FACTORS AFFECTING SMES' CREDIT RISK AND CREDIT RISK ASSESSMENT BASED ON BLOCKCHAIN-DRIVEN SUPPLY CHAIN FINANCE

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SULTAN IDRIS EDUCATION UNIVERSITY

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FACTORS AFFECTING SMES' CREDIT RISK AND CREDIT RISK ASSESSMENT BASED ON BLOCKCHAIN-DRIVEN SUPPLY CHAIN FINANCE

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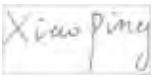

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ABSTRACT

The purpose of this research is to examine the factors affecting SMEs' credit risk and credit risk assessment based on blockchain-driven supply chain finance. This research mainly includes three objectives: The first objective is to examine whether the financing enterprises, core enterprises, assets position under financing, blockchain platform and supply chain operation have significant impacts on credit risk by using logistic regression and entropy method. The panel data were collected from CSMAR on fifty-six SMEs, eight core enterprises and twenty-six blockchain enterprises in the period of 2016-2020. The second objective is to establish a credit risk evaluation index system and used factor analysis to extract the principal factors, then 11 factors are extracted as the variable sources for credit risk assessment modeling. The third objective is to build a credit risk assessment model by using five methods: Classification Tree, Bagging algorithm, AdaBoost algorithm, Random Forest and Logistic Regression to construct the credit risk assessment model. Then, according to the model evaluation criteria, this research found out the credit risk assessment model with the best prediction classification performance. The findings show that the financing enterprises, core enterprises, assets position under finance, blockchain platform, and supply chain operation have significant impacts on SMEs' credit risk when the confidence level is 90%. In general, the performance of AdaBoost algorithm model is the best. It has the strongest ability to distinguish between enterprises with credit risk and without credit risk, and has strong stability. The research not only enriches the theories and method of credit risk assessment of SMEs, but also provides assistance in solving the problem of financing difficulties for SMEs due to its ability to accurately assess credit risk.

KAJIAN TERHADAP FAKTOR-FAKTOR YANG MEMPENGARUHI RISIKOKREDIT SME DAN PENILAIAN RISIKO KREDIT BERASASKAN KEWANGANRANTAIAN BEKALAN DENGAN RANTAI BLOK

ABSTRAK

Tujuan kajian ini adalah untuk mengkaji faktor-faktor yang mempengaruhi risiko kredit PKS dan penilaian risiko kredit berdasarkan kewangan rantaian bekalan yang didorong oleh rantai blok. Kajian ini melibatkan tiga objektif utama: Objektif pertama adalah untuk memeriksa sama ada pembiayaan perusahaan, perusahaan utama, kedudukan aset didalam pembiayaan, platform blok rantai dan operasi rantaian bekalan mempunyai kesan yang signifikan pada risiko kredit dengan menggunakan kaedah regresi logistik dan Kaedah entropi. Data panel telah dikutip dari CSMAR terhadap lima puluh enam PKS yang dipilih, terdiri dari lapan perusahaan utama dan dua puluh enam perusahaan blok rantai dalam tempoh diantara 2016-2020. Objektif kedua adalah untuk menetapkan sistem indeks penilaian risiko kredit dan analisis faktor yang digunakan untuk mengekstrak faktor utama, kemudian 11 faktor diekstrak ini digunakan sebagai sumber pembolehubah penilaian risiko kredit. Objektif yang ketiga adalah untuk membina model penilaian risiko kredit dengan menggunakan lima kaedah: Pohon Klasifikasi, Algoritma Bagging, Algoritma AdaBoost, Random Forest dan Regresi Logistik untuk membina model penilaian risiko kredit tersebut. Seterusnya, menggunakan kriteria penilaian model, penyelidikan ini dapat mengenalpasti model penilaian risiko kredit dengan prestasi klasifikasi ramalan terbaik. Dapatan menunjukkan bahawa pembiayaan perusahaan, perusahaan utama, kedudukan aset didalam pembiayaan, platform blok rantai, dan operasi rantaian bekalan mempunyai kesan yang signifikan pada risiko kredit PKS dengan aras kepercayaan adalah 90%. Secara umum, prestasi model algoritma AdaBoost adalah model yang terbaik. Ia mempunyai kemampuan yang paling kuat untuk membezakan antara syarikat dengan risiko kredit dan syarikat tanpa risiko kredit, dan mempunyai kestabilan yang kuat. Kajian tidak hanya memperkaya teori dan kaedah penilaian risiko kredit PKS, tetapi juga memberikan bantuan dalam menyelesaikan masalah kesulitan pendanaan PKS kerana kemampuannya untuk menilai risiko kredit dengan tepat.

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LIST OF ABBREVIATIONS

AUC	Area under Curve
BP	Back Propagation
CBRC	China Bank Regulatory Commission
CNNIC	China Internet Network Information Center
CSRC	China Security Regulatory Commission
CSMAR	China Economic and Financial Research Database
DPSO	Dynamic Mutation Particle Swam Optimization
KS	Kolmogorov Smirnov
OOB	Out of Bag
P	Accuracy
S_e	Sensitivity
S_p	Prediction Accuracy
SCF	Supply Chain Finance
SCRM	Supply Chain Risk Management
SLR	Systematic Review Procotol
SML	Supervised Machine Learning
SMEs	Small and medium-sized enterprises
SVM	Support Vector Machine
WoS	Web of Science

APPENDIX LIST

CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter is an introduction to the issues related to the research in general. The research background is described from four aspects: the development process of Small and medium-sized enterprises (SMEs), the historical development of supply chain finance (SCF), the development of blockchain technology, and risk management, describing the issues to be studied in the research, proposing the research objectives. In addition, this chapter presented the research questions based on the objective of the study, explaining the aspects related to theoretical framework that underlie study based on the resources that reliable from researchers in the field. Furthermore, the definition of terms is elaborated, which consists of blockchain platform, credit risk, financing enterprises, core enterprises, assets position under financing and supply chain operation. The significance of the study was presented in the chapter and scope and limitation of the study was clearly explained.

1.2 Background of the Study

SMEs are the new force of China's economic development. As a main component of China's economy, SMEs account for 90% of the total, providing 80% of urban employment, creating 70% of GDP, 60% of scientific and technological innovation and 50% of tax revenue. By 2021, SMEs accounted for 96.5% of China's market participants, contributing more than 60% to GDP and 79.4% to urban labor employment (Economic Daily, 2022). SMEs have played a non-substitutable function in boosting employment that promoted national economic development and ensuring social stability (Deng et al., 2022). There are a large number of capital gaps, but the general financing cost is high. With the impact of epidemic, the financing situation is more severe. In response to the financing constraints of SMEs, the China Bank Regulatory Commission (CBRC) required the five state-owned banks to increase their loan targets for SMEs by 30% or more in March 2021 (Prospective Economics, 2021). The Central Bank and other five departments issued documents to further extend policies related to inclusive finance.

However, although SMEs play such an important function in China's economy, and the Chinese government places a high premium on the development of SMEs, SMEs still face various difficulties in their production and business activities, especially the financing difficulties (Dong, 2022). In order to solve the pressure imposed on SMEs by the slowdown of China's economic growth in recent years, the People's Bank of China has also released liquidity to the market through corresponding fiscal and monetary policies to activate the productivity of SMEs. Due

to the imperfect management system and financial system, and the lack of sufficient collateral, commercial banks are more willing to extend credit to large enterprises with relatively low credit risk than SMEs. The financing difficulties of SMEs have not been solved, which has become a concern in recent years (Fire Coin Research Institute, 2020).

In the traditional financial environment, core enterprises have the characteristics of high industry status, great market influence, strong economic strength and high integrity, which are recognized as high-quality enterprises by banks and other financial institutions. However, SMEs have the characteristics of low industry status, weak economic strength and low financial transparency, which are often recognized as high-risk enterprises by banks and other financial institutions (Zhu, 2016). Therefore, it is generally difficult to obtain financing from financial institutions. Even if obtained financing, SMEs need to pay high financing costs.

As core enterprises have strong bargaining power and industrial position advantages, credit sales have become the mainstream way of transaction in the supply chain (Lu, Song, & Yu, 2022). In view of this, upstream and downstream suppliers are prone to financial shortage. The rupture of the downstream capital chain will have a greater impact on the supply chain. In this context, all industries in the world have recognized the importance of supply chain management. In order to manage the supply chain more efficiently and reduce risk, the concept of SCF has been introduced (Fire Coin Research Institute, 2020).

However, in the SCF mode, banks take core enterprises as the center, who managed the capital flow, the business procedure between core enterprises and upstream and downstream SMEs transform the uncontrollable risks of SMEs into controllable risks of the whole supply chain, and control the risk to the lowest extent (Zhu, 2016). Therefore, SCF is conducive for SMEs to obtain finance without paying high financing costs. In the traditional supply chain model, supporting the financing difficulties of upstream and downstream enterprises in the supply chain is the deep-seated reason that restricts the effective operation of the entire supply chain (Zheng et al., 2022). SCF is expected to play a positive function in alleviating the lack of funds of SMEs, loosening the financial constraints of core enterprises and promoting the stable growth of supply chain.

With the globalization of economy and politics, the production division of different industries has become more detail and clear, and the competition between supply chains has replaced the original competition pattern. Most enterprises choose to build modules with their own comparative advantages for modules that may divert their energy and resources, they choose to outsource to other enterprises and cooperate to achieve efficient control of supply chain costs (Song & Yang, 2022). At the same time, as the core enterprises in the supply chain have great demand for orders, SMEs are scrambling to become a member of the core enterprise in supply chain (Lu, Song, & Yu, 2022).

The concept of SCF came into being in the 1980s in China (Caniato et al., 2016; Zhao & Huchzermeier, 2018), offering financing solution for SMEs is their purpose (Li et al., 2020), as well as improving the productivity, velocity and accuracy

of responding to rapidly changing customer needs by coordinating and integrating information and capital flows (Chen et al., 2020). SCF has attracted extensive attention internationally, and many researchers have studied SCF from different perspectives. SCF was originally defined as a solution to short-term financing difficulties (Camerinelli, 2009; Lamoureux & Evans, 2011; More & Basu, 2013).

In addition, SCF is regarded as a capital flow process between participating enterprises in the supply chain (Liu, Zhou, & Wu, 2015), which is a financial solution provided by financial institutions to solve the financing issue of SMEs with capital needs (Zhang et a., 2015). In other words, SCF is a unique commercial financing model, it depends on core enterprises to provide extensive financial services to financing enterprises, so as to stabilize the production, supply and marketing chain between core enterprises and upstream and downstream enterprises in the supply chain, reduce operating costs, and make banks, enterprises and supply chain coexist harmoniously.

Although the main participant of China's supply chain financial services generally believes that China's supply chain financial market has development potential, but there are still many issues in the growth of supply chain financial business, such as capital bottleneck, technical bottleneck and unclear policy and system supervision, among which the issues related to capital, technology and risk control are of high concern (Liang & He, 2020). As information flows are closely related to risk levels, they are intrinsically closely related to SCF (Valeri et al., 2022). In the supply chain, a company's financial difficulties often affect related companies. This leads to the contagion effect of the entire credit risk (Chang et al., 2015).

Therefore, fewer and fewer financial institutions are willing to provide financing to SMEs because of credit risk (Song et al., 2021). As it is difficult to assess credit risk, banks in SCF are unwilling to provide funding to SMEs.

The main motivation of SCF is to better ease the financing difficulties of SMEs (Wang et al., 2020). However, information asymmetry is one of the reasons why it is hard for SMEs to gain credit. At the moment, big data and cloud computing on behalf of the new generation of information technology is speeding up the reconstruction of the production and lifestyle, and promoting human beings to enter the era when all goods and services are around consumers, which puts forward high requirements for product supply chain management (Adams et al., 2018). From the above literature, it can be seen that addressing information asymmetry is an important task in supply chain management.

Some banks, such as the People's Bank of China, have been constructed a credit reporting channel to integrate an intact set of credit information, and used the credit information database for the most comprehensive coverage (Credit Investigation Center of the People’s Bank of China, 2020). However, In the supply chain, information about many licensed financial institutions, in addition to debtor liabilities, also includes information about internet-based financial institutions (Borodako et al., 2021). Therefore, a highly information integrated agile supply chain system is gradually being established from production, warehousing, logistics, distribution to retail, which provides a basis for the application of blockchain technology in the supply chain (Du et al., 2020).

There are a number of elements that contribute to the credit risk of the supply chain, some of which are demand uncertainty, supply instability, and information random asymmetry. These issues may result in significant risk and loss of profit (Liu et al., 2020). For instance, banks or core firms will be subject to a variety of risks, including policy, operation, market and credit (Sang, 2021), and competing retailers are often unequal in many aspects (Wu et al., 2019). Due to the large number of participating enterprises in the supply chain model, there are many connections between enterprises, which can easily lead to credit risk.

In addition, the infectious impact of SMEs' credit risk on core firms will have a large negative effect on their operation and growth of those enterprises, which will subsequently disrupt the steady operation of the entire supply chain. This will have a domino effect on the entire economy (Xie et al., 2020). While this is going on, there will be isolated islands of information in the supply chain. Asymmetric information will lead to repeated pledge, empty pledge and other risk events, seriously hindering the mutual trust of financing parties, and bringing difficulties to financing (Du et al., 2020). One of the challenges faced by SMEs is the lack of effective tools or methods to transmit their potential information (Song et al., 2021), which may lead to credit risk.

Credit risk, which is one of the most significant concerns associated with SCF, is contagious, which results in the propagation of credit risk across the supply chain economy (Zhang, 2016). Credit risk is easily transmitted and amplified by supply chain relationship, and develops into system risk (Li et al., 2020). However, there are amounts of issues farther down the supply chain, such as shifts in consumer behavior

and changes in demand, that are very important to the overall development of the supply chain's feeling of responsibility and adaptability (Singhal et al., 2011). At present, a key challenge confronted by the supply chain information system is to integrate and provide information about the company's external orders, inventory and product status (Nandi et al., 2020). The fact that the deployment of blockchain technology may successfully integrates information is shown by the preceding reference.

With the emergence and development of technologies such as artificial intelligence, blockchain, cloud planning and big data, SCF solutions have become more powerful (Zhu & Zhou, 2016). In 2016, blockchain technology rose in China. After it appeared, it won the favor of the financial industry, and also got the attention of various fields. For a time, blockchain technology has been promoted in various markets in China (Adams et al., 2018). Currently, in many regions, especially in China, several blockchain platforms have emerged to provide information services for enterprises.

Blockchain has officially become a national strategy in the Fourteenth Five Year Plan for National Economic and Social Development (2021-2025) and the Vision of the People's Republic of China for 2035 (Dutta et al., 2020). Therefore, the number of blockchain driven projects used to improve the efficiency of SCF is growing rapidly (Rega et al., 2018). High level officials stressed the need to boost the profound conformity of blockchain and real economy, and handle the issues of SMEs' loan financing, bank risk command and department monitoring (Li et al., 2020). Because of its technological features, such as no transaction, distributed ledger, and

traceability, blockchain technology offers inherent benefits in SCF (Wang & Wu, 2021). Traceability is one of the most significant function indicators of global supply chain management (Debajyoti et al., 2022). This above research indicated that blockchain technology is largely used in the Chinese market, which can indeed solve the financing difficulties of SMEs, providing a platform for risk control of capital providers.

The standard of China's supply chain financial market depends on the total financing demand of SMEs. Since the 21st century, banks and SMEs have jointly promoted the rapid development of the supply chain financial business, and the variety of supply chain financial products has been constantly enriched, forming a pattern where banks and core enterprise products have developed together. The scale of China's supply chain financial market rose from 10.5 trillion yuan in 2014 to 15.2 trillion yuan in 2018, with a compound annual growth rate of 9.7%. In 2018, the Ministry of Industry and Information Technology of China (2020) issued the Implementation Guide for Promoting Enterprises to Cloud (2018-2020) to promote the large-scale application of cloud computing in China, and put millions of enterprises to cloud on the national agenda. At the same time, the popularity of blockchain technology and the growing maturity of the logistics network have enabled SCF to benefit from a number of scientific and technological development achievements (Sharma, Jindal, & Borah, 2022).

The access threshold and financing costs of SCF have been further reduced, and the industry has made more efficient judgments on high-quality projects. On the basis of the large number of SMEs in China, the total number of high-quality projects

will usher in a qualitative leap, which will provide space for the long-term and high-speed development of the supply chain financial market scale (Xie, Shi, Gu, & Xu, 2022). Although China's real economy is facing downward pressure, there are a large number of SMEs. Under the premise that financing needs have not been met, financing needs remain rising. In the next five years, the size of the supply chain financial market will remain stable growth. It is estimated that by 2023, the size of China's supply chain financial market will grow to 23.8 trillion yuan (LeadLeo research institute, 2019).

The empowerment of new technology makes the overall cost of the supply chain decrease and the efficiency improve. The new benefits will bring value to the core enterprises and SMEs both (Wamba & Queiroz, 2020). Through blockchain technology, it is possible to assure the reliability of the data and mutual recognition of those data so that transfer core corporate credit and minimize performance risks, as well as increase operational efficiency and decrease business expense. The use of blockchain technology in the realm of SCF has the potential to ultimately satisfy the requirement for the mutual confirmation and matching of numerous information origin in supply chain, and alleviating a significant source of discomfort (Xingxiong et al., 2018). In addition to this, in contrast to the conventional supply chain, the supply chain supported by blockchain will undoubtedly produce less operational risk (Choi, 2020). Blockchain technology helps solve the financial problems of SMEs, thereby reducing the financial risks of financial institutions (Xue, 2022)

Valeri et al. (2020) adopted blockchain and smart contracts to boost supply chain procedure and SCF through mapping method. Three blockchain adoption

scenarios in a dual channel supply chain composed of e-retailers and manufacturers were explored (Tianyu et al., 2022). Guo et al. (2021) used blockchain and the Internet of Things to propose a new information management framework to solve the problem of information asymmetry in SCF transactions, which promotes the effective supervision of information flow and business processes, strengthens process management, and reduces the operational risk of SCF. In order to maintain the information sharing of alliance members in the supply chain, the enterprise credit information sharing model based on blockchain technology is adopted (Zheng et al., 2022).

The phases of supply chain risk management (SCRM) may be broken down into the following categories: identifying the risk, evaluating the risk, processing the risk, and monitoring the risk (Chen et al., 2018). It is vital to do a credit risk assessment since doing so will help the connection that exists between SMEs and banks (Sang, 2021). Various data-driven methods are used to process credit risk prediction, such as regression model, data envelopment analysis (Cielen et al., 2004) and classification algorithm (Zhu et al, 2019). Although this problem has been solved in previous studies, few studies benefit from network perception analysis, which considered the characteristics of network relations between partners to train Supervised Machine Learning (SML) algorithm to predict credit risk (Fayyaz et al., 2021). The conventional approach for predicting credit risk cannot accommodate the specific requirements of this kind of forecast.

Several models have been developed to assess credit risk, they have certain significance, but they also have some major defects. Support vector machine (SVM)

is a generalized linear classifier that groups data via the use of supervised learning. On the other hand, in contrast to the recently created algorithm, the efficiency of this method is relatively low in terms of the required time and band performance (Wei et al., 2016). Logistic regression is the appropriate kind of regression analysis to use in situations in which the variable in question is binary. This approach is used in order to provide an explanation for the connection between differential binary variables. However, logistic regression is very sensitive to the multicollinearity of the independent variables in the model (Yan, 2021). This means that one variable will have a significant influence on the production of other variables.

In machine learning, the approach of inductive reasoning known as the decision tree is the one that is employed the most often. On the other hand, the outcomes of the decision tree might be unreliable due to the fact that even minute shifts in the data could result in the generation of whole new trees. This problem, however, can be circumvented by using the integrated decision tree (Dahiya et al., 2016). Many researchers believe that machine learning is a good tool (Zhu et al., 2019). The use of tools connected to machine learning for the purpose of prediction is not only an interesting development, but also a potentially useful strategy for coping with the unpredictability of occurrences in the future (Fonseca et al., 2020). Therefore, this research used machine learning method to evaluate credit risk.

Based on the findings of past studies, it is clear that the most significant factor contributing to the difficulties that it is hard for capital providers to evaluate SMEs' credit risk especially in the complex mode, every participant in the blockchain-driven SCF mode may have an effect on the credit risk of financing enterprises (Zhu et al.,

2016), such as core enterprises (Xie et al., 2020), blockchain platform (Tan et al., 2020), supply chain operation (Liu & Huang, 2020; Zhu et al., 2019) and assets position under financing (Sang, 2021). How to effectively assess credit risk has become the most important task to reduce credit risk.

Particular attention was paid to the credit risk elements as part of the process of developing the risk assessment model for blockchain-driven SCF. This research conducted an empirical investigation to determine if financing enterprises, core enterprises, assets position under financing, blockchain platform, supply chain operation affect credit risk in the mode of blockchain-driven SCF. Then, collected the relevant indicators of credit risk influence factors, and used machine learning method as a way to construct credit risk assessment model to forecast SMEs' credit risk.

1.3 Problem Statement

As the economy of the world enters the downward adjustment cycle, the number of fraudulent loans and default events has increased, and the commodity credit crisis is gradually developing. Due to the harsh information system that is controlled by state-owned capital, SMEs often have difficulty obtaining financial backing via equity finance (Du et al., 2020). Due to the strict information system dominated by state-owned capital, SMEs are often difficult to gain financial support through equity financing (Zhan et al, 2018) and high credit risk hinder the further development of accounts receivable financing (Caniato et al., 2016).

Asymmetric information has led to repeated pledge, empty pledge and other risk events, which has severely damaged the mutual trust mechanism of financing parties and brought difficulties to financing (Du et al., 2020). According to the data shown above, information asymmetric is one of the factors contributing to the challenges that SMEs have while attempting to get finance. However, in the actual operation of SCF, SMEs will be in a situation of capital constraint and narrow financing channels. The accounting period pressure of core enterprises increases, and the difficulty of supplier chain management increases. Due to information asymmetry, SMEs are hard to achieve success in developing (Li et al., 2020). These points have been restricting the supply chain. In the final analysis, it is a double-edged sword for SCF to obtain high authenticity, wide coverage and effective data.

In the supply chain model, SMEs are usually upstream and downstream enterprises. The emergence of supply chain financial business promoted the development of SMEs and commercial banks, but the default of financing enterprises not only damaged the interests of banks, but also affected the defaulting enterprises and their upstream and downstream related enterprises (Xia, 2021). Although SCF provided financing facilities SMEs, once SMEs have problems, they will be transmitted to other supply chain participating enterprises. However, with the growth of SCF, credit risk increases with the limitation of SMEs' quality and supply chain financial management policies (Liu et al., 2020).

There are a number of elements that contribute to the credit risk of the supply chain, some of which are demand uncertainty, supply instability, and information random asymmetry. These issues may result in significant risk and loss of profit (Liu,

et al., 2020). For instance, banks will be subject to a variety of risks, including policy, operation, market, and credit (Sang, 2021), and merchants that compete with one another are often asymmetric in many respects (Wu et al., 2019). Additionally, the infectious effect of SMEs' credit risk on core enterprises will have a large adverse effect on the operation and growth of those enterprises, which will subsequently disrupt the steady operation of the whole supply chain (Xie et al., 2020). This will have a domino effect on the entire economy.

In every supply chain, there is at least one firm that serves as the hub. SMEs may be found either upstream or downstream of firms, the development of which is contingent on the growth of core enterprises (Xia, 2021). As more banks participate in the supply chain, the credit position of core businesses and SMEs will improve owing to the increased connectivity of the supply chain. Nevertheless, the credit risk will also increase and might potentially be conveyed across the whole supply chain (Kuang, Du, & Feng, 2020). Therefore, the healthy credit standing of the core organizations in the supply chain is a vital guarantee for the continued existence and growth of the SMEs.

Credit risk associated with SCF is contagious, which results in the proliferation of credit risk inside the supply chain economy (Zhang, 2016). Credit risk is easily transmitted and amplified by supply chain relationship, and develops into system risk (Li et al., 2020). However, few academics pay attention to downstream issues like demand variations and consumer behavior, despite the fact that these aspects play a crucial role in strengthening the supply chain's adaptability as well as its feeling of responsibility (Singhal et al., 2011). The credit risk of core enterprises

will spread throughout the supply chain, thus threatening the financing security of the entire supply chain (Zheng & Zhang, 2020).

The relationship between SMEs and upstream and downstream can be reflected in assets position under financing (Sang, 2021). At present, a key challenge faced by the supply chain information system is to integrate and provide information about the company's asset position under financing, such as inventory and product status (Nandi et al., 2020). Assets position under financing are mainly reflected in accounts receivable or inventory, and the connection between SMEs and both the upstream and the downstream processes (Yin et al., 2020). Besides the fact that it is quite difficult to verify the genuineness of the business histories of companies, to confirm the right of accounts receivable of core enterprises, to collect the money according to the agreement of core enterprises, as well as to conduct due diligence SMEs, enterprises generally have limited rationality on the environment and trade activities themselves, which may lead to opportunistic behavior.

Not only the internal financial status and management status of SMEs, which we called financing enterprises, but also the financial status and credit degree of counter parties in the supply chain are factors that have a hold on the credit risk of SMEs. This means that the factors that affect the credit risk of SMEs include both of these aspects (Zhang et al., 2015). SCF, which acts as an approach between supply chain members, combines the financing procedure of whole members of the supply chain and enhances the worth of the supply chain (Bals, 2019). This is in contrast to the conventional method of financing, which is used in most cases. As a result, the credit risk of SMEs is influenced not only by the SMEs themselves, but also by

supply chain operation factors (Yi & Guo, 2021).

These factors include the financial and non-financial situation of enterprises, the supply chain operation situation, and the characteristics of pledge objects (Zhu et al., 2019). SCF itself also has environment risk, financing risk, information technology risk, human resource risk and basic mechanics risk, thus damaging the existence and debt paying of financing enterprises (Yan & He, 2019). In the middle of the supply chain there lies an information island (Xie et al., 2020). Finally, it turns into the credit risk of SMEs. Although the present academic study on SCF is more in-depth, it is still in the beginning stages of its development (Thurner, 2018).

The improvement of application system and blockchain platform can promote business operation and improve the speed of capital flow (Yang, 2019), but the centralized supply chain financial platform is facing the challenge of information abuse, record tamper, transaction unverifiable. The willingness of enterprises to join the platform is reduced as a result of these restrictions, which has a negative effect on the value that is created by supply chain participants (Choi & Luo, 2019).

The SCF business introduced by blockchain platform is bound to have an impact on the operation business of the original platform. The smooth development of blockchain-driven supply chain business has a strong correlation with the cooperation mode of supply chain participants, and the supply chain financial risk driven by blockchain also needs systematic research (Tan et al., 2020). Therefore, blockchain-driven SCF is a new model, whether could reduce the credit risk of financing enterprises is an important research topic.

Accurately grasping the risk transmission mechanism of the supply chain and analyzing the factors that affect the risk transmission of the supply chain are crucial to grasping the risk transmission law of the supply chain that stopping the risk transmission in the supply chain network in time for the supply chain risk early warning, and minimizing the threat and loss of the risk to the supply chain (Wang & Zhang, 2022). Therefore, it is vital to study the credit risk factors of SMEs in the mode of blockchain-driven SCF.

The ability to properly integrate the many sources of risk, enhance the risk management practices that correspond to those risks, and exercise proper risk control is essential to the success of a supply chain financing company (Jiang et al., 2019). Even while the current body of research has singled out a number of risk variables and approaches to managing supply chain risk, a strategy that is more all-encompassing is still required (Kumar & Park, 2019).

However, the amount of credit risk that firms face has also changed dramatically as a result of the strong relationship that exists among enterprises regarding the flow of information, finance, and other elements. Because of the complexity of this kind of financing, it is becoming more difficult to accurately determine the credit risk of businesses. Previous research on SCF focused mostly on credit risk assessment systems, but such studies were unable to identify the most important components that influence credit risk (Yang, Chu, Pang, Liu, & Yang, 2021). As a result, it is required to investigate the elements that influence credit risk and to devise a risk assessment index system that is both scientific and fair by using

the factors as the basis for its calculations.

The credit risk assessment index system that is currently in place is unable to accurately represent the full features of the whole supply chain. There has been very little study done on the impact mechanism of blockchain platforms' effects on the credit risk of SMEs, and this is especially true now that blockchain technology has been deployed (Zhang & Song, 2022). The supply chain financing sector in China has just recently begun to expand, and the data collecting that is associated with it is quite challenging. At the moment, there is a lack of an evaluation system that is able to effectively differentiate risks in the practice field of domestic commercial banks and better fit the features of blockchain-driven SCF businesses (Mia et al., 2022).

The early evaluation model is mainly subjective and depends on specialist experience. Although specialist have efficient experience, the method lacks objectivity and is too subjective (Zhu et al., 2019). The superiority of credit risk assessment model based on traditional financial index is that it can extensively involve multifarious financial indicators. However, it just be devoted to evaluate finance information. The improved financial indicator credit risk assessment model adds non-financial index, but most assessment methods are assumed to be linear (Wu et al., 2022).

Machine learning method has several advantages compared to traditional linear models such as multiple regression models and SEM. Firstly, Machine learning method can not only identify linear relationships between multiple predictive factors and outcome variables, but also complex nonlinear relationships, allowing for the

exploration of hidden patterns from real data (Hew et al., 2019). In machine learning method, the inductive reasoning method called decision tree is the most commonly used method. On the other hand, the outcomes of the decision tree might be unreliable due to the fact that even minute shifts in the data could result in the generation of whole new trees. However, this problem can be circumvented by using the integrated decision tree (Dahiya, Handa, & Singh, 2016).

Various data-driven methods are used to process credit risk prediction, such as regression model, data envelopment analysis (Cielen et al., 2004) and classification algorithm (Zhu et al., 2019). Guan et al. (2023) considered Artificial Neutral Network, support vector machine (SVM), decision tree, Bayesian network and logistic regression are widely used in supervised machine learning method for classification problems. Although this problem has been solved in previous studies, few studies benefit from network perception analysis, which considers the characteristics of network relations between partners to train machine learning algorithm to predict credit risk (Fayyaz et al., 2021).

The traditional credit risk assessment methods largely rely on human judgment based on a set of decision-making rules and policies. Therefore, machine learning method and data mining technologies have been developed to help financial decision-making based on big data and improve prediction accuracy (Shen, Zhao, Li, Li, & Meng, 2019). However, most studies ignored the impact of changes in time and credit assessment criteria (Dahooie et al., 2021). Therefore, this research used machine learning method to construct a credit risk assessment model.

The conventional approach for predicting credit risk cannot accommodate the specific requirements of this kind of forecast. As using machine learning related tools for prediction is not only a noteworthy trend but also a promising method to deal with the uncertainty of future events, many researchers believe that machine learning is a good tool (Zhu et al., 2019). This is because the use of machine learning related tools for prediction is not only a good tool for dealing with the uncertainty of future events, but also a good method for prediction of relatively large datasets (Fonseca et al., 2020). As a result, the technology of machine learning was used in this study to assess the level of credit risk.

At this time, the academic study being conducted on the topic of how blockchain technology may be used in SCF is qualitative research (Zheng et al., 2022). In addition, research on the credit risk assessment of SCF that is powered by blockchain platforms is scarce. Because of the complexity of this style of financing, it became much more difficult to accurately assess the credit risk posed by businesses. As a result, it is necessary to do research on the correlation between the variables of credit risk assessment in blockchain-driven SCF mode, particularly the interaction between credit risk and blockchain platform.

In the meanwhile, it is essential to create a rational and scientific risk assessment index in order to re-evaluate it (Sang, 2021). However, the amount of data required and the conditions that must be satisfied varies somewhat depending on the technique used (Fu & Wang, 2020). The fundamental study on the standardization of risk identification is still in its infancy and has a long way to go. Even if the assessment of the whole supply chain system has been ensured and the excellent

credit of major businesses, the credit risk of SCF cannot be totally removed (Liu et al., 2020). At the moment, there is very little in the way of an assessment model that is capable of better matching the qualities of blockchain-driven SCF businesses.

In general, credit risk in the blockchain-driven SCF model is mainly influenced by financing enterprises, core enterprises, assets position under financing, blockchain and supply chain operation. Due to the increased connections between the participating enterprises under the blockchain-driven SCF model, credit risk will be transmitted between enterprises, and the information asymmetry between enterprises makes credit risk assessment difficult. Therefore, it is important to explore the factors that affect SMEs' credit risk and establish a credit risk assessment model to predict SMEs' credit risk.

1.4 Research Objectives

The general purpose of this research is to find out influencing factors of SMEs' credit risk, using logistic regression method to examine whether financing enterprises, core enterprises, assets position under financing, blockchain platform and supply chain operation have effect on credit risk, which is a basic for credit risk assessment. In order to solve the problem of credit risk identification, this study constructed credit risk assessment index, then used machine learning method to build credit risk assessment model to forecast SMEs' credit risk. The specific objectives of the research are:

1. To examine the relationship between financing enterprises and SMEs' credit risk.

2. To examine the relationship between core enterprises and SMEs' credit risk.

3. To examine the relationship between assets position under financing and SMEs' credit risk.

4. To examine the relationship between blockchain platform and SMEs' credit risk.

5. To examine the relationship between supply chain operation and SMEs' credit risk.

6. To construct the credit risk assessment model through Machine learning method to predict SMEs' credit risk.

1.5 Research Questions

Based on the research problem, this study aimed to examine the influencing factors of SMEs' credit risk, constructed credit risk assessment index according to the influencing factors of SMEs' credit risk, then used machine learning method to build credit risk assessment model to forecast SMEs' credit risk. In general, this study aimed to answer the following questions:

1. Do the financing enterprises have significant effect on SMEs' credit risk?

2. Do the core enterprises have significant effect on SMEs' credit risk?

3. Do the assets position under financing have significant effect on SMEs' credit risk?

4. Do the blockchain platform have significant effect on SMEs' credit risk?

5. Do the supply chain operation have significant effect on SMEs' credit risk?

6. Do the credit risk assessment model have good prediction classification performance in SMEs' credit risk?

1.6 Research Hypotheses

Based on the research question and research objective. This are the hypotheses for the research:

Hypotheses H1: Financing enterprises have significant effect on credit risk

Hypotheses H2: Core enterprises have significant effect on credit risk

Hypotheses H3: Assets position under financing has a significant effect on credit risk

Hypotheses H4: Blockchain platform has a significant effect on credit risk

Hypotheses H5: Supply chain operation has a significant effect on credit risk

Hypotheses H6: Credit risk assessment model has a good prediction classification performance.

1.7 Theoretical Framework

The focus of the section is to develop a theoretical framework to achieve a schematic diagram with relevant theories.

1.7.1 Information Asymmetric Theory

The initial literature analyzed the information asymmetry in supply chain management that mainly focused on asymmetric cost information and demand

information (Corbett & Groote, 2000). Information asymmetry contains two basic meanings: To begin, one of the party accounts for a greater share of the information about market transactions than the other party does. This is because the distribution of information regarding market transactions between the two parties is asymmetric. Second, both of the parties involved in the transaction have a solid understanding of the position that corresponds to their respective information. The party at a disadvantage in terms of information lacks relevant information. Nonetheless, the probability distribution of related information may be comprehended, and certain plan can be formed about the market (De Meza & Webb, 1987).

Some economists consider that information asymmetry affects individuals' evaluation of the quality of goods and services in the market and that is the main reason for market failure (Akerlof, 1970) and decided how they anticipate the intentions and agents of others (Spence, 1976). A condition of having insufficient information is basically what uncertainty is, and knowledge might help remove some of that doubt. Therefore, if there is a rise in the amount of information, there will be a decrease in the amount of ambiguity, and the level of risk will also decrease proportionally (Knight Frank, 1921).

The subjective moral hazard of the transaction subject will further worsen the situation of information asymmetry. Providers may take advantage of this convenience to deliberately conceal the true information of the enterprise's financial situation and provide false quality information for the two sides of financial transactions occupy different positions in the transaction. Arrow (1963) showed that the essence of moral hazard is the principal-agent problem of both parties to the

contract. After the transaction agreement is signed, the principal cannot fully monitor all the behaviors of the agent. The agent used information asymmetry to purposely damage the interests of the other party and increase its own interests. In developing countries with imperfect information system, credit fraud caused by information asymmetry is very serious (Mishkin, 1990).

Pishchulov, Richter and Golesorkhi (2022) adopted a traditional supply chain coordination model and studied it under the condition of asymmetric information, which may bring about coordination failure and low performance. Their purpose was to examine the extent to which the claims in the literature about the ability of partial credits to improve total earnings are applicable to the environment under study. From the perspective of management, it is believed that supply chain performance will continue to improve with closer integration. Specifically, tighter integration may actually damage supply chain performance or have no impact. The results show that supply chain coordination under asymmetric information can be achieved by holding only a few shares, which can absorb coordination deficits and produce fully integrated supply chain efficiency.

Enterprises in the supply chain usually deal with barriers according to related information (such as requirement, subscriber fondness, technology investment cost, etc) (Lu, Gu, & Huang, 2019). However, supply chain members in different links will decide to optimize their income according to the information they have, which is usually private information. Participant with information advantages can obtain more income by concealing their private information, which has an effect on supply chain management (Li & Lai, 2021). Xin et al. (2021) used the demand distribution of two

enterprises to analyze the supply chain contract problem with asymmetric information. In particular, in the case of asymmetric information, only the incumbents can obtain actual and private demand information, while suppliers and entrants cannot obtain information about market demand status.

1.7.2 Supply Chain Finance Theory

The research of SCF started from the theme of inventory financing and accounts receivable financing in the late 1940s, and gradually expanded to a wide range of research areas, especially after 2005, the SCF problem has been more widely and deeply studied. Finances for the supply chain originally, the word "theory" referred to a remedy for a temporary financial problem (More & Basu, 2013; Lamoureux & Evans, 2011; Camerinelli, 2009). In addition, SCF is considered to be the capital flows that occur within a supply chain (Liu et al., 2015). SCF is a range of financial methods that are proposed by financial institutions to suppliers and customers who are experiencing requirement on their working fund (Zhang et al., 2015).

The objective of SCF is to give a financing method for SMEs (Li et al., 2015), and to promote the productivity, velocity and precise of responses to rapidly changing customer demand through the harmony and integration of materials, news and financial flows. The administration of supply chain working capital, the management of supply chain buyer and seller payment processes, and the management of supply chain capital flow are all components of the supply chain financial industry. It is

generally agreed that supply chain accounts receivable finance, supply chain accounts payable financing, and supply chain inventory financing constitute the primary financing methods for supply chain financial businesses (Hofmann, 2009).

Shenzhen Development Bank was the institution that first presented the idea of SCF to the Chinese public in June of 2006. Since that time, the bank has also developed a variety of products related to SCF (Liu et al., 2015). In general, Chinese academics have defined SCF as a synthetic financial product and service that is furnished to upstream and downstream enterprises in the supply chain. This is accomplished through the utilization of self-repaying trade finance, third-party supervision, and other means in order to control property rights or close the flow of funds or financial flows. To put it another way, SCF is an unconventional model for a business's financial operations (Li et al., 2015).

The SCF providers, the SCF receivers, and the focal firm are the three primary players in a typical SCF transaction (Bals, 2019). In addition, the three forms of finance that make up the supply chain are accounts receivable finance, inventory finance, and account payable finance (Wang, Wang, Lai, & Liang, 2020). In addition, SCF is a topic of study that draws from a wide range of disciplines, including sociology, computer science, mathematics, management and finance. When it comes to the supply of financial services for supply chains, money flow and logistics should flow according to the manner specified in the contract. This will surely lower the level of risk (Zhang, Zhang, Ma, & Chen, 2019). SCF has been growing and developing in China for over 20 years, and it now plays an essential role in the financing of small and medium-sized businesses (Gong et al., 2021).

With the support of the robust financial strength and important industrial standing of core firms in the supply chain, this perspective created the fundamental theoretical framework of SCF. Its objective is to assist SMEs in the chain in reducing their debt levels (Kouvelis & Zhao, 2018). It was not until 2006 that Berger et al. (2006) putted forward a more comprehensive financing theory of SCF business. Its core idea is to propose mortgage financing of current assets in the supply chain, consist of bill mortgage financing and goods mortgage financing. According to Pfohl and Gomm (2009), SCF is a method of optimizing financial transactions between businesses that are part of the supply chain. The goal of the strategy was to increase the value of each participant in the supply chain by integrating the financing processes of consumers, suppliers, and service providers in the supply chain.

In order to stabilize the supply and sales chains of upstream and downstream enterprises in the supply chain and to relieve capital pressure, it provided comprehensive financial services to multiple enterprises base on core enterprises. In addition, SCF has changed the process of banks providing credit directly to SMEs, making it possible to lower the threshold for SME financing (Wang et al., 2020). When the bank is credit granting, it will not be restricted to the static financial statements of SMEs, but rather examined its transaction background in SCF (Zhu et al., 2019).

1.7.3 Blockchain-driven SCF Theory

Scholars have begun to explore more deeply the formal analysis and modeling technology of blockchain technology in production, operation and supply chain. Although many conceptual and empirical studies have been done, they play an increasingly significant function in evaluating ceremonial analysis modeling solutions to further understand blockchain phenomena. It is helpful for later researchers to propose a comprehensive and compact assessment of this topic.

A revolutionary computer technology that can sustain many probable procedure and supply chain related applications which is called blockchain (Sharma, Jindal, & Borah, 2022). Blockchain technology has greatly affected trade, commerce and research fields. Blockchain based employment are studied based on the following types: security, data store, entry control, common understanding, and smart contracts.

Lambourdiere (2020) took the time to extensively examine the necessary literature in order to explain how blockchain technology might enhance supply chain performance based on dynamic capability, supply chain management, and digital supply chain theory. Blockchain primarily increased the expression of the supply chain by using the resources offered by the marine supply network to generate formless capabilities. This allowed for the chain's overall performance to be improved (Lambourdiere & Corbin, 2020).

Bitcoin was the initial use of blockchain technology for conducting safe and

anonymous payments, but many other unique applications of blockchain technology have been suggested, notably for supply chain management (Nakamoto & Bitcoin, 2008). Agi and Jha (2022) developed an overall framework for the adoption of blockchain in the supply chain by identifying contributing factors and assessing their interdependence and effect on adoption based on experience. Emerging in the market were systems for SCF based on blockchain technology (Wang et al., 2017).

Through extensive literature review and the theory of innovation diffusion, as well as the theoretical perspective of the business technology adoption model improved by Iacovou, Benbassat and Dexter (1995), 20 factors contributing to the adoption of blockchain in the supply chain were identified. In the validation phase, the decision test and evaluation laboratory method were used to extract logic from the data collected by 37 French experts to understand the impact of the contributing factors and their interdependence. This study stretches multi theoretical empirical research to blockchain technology, and determines the contributing factors for blockchain adoption from the perspective of technology, organization, supply chain and external environment. Considering the significance of the category of contributing factors, it is found that the comparative advantage of technology and external pressure are the most eminent classification of contributing factors that affect the adoption of blockchain in the supply chain (Wang, 2021).

Xu and Yao (2016) designed a digital bill trading platform, in which the agreement between members such as the status of each member is completed through the smart contract. Through the combination of induction and deduction, 94 selected publications from the top journals published from 2018 to 2021 were extracted. Then,

they developed a blockchain delegation model, which shows the interconnection of the three trust dimensions according to the content analysis results. In general, blockchain promote accuracy and transparency of information by delivering relevant information and boosting the adoption of electronic tokens to follow goods as the move along the purchases (Bajwa, Prewett, & Shavers, 2020). This review is intended to be the first comprehensive study of previous studies on integrating and integrating blockchain and trust to response the question of how this technology affects trust factors in the supply chain.

Tan et al. (2020) focused on the adoption of blockchain benefits in the project of credit control system composition for SCF. According to them, the key to improving efficiency is the quantization of intelligent agreement under blockchain technology, which exacerbated the risk of information asymmetry. The performance of blockchain can make decentralized supply chain members integrate and achieve a collective goal (Adams et al., 2018). Lambourdiere and Corbin (2020) proposed a theory about how to boost the efficiency and effectiveness of an offshore supply chain by implementing digitization in the form of blockchain technology to blend blockchain technology in their supply chain machinery and activities (Du et al., 2020). It is believed that blockchain can bring comprehensive improvement to SCF, boost the efficiency of business processing and reduce the total business cost.

In order to coordinate the monitoring of food across the agricultural supply chain in a way that is both more secure and more efficient, the model that has been developed uses blockchain technology, smart contracts, and MAS to coordinate the tracking of food in the agriculture supply chain that improved security and efficiency

(Chen et al., 2019). Nayak and Dhaigude (2019) constructed SCF for supply chain control in SME using blockchain technology coupled with discussions with industry specialist, from the model, then using MICMAC analysis categorized SCF based on the driving power and dependence.

Based on the modified demand function, Wan, Yang and Teng (2022) constructed the profit model of producers and e-commerce platforms before and after adopting blockchain technology, and studied the investment decision situation and contract motive framework of supply chain members using blockchain method. Applying blockchain technology to the supply chain, members can optimize costs and increase profits by extracting more valuable information. When the investment cost meets certain conditions, the use of blockchain technology can make participant more profitable.

Chen et al. (2020) took the automobile retail industry as an example, this study introduced a blockchain technology driven system design, solved these key problems in SCF, and provided the detailed implementation plan, as well as successfully developing a blockchain technology-driven SCF platform. On this platform, the smart contract technology is used to partially automate the workflow, and both human errors and interruptions during the execution of contracts are kept to a minimum. Yang, Gao and Feng (2022) have proposed a Stackelberg model and considered four situations: cooperation without blockchain, cooperation with blockchain, competition without blockchain and competition with blockchain. This research studied how manufacturers will choose between cooperation mode and competition mode when blockchain is adopted to delete consumers' concerns about

the quality of re-manufactured products.

Wang and Wu (2021) putted forward the supply chain financial risk assessment algorithm and the supply chain financial game algorithm on the blockchain for analysis. Li, Shao, Ye, Xu and Huang (2020) proposed a blockchain based logistics finance execution platform as an integrated scheme to promote the e-commerce retail. Aslam, Saleem, Khan and Kim (2021) confirmed different blockchain characteristics and their impact on different supply chain practices.

Nandi, Moya, and Kaynak (2020) aimed to explore how enterprises strive to integrate blockchain technology into their supply chain systems and activities. Chen (2020) adopted a blockchain-driven SCF platform, which committed to ensure the trust between creditors and debtors and reduce the financing cost. It can be seen from the above literature that blockchain can solve information asymmetry, and credit risk that is caused by information asymmetry. Therefore, this study uses a blockchain-driven SCF model to verify whether blockchain has an impact on credit risk.

1.7.4 Theoretical Framework

The part is mainly to construct a work blueprint. In order to study the factors affecting SMEs' credit risk, this study presented the existing theoretical relationship structure.

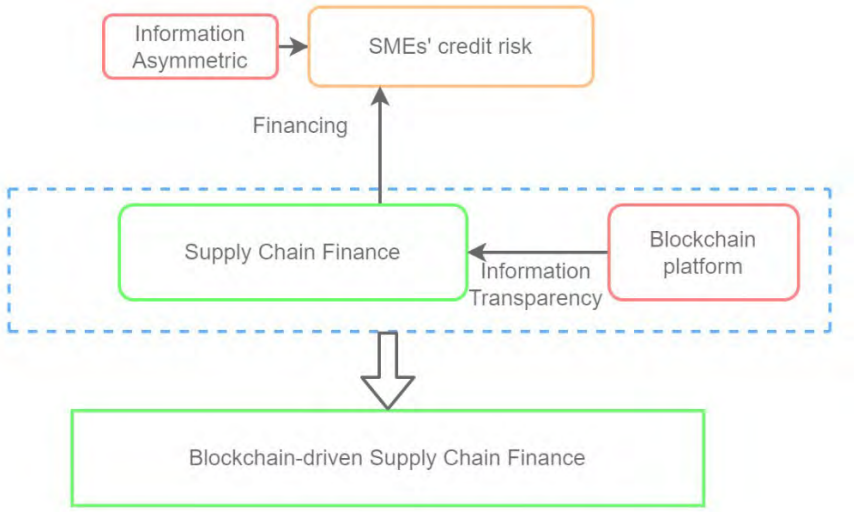

Figure 1.1. Theoretical Framework. (*Data source: Tsinghua University blockchain and supply chain financial report,2020*)

1) The mode of blockchain platform applied in accounts receivable financing. In the context of blockchain, the participants of the entire SCF include suppliers, financing businesses, core companies, and capital providers. These parties must first register as members of the blockchain platform before participating in the SCF. For the purpose of preventing information asymmetry, the information flow, data flow, business flow, and logistics of these parties are all thoroughly documented on the blockchain platform (Zhu et al., 2018). Taking use of the fact that blockchain is capable of storing information in a transparent manner, all participants in this platform are able to get information on the interest rates of other parties. Direct applications for loans are submitted by financing firms via the multiples of core enterprises that are conveyed on the blockchain network. In the meanwhile, the capital provider examines the multiples of core firms via the blockchain platform, determines the validity of the transaction, and then chooses whether or not to lend depending on the credit risk

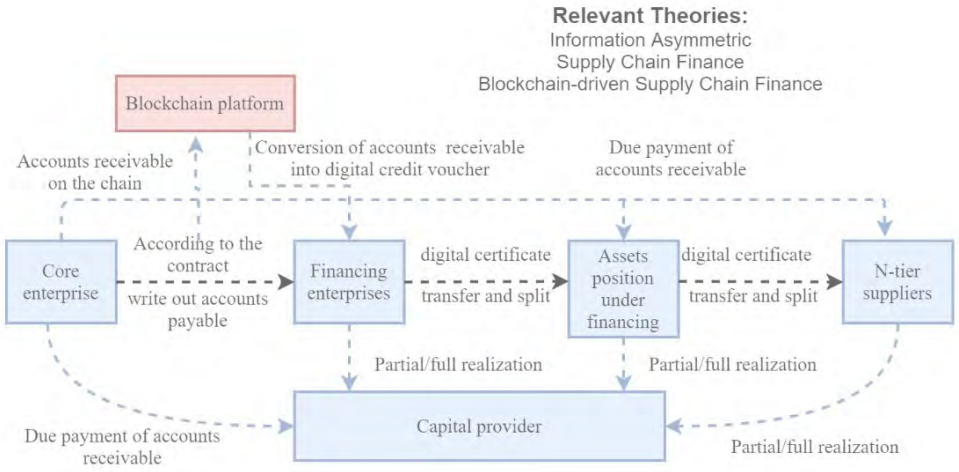

Figure 1.2. Blockchain-driven SCF Mode. *(Data source: Tsinghua University blockchain and supply chain financial report, 2020)*

Consider the case of financing accounts receivable as an illustration. To begin, the major financing businesses and the core company come to an agreement on the terms of the supply contract (Martin & Hofmann, 2019). Due to the fact that the core business is unable or unwilling to pay the main supplier promptly, accounts payable are issued by the core enterprise to the primary supplier. Confirming whether or not the accounts payable are connected to the main business is one of the functions of the blockchain platform. Following the validation of the core business, the blockchain platform transforms the accounts payable of the core business into a digital debt voucher, which is then distributed throughout the chain (Xue, Dou, & Shang, 2020).

It is possible to divide digital creditor's rights certificates, transfer them, keep them until they mature, and finance them. Businesses that provide financing on any level have the ability to divide and transfer a portion of the digital debt voucher to a better provider in exchange for payment for products (Vipin & Amit, 2021). In order to keep a portion of the voucher, it will be realized after the core business cashes the

accounts payable. Additionally, the digital debt voucher will be used to finance in financial institutions in order to maintain this portion of the voucher. Due to the fact that the debtor of the digital creditor's rights certificate is the core enterprise, financing in financial institutions is possible at all degree of the digital creditor's rights certificate. The high credibility of core enterprises may be utilized by financing companies, making it easier to obtain cheaper funds (Emtehani, Nahavandi, & Rafiei, 2021). Following the cashing out of the account by the core enterprise, the capital provider and all of the financing businesses at all standards are able to get the matching amount by virtue of the digital debt voucher that they own.

For example, Zheshang Bank established the accounts receivable platform in 2017. The platform adopts the model of "blockchain+SCF", which can handle the issuance, acceptance, confirmation, payment, transfer, pledge, cashing and other businesses of accounts receivable, transform accounts receivable into electronic payment settlement and financing tools, revitalize the originally illiquid accounts receivable assets, and provide core enterprises and member units of the supply chain with upstream and downstream enterprises, who have expanded innovative financing channels and built a supply chain financial ecology (Zheshang Bank Co., Ltd, 2021).

2) Prepayment financing mode under blockchain-driven supply chain. For prepayment financing, there are few projects on the whole, and most blockchain prepayment financing is a subsidiary project of accounts receivable financing. After a lot of information query, the existing blockchain prepayment financing projects can be roughly divided into the following three categories: supply chain financing projects specifically for prepayment financing needs. Risk control projects providing

information and data services for SCF, and subsidiary items attached to accounts receivable financing (Choi, 2020).

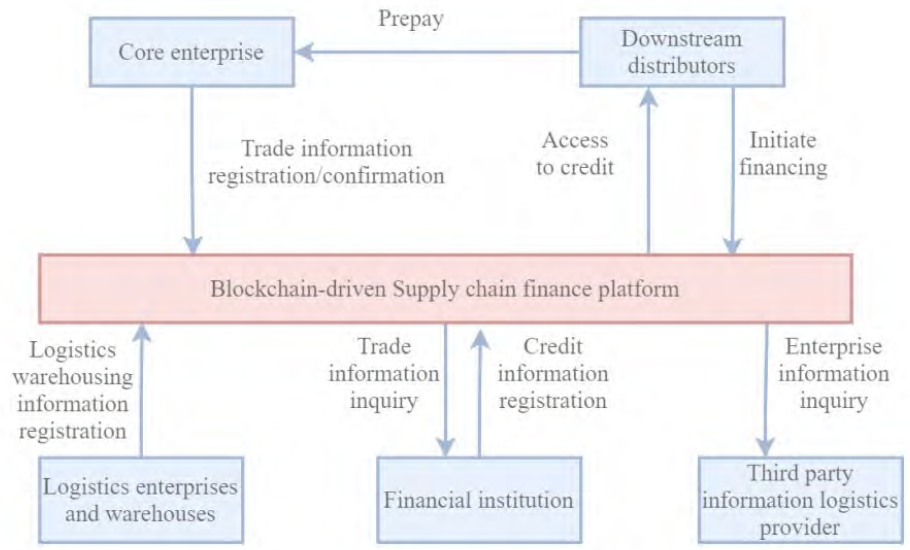

Figure 1.3. Prepayment Financing Mode under Blockchain-driven SCF. *(Data source: Tsinghua University blockchain and supply chain financial report, 2020)*

For example, Zheshang Bank realizes the block chain installment mode based on the accounts receivable platform, and core enterprises cooperate with Zheshang Bank to meet the needs of downstream enterprises or end consumers for installment procurement. Downstream enterprises or end consumers can issue installment receivables to pay to core enterprises according to actual needs, so as to relieve the tension of single payment (Emtehani, Nahavandi, & Rafiei, 2021). After receiving installment receivables, core enterprises can confirm sales receipts in advance to expand sales. The application scenario of Installment Pass is highly suitable for customers in the industry chain such as automobiles, large equipment manufacturing enterprises, and leasing companies (Jabbar et al., 2020).

Relying on this model, Zheshang Bank and Chuanhua Financial Leasing Company carried out platform and business cooperation, designed and developed the Installment Platform product, set the control quota with Chuanhua Financial Leasing as the core enterprise, and took truck drivers as platform members. For the rent receivable from Chuanhua Financial Leasing to truck drivers, the corresponding receivables accepted by truck drivers were issued through the Installment Platform, and after Chuanhua Financial Leasing applied to Zheshang Bank for confirmation and transfer, provided truck drivers with full line financing support (Zheshang Bank, 2021). This platform mode is helpful to improve the market competitiveness of its truck staging business. At the same time, help bus drivers solve the problem of insufficient funds for car purchase and provide guarantee for transportation business (Adams et al., 2018).

3) Movable asset finance mode under blockchain-driven supply chain. The adoption of blockchain technology to the large warehouse receipt platform of a certain bulk commodity is the most applicable field of blockchain in chattel pledge at present (Yavaprabhas et al., 2022). Based on blockchain technology, a comprehensive warehouse receipt platform integrating warehouse receipt issuance, transfer, pledge, financing, transaction, liquidation, bill of lading and other functions, including warehouse receipt issuance, warehouse receipt transfer, pledge financing and efficient bill of lading pickup, that can provide a systematic service scheme of integrated linkage of import and export financing and domestic and foreign trade for bulk commodity trading (Zhang et al., 2022).

For a long time, the traditional warehouse receipt transaction information has the problems of data falsification, easy tampering, low credibility and so on, which will lead to the repeated pledge of warehouse receipt. Take the blockchain warehouse receipt as the industry standard and promote it. The digital warehouse receipt will be produced simultaneously when the goods are put into the warehouse. The quantity, specification, photos and other information of the goods will be written into the blockchain to handle the problem of warehouse receipt credibility (Wan et al., 2022). At the same time, using the characteristics of blockchain warehouse receipts, it can realize multi-party witness, ensure the consistency and credibility of warehouse receipts information, avoid risks, standardize warehouse receipts pledge business, and avoid repeated warehouse receipts pledge (Yavaprabhas et al., 2022). In this way, the interests of the upstream and downstream of the transaction are guaranteed, the credibility of the parties to the transaction is greatly improved, the traditional mode of transaction is reduced, the security the business are improved.

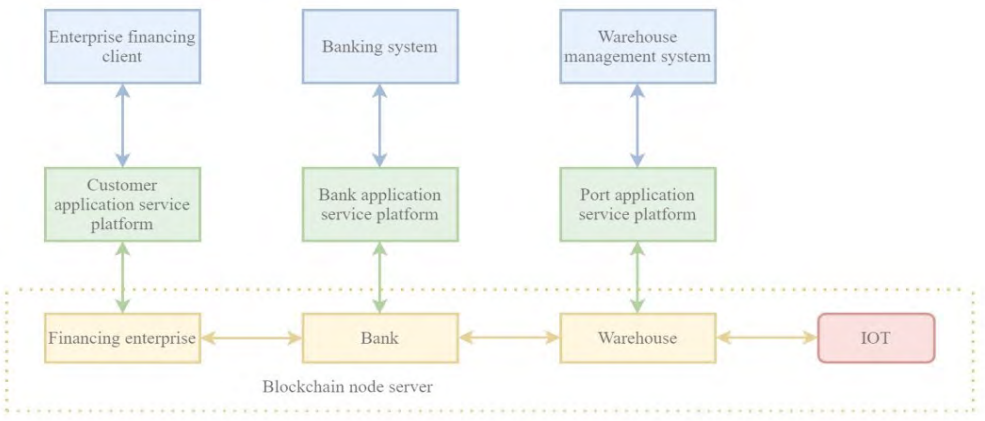

Figure 1.4. Overall System Architecture of Chattel Pledge Blockchain. *(Data source: Tsinghua University blockchain and supply chain financial report, 2020)*

In the current blockchain-driven SCF model, SMEs obtain financing by mortgaging assets to banks, and the value of collateral is guaranteed by the credit of

core enterprises. Therefore, the credit of core enterprises is the key for SMEs to obtain financing in the existing model (Wang et al., 2022). In other words, if the credit of the core enterprise declines, even if the blockchain realizes information transparency and sharing, the financing mode of accounts receivable and prepayment is difficult to be recognized by the bank. The chattel pledge mode can still achieve the purpose of financing due to the value of the chattel itself, but the repayment or repurchase commitment of the core enterprise is no longer effective, the effectiveness of this financing model will also decline (Wan et al., 2022).

For example, Zheshang Bank (2021) launched the warehouse receipt communication platform based on blockchain technology in 2018. Under the blockchain warehouse receipt communication mode, core enterprises and Zheshang Bank cooperate to provide inventory right pledge financing services for the depositors and dealers. The stockholder issue blockchain warehouse receipts based on the warehousing goods. They can handle circulation transfer or pledge financing and other businesses on the warehouse receipt communication platform, and can also pick up warehousing goods from the warehousing enterprises.

Zheshang Bank (2021) provides capital supervision, warehouse receipt pledge, notice of payment and delivery, financing and other services in this process. Warehouse Order Link helps inventors to revitalize their goods rights, solve the problem of difficult and expensive financing, provide efficient and safe pledge financing, transaction and circulation services for non-perishable bulk goods and seasonal goods, help core enterprises grow up to a steady sales system and customer

base, and is of great value to the supply chain finance of bulk commodities.

Relying on this platform, Zheshang Bank, together with Zhejiang Petrochemical Trading Center, has created the first oil trading blockchain warehouse receipt communication platform in China to realize online operation of the whole business process (Zheshang Bank, 2021). The blockchain warehouse receipt communication platform solution adds an electronic trading platform party on the basis of the tripartite model of the warehouse supervisor, the bank and the depositor, becoming the Quartet model (Yermack, 2017). The warehouse receipt communication platform is connected with the platform of Zhejiang Oil Center and the storage supervisor respectively. The warehouse receipt issuance, financing and withdrawal functions are completed on the warehouse receipt communication platform, and the transaction is completed on the platform of Zhejiang Oil Center.

The warehouse receipt communication platform of Zhejiang Oil Center implements life-cycle control over warehouse receipts issued on the platform, and the operational blockchain technology records the issuance, transfer, payment, financing, picking and other nodes and states of warehouse receipts, and synchronizes them to the system of Zhejiang Oil Center (Zheshang Bank, 2021). The scheme innovates the application scenario of the warehouse single transaction platform, improves the value of the warehousing supervision enterprise, activates the inventory of the depositor, and expands the market sales scale (Wan et al., 2022).

According to the preceding analysis, the primary adoption modes of blockchain-driven SCF propose the traditional SCF principle, and combined with the characteristics of blockchain technology information sharing, transparency, tamper proof and traceability, in order to handle the problems of information asymmetry that are the present purpose of traditional SCF, which prevent the transfer of credit to core enterprises. At the same time, it enhances the risk control capabilities of financial institutions, such as banks and lenders.

1.8 Definition of Terms

1) Credit Risk. Credit risk is a kind of default risk, which refers to the default result affected by the borrower or counterparty's unwillingness or inability to perform the contract conditions due to various reasons, resulting in the loss of banks, investors or the counterparty (Zhu et al., 2019). The credit risk defined in this research refers to the financial risk of the supply chain driven by the whole blockchain caused by SMEs' default and non-payment of debts.

2) Financing Enterprises. SMEs in the supply chain are usually midstream and downstream enterprises in the supply chain. They are the demanders of creditor's rights financing, called financing enterprises. The core enterprises are creditor's enterprises providing financing, and can also be counter-guaranteed creditor's enterprises (Lu, Gu, & Huang, 2019).

In the supply chain model, SMEs are usually upstream and downstream

enterprises. The financing enterprises in this research refer to the SMEs participating in the supply chain.

3) Core Enterprises. The concept of core enterprise was first mentioned by Ma (2013) in the definition of supply chain: it refers to the core enterprise in the whole supply chain, which is mainly responsible for concerting and governing the message flow, material line and fund flow of upstream and downstream enterprises in the supply chain, so as to ensure the efficient operation of the whole supply chain (Ma, 2013).

The core enterprises in the supply chain refer to the backbone enterprises that have the most voice in the supply chain, and have close trade relations with upstream and downstream SMEs. In this research, the core enterprises in the supply chain financial environment are defined as: some large firms listed on the central board of Shanghai Stock Exchange and Shenzhen Stock Exchange have significant characteristics of core enterprises, and have actual business dealings with some SMEs listed on the SMEs Board of Shenzhen Stock Exchange.

4) Assets Position under Financing. This kind of index is also an important part of the credit risk assessment index system of SMEs in the SCF surroundings. In the SCF business, the bank's credit extension is mainly carried out for a single business. It examines the ability of SMEs to repay debts in a single financing business, which not only refers to the solvency of SMEs themselves, but also includes the liquidity of assets under financing (Sang, 2021).

In other words, when SMEs break a contract, banks can sell out the assets position under the financing to compensate for the wastage affected by the default of SMEs. The receivables turnover ratio, inventory turnover ratio was adopted to indicate the assets position under financing, which relevant to financing enterprise in this research.

5) Blockchain Platform. Blockchain platform is a kind of traceable data structure chain platform which merges the Information blocks generated consecutively in chronological order (Boroujerdi, 2015). It is a kind of distributed ledger which guarantee the data cannot be tampered and forged by cryptography. Blockchain is an innovative application of asymmetric thicken algorithm, consensus machine-made, distributed inventory, point-to-point conveying and other cognate technologies (Adams et al., 2018).

In this research, the blockchain platform is an organic integration of current mature technologies, including distributed ledger technology, point-to-point technology, asymmetric encryption technology, intelligent contract technology, and consensus mechanism.

6) Supply Chain Operation. Supply chain is an operation system composed of various participants. Wu, Al-Khateeb, Teng and Cárdenas-Barrón (2016) exploited a supplier-retailer-customer supply chain mechanism, in which the retailer gains all the upstream change trustworthiness from the supplier and provides part of the downstream change trustworthiness to the credit risk customers.

This research selected macro environment, sustainability and relationship strength of supply chain as the supply chain operation according to previous literature.

7) Credit Risk Assessment. Risk assessment is the first step of supply chain risk management, which related to systematically comprehending multifarious risks and analyzing the latent reason of risk issue (Li, Sun, & Liu, 2021). Risk assessment is the procedure of deciding risk priority. Assessing risk priorities is essential for the company and relevant organizations to formulate suitable strategies and measures to deal with serious risks. Risk assessment can provide insight into effective risk response and reduce risk incidence (Zhang & Song, 2022). It is necessary to reduce the credit risk faced by capital providers.

In order to reduce the adverse impact of credit risk, the bank must evaluate the financing enterprises' ability to fulfill the repayment obligation according to the agreement signed by both parties, so as to assess the possibility of financing enterprises' default. Credit risk assessment has focused on two aspects: determining the influencing factors of credit risk, and evaluating the possibility of default.

8) Blockchain-driven SCF. Blockchain-driven SCF is a set of financing mode for SMEs (Pawlicka & Bal, 2021). Through efficient command of fund flow, information flow and logistics, funds are integrated into supply chain control, with core enterprises as the core and practical trade as the background, the unmanageable risk of a single enterprise can be convert into the manageable risk of the entire supply chain enterprise, and the risk can be controlled to the minimum by accessing to all kinds of information through blockchain platform so as to improve the possibility of

enterprises on the chain to obtain capital in the financial market, and then promote the active operation of enterprises on the chain, and realize the effective integration of resources (Zhao & Huchzermeier, 2018).

In general, blockchain-driven SCF introduces the blockchain platform into the traditional SCF model to solve the problem of information asymmetry and strengthen credit risk management.

1.9 Scope and Limitation

According to previous studies, the research learned some factors that affect credit risk in the supply chain, and summarized them. This research is to find the factors affecting SMEs' credit risk through examining the relationship between SMEs' credit risk and financing enterprises, core enterprises, blockchain platform, assets position under financing and supply chain operation in the mode of blockchain-driven SCF. In order to solve the problem of credit risk assessment, this study established credit risk assessment index, then used machine learning method to structure credit risk assessment model. The purpose is to find a credit risk assessment model with the best prediction ability, which has practical value for predicting credit risk.

As the growth of SCF in China is still in its primary stage, there is a lack of systematic data sets, and the business operation, finance and other data involve trade secrets, which is difficult to obtain through field research, questionnaire survey and

other methods. Therefore, this research adopted the public data of listed companies as the sample, which mainly covered the small and medium-sized board enterprises of Shenzhen Stock Exchange, and took the large enterprises in the main board market of Shenzhen Stock Exchange as the core enterprises. On account of the application of blockchain in SCF in China widely emerged in 2016 (Gong et al., 2021), so the data was collected in the period of 2016-2020. Financial data in all the sample are primarily obtained from CSMAR database and Wind database, the blockchain platform in the supply chain gained from the blockchain platform website, non-financial data are adopted through the company's annual report and related news reports.

This study has the following limitations. First, based on the workability of data, This study only uses data from listed companies in the matching group, and conducts one-on-one sample matching for SMEs, core enterprises, and blockchain enterprises, ensuring that all three types of enterprises are in a blockchain-driven SCF model and have business dealings with each other. In the meanwhile, as the application of blockchain in SCF in China widely emerged in 2016 (Gong et al., 2021) and the doctoral period is from 2020 to 2023, so the data was collected in the period of 2016-2020. Many of the above limitations will result in a small sample size. Second, only SMEs in the manufacturing industry have been probed, and the research findings may not be fully usable to other profession. Third, credit risk indicators were only divided into two categories in this research: enterprises with credit risk and enterprises without credit risk. In fact, risks can vary in degree, such as low risk, medium risk and high risk. Future research will subdivide risks for analysis. Fourth, this research focuses on the study of credit risk assessment for SMEs based on blockchain-driven

SCF, in order to predict the possible credit risks that SMEs may face. How to reduce the credit risk of SMEs by improving and optimizing the blockchain-driven SCF model will be the direction of future research. However, this study did not clarify how blockchain improves and optimizes the supply chain.

1.10 Significance of Study

There is a common problem of financing difficulties for upstream and downstream SMEs dominated by core enterprises in the SCF system. With the development of blockchain and technology, problems such as information asymmetry, financing difficulties, and high financing risks among various participants in SCF can be optimized by embedding and integrating the blockchain technology (Feng & Li, 2022). The supply chain financial innovation based on blockchain technology is of positive significance for improving the efficiency of financial support for SMEs in the supply chain, improving the competitiveness and security of the industrial supply chain, and supporting the construction of a double cycle dual circulation (Gong et al., 2021).

The accounts receivable and enterprise transaction information involved in the process of trade at all levels are completely recorded on the blockchain. Financial institutions have the ability to examine the transaction information of suppliers at any level. Any level of a supplier's organization may benefit from the core business's credit endorsement, which in turn lowers the supplier's cost of financing (Dickson, 2016). Since the blockchain platform has been implemented, the information of core

firms may now be dismantled and sent to retailers and suppliers in the supply chain. Assets position under financing arise from trade transactions between upstream SMEs and downstream core enterprises. As the debtor and first repayment party of accounts receivable, downstream core enterprises' business status, credit level, bank credit and risk resistance ability will have a significant impact on them (Feng & Li, 2021).

Blockchain technology and SCF fit very well (Zhu & Zhou, 2016). To begin, the structure of blockchain is a sort of time series data that can be used to store information. This data may be chained together. It realizes the visualization of all transaction information and ensures the information transparency of all parties involved, which is similar to the form of bill flow in SCF. At the same time, the digital bill that is based on blockchain technology has the fundamental properties and characteristics of an electronic bill, which is of utmost relevance for enhancing the safety and traceability of transactions in the bill market (Cao et al., 2022).

Each participant can share the whole supply chain according to its authority. In this way, participants can make more correct decisions about the real messages on the network, and boost the productiveness of the whole supply chain. At the same time, as the platform is decentralized, all transactions do not need a third-party intermediary, can be self-certified, and can be automatically implemented through smart contracts, which greatly decrease the related costs and is more secure (Natanelov et al., 2022).

It can realize the features that cannot be tampered with: first, the information is symmetrical, which resolves the trust issue of all parties in the business chain, and

the risk is more controllable. Second, eliminate redundant links, reduce manual operations, and reduce costs. Third, the participants can track and view asset information and improve asset financing capability in real time (Tsai. 2022). As a new financial innovation service goods, SCF has tremendous market latent capacity and is becoming a new rival territory for ordinary banks. Hence, it is needed to systematically study the risk management and financing mode of SCF. SMEs can gain funds through SCF, which can accelerate the line of inventory and accounts receivable, so as to improve cash flow and fund shortage (Gao, 2022).

The currently available studies focus on analyzing the credit risk posed by the firm itself, while only sometimes taking into account other elements that contribute to credit risk throughout the supply chain (Yi & Guo, 2021). Some academics typically only choose quantitative indicators in order to make empirical research more manageable (Chen & Tao, 2021). However, by doing so, they ignore the fact that the choice of qualitative indicators is what causes the credit assessment based on the blockchain-driven SCF to be unable to fully cover the default risk posed by the entire supply chain.

Before the popularization of internet technology, traditional statistical models and expert analysis models generally evaluated credit risk by studying a small number of loan users and developing a set of criteria applicable to all users. In the information age, lending institutions can obtain information on various dimensions of loan users, and the number of samples collected is close to the overall number. In this scenario, using traditional models to evaluate credit risk will lose a lot of useful information. However, machine learning method have natural advantages in handling

complex high-dimensional data, which will greatly improve the accuracy and precision of credit risk assessment (Ma, 2021).

The in-depth study of SME credit risk assessment under the supply chain financial environment is not only helpful to understand the formation mechanism of SME credit risk, but also conducive to the formulation of strict credit risk assessment index system by supply chain financial participants and regulators and accurate prediction of SME credit risk trends (Wang et al., 2022). Therefore, it has important practical significance for the management of SCF.

On the basis of this, this study investigated the building of an enterprise credit risk index system against the backdrop of blockchain-driven SCF, and it employed a technique of machine learning method to anticipate the credit risk of SMEs. In the past, there have been very few studies that have concentrated on the credit risk posed by SMEs operating under a blockchain-driven SCF model. Following is a summary of previous research that this study conducted, which focused on two research areas that are most directly connected to the work that we do: 1) the elements that contribute to the credit risk that SMEs face in blockchain-driven SCF. 2) the techniques for estimating the credit risk that is posed by SMEs in blockchain-driven SCF. The findings of the study in this area will have significant implications for practice.

1.11 Summary

The proposed chapter fundamentally introduced the entire opinion and the motivation of implement the present study. In particular, the chapter comprised ten main sections consist of background of study, problem statement, research objectives, research questions, research hypotheses, the theoretical framework, definition of terms, scope and limitation, significance of study, and ultimately summary of the chapter. The research background combs the development of SMEs, the process of supply chain finance and the reference of blockchain technology, and leads to the problem of credit risk. Problem statement represent the problems of SCF, especially the SMEs' credit risk caused by information asymmetry. There are six research objectives correspond to the research questions. The theoretical framework is the theoretical basis of this study. The definition of terms is the main research object of this study, and also provides a theoretical basis for selecting variables in the following text. The scope and limitation described the scope of the study, mainly the sample size and sample time, and put forward the limitations of this study, which providing ideas for future research. The next chapter reviewed the relevant literature.