

Research on Risk of Supply Chain Finance of Small and Medium-Sized Enterprises Based on Fuzzy Ordinal Regression Support Vector Machine

Ying Chen

Sydney Institute of Language & Commerce, Shanghai University

Chengzhong road 20, Jiading district, Shanghai, China

E-mail: dorothychen@staff.shu.edu.cn

Received: January 11, 2012

Accepted: February 14, 2012

Published: April 16, 2012

doi:10.5539/ijbm.v7n8p115

URL: <http://dx.doi.org/10.5539/ijbm.v7n8p115>

Abstract

This article explained the financial innovation service product - fundamental mode of supply chain finance, and explored the risk of supply chain finance. Fuzzy ordinal regression support vector machine is used to analysis the risk of supply chain finance by the index system of risk assessment, and the results were effective and could be improved in the future.

Keywords: Supply chain finance, Risk, SME, Fuzzy ordinal regression support vector machine

1. Introduction

Since the 1990s, market competition is no longer between the individual enterprises, but is competition between supply chains. Supply chain is a concept which refers to the process of commodities from purchasing raw materials, manufacturing to selling. It includes energy enterprises, manufacture enterprises, commercial enterprises and so on. These enterprises have their own business modes, suppliers and retailing patterns as well as their derivative supply chains. Obviously decentralized supply chain inevitably leads to decentralization of financial management and economic resources. As a result, it is unable to integrate various resources from supply chain. Enhancing the efficiency of supply chain will definitely result in request for optimizing economic resources in supply chain. Only financial instruments can integrate supply chain resources. When goods are moving into supply chain, cash flows are in motion simultaneously because flows of logistics and cash flows are inseparable. There is inalienable relationship between finance and logistics. Financial instruments can keep assets moving, reasonably allocate and restructure cash flow in supply chain. Thus the issues of competition between supply chains have changed into how to use finance instruments in supply chains. Therefore, analyzing the relationship between supply chains and cash flows has become a crucial question.

It is in no more than 30 years since the concept of supply chain appeared in developed countries in Europe and America. It is a shorter history that financial instruments used in supply chain. Supply chain finance refers to financial management based on supply chain. It is intrinsic requirement of market competition as well as the inevitable outcome of economic development.

At present, supply chain finance has been a new financial product used in increasing number of major companies and banks. Domestic major banks have put forward their corresponding solutions. However, in practice, many issues arising in operation have not been given enough attention by researchers, functional departments and the management. Financial risks arising from supply chain has received little attention and rarely researched. However, this is the key to the development of supply chain finance and to sustainable and healthy development in global market. It is also the practical problem for Chinese government and enterprises.

2 Literature review

2.1 Literature review on supply chain finance

Since 1990s, literature has focused on supply chain optimization and improvement of supply chain efficiency and effectiveness. To be specific, it mainly concerns joint optimization of production, transportation, and inventory of supply chain. Usually, confined by the level of service, the goal of decision-making for optimizing the supply chain is set to save cost and time, putting structure of cost (including transportation costs,

warehousing costs, order cost, purchase costs, manufacturing costs, inventory costs, out of stock, and other costs), product characteristics (including consumable and dangerous goods etc.), time constraints, different information, the uncertainty characteristics (uncertainty of demand, uncertainty of production, transportation of raw materials as well as the uncertainty of supply) and other factors into consideration. Methods and tools involved to gain optimization decision of supply chain include line planning, non-linear programming, dynamic planning, network technology and simulation.

In 2006 supply chain finance was first promoted by Shenzhen Development Bank. In recent years the combination of finance and supply chain has been explored and practiced by many corporations, for instance, Shenzhen Development Bank and Chinese foreign trade transportation (group) corporation, China Construction Bank and Chinese Commodity Storage and transportation Corporation, the Industrial and Commercial Bank of China and Sino-trans Group. Foreign banks also join the competition of supply chain finance through various ways, striving for more large-scale core enterprises as their target customers. To illustrate, Citibank, Hong Kong and Shanghai banking corporation (HSBC), Standard Chartered Bank provide such supply chain finance service as well. Hans Christian (2009) explained supply chain finance (SCF) was the inter-company optimization of financing as well as the integration of financing processes with customers, suppliers, and service providers in order to increase the value of all participating companies. Lennart Söderberg (2010) indicated that there was a strong relationship between supply chain maturity and supply chain performance in small and medium sized enterprises, as well as some relationships between supply chain maturity and financial performance. And if firms use maturity indicators in the Supply Chain Operations Reference areas to improve their processes, they will most likely achieve positive effects on supply chain performance and probably also on financial performance.

2.2 Literature review on fuzzy support vector machine

Qi Wu (2010) presented a new version of fuzzy support vector machine (SVM) which can penalize Gaussian noise to forecast fuzzy nonlinear system. Since there existed some problems of finite samples and uncertain data in many forecasting problem, the input variables are described as crisp numbers by fuzzy comprehensive evaluation. The results of the application in sale system forecasts confirm the feasibility and the validity of the Fg-SVM model. Compared with the traditional model, Fg-SVM method requires fewer samples and has better generalization capability for Gaussian noise. Min-Yuan Cheng (2011) represented the Evolutionary Fuzzy Support Vector Machine Inference Model for Time Series Data (EFSIMT), an artificial intelligence hybrid system focusing on the management of time series data characteristics which fuses fuzzy weighted support vector machines (weighted SVMs) and a fast messy genetic algorithm (fmGA), to predicting cash flow. Simulations performed on historical cash flow data demonstrate the EFSIMT is an effective tool for predicting cash flow. Wei-Yuan Cheng (2011) proposed an incremental support vector machine-trained TS-type fuzzy classifier (ISVM-FC). The ISVM-FC is a fuzzy system that consists of Takagi–Sugeno (TS)-type fuzzy rules, compared with fuzzy classifiers and Gaussian-kernel SVM, which improved training and test times, and reduced memory consumption for classifier storage without deteriorating the generalization ability. Fengyi Lin (2011) explained a hybrid manifold learning approach model which combined both isometric feature mapping (ISOMAP) algorithm and support vector machines (SVM) to predict the failure of firms based on past financial performance data. Analytic results demonstrate that our hybrid approach not only has the best classification rate, but also produces the lowest incidence of Type II errors, and is capable of achieving an improved predictive accuracy and of providing guidance for decision makers to detect and prevent potential financial crises in the early stages. Arindam Chaudhuria (2011) used a novel Soft Computing tool viz., Fuzzy Support Vector Machine (FSVM) to solve bankruptcy prediction problem. Experimental results on FSVM illustrate that it is better capable of extracting useful information from corporate data.

At present, supply chain finance has been a new financial product employed by an increasing number of major companies and banks. Domestic major banks have put forward their corresponding solutions. However, in practice, many issues arising in operation have not been given enough attention by scholars, functional departments and the management. Financial risks arising from supply chain have received little attention and rarely been researched. However, a key to the development of the supply chain finance and to sustainable and healthy development in the global market, supply chain finance is also a practical problem facing Chinese government and enterprises.

Thus, there is a research gap between commercial banks and other financial institutions to evaluate credit risk in supply chain finance in that supply chain is combined by core enterprises and many small and medium enterprises. Commercial banks and other financial institutions should provide suitable enterprises with financial services. Consequently, it is essential to design a comprehensive evaluation system to categorize small and medium enterprises.

3. Basic mode of supply chain finance

Supply chain finance is to provide financial services to all related businesses in supply chain. As a result, the supply chain-related enterprises receive financial support and grow rapidly, so as to solve the problem of uneven funds distribution and upgrade the entire supply chain, even the competitiveness of whole industry. And the commercial banks provide financial services of supply chain to opened up their own business channel, and even dominate the chain of all relevant financial business enterprises. This innovative model has brought dramatic improvement in the rationalization of allocating resources and performance to the banks and enterprises on supply chain. For example in 2006, Shenzhen Development Bank integrated resources and provided such financial services as RMB, foreign currencies and integrative off and on shore financial services in full-chain to chain-oriented industries. Trade financing customers and business volume both had the 50% growth, and that year the total amount of finance was up to 300 billion , at the same time their ratio of non-performing loans kept below 1 percent, and the overall ratios of non-performing loans were only 0.4%. In the process, business cash flow has been ensured, and then doubled sales growth, such as Yongan Corporation in Chongqing, cooperated with Shenzhen Development Bank for three years, their sales increased from 600 million yuan to 2.5 billion.

Despite the Shenzhen Development Bank, Shanghai Pudong Development Bank, Minsheng Bank, Industrial and Commercial Bank of China have their respective supply chain finance programs, but their basic pattern is the same, which is a financial service, with well-known large-scale manufacturing enterprises as the core, makes full use of the core upstream and downstream businesses and fixed commercial relationships. This kind of upstream and downstream business relationships arising from logistics and cash flow removes the obstacles in the logistics through improvements in cash flow, thus greatly increasing performance in banks and the supply chain. The chart below is a comparison between the basic model of supply chain in finance and the traditional model

From Figure 1, the basic pattern of supply chain finance is that the bank providing comprehensive financial services to an industry through a single enterprise or a number of upstream and downstream enterprises in the supply chain in order to promote and support the operations in these enterprises effectively and efficiently, thus to build up commonwealth among banks, enterprises and supply chain to achieve mutually beneficial co-existence and sustainable development. Because 80% of enterprises on supply chain in China are SMEs, with the shortage of cash flows, small and medium-sized enterprises are not only the main customers to demand financial support from supply chain finance but also the important entry for banks to break into the industrial chain.

From Figure 2, it can be found that in traditional model, the relationship between banks and supply chain is that the dominant core enterprises take advantage of its strong position to demand for delivery of raw material suppliers before payments while they request payment before delivery of goods from wholesalers and retailers. There are many critical terms from these core enterprises in trading process of delivery, pricing, accounting from the upstream and downstream enterprises, thereby causing tremendous pressure on these enterprises. However the upstream and downstream enterprises are always small and medium-sized enterprises. Therefore it is difficult to finance from banks. As a result, it is very tense for funding chain, causing an imbalance in the whole supply chain. The core businesses with larger-scale and stronger competitiveness give more pressure on the funds for upstream and downstream enterprises, and these upstream and downstream enterprises are being affected by the limitations of all kinds of resources and small-scale and difficult to negotiate with their respective banks individually to require funds, even the preferential loan. Therefore, the reasons for financing problem in those small and medium-sized enterprises are not in the enterprises themselves, because the core businesses in supply chain have occupied cash flows of small and medium-sized suppliers and wholesalers, for example, the inventory and accounts receivable owned by the core business is about 1.5 times of their needs. If these inventory and accounts receivable could be used efficiently, it will solve the financial problems in supply chain and increase the profit for banks, thus giving rise to the concept of supply chain finance.

For example, Guangzhou Branch of Shenzhen Development Bank had found from their practice that the suppliers of energy industry generally did not have fixed assets, but had adequate accounts receivable. The staff customized a financing solution to solve these enterprises shortage of cash, which pledged accounts receivable to the bank financing. Shenzhen Development Bank attracted a large number of dealers. Having established the long-term credit relationships with many suppliers, Shenzhen Development Bank had negotiated with the refineries, taking the refineries as the center and providing cash flows to their raw materials suppliers and imported enterprises or to the distributors selling gasoline, diesel, PVC series of petrochemical products. After this, Shenzhen Development Bank and millions of distributors negotiated with the domestic energy giants such as Petrol China, Sinopec, CNOOC and so on. Then setting up financial system with these corporations throughout the country, Shenzhen Development Bank had become a dominant bank in the energy field.

Nowadays, there were many financial service products in Shenzhen Development Bank, such as short-term loans, banks acceptance, commercial acceptance bill discounting and other products. For specific customer, they also developed a business vote discounting and management, export credit insurance financial products of the extension and expansion of supply chain finance model. It not only helped domestic bank solve the long-term financing problems of small and medium-sized enterprises, but also provided a great deal of new business opportunities for banks.

It could be seen from the basic model of supply chain finance that the effect of such a mode of financing is the concentration of much more financial resources toward those core groups of enterprises. In practice, the domestic banks would usually enlarge the credit of core business by 10% -20% to increase more business through greater credit support to enterprises in supply chain. These resulted in a series of practical problems. First, if this core group companies had the business linking with 10 banks and each bank provided similar credit support, the credit for those companies would be invisibly expanded by 100% -200%; however, these enterprises whether their strength and capacity could support such a huge credit growth was still in doubt? Second, how did the banks supervise risks from the tremendous growth in credit? Third, given the lower degree of information technology in China, how to review and evaluate authenticity of the large number of trade documents? Fourth, how did we guard against and prevent financial risks and moral risk?

Risks of supply chain finance would be analyzed below to tackle these problems. First, the core corporations don't have an adequate understanding of the risks. Because assets management in large groups in Chinese had often been neglected, many groups could not distinguish between assets management department and investment department. With the lack of assets management rules as well as the shortage of appropriate professional staff, not enough attention had been paid to supply chain risk. The financial system in groups, because of their less sensitivity to market and their shortage of rational management system, had brought a lot of financial risks. Assets management of supply chain had caused operating difficulties or bankruptcy to several domestic companies. Once the financial chain of the core enterprises broke down, it would bring disaster to the whole supply chain.

Second, the credit environment was complex. The credit situation in China was very serious. It was not rare to find that the credit is not honored. For example, the debtors dared to borrow and use the large number of money, even dared not to return, a few enterprises owed enrichment and performance to justified arrears, there were lots of phenomena that scraping debts were paid, deadbeats were meritorious and refused paying debts was justified. International letter of credit is used to guarantee international trade, but there was no such domestic letter of credit in domestic trade. The bill settlement of accounts was mostly used in domestic trade. Administrative regulations on domestic letters of credit were announced in 1997, which had not been renewed within 10 years. There was less feasible pattern for RMB letter of credit in procedure where deposits and withdrawals were processed at any branch of bank. The domestic trade settlement lacked consistent guarantee that could be circulated and accepted by all sides, which contributed to the risk in supply chain finance transactions and the operations.

Third, the process and recognition of property rights were complicated and confused. In China, there was lack of uniform standards in transportation and warehousing norms, and many property rights cases appeared frequently in transaction. The way that Chinese current legislations and regulations deal with such cases was quite confused. It usually used contract approach, but the contract was only the evidence of changes in debts, and it was not effective enough to bear evidence to illustrate the effect of changes in property rights occurred in circulation. Because it was difficult to obtain the corresponding guarantee, the banks could hardly exercise control over the property rights process, resulting in vulnerabilities inherent in supply chain management of financial risks.

4. Research methodology

Based on the above analysis, in order to prevent possible risks, the key was to establish a national credit management system and improve the formulation of standardization of financial instruments in trading process. Prior to that, it was necessary to establish a relatively unified index system of risk assessment to analysis risk of supply chain finance of SME, which includes industry and market prospect analysis (national industrial policy, local support policy, international market situation analysis), financial analysis (return on equity, inventory turnover, accounts receivable turnover, sales growth rate), business process analysis (effective delivery lead-time rate, ordering satisfying rate, production flexibility, supply chain added value ratio), feedback service analysis (time of operating circle, customer satisfaction rate, customer holding rate, level of member coordination, level of information sharing).

Thus we collected 336 small medium-sized companies from the customer database of a commercial bank in

Zhejiang province in China, whose customers were most of the small and medium sized enterprises in east of China. The one third of these companies did not receive the loans from the bank, because of poor performance, the one third of these companies was the VIP customers of the bank and the rest of them were ordinary customers. And some small and medium-sized companies did not have enough information, default data was 0. And sample data obtained mostly were qualitative variables, we should use the theory of fuzzy sets proposed in 1965 by Zadeh, which has been used for handling fuzzy decision-making problems. The elements of fuzzy sets have degrees of membership. A fuzzy set is a pair (A, m) where A is a set and $m: A \rightarrow [0, 1]$. For each $x \in A$, $m(x)$ is called the grade of membership of x in (A, m) . For a finite set $A = \{x_1 \dots x_n\}$, the fuzzy set (A, m) is often denoted by $\{m(x_1) / x_1, \dots, m(x_n) / x_n\}$. Let $x \in A$. Then x is called not included in the fuzzy set (A, m) if $m(x) = 0$, x is called fully included if $m(x) = 1$, and x is called a fuzzy member if $0 < m(x) < 1$. The set is $\{x \in A \mid m(x) > 0\}$ is called the support of (A, m) and the set $\{x \in A \mid m(x) = 1\}$ is called its kernel. After calculation, we changed quantitative variables into data $[0, 1]$, and easily used in next calculation.

And the selected indicators will duplicate information, such as total assets, and debt ratio. Therefore, principal component analysis is used to dimension reduction analysis, which obtained variables through computing process.

Because this problem belongs to small sample classification question, it selects support vector machine of multi-classification algorithm on small sample learning. Assigns training set:

$$T = \{(x_1, x_2), \dots, (x_1, x_2)\} \in (R^n \times Y) \quad x_i \in R^n, y_i \in Y = \{1, -1\}, i = 1, \dots, l \quad (1)$$

Support vector machine solving multi-classification problem is to construct a series of problems into two classifications, and establish corresponding two classified machines, to determine which category input x belongs to based on two classified machines. One versus one method, one versus the rest method, and Crammer-Singer multi-classification support vector machines. It is selected ordinal regression support vector machine, consider that M category of input is sequential from 1 to M in space R^n , which has identified adjacent relationship, that is, class j is the adjacent class of $j-1, j+1$, and class $j-1$ and class $j+1$ are not adjacent class, and space can be separated by $M-1$ parallel hyper plane.

$$T = \{x_i^j\}_{i=1,2,\dots,l}^{j=1,2,\dots,M} \quad (2)$$

Here, x_i^j is training input, superscript j expresses the category of corresponding training, l_i is the number of j th kind training data.

The primitive question is:

$$\min_{w,b} \frac{1}{2} \|w\|^2 \quad (3)$$

$$s.t. \quad (w \cdot x_i^j) - b_j \leq -1, j = 1, \dots, M, i = 1, \dots, l^j \quad (4)$$

$$(w \cdot x_i^j) - b_{j-1} \geq 1, j = 1, \dots, M, i = 1, \dots, l^j \quad (5)$$

Here $b = (b_1, \dots, b_{M-1})^T, b_0 = -\infty, b_M = +\infty$

According to the training regulations and training set, introduce to slack variable $\xi^{(x)} = (\xi_1^1, \dots, \xi_{l^1}^1, \dots, \xi_1^M, \dots, \xi_{l^M}^M, \xi_1^{*1}, \dots, \xi_1^{*M}, \dots, \xi_{l^M}^{*M})^T$ and penalty parameter $C > 0$, primitive question transforms to convex quadratic programming problem:

$$\min_{w,b,\xi^{(*)}} \frac{1}{2} \|w\|^2 + C \sum_{j=1}^M \sum_{i=1}^{l^j} (\xi_i^j + \xi_i^{*j}) \quad (6)$$

$$s.t. \quad (w \cdot x_i^j) - b_j \leq -1 + \xi_i^j, j = 1, \dots, M, i = 1, \dots, l^j$$

$$(w \cdot x_i^j) - b_j \geq -1 + \xi_i^{*j}, j = 1, \dots, M, i = 1, \dots, l^j$$

$$\xi_i^j \geq 0, \xi_i^{*j} \geq 0, j = 1, \dots, M, i = 1, \dots, l^j$$

And $b = (b_1, \dots, b_{M-1})^T, b_0 = -\infty, b_M = +\infty$

5. Conclusion

Using support vector machine to classify the risk of supply chain finance of small and medium-sized companies, according to the experimental results, accuracy rate of training set were 82.6%, 81.3%, 80.5%, accuracy rate of testing set were: 71.3%, 70.9%, 70.4%. (Table 1) The results were effective and could be improved in the future. For these exceptional phenomena, it is manually adjusted by artificial expert method in practice, and achieves the better results of judgments. Thus, it is certified that we reformulated support vector machine for ordinal regression method so that different input points can make different contributions to decide hyper plane, to analyze multi-classification problems, and divided them into different categories to demonstrate the good performance. The effectiveness of this improved method is verified in multi-classification of credit rating of small and medium-sized companies in growth enterprises board. The experiment results show that our method is promising and can be used to comprehensive evaluation, sequencing problems, and other multi-classification problems. Our future direction of the research will focus on how to improve the accuracy of multi-classification. We believe that more suitable parameters and variables selection will affect and improve the performance of generalization. Extending the multi-class classification to solve other problems is also our future research work.

References

- Akkermansh, Bogerd P, Vosb. (2004). Virtuous and vicious cycles on the road towards international supply chain management. *International Journal of Operation and Production Management*, 19(56), 566-581.
- Arindam Chaudhuria., & Kajal De. (2011). Fuzzy Support Vector Machine for bankruptcy prediction. *Applied Soft Computing*, 11, 2472-2486. <http://dx.doi.org/10.1016/j.asoc.2010.10.003>
- Baptista R. (2001). Geographical cluster and innovation diffusion. *Technological Forecasting and Social Change*, 66, 31-46. [http://dx.doi.org/10.1016/S0040-1625\(99\)00057-8](http://dx.doi.org/10.1016/S0040-1625(99)00057-8)
- C. Scott et al. (2011). Guide to Finance in Supply Chain Management. *Guide to Supply Chain Management*, Springer-Verlag Berlin Heidelberg, 141-154.
- Fengyi Lin., Ching-Chiang Yeh., & Meng-Yuan Lee. (2011). The use of hybrid manifold learning and support vector machines in the prediction of business failure. *Knowledge-Based Systems*, 24, 95-101. <http://dx.doi.org/10.1016/j.knosys.2010.07.009>
- Hans-Christian Pfohl., & Moritz Gomm. (2009). Supply chain finance: Optimizing financial flows in supply chains. *Logistics Research*, 1, 149-161. <http://dx.doi.org/10.1007/s12159-009-0020-y>
- Jukka, H., Urbh, P., & Veli-Mattiv. (2004). Risk management processes in supplier networks. *International Journal of production Economics*, 90, 47-58. <http://dx.doi.org/10.1016/j.ijpe.2004.02.007>
- Le Jizi, Liu Chunling. (2006). Cluster supply chain: coupling industrial clusters and supply chain. *Modern Economic Research*, 5, 5-9.
- Lennart Söderberg., & Lars Bengtsson. (2010). Supply chain management maturity and performance in SMEs. *Operational Management Research*, 3, 90-97. <http://dx.doi.org/10.1007/s12063-010-0030-6>
- Min-Yuan Cheng., & Andreas F.V. Roy. (2011). Evolutionary fuzzy decision model for cash flow prediction using time-dependent support vector machines. *International Journal of Project Management*, 29, 56-65. <http://dx.doi.org/10.1016/j.ijproman.2010.01.004>
- Qi Wu., & Rob Law. (2010). Fuzzy support vector regression machine with penalizing Gaussian noises on triangular fuzzy number space. *Expert Systems with Applications*, 37, 7788-7795. <http://dx.doi.org/10.1016/j.eswa.2010.04.061>
- Ralf W. Seifert., & Daniel Seifert. (2011). Financing the chain. *International commerce review*, 10, 1, 32-44.
- Sheffiy. (2001). Supply chain management under the threat of international terrorism. *International Journal of Logistics Management*, 12, 1-11.
- Shenzhen Development Bank. (2009). *China Europe international business school, Supply Chain finance: new finance in new economy*. Shanghai far-east publisher.
- Sunil, c., & Manmohan S. S. (2004). Managing risk to avoid supply – chain breakdown. *MIT Sloan Management Review*, fall, 53-61.
- Wang Ling-bin. (2006). Based on information-sharing mechanism for financing the supply chain risk management study. *Shenzhen special zone economy*, 10, 105-106.
- Wei-Yuan Cheng., & Chia-Feng Juang. (2011). An incremental support vector machine-trained TS-type fuzzy

system for online classification problems. *Fuzzy Sets and Systems*, 163, 24-44. <http://dx.doi.org/10.1016/j.fss.2010.08.006>

Wu Jun. (2006). Supply chain risk management in several important issues. *Journal of Management Science in China*, 12, 1-12.

Zsdian G. A. (2003). Managerial Perceptions Supply Risk. *Journal of Supply Chain Management: A Global Review of Purchasing and Supply*, winter, 14-25.

Table 1. The experimental results

Training set	Accuracy rate	Testing set
The companies with no loans	82.6%	71.3%
The ordinary companies	81.3%	70.9%
The VIP companies	80.5%	70.4%

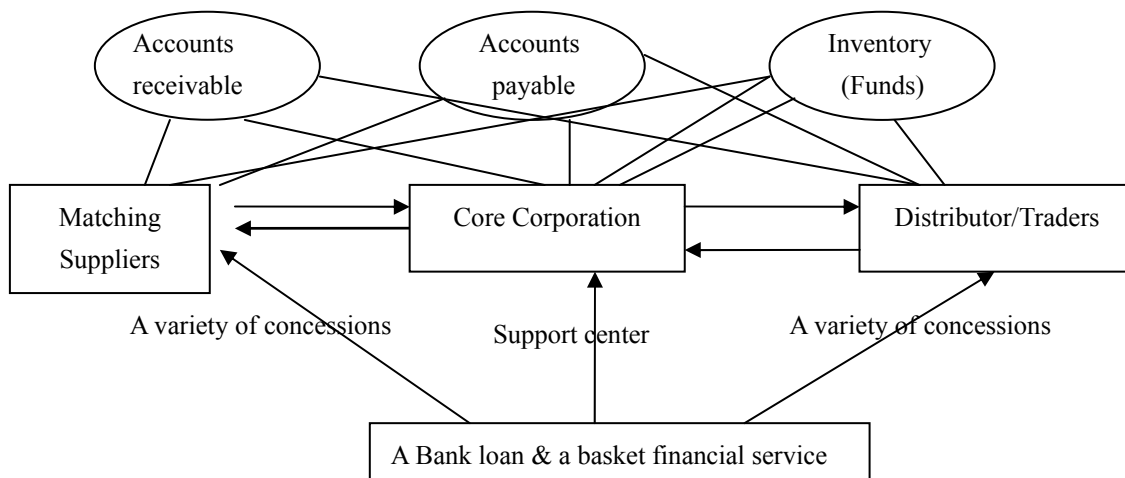


Figure 1. The relationships in supply chain finance mode between commercial bank and supply chain enterprises

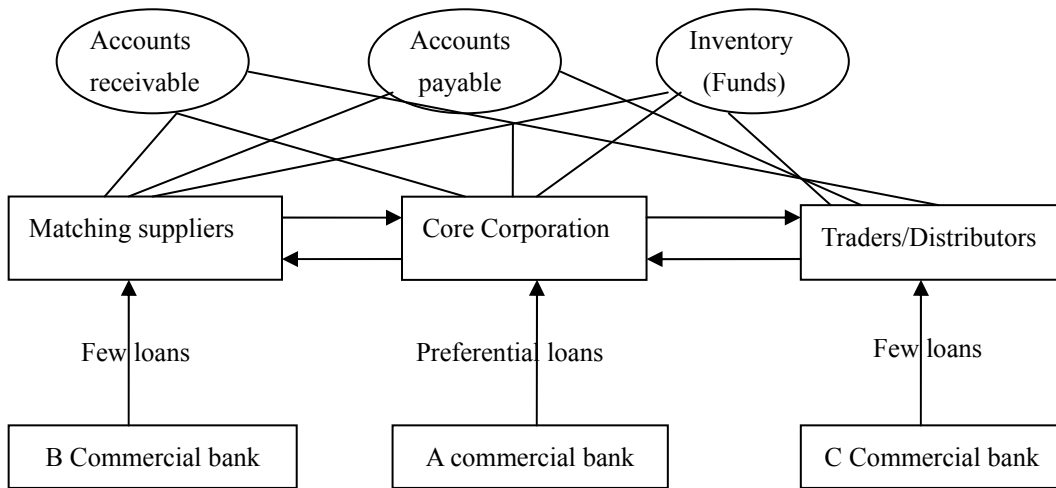


Figure 2. The traditional relationship between commercial bank and supply chain enterprises