In the web of science, the subject term is set to smart contract, and 5662 articles were detected. By eliminating the documents with low correlation, 3000 documents were retrieved, and all documents were converted to the data format that CiteSpace can process.

2.2 Research methods

In this paper, we adopt Citespace to visually analyze relevant literature. Citespace is a data visualization analysis tool that combines bibliometrics, statistics, information science and other disciplines, and it is used to map the knowledge of relevant research^[4]. It is mainly based on the co-citation analysis theory and the path finding network algorithm, etc., to measure the literature (collection) of a specific field, which explores the key path and knowledge inflection point of the evolution of the subject field. Through a series of visual maps, the analysis of the potential dynamic mechanism of discipline evolution and the frontier of discipline development are formed^[5]. Bibliometrics is a quantitative, scientific and objective analysis of the evolution and development trend of related research in terms of knowledge status and characteristics, which provides a vivid picture of the academic dynamics of research and has been widely used. In this paper, we use the bibliometrics method of Citespace to quantitatively analyze and interpret 815 domestic and 3000 foreign research literatures on smart contract, and draw a knowledge map of the current situation and content of the smart contract field. We analyze the author co-occurrence, keyword co-occurrence, and keyword emergence of literatures through node size, frequency of occurrence, network connection, and connection strength.

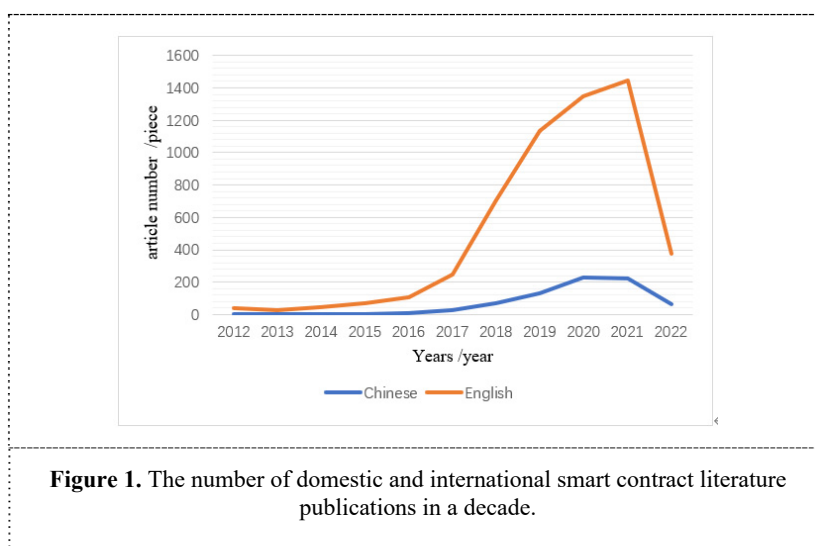
3 Research status analysis

3.1 Time distribution characteristics

The relevant topics in Chinese and foreign languages were searched, and the retrieved literature was sorted out to obtain the annual distribution of literature, as shown in Figure 1. The overall development trend of the research field and the national attention to the research can be judged by the number of publications and the growth trend of the literature^[6]. It can be seen from Figure 1, the research on smart contract at home and abroad is on a growing trend, and the core research on smart contract has only started to grow since 2015. This is because Ethereum, based on smart

contract, first appeared at the end of 2015. Foreign research on smart contract is developing rapidly.

In comparison, our country's research on smart contract is far less than foreign research. The reason is that the technology has developed late in China and has still some doubts. However, as General Secretary Xi Jinping emphasized in the 18th collective study emphasized the integrated application of blockchain technology plays an important role in new technological innovations and industrial changes [7], blockchain technology has gained attention, while smart contract technology has also developed accordingly, but our country's research on smart contract is also reducing the gap. It can be predicted that the research in the field of smart contract at home and abroad will be on a continuous rise.



3.2 Author co-occurrence analysis

By analyzing the volume and interrelationship of the core authors about smart contract research at home and abroad, we can see magnitude of researchers' contributions and the closeness of collaboration among them in the field of smart contract. This can help scholars to further understand the research status and research strength of domestic and foreign research. In Citespace, the node type is selected as Author. Figure 2 shows the co-occurrence graph of Chinese authors, with a network density of 0.0077, a total of 205 nodes and 160 links. Figure 3 shows the co-occurrence graph of foreign authors, with a network density of 0.0111, a total of 362 nodes and 727 links. The nodes and font sizes in Figure 2 and Figure 3 correspond to the author's published volume. The larger the node, the more the published volume^[8]. Lines around an author indicate connections between him and other authors. The more lines around the author, the stronger the relationship between them.

As we can see from Figures 2 and 3, compared with Chinese literature, there are more authors with more than three papers published in foreign languages. There are many core researchers

on smart contract abroad, and the authors have a close relationship with each other. Foreign research on smart contract have formed a mature system compared to China, and there exists more core authors, and relatively stable cooperative relationships have been formed. The development of a research field requires authors to continue to explore and send out high-quality and high-volume research literature. This can lead the positive development of the research field. It also requires highly productive authors to establish close cooperation with other authors, which this will promote the progress and innovation of academic research. In addition, there are many independent researchers in Chinese and foreign literature. Although there are fewer authors in Chinese literature compared to those in foreign literature, there are also some influential authors, such as Zhu Yan, Guo Qian, Wang Di, etc. These highly-impact authors are located at key nodes, which are important nodes connecting different authors' research cooperation. The problems researched by these scholars at key nodes have the function of carrying forward and backward^[9]. By focusing on them, we can grasp the key research directions in the field of smart contract. Through the analysis, our scholars in this field still need to be continuously expanded, broaden the scope of research, increase research, and improve the number of publications.

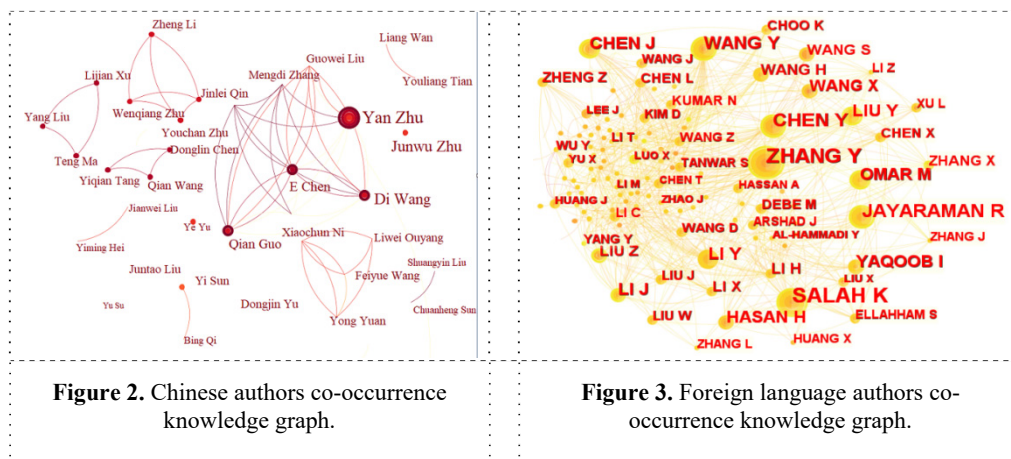


Figure 2. Chinese authors co-occurrence knowledge graph.

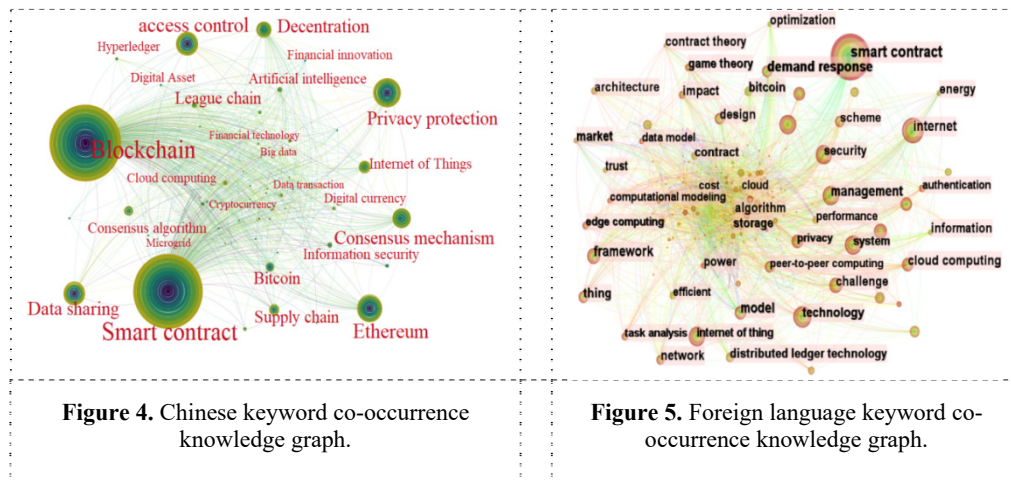
Figure 3. Foreign language authors co-occurrence knowledge graph.

4 Research content analysis

4.1 Keyword co-occurrence analysis

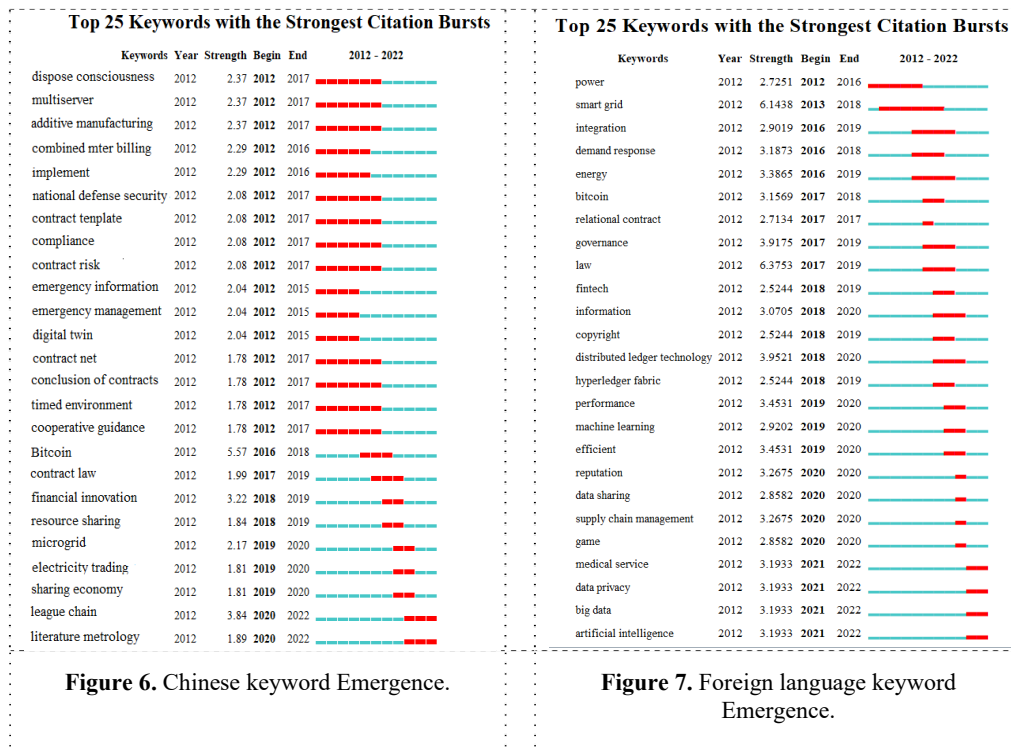
The keywords reflect the main content and viewpoints of the literature^[10]. The core ideas in the article can be seen through the keywords. The co-occurrence relationship of the keywords reflects the hot research content of smart contract in the process of development. Therefore, our study of the keyword co-occurrence of smart contract has significant implications for the subsequent research on smart contract. Run the Citespace platform and set the node to Keyword. Figure 4 shows the keyword co-occurrence mapping in Chinese, and Figure 5 shows the keyword co-occurrence mapping in foreign language. It can be seen from two Figures, the frequency of smart contract and blockchain is equally high in Chinese and foreign literatures, which is much higher than other keywords. The reason is that blockchain and smart contract are the current research hotspots, and the former is the infrastructure of the latter. In addition, the

frequency of keywords such as "decentralization", "consensus mechanism", "Ethereum", and "privacy protection" is also relatively high. These keywords are the focus of smart contract research, and they are closely to each other. For example, smart contract is deployed in the blockchain and implemented by the consensus mechanism, and the application of smart contract can ensure the privacy protection of data. The research of foreign smart contract mainly focuses on "Ethereum", "privacy", "internet", "security", and "internet of thing". It can be seen that the research fields of smart contract at home and abroad are similar, but it can be seen that domestic research based on smart contract is mainly at the bottom, while foreign research is more about the application of smart contract.



4.2 Keyword Emergence Analysis

Emergent words of keywords refer to keywords that researchers generally pay attention to or suddenly increase in a certain period of time^[11]. In this research, we analyze the emergence of smart contract keywords, mainly using the burstness analysis function in Citespace^[12]. We analyze the keywords of the literature in the past decade, which led to the keyword emergence map (Figures 6, Figure 7). The analysis results reflect the research hotspots and frontiers in the field of smart contract technology research at home and abroad in 2012-2022. Figure 6 shows a total of 25 keywords in Chinese documents arranged by year. From 2012 to 2017, smart contract mainly focused on multi-server, contract risks, etc. The research on smart contract technology only involves theoretical research. From 2017 to 2020, the research focused on Bitcoin, resource sharing, etc. It can be seen that the domestic research on smart contract is more in-depth and gradually transitioning to technology. In 2020 to 2022, the research focuses on the sharing economy and alliance chain. Figure 7 shows a total of 21 keywords in foreign language documents arranged by year. The foreign frontiers of smart contract from 2012 to 2017 were mainly based on the bottom layer. With the development of technology, the foreign research frontiers gradually transition from the bottom layer to the application. There are "dapp", "ipfs", etc. From 2020 to 2022, it will mainly focus on "electric vehicle", "computing", etc. The research is almost at the application level.



5 Conclusion

In this paper, we comb the research contents of smart contract at home and abroad through CiteSpace tool, and get the current situation, hot spots and development trend of smart contract research, hoping to bring clear research ideas and directions to scholars. Judging from the number of domestic and foreign publications and author relations, China's research on smart contract technology is far less than foreign research, but it is also making progress. Smart contract research hotspots focus on the following three aspects: (1) Underlying architecture. The underlying technologies required for smart contract deployment to blockchain include alliance chain, consensus algorithm, consensus mechanism, Ethereum, etc. (2) Contract application. The development of contract will promote the progress of some applications, such as privacy protection, fair payment, cloud computing, electric vehicles, and sharing economy. (3) Security of the contract. The security of smart contract will be the future development trend, which can be seen through the keywords "compliance", "contract risk" and "security".

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