

Research on the application of smart supply chain finance in the financing of private scientific and technological enterprises in China

Yaqin Dou ^{1,*}
Mingxuan Zheng ²
Yisheng Wu ³
Shaobu Bai ⁴

*Corresponding author

¹ Professor, NJIT Institute of Industrial Economy and Innovation Management, Nanjing, China, douyq@njit.edu.cn

² Master degree candidate, Mingxuan Zheng, Southwest Jiaotong University, Chengdu, China, zhengmx1999@126.com

³ Professor, Nanjing Institute of Technology, Nanjing, China, wyslqh@163.com

⁴ Professor, Nanjing Institute of Technology, Nanjing, China, baisb@njit.edu.cn

ABSTRACT

Supply chain finance (SCF) has experienced the development stages of offline SCF, online traditional SCF, and Internet SCF, and has developed to the stage of smart supply chain finance (SSCF) driven by digital technology in China. We analyze the theoretical framework of SSCF model from three aspects: loose coupling alliance organizational structure, visual operation and management process and symbiotic multi-agent coordination mechanism. In the financing of private scientific and technological enterprises, SSCF will show smart effects such as intelligent decision-making, harmonious service, penetrating management and digital risk control. Further, the process of SSCF providing financing services for private scientific and technological enterprises is designed. Finally, in view of the problems and challenges faced by private scientific and technological enterprises in the application of SSCF, we put forward countermeasures and suggestions from the aspects of expanding the dimension of smart transformation, building a perfect regulatory system and legal system, and strengthening the cultivation of compound talents in this paper.

Keywords: Smart supply chain finance, Private scientific and technological enterprises, Digital technology.

INTRODUCTION

Private scientific and technological enterprises refer to knowledge intensive economic entities that take scientific and technological personnel as the main body, follow the principle of "Independent management, profit-and-loss responsibility", engage in technology development, transfer, consultation and service activities, and integrate production, sales and scientific research (Lu & Zhang, 2020). With the rapid development of economy and the continuous progress of science and technology, private scientific and technological enterprises have developed rapidly in China, playing an important role in stimulating economic growth, optimizing industrial upgrading, driving innovation strategies and so on. However, most private scientific and technological enterprises are difficult to obtain financial resources from formal financial institutions due to the inherent defects of less fixed investment, short operation cycle, large innovation investment and high operational risks. Many private scientific and technological enterprises rely on own funds for their innovation investment. The difficulty and high cost of financing are the pain points that have plagued the innovation and development of private scientific and technological enterprises for a long time (Dou et al., 2019). How to obtain financing efficiently, conveniently and safely has become the key to the high-quality development of private scientific and technological enterprises. Therefore, it is of great significance to actively open up new financing channels, break through financing bottlenecks, and provide high-quality financial support for the innovative development of private scientific and technological enterprises.

SCF is a financing mode that breaks through the weak credit of SMEs in the chain by using the energy diffusion effect of core enterprise advantageous resources in the industrial chain. It is a financing way tailored for private scientific and technological enterprises. However, traditional SCF has the disadvantage of single-layer credit transmission. A large number of private scientific and technological enterprises at the long end of the supply chain can't take advantage of the credit of focus enterprises, which limits the inclusive effect of SCF (Dou et al., 2019). There is an urgent need to innovate the SCF model and provide development funds for more private scientific and technological enterprises. Driven by emerging technologies such as big data, Internet of things, blockchain and artificial intelligence, SCF is undergoing intelligent transformation and ushering in the stage of SSCF (Song & Yang 2019). Sfar et al. (2018) proposed that SSCF should include the cooperation of supply chain management, efficient operation, predictive maintenance and inventory optimization. Wan et al. (2020) pointed out that AI, machine learning, big data computing and other technologies have promoted the development of SSCF. Song (2019) proposed that SSCF is to carry out financial services more efficiently, transparently and openly with the help of artificial intelligence, blockchain, cloud computing, big data and other technologies. To sum up, in essence, SSCF means that driven by new information technologies such as big data, Internet of things, blockchain, artificial intelligence and cloud computing, SCF is

highly integrated with financial technology, and provides more efficient, open and comprehensive new financing services for enterprise production and operation by virtue of digital transaction processes, visual operation management and intelligent financing decisions. SSCF will realize the deep integration of "intelligence + industrial ecology + modern finance", which can provide fast, convenient and affordable financial services for more private scientific and technological enterprises, and meet the needs of high-quality financial support for the innovative development of private scientific and technological enterprises.

We first analyze the development and evolution of SCF in this paper, study and define the theoretical framework of SSCF, and further discuss the innovative application of SSCF in private scientific and technological enterprises from the two aspects of the smart effect principle and operation design of SCF. Finally, in view of the problems and challenges that may exist in the application of SSCF in private scientific and technological enterprises, we put forward corresponding countermeasures, so as to provide decision-making reference for private scientific and technological enterprises to more effectively apply SSCF to alleviate financing difficulties.

THE DEVELOPMENT AND EVOLUTION OF SCF IN CHINA

SCF started at the beginning of the 21st century in China, and has experienced the traditional SCF stage and the online SCF stage. With the intervention of Internet technology, it has developed to the Internet SCF stage, which has made contributions to easing the financial constraints of SMEs, including private scientific and technological enterprises. Now, driven by the digital economy and financial technology, the development of SSCF has brought new opportunities for the financing needs of technology-based enterprises.

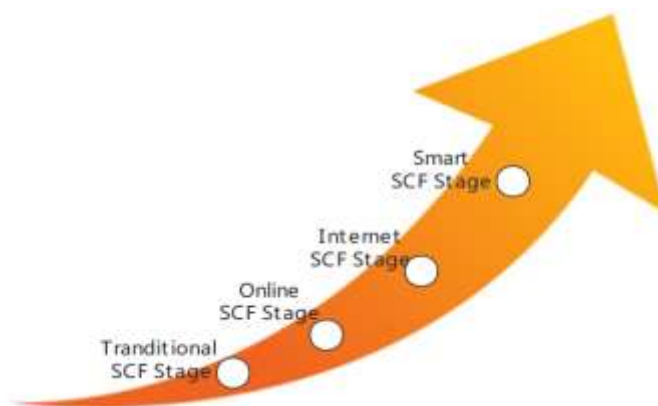


Figure 1: Development and evolution of SCF

Traditional SCF stage

SCF business can be traced back to the first cargo mortgage financing initiated by Shenzhen Development Bank (now renamed Ping An Bank) in Guangdong Province, China in 1998, and put forward the service concept and financial products of SCF in 2002. The real SCF business in China should begin with the strategic cooperation between Shenzhen Development Bank and the three logistics companies of China Foreign Trade Transportation Corporation, China National material storage and Transportation Corporation and China Ocean Logistics Co., Ltd. in 2005. Hundreds of enterprises obtained financing through SCF in more than a year, creating a high credit financing of 250 billion yuan. At this stage, the business of SCF is generally dominated by commercial banks, core industrial enterprises or an alliance of the two, and focuses on providing financial services for SMEs upstream and downstream of the supply chain based on the credit of the core enterprises of the supply chain. Limited by technology, the development means of SCF mainly rely on traditional paper media, so the service quality and efficiency of SCF are poor.

Online stage of traditional SCF

With the development of e-commerce, more and more enterprises begin online transactions. The traditional offline SCF services begin to encounter bottlenecks in many aspects, such as target customers, financing lines, financing frequency, credit conditions, rating mode and service efficiency, which urges the online expansion of SCF. In 2010, Shenzhen Development Bank took the lead in the online business model. In June 2012, China Construction Bank began to launch "Shanrong commerce". Various banks have launched e-commerce financial service platforms, launched online SCF services, developed supporting systems combined with SCF, realized docking with core enterprises, and input transaction data such as transactions, warehousing, logistics, payment, etc. into the system. Compared with the traditional SCF stage, the leading force, service content and service mode of online SCF business have not changed substantially. As the transitional stage from traditional SCF to Internet SCF, online SCF alleviates the asymmetry of information to a certain extent and improves the efficiency of financial services due to the application of network technology. However, at this stage, the transaction data of core enterprises are more involved. Banks and other financial institutions still have insufficient control over upstream and downstream enterprises. The real borrowing enterprises have not formed actual and effective data to control, so it is difficult to achieve a comprehensive risk assessment.

Stage of Internet SCF

The combination of SCF and Internet has greatly expanded the connotation and application scope of SCF, and SCF has begun to enter the stage of Internet development. In the stage of Internet SCF, leading institutions are no longer limited to commercial banks or industrial giants. e-commerce platforms, P2P platforms, third-party payment institutions and others have landed in the field of SCF, relying on their own advantageous resources to expand SCF business. With the vigorous development of e-commerce, the Internet SCF platform can monitor all kinds of transaction behaviors in the platform point-to-point, ensure the consistency of capital flow and transaction behavior, and provide a highly matched financing scheme based on the historical data precipitated by the transaction, combined with the financing transaction needs, risk preferences and other characteristics of both parties. Data such as e-commerce transactions, online payment, capital settlement and logistics management can realize high-level information sharing in Internet SCF, and promote the "four flows in one" of business flow, capital flow, information flow and logistics of SCF. Internet SCF presents a complex and interdependent ecological network structure, realizes the integrated management of horizontal and vertical industrial chains and service chains, and forms the ecosystem big data of transaction precipitation. However, with the continuous complexity of participants, trading behavior and risk control, the requirements for the accuracy, visualization and intelligence of Internet SCF services are becoming higher and higher, and there is an urgent need to add new generation technologies such as big data, Internet of things, blockchain and artificial intelligence.

SSCF stage

With the innovation and transformation of digital technologies such as Internet, big data, cloud computing and artificial intelligence, platform organizations based on new technologies continue to show a trend of integration and development with traditional industries, giving birth to new formats of digital economy (Zhang, 2019), promoting the multi-dimensional integration of SCF and digital technology, and promoting the development of SCF into an intelligent stage. According to the data of the "2019 China SCF Research Report", 55% of the surveyed enterprises applied big data and artificial intelligence technology, 44% applied cloud computing, 39% applied blockchain technology, 29% applied Internet of things technology, and only 13% did not use any financial technology. The wide application of various digital technologies in SCF marks that SCF has entered the stage of SSCF in China. At this stage, the participants of SCF are more diversified, and members of different types and different network locations form more complex dependencies, and support and control are achieved through the integration of digital technology (Song, 2019). From the perspective of theoretical research, scholars at home and abroad have begun to pay attention to the intelligent transformation of SCF and explore the function of digital technology in SCF. Previous studies have found that the application of big data in SCF helps identify enterprise credit (Jiang, 2015) and can play a unique advantage in risk control (Yan & Sun, 2015); The Internet of things is applied to the inventory pledge financing mode, which can reach the bottom business information of the supply chain (Wang et al., 2019); Blockchain technology has great potential in preventing transaction data tampering, breaking through credit limitations, reducing monitoring costs, etc. (Saber et al., 2019), is conducive to creating a more stringent regulatory environment (Sun et al., 2022), and expands its application in inventory financing, order financing, accounts receivable financing and other business areas (Hofmann et al., 2018).

THEORETICAL BASIS AND RESEARCH FRAMEWORK OF SSCF

Theoretical basis of SSCF

Long tail theory

Chris Anderson, an American Internet economist, mentioned in his book the long tail theory in 2004 that the focus of cultural economy is accelerating the shift from a few hot spots (mainstream products and markets) in the demand curve to a large number of niche products and markets at the end of the demand curve. The long tail theory believes that we should not only pay attention to the long tail goods at the head, but also pay attention to the tail goods that can meet the personalized needs. The profits brought by these tail goods add up, and even higher than the profits brought by the long tail market. The traditional credit model pays more attention to the large-scale core enterprises in the industrial chain, ignoring the private scientific and technological enterprises at the end of the supply chain, and the benefits brought by these enterprises are crucial to the sustainable development of the industrial supply chain. With the penetration and influence of digital technology in the SCF system, the ecological operation platform has built a data system based on the deep integration of industrial chain operation and financial information formed by digital trust. After private scientific and technological enterprises send out loan applications, the platform automatically reviews the information of their pledged assets, making the enterprise credit portrait more accurate. At the same time, banks can accurately grasp the structured credit of the supply chain, The convergence of various credit guarantee systems and social credit reporting systems has promoted the formation of third-party guarantee and credit enhancement schemes, expanded the credit enhancement of the SCF system to a greater extent, and all kinds of digital credit are integrated, which can be conducted and traced within the whole ecological community, creating financing opportunities for more long tail private scientific and technological enterprises at the end of the supply chain.

Theory of combination of industry and Finance

The combination of industry and finance, that is, the integration of industrial capital and financial capital, realizes the internal integration of economic operation through various forms such as participation, shareholding, holding, personnel participation and so on. As early as the end of the 19th century, European and American countries basically had no restrictions on the cross-industry business of commercial and financial institutions, but at that time, the industry was highly dependent on banks. After the reform and opening-up, real economic market and financial market have developed together in China, forming

a strong joint force. 1978 ~ 2001 was the initial stage of domestic financial integration in China. Enterprises obtained capital from banks through various forms of financing, which laid a solid foundation for the realization of "industrial and financial integration". The second stage is from 2002 to 2012. The financial market is diversified, and the financial means used by enterprises are more diversified. Through the combination of industry and finance, resources can be allocated effectively. The third stage is from 2013 to now. The combination of industry and finance has reached a new height of development. Financial innovation from theory to practice, diversified development of the combination of industry and finance, and continuous integration. SCF is a new model of the combination of industry and finance. In the context of the new economic era, the combination of industry and finance will be the main driving force for the new wave of rapid growth in China, and SCF is an effective way to promote the combination of industry and finance. Based on the real trade background between enterprises in the industrial chain, SCF relies on the advantageous resources of core enterprises in the supply chain to complete the inflow of financial capital into the real economy of the industrial chain, and realize the combination of industry and finance in which funds flow from finance to industry. The regulation and guidance of SCF policies have promoted the flow of financial capital to the industrial field, which can not only promote the transformation of finance from virtual to real, reduce financial risks, but also provide financial resources for the survival and development of real industries. SCF shows great market vitality in the continuous innovation and development. It will have a very positive significance in optimizing the industrial ecological environment, improving the financing channels of private scientific and technological enterprises, and improving the service methods of financial institutions.

Digital ecology theory

Digital ecology is a new form of economic organization formed after the deep integration of the real economy with big data, the Internet and artificial intelligence. With the help of big data and Internet technology, heterogeneous organizations such as private scientific and technological enterprises, financial institutions and other production-oriented service entities operate in the SCF ecosystem. On the premise of maintaining the ownership of the entities, they realize cross industry business reengineering through data fusion based on ecological contracts, form an organic whole of different entities with high efficiency and low cost, and realize the multi-agent joint operation of the ecological platform, innovate the new ecological mode of digital restructuring industry. On the one hand, it can gather private scientific and technological enterprises in the platform to jointly purchase, produce and sell, and make use of peer collaboration to improve efficiency and reduce costs; On the other hand, supply chain products are grafted to the ecological platform to enjoy all kinds of public services provided by the ecological platform, including finance, channels, after-sales, and obtain dividends from the complementarity of different industry alliances. Therefore, the digital ecological platform is not a simple information sharing platform, but a joint operation carrier deeply integrated with users. From the enterprise level, the ecological platform will connect all kinds of subjects who have transactions with private scientific and technological enterprises with new linking means to form a value cycle system; From the perspective of industry, the digital ecological platform reorganizes the advantageous resources of industry, service industry and agriculture to form an industrial integration mechanism; From a social perspective, the digital ecological platform will gather different economies across time and space and industries to form a collaborative symbiosis system. Meng et al. (2020) believe that the digital ecosystem is composed of central enterprises, digital populations and value communities, which organically cooperate to form a benign and efficient material cycle, information transmission and energy flow. Digital ecology plays an important role in integrating, deconstructing and reconstructing the industrial chain (Li, 2020) and promoting the deep integration of technology and the real economy (Qi et al., 2020).

Research framework of SSCF

The emergence of SSCF cannot be separated from the integration support of digital technology. Compared with traditional SCF, SSCF platform is more complex, intelligent and interactive, showing huge differences in structure, process and elements.

Organization structure of loosely coupled Alliance

Under the integration and synergy of various digital technologies, the participants of SCF have been greatly expanded. There are mutual influences and interactions between each participant. The whole SSCF presents an organization structure of loosely coupled alliance. Based on a good introduction mechanism, the platform has accumulated a large number of various participants with advantages in risk control, credit enhancement and capital. More and more third-party service roles continue to participate in SCF services, but the participation of each new business will not cause the change of the original business. The accumulation of a large number of advantageous resources has weakened the excessive dependence of private scientific and technological enterprises in the upstream and downstream of traditional SCF on focus enterprises, and business entities continue to tend to interact independently. Under the loose coupling structure mode, on the one hand, it has fully expanded network resources, stimulated market vitality, increased the number of transactions, and greatly expanded the depth and breadth of SSCF business. On the other hand, it makes the SCF platform environment more flexible and agile to meet various transaction needs, more convenient for system maintenance, and greatly improves the service quality and efficiency of SCF.

Visual process of operation management

With the continuous innovation and development of SCF, there are more and more factors that affect the operation of the supply chain. The variability of customer demand, the complexity of the supply network, sudden natural disasters, etc., have higher and higher requirements for the flexibility of the supply chain operation. Under the influence of new generation technologies such as big data, Internet of things, blockchain and artificial intelligence, SSCF can realize visual management from many aspects such as process management, warehousing management, logistics management and data management,

which greatly improves the flexibility of smart service of SCF. As shown in Figure 2, the visualization of process processing is reflected in the order processing, order checking, order realization, order arrival, etc. of private scientific and technological enterprises in the upstream and downstream of SSCF. Warehousing visualization: when warehousing, storage units are automatically allocated to trading products according to attribute elements, and when outbound, operators pick up goods from specific storage units. The visualization of logistics tracking management reflects the transaction time, transaction location, storage status, cargo dynamics and other information of different goods of multiple enterprises, so as to make a timely response according to specific needs. Data application visualization, the historical transaction information between enterprises can be intuitively reflected on the platform. The platform can collect and refine data according to the needs of financing enterprises, and then further count, analyze and generate data models to facilitate financing enterprises to make management decisions. The realization of visual operation management enables each transaction node to be monitored in real time, find problems in time, and solve problems effectively, which greatly reduces the overall risk of financial operation activities in the supply chain.

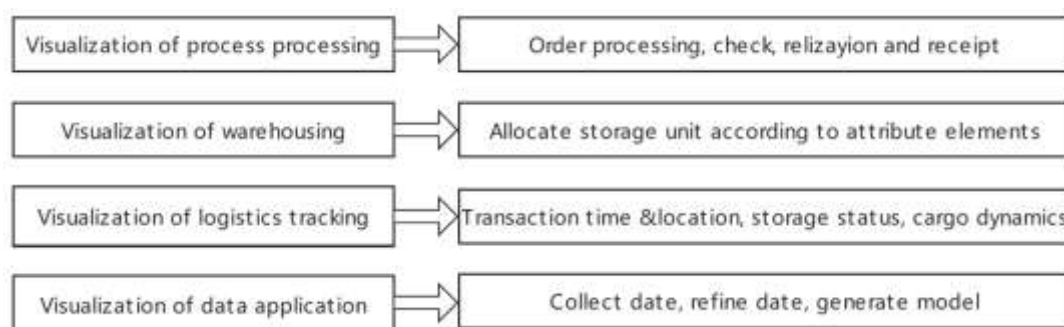


Figure 2: Visual process of operation management

Mechanism of symbiosis and coordination of multiple subjects

With the strong promotion of digital technology, the participants of SCF are becoming more and more complex, including ecological operation platforms of SCF, financial institutions, upstream and downstream private scientific and technological enterprises and other service providers. In the SCF ecosystem, various connection relationships, transaction relationships and collaborative relationships have been formed between private scientific and technological enterprises, financial institutions, ecological operation platforms and other entities and between the entities and systems by means of digital links, forming sticky and common vision goals based on symbiotic needs. In the operation mode of SSCF, private scientific and technological enterprises submit business applications to the SCF platform. The platform conducts data mining, collection, analysis and integration according to the transaction flow information of private scientific and technological enterprises, and submits the formed enterprise credit report to the fund provider for decision-making. Other service providers follow the corresponding intelligent contract according to the transaction instructions of the SSCF platform. Provide logistics, digital technology, infrastructure, industrial and commercial taxation and other services to the platform. Assist in financial risk identification, prevention and control, and ensure the efficient operation of financing activities. The essential object of SCF is capital. Under the multi-dimensional evaluation of borrowing enterprises by capital providers and the point-to-point monitoring of business activities by the SSCF platform, the authenticity, preservation and value-added of working capital in the business process are guaranteed. During the operation of SSCF, the interdependent integration of all parties involved, multiple participants go hand in hand, handle all financing links in SCF in a coordinated manner, and the whole process operates efficiently and orderly, jointly creating the ecological coordinated development of SSCF.

INNOVATIVE APPLICATION OF SSCF IN PRIVATE SCIENTIFIC AND TECHNOLOGICAL ENTERPRISES

Principle of intelligent effect

With the empowerment of digital technology, the operation activities and transaction nodes in supply chain can be truly and transparently reflected, which makes the credit differentiation and credit decision more intelligent. The transaction nodes of supply chain can realize penetrating monitoring and management. At the same time, improving the fair information platform has driven the efficient development between enterprises and the harmonious services of various public service institutions. The dynamic tracking of data makes the means of risk control further upgraded, so as to realize the intelligent effect of "intelligent decision-making, harmonious service, penetrating management and digital risk control", and timely and effectively solve the value demands of private scientific and technological enterprises. The key points of intelligent effect are shown in Figure 3.

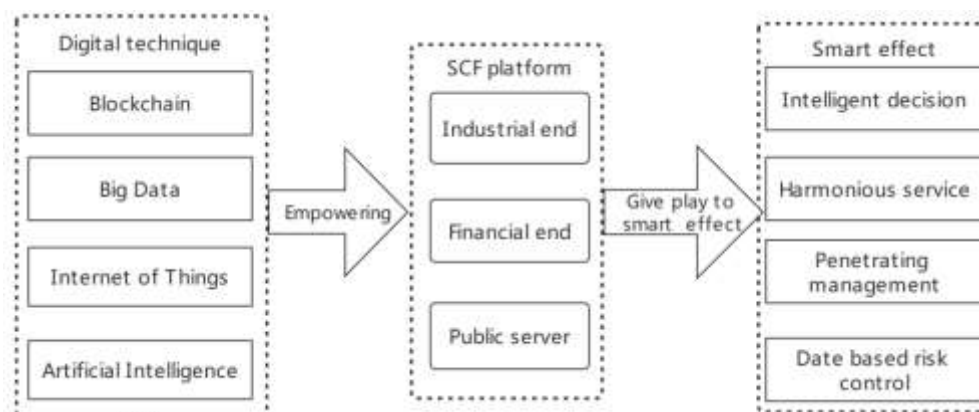


Figure 3: Smart effect of SSCF

Intelligent decision-making

The financing application of the SSCF platform for private scientific and technological enterprises first enters the intelligent screening mechanism, and enters the intelligent risk control system of the platform through the enterprise data information of the automatic screening system. The platform relies on own model of the risk control end and the embedding of external risk control services to jointly depict the accurate portrait of private scientific and technological enterprises, which is stored in the proprietary system of the platform risk system. The credit enhancement system enters the intelligent credit enhancement mode for the data information transmitted by the risk control end, completes the credit guarantee of private scientific and technological enterprises by means of credit enhancement configuration, credit guarantee, smart contract and so on, and stores the output information in the proprietary system of the credit enhancement system to provide credit support for the decision-making and credit granting of financial institutions in the next stage. The financing final settlement system intelligently selects the optimal financing scheme through the fund allocation system, issues instructions to the corresponding fund supply system, and completes the distribution and recovery of funds through the automatic credit extension and collection system. This series of intelligent financing means improves the operation efficiency, greatly reduces the occurrence of financial risks, and ensures the effective return of funds.

Harmonious service

More and more participants continue to join the camp, and SSCF has formed a large financing operation platform. At this time, SSCF is not only a traditional value-added chain, but gradually evolved into a cooperative chain of benefit sharing and risk sharing. Therefore, reasonable transactions and fair operating rules are very important for the whole SSCF, especially for emerging enterprises such as private scientific and technological enterprises that attach great importance to data information. A perfect and fair information platform will drive the harmonious and efficient development among enterprises. By building a high-level information sharing center and formulating a fair and equitable benefit distribution mechanism, the SSCF platform can comprehensively measure the investment products and financing needs with the help of the information platform, excluding enterprises that do not comply with the financing rules and credit, overcoming the imbalance caused by the allocation of power or resources, and effectively preventing the occurrence of moral hazard and speculation. Therefore, the harmonious service of SSCF realizes business interoperability, data availability and resource sharing, promotes the value creation and benign interaction between investment and financing parties, and achieves efficient coordination, harmony and win-win results.

Penetrating management

Traditional SCF is difficult to grasp the complicated operation state, especially at the far end of SCF. The expansion and application of digital technologies such as blockchain, big data, Internet of things, artificial intelligence and cloud computing have made private scientific and technological enterprises at all nodes of SSCF gain penetrating control. Big data modeling can provide private scientific and technological enterprises with qualification screening and accurate portrait services, so as to have a more comprehensive grasp of information of the traders and help them identify corporate credit. The combination of Internet of things and SCF mainly uses sensing technology, navigation technology, positioning technology and other methods to identify information, which is conducive to reaching all kinds of business information. Full process tracking management, automatic monitoring of warehousing and freight links to control the transaction process, so as to improve the authenticity of terminal transactions. As a distributed ledger database, blockchain technology makes use of the characteristics of distributed data storage, point-to-point transmission, consensus mechanism and so on, so that the information of the intermediate links of transactions between private scientific and technological enterprises can be traced. AI collects the business information of each scenario of the enterprise through sensors or manual input, intelligently analyzes and compares it with the stored information, and describes various possible implementation schemes, which saves the consumption of human and financial resources to a certain extent. The application of the above digital technology realizes the penetrating monitoring and management of each transaction node in the supply chain, and greatly improves the overall service quality and efficiency of SSCF.

Data based risk control

With the help of financial technology, in the SSCF system, through automatic and intelligent collection, analysis and processing of data information, improve information abundance and reliability. Big data can help the SSCF platform master the financial data, transaction data, industrial and commercial registration data, tax payment data, customs data and individual credit data of private scientific and technological enterprises, improve the ability of risk identification and simplify the risk process. The use of Internet of things technology can help the SSCF platform to dynamically track all participants. When national policies are adjusted or the market is impacted, it can timely know the changes in the business status of all participants and formulate risk response strategies in advance. At the same time, Internet of things technology can effectively build the cooperative relationship between the upstream and downstream of private scientific and technological enterprises through data information, so as to reduce the risk caused by the unstable relationship between enterprises in the supply chain. The incorrigibility of blockchain technology permanently stores information and data (Huang *et al.*, 2018) which will not be lost in the transaction link, and is transparent and traceable, ensuring the security and stability of data. Digital risk control provides the intelligent SCF platform with accurate identification of financial risks, and timely and effectively avoids the occurrence of financing accidents.

Operation design of SSCF

The penetration of digital technology has brought great changes to SCF. With the technological empowerment of blockchain, Internet of things, big data and other technologies, the credit enhancement, risk control and capital advantage resources attracted by the platform have brought diversified services to private scientific and technological enterprises on the platform, and the original complex and cumbersome financing process has become more efficient and convenient. private scientific and technological enterprises rely on their creditor's rights, physical or intangible assets, through the credit evaluation, risk rating and supply and demand distribution of the platform, to increase their credit and match the appropriate capital port to obtain financing funds; At the same time, the SCF platform uses the synergy of blockchain, big data, Internet of things and other technologies to provide intelligent risk management for financing services; The future sales or intangible asset transfer fees of private scientific and technological enterprises enter the SCF platform as a source of repayment, and the platform realizes automatic allocation of funds through intelligent payment and settlement. The specific process is shown in Figure 4.

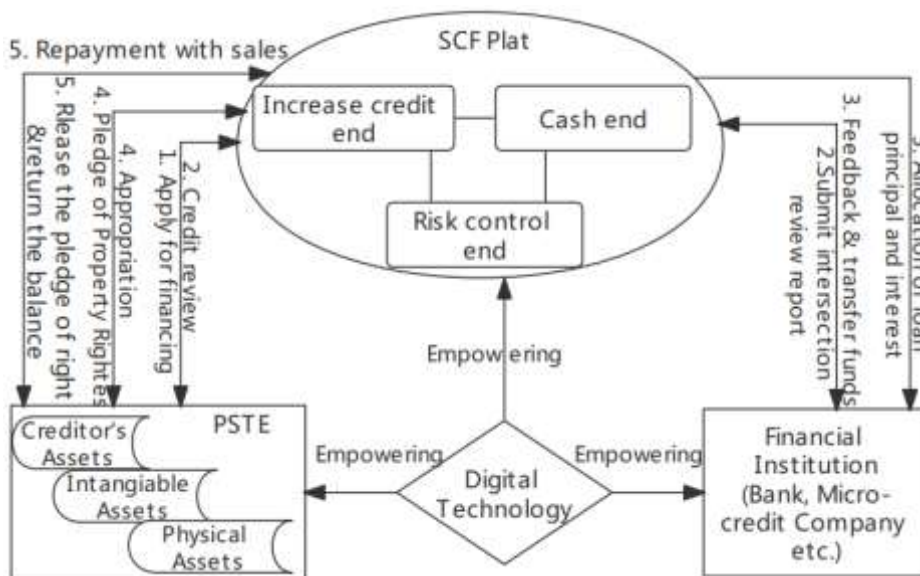


Figure 4: Operation process of SSCF

The operation process of SSCF is shown in Figure 4. First, private scientific and technological enterprises with creditor's rights assets, physical assets or intangible assets submit relevant purchase and sales contracts or asset certificates to the SCF platform and file financing applications. Second, the platform captures the circulation and transaction information of private scientific and technological enterprises through blockchain, big data and other technologies, and uses its own model to extract, integrate and analyze the data with the help of cloud computing to form a risk rating; Then, the evaluation information is transmitted to the credit investigation and evaluation institutions on the SCF platform, as well as the public utility systems such as the tax bureau and the administration for industry and commerce, to make credit evaluation reports and compliance guarantees for private scientific and technological enterprises; Further, according to the risk rating and credit evaluation, the financing needs are divided into appropriate financial institutions, and the credit review report is submitted. Third, financial institutions conduct multi-dimensional evaluation based on the offline credit status of private scientific and technological enterprises, provide financing credit to private scientific and technological enterprises, make credit decision feedback and allocate funds to the SCF platform. Fourth, agricultural enterprises pledge their sales claims, inventory possession rights or intangible asset use rights to SCF platforms. The platform will distribute funds to private scientific and technological enterprises; At the same time, the risk control end uses the Internet of things and artificial intelligence technology to continuously supervise the pledged assets and

share real-time data with financial institutions. Finally, the future sales payment or intangible asset transfer fee of private scientific and technological enterprises enter the capital end of the SCF platform through the smart contract signed with the platform. The platform automatically transfers the loan principal and interest to the account of financial institutions, collects a certain handling fee, returns the remaining amount to private scientific and technological enterprises, and removes the pledge of rights.

SSCF is based on the real business background to finance private scientific and technological enterprises that meet the pledge conditions. The platform uses digital technology to respond in a timely manner, cooperates with logistics enterprises, asset evaluation institutions and financial institutions to make online financing instructions in an orderly manner at every step, and carries out real-time dynamic monitoring of the business activities of private scientific and technological enterprises. The application of emerging communication technologies is in line with the characteristics of "short, frequency and fast" of private scientific and technological enterprises. It should be noted that in the SSCF platform, the risk control end will describe the risk characteristics of private scientific and technological enterprises, the credit enhancement end will describe the credit characteristics of private scientific and technological enterprises, and the capital end will provide the results of supply and demand matching for both parties of capital lending. Risk profile, credit characteristics and capital matching results are important basis for financial institutions to make credit decisions. Therefore, with the integration and support of a variety of digital technologies, the risk control end, credit enhancement end and capital end that absorb a large number of advantageous resources are the key control points for the operation of the SSCF platform, and also an important guarantee for the benign operation of SSCF.

COUNTERMEASURE FOR PRIVATE SCIENTIFIC AND TECHNOLOGICAL ENTERPRISES TO APPLY SSCF

Theoretically, with the empowerment of digital technology, SSCF can play an intelligent role in intelligent decision-making, harmonious service, penetrating management, and digital risk control. However, at present, whether at the organizational level or the supply chain level, the healthy operation of SSCF still faces great challenges. This challenge may come from the defects of knowledge, organizational structure or process design required for the successful implementation of SSCF within the organization, or may be related to external technical support, operation region and cultural complexity. The challenges faced by private scientific and technological enterprises in applying SCF are mainly manifested in three aspects: insufficient application of digital technology, imperfect institutional environment and serious lack of compound talents. The dynamic changes of these challenges will bring difficulties to the management, control and strategy implementation of SSCF. Therefore, this section puts forward the following three countermeasures and suggestions:

Expand the dimension of intelligent transformation

The intelligent transformation of SCF is essentially a new way for SCF to achieve exponential growth. Therefore, intelligent transformation is the only way for SCF to maintain agility and deepen competitiveness. Song(2020) divided SCF into traditional online SCF mode, circulating digital SCF mode, integrated digital SCF mode and integrated digital SCF mode according to the differences in the breadth and depth of application of SCF in digital platforms. Among them, the integration mode requires SCF to be relatively strong in the breadth and depth of application of digital technology. Intelligent SCF requires the application of digital technology to expand infinitely in the platform, covering all kinds of service providers and enterprises at all levels of the supply chain, and the digital technology should be deeply integrated with the industry, sink into all transaction links and processes of the participants, and ensure that the data of the whole chain is unobstructed and unblocked. In the process of digital transformation of SCF, having a large amount of data is the foundation. Understanding the development trend of digital technology is only the initial stage of intelligent transformation. Using strategic data management methods such as management, governance and mobile to convert data into insight, and then converting insight into action under the guidance of correct data strategies is the key to the success of intelligent transformation. This requires that SCF must rely on low-level and cutting-edge technologies and high-level digital tools and products to make breakthroughs in digital accuracy.

Establish a sound regulatory system and legal system

Building a sound regulatory system and legal system and other institutional environment is an important guarantee for the high-quality service of SSCF and the innovative development of private scientific and technological enterprises. From the perspective of the subject supervision system, the access mechanism of the SCF platform is the basis of the whole supervision system. The strict control of the access link can not only exclude some financing subjects with poor credit, but also carefully check the business qualifications of various service providers. Among them, for service providers of core modules such as risk control end, credit enhancement end and capital end, relevant laws and regulations require licensed services, such as payment and settlement, fund-raising, loan issuance and third-party guarantee, must be provided by licensed institutions; For businesses that do not strictly require licensed services in relevant regulations, such as technical services and post loan management, licensed institutions can cooperate with non-licensed institutions with professional advantages, in which licensed institutions are the key regulatory objects. The regulatory authorities can also expand the scope of supervision according to relevant regulations and cooperate with the SCF platform to supervise and inspect non licensed institutions. From the perspective of legal system, on different nodes of the SCF platform, different service providers responsible for risk control, credit enhancement and capital give full play to their respective professional advantages to jointly realize the innovation of SSCF model. However, in terms of risk sharing, clear unified norms and legal relations have not yet been formed. Therefore, clarifying the legal relationship of the participants and standardizing the behavior of the participants are the core issues to

ensure the good operation of the SSCF platform. At the same time, the wide application of digital technology in SCF urgently requires relevant laws and regulations to formulate corresponding legal standards for technical service institutions in terms of digital business qualifications, strengthen the formulation and improvement of relevant laws and regulations, and promote the standardized development of SSCF mode from the legal system.

Strengthen the cultivation of compound talents

Talent support is one of the key factors in the development of SSCF. All sectors of society should focus on strengthening the cultivation of compound talents and opening up channels for talent flow. First of all, from the government level, it is necessary to formulate and implement the development strategy of SCF talent construction from the top, formulate the training plan of leading talents in SCF, build a perfect talent training system of "supply chain management + modern finance + digital technology", and rely on universities and scientific research institutions to increase the training of professional and compound talents. At the same time, we should carry out or participate in international academic exchanges with an open attitude, actively absorb the advanced ideas of foreign SCF development and the innovative experience of science and technology, encourage enterprises to strengthen the effective output and learning of backbone personnel, and introduce high-level SCF compound talents to the world. Second, explore the cooperative training mode of "industry university research" in SCF. Promote social training institutions to strengthen exchanges and cooperation with enterprises and universities, realize the effective connection between enterprises, universities and scientific research institutions, build a SCF industry university research cooperation base, and improve the application and transformation ability of scientific research achievements in enterprise practice. Third, we should give full play to the important value of the SCF business to the continuous cultivation of talents. Enterprises should always adhere to the business philosophy of relying on talents for development, increase investment in talent construction, create favorable conditions and attract high-end talents. All kinds of enterprises, especially the core enterprises in the supply chain ecological environment, should build a good SCF talent training platform, a platform for talents to display their talents, optimize the talent development environment, based on enterprise practice, cultivate SCF elite talents, and create conditions for the benign operation of SSCF in China.

CONCLUSION

SCF has experienced the development stages of offline SCF, online traditional SCF, and Internet SCF, which has made contributions to alleviating the innovative development of private scientific and technological enterprises in China. However, with the transformation of China's economy from high-speed growth stage to high-quality development stage, higher requirements are put forward for the high-quality development of private scientific and technological enterprises. The high-quality development of private scientific and technological enterprises needs high-quality finance to support. Therefore, based on the background of the digital economy era, we propose a SSCF service model in this paper, and analyze the long tail theory, the combination of industry and finance theory and the digital ecology theory, which are the theoretical basis for the application of SSCF. We also focus on combing the theoretical framework of s SSCF from three aspects: loose coupling alliance organizational structure, visual operation management, and coordination element mechanism. Further, it explores the intelligent effect of "intelligent decision-making, harmonious service, penetrating management, and digital risk control" in the application of SSCF in private scientific and technological enterprises, and makes an innovative design for the operation process which private scientific and technological enterprises put to use SSCF. Finally, in view of the problems and challenges of SSCF in technology application in China, laws and regulations and talent construction at this stage, we put forward countermeasures and suggestions to expand the dimension of smart transformation, build a perfect regulatory system and legal system, and strengthen the cultivation of compound talents in this paper.

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REFERENCES

- Dou Y.Q, Zheng, M.X. & Gao, Xin. (2019). Research on the Innovative Application of Digital Supply Chain Finance in private Science and Technology Enterprises in China. ICEB 2019 Proceedings. 38. <https://aisel.aisnet.org/iceb2019/38>
- Hofmann E., Strewé U. & Bosia, N. (2018). Discussion—How Does the Full Potential of Blockchain Technology in Supply Chain Finance Look Like?. In: Supply Chain Finance and Blockchain Technology (pp77-87). Springer Briefs in Finance. Springer, Cham. doi: [org/10.1007/978-3-319-62371-9_6](https://doi.org/10.1007/978-3-319-62371-9_6)
- Huang C.C., Ye C.S., Wang X.X. & Shi Z.M. (2018). Research on the Construction of Wisdom Supply Chain System. Value Engineering, 37(23),121-123. doi:10.14018/j.cnki.cn13-1085/n.2018.23.049

- Jiang C.F.(2015). Service Innovation in Supply Chain Finance. *China Business and Market*, 29(01): 64-67. doi: 10.14089/j.cnki.cn11-3664/f.2015.01.009
- Li C.F. Li D.D. & Zhou C. (2020).The Mechanism of Digital Economy Driving of Manufacturing: Based on the Perspective of Industrial Chain Transformation and Upgrading Restructuring. *Commercial Research*, (02):73-82. doi:10.13902/j.cnki.syyj.2020.02.008
- Lu Y.J. & Zhang L.Y. (2020). Research on Financing differences and technology loan performance of private science and technology enterprises -- Based on the research of Yixing City, Jiangsu Province. *Academia Bimestris*, (06):51-56. doi:10.16091/j.cnki.cn32-1308/c.2020.06.010
- Meng F.L., Wang Z.Y., Zhao Y.J. & Yao X. (2020). The operational mechanism and evolution of the digital economic-ecological system. *Macroeconomic Management*, (02),50-58. doi:10.19709/j.cnki.11-3199/f.20200302.004
- Qi Y.D. & Xiao X.(2020). Transformation of Enterprise Management in the Era of Digital Economy. *Journal of Management World*, 6(06):135-152. doi: 10.19744/j.cnki.11-1235/f.2020.0091
- Saberi S., Kouhizadeh M., Sarkis J. & Shen L.(2019). Blockchain technology and its relationships to sustainable supply chain management. *International journal of production research*, (7):2117-2135. doi:org/10.1080/00207543.2018. 1533261
- Sfar, A. R., Natalizio, E., Challal, Y., & Chtourou, Z. (2018). A roadmap for security challenges in the Internet of Things. *Digital Communications and Networks*, 4(2), 118-137. doi.org/10.1016/j.dcan.2017.04.003
- Song H. &Yang Y.D. (2019). Innovation and Development of Modern ICT-enabled Smart Supply Chain Finance. *China Business and Market*, 33(12) :34-41.doi:10.14089/j.cnki.cn113664/f.2019.12.004
- Song H. (2019). The Development Trend of China's Supply Chain Finance. *China Business and Market*, 33(03):3-9. doi:10.14089/j.cnki.cn11-3664/f.2019.03.001
- Sun R., He D.Y. & Su H.L.(2022). Application of blockchain technology to preventing supply chain finance based on evolutionary game. *Chinese Journal of Management Science*. doi: 10.16381/j.cnki.issn1003-207x.2021.1538
- Wan X.L. & Qie X.Q. (2020).Poverty alleviation ecosystem evolutionary game on smart supply chain platform under the government financial platform incentive mechanism. *Computational and Applied Mathematics*, 372(10):112-115. doi.org/10.1016/j.cam.2019.112595
- Wang R , YU C & Wang J. (2019). Construction of supply chain financial risk management mode based on Internet of Things. *IEEE access*, (7):110 323-110 332. doi: 10.1109/ACCESS.2019. 2932475
- Yan N & Sun B. (2015). Comparative analysis of supply chain financing strategies between different financing modes. *Journal of industrial and management optimization*, (4):1073-1087. doi: 10.3934/jimo.2015.11.1073
- Zhang P.(2019).The Essence of Digital Economy and Its Development Logic. *Economist*, (02):25-33. doi:10.16158/ j.cnki.51-1312/f.2019.02.004