Study on Supplier-Led Supply Chain Finance

Yang Wang, Yunlu Ma and Yuhe Zhan
School of Business Administration, South China University of Technology Guangzhou, 510640, P.R. China

Abstract: This study analyzes a class of supply chain financing system that includes the small and medium-sized manufacturer, the retailer and the raw material supplier which is the core enterprise. Both the manufacturer and the retailer face cash-constraint and cannot produce/order their optimal quantity. Our study is mainly to discuss two financing methods: direct financing and supply chain finance financing, to analyze the two methods of supply chain profit distribution status and then to derive the model of mechanism about the distribution of profits. According to the profit function, it indicates that choosing the supply chain finance financing is more beneficial for the supply chain.

Keywords: Cash-constraint, finance, optimal configuration, supply chain

INTRODUCTION

Trade-credit, including supply chain finance financing, has been the largest source of working capital for a majority of business-to-business firms in the United States and has been a critical source of capital for many businesses, especially for startup and growing businesses (Srinivasa Raghavan and Vinit, 2011). China supply chain financial started later, until the 1990s, it emerge some scattered single node financing business. With impact of globalization, in recent years, China supply chain financing activities has been gradually catching up the pace of the world, such as the Eternal Asia (a supply chain enterprise) make its profit continue rapidly increase through the supply chain financing services, Alibaba (a B2B internet corporation) align with its suppliers to apply loan from Industrial and Commercial Bank of China (ICBC) and so on.

The theory study on supply chain financing is relatively lagging behind. The classical M-M theory and EOQ model (Gormley and Meade, 2007; Li et al., 2010) which is focused on the single field of Corporate Finance or Operations Management, however, the new practice and theory have shown that the two areas is connected (Protopappa-Sieke and Ralf, 2010; Hsu et al., 2010) and then the study on supply chain financing, which consider the two field of Corporate Finance and Operations Management, is already underway. Recent studies are some new ideas or frameworks of small enterprises on financing, preliminary analysis the mechanism and functions of the inventory financing methods, which is adopted by small enterprises in the supply chain. However, it is still comparatively lack of studies on the modern supply chain financing mechanism; these kinds of cross-over problems attract many scholars attention.

The latest study on supply chain financing is mainly from banks perspectives, which is focus on the banks motivation and coordination function toward the operation of supply chain, however, its regulatory mechanism haven got an agree in academic circles. The operation of supply chain under the cash-constraint is better to supply the loan from the supply chain than direct financing from the commercial bank (Srinivasa Raghavan and Vinit, 2011; Gupta and Kaushik, 2011). In the implementation, some related studies think that the bank could set appropriate loan interest rate to adjust (Rajamani et al., 2006); but others think that it should be achieve by trade-credit rather than by real contract (Lee and Byong-Duk, 2011; Wang et al., 2008; Wang and Huang, 2010) and its practical effective coordination mechanism needs further study. So the supply chain alliances co-financing is fit the pursuit of entrepreneurs to build a network of relationships. Thus, as long as supply chain financing can bring more profit, the core enterprise would be more likely to integrated supply chain resources and assume a greater portion of the risk, at the same time to convince small and medium-sized enterprises to accept the alliance. The supply chain finance financing which is led by the core enterprise rather than the commercial bank, will soon be the method of Chinese special characteristic supply chain mainstream financing. Before it comes true, academics have the responsibility to find out the operation mechanism and decision method of supply chain finance financing which is led by core enterprise, so as to help enterprises enhance the visibility of decision making.
Capital plays an importance role in the small and medium-sized manufacturer, cash-constraint will lead the enterprise fail to play the order to upstream enterprise and the production is unable to the optimal. If the startup firms cannot find out enough funds at the beginning, the livability of them will be largely reduced and a small amount of cash can give a steep rise to survival probabilities. When it comes to the entire supply chain, cash-constraint will make the entire supply chain does not work and the profits of the core enterprises would glide, in order to support the downstream small and medium-size enterprises, to achieve more profits, propose the concept of the financial supply chain management, through the implementation of the supply chain of business financing and cash flow planning and arrangements, reasonable distribution the liquidity of every nodes, so as to minimize the financial cost of the entire supply chain. These studies and theory made great impact on the new or small enterprises in every nodes of supply chain.

Nowadays there are two difference methods of supply chain financing: traditional direct financing and supply chain finance financing. The cash brings by financing could downsize the essential capital investment for the business of nodes enterprises. To most America startup and growing enterprises, trade-credit has been the main source of working capital for a majority of them (Ozbayrak and Akgun, 2006). Numerous studies focus on the coordination of supply chain cash. If every participant is an independent decision maker, each one makes decisions to maximize its own individual profit and then it will lead the entire supply chain poor performance. At the same time, because of the commercial bank can master most of information about the reputation of the startup enterprise, it is difficult to judge its profits. In the case of lack information, the commercial bank rarely is willing to support the development of startup enterprises.

Some scholars proposed the supply chain finance financing, which means that commercial banks check the entire supply chain and the information and the credit strength of the core enterprises and then offer flexible financing product and service to core enterprises and other upstream and downstream enterprises. As a result, this to some extend ease the difficult situation of capital turnover of startup and growing enterprises. In other word, the banks rely on the core enterprises so as to offer financing service to other enterprises. During the past several decades, numerous theories have been proposed on the interior supply chain financing, which are from the core enterprises perspectives (e.g., large raw material suppliers), focusing on the trade financing of manufacturers and retailers. Some scholar proposed that the core enterprises of supply chain, compared with traditional borrowers, have more attraction for downstream buyers financing, which is called the financing advantage theory. Because the core enterprise masters more information about the market demand of cargos and the conditions of the entire supply chain and downstream enterprises, trade financing may be used to improve efficiency in the entire supply chain. Many numerical simulations, which changing the scale of trade financing to calculate the shopkeepers and buyers benefit, reveal that trade financing may enhance the efficiency of the whole supply chain (Gupta and Kaushik, 2011).

Previous literature mostly focus on single node enterprise financing in supply chain or involves only suppliers and retailers, this assumption is often contrary to the multi-node enterprise in supply chain. In this study, we start from manufacturing supply chain and study the financing mode that the raw material suppliers as a core enterprise which lead the downstream small manufacturers and retailers. In this more realistic premise, we analyze the influence of the traditional direct financing model and supply chain finance financing on the performance of the entire supply chain.

In this study, we analyzes a class of supply chain financing system that includes the small and medium-sized manufacturer, the retailer and the raw material supplier which is the core enterprise. Our study is mainly to discuss two financing methods: direct financing and supply chain finance financing, to analyze the two methods of supply chain profit distribution status and then to derive the model of mechanism about the distribution of profits. According to the profit function, it indicates that choosing the supply chain finance financing is more beneficial for the supply chain.

**THE MODEL**

This study discusses a raw material manufacturing supply chain, which is consist by three nodes: Supplier (S), Manufacturer (M) and Retailer (R). The product life cycle is short, such as consumer electronics and in the short term the retail price is constant. Supplier, as the core enterprise of the supply chain, both its scale and inventories are large. Manufacturer is a new or small enterprise, its lack of funds. Retailer, which is on a small scale, purchasing products ability is limited by capital constraints.

In our setting borrowers M and R are small firms with no bargaining power in financing process. While S is a large company with good reputation and well asset status, dominating the supply chain financing process. This study study on two financing methods: direct financing and supply chain finance financing, through compared the total profits on the two methods, to find out the small and medium-sized enterprises in the supply chain under capital constraints, how to carry on the financing to make the whole supply chain benefit maximization. We assume that all participants in a constant risk-free rate $\alpha_v$. 

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The rest assumption as follows: owing to capital constraints, the manufacturer and the retailer need to undertake financing to continue the production and business operation. We proposed two financing methods: direct financing (manufacturer and retailer finance directly from a financial institution) and supply chain finance financing (the core enterprise financing from the financial institution and then it expand financing to downstream enterprises.)

Let denote the risk-free interest rate, such as the rate on china treasury bills. In the case of direct financing, the financial institution according to the reputation of the manufacturer and the retailer, asks them to pay loan interest rate \( \alpha_m \) and \( \alpha_r \), which include the risk-free interest rate. Because of the commercial bank can't master most of information about the reputation of the small or new enterprise, it's hard to set the loan interest rate \( \alpha_s \), according to its limited material and the ruin probability of manufacturer and retailer \( \theta_m \) and \( \theta_r \). As a result, the loan interest rate \( \alpha_m \), \( \alpha_r \) are relatively high. In the case of supply chain finance financing, supplier as the core enterprise of the supply chain, according to the downstream capital circumstance, proposed financing from the commercial bank. The commercial bank according to the core enterprise credit level and its present and predictable future operations, combining with its industry ruin probability \( \theta_s \), set the loan interest rate \( \alpha_s \) to supplier and the loan interest rate \( \alpha_m \), \( \alpha_r \). Then the supplier finances its downstream enterprises: the manufacturer and the retailer. The supplier masters more information about the manufacturer and the retailer, comparing with the commercial bank, so it charge the loan interest rate from the manufacturer and the retailer \( \alpha_m \), \( \alpha_r \). The supplier is symmetric information with its downstream enterprises, at the same time; it wants to support downstream enterprises to operate its own business, so let \( \alpha_m = \alpha'_m \) and \( \alpha_r = \alpha'_r \), otherwise the manufacturer and the retailer will take direct financing from the commercial bank.

Supplier operating cost is \( c' \); \( c \) as the raw materials’ price; \( w \) as the manufacturer’s wholesale price; \( p \) as the retail price. At the end of the sale period, the manufacturer buys-back the leftovers at the price \( w'(w'<p) \). Demand \( y \) follows continuous distribution with density. Let as the retailer’s order quantity and the manufacturer according to the market demand function to compute expected lose. Similarly, when the manufacturer is facing bankruptcy, the supplier to expect the loss depends on the downstream enterprise’s sales.

The amount of the expected sales \( q_r \) of the retailer is depended on the sales period demanding function \( y \). Related function for:

\[
S(q_r) = \int \int f(y)dydy = \int q_r f(y)dy = q_r - \int F(y)dy
\]

The manufacturer’s order to the supplier \( q_m \) is based on the retailer’s order \( q_r \) and its respect on the market demand. Related function for: \( q_m = \lambda q_r \)

Suppliers (S), the Manufacturer’s (M) and the Retailer’s (R) expected profit at the end of the sale in the case of no financing (W), Direct financing (D) and supply chain finance financing (T). According to the above statement, in the case of no financing, the supplier expects the following profit:

\[
\prod^W_s(q_s) = - c'q_m
\]

In the case of direct financing, The supplier’s profit:

\[
\prod^D_s(q_s) = cq_m - c'q_m
\]

The manufacturer’s profit:

\[
\prod^D_m(q_m) = \lambda q_r \cdot (\lambda c - mw) - \lambda c q_m - EBL_m
\]

The retailer’s profit:

\[
\prod^D_m(q_m) = \lambda q_r \cdot (\lambda c - mw) - \lambda c q_m - EBL_m
\]

The supply chain’s profit:

\[
\prod^D_m(q_m) = \lambda q_r \cdot (\lambda c - mw) - \lambda c q_m - EBL_m
\]

In the case of supply chain finance financing, The supplier’s profit:
\[
\prod_{m}^{D}(q_m) = w_q - w[q_r - S(q_r)] - \lambda q_r c - mq_r - (\lambda c q_m EBL_m)
\]

The manufacturer’s profit:

\[
\prod_{m}^{D}(q_m) = w_q - w[q_r - S(q_r)] - \lambda q_r c - mq_r - (\lambda c q_m EBL_m)
\]

The retailer’s profit:

The supply chain’s profit:

\[
\prod_{m}^{D}(q_m) = w_q - w[q_r - S(q_r)] - \lambda q_r c - mq_r - (\lambda c q_m EBL_m)
\]

**SUPPLY CHAIN DECISIONS**

We first discuss the case of directing financing, in which both the manufacturer and the retailer direct financing from the financial institution. In this case, suppose that the retailer goes bankrupt and then the commercial’s recovery amount is:

\[
E(R) = \left\{ \begin{array}{ll}
Py + w'(q_r - y) & \text{if } y \leq q_r(w + w\alpha'_r - w')/(p - w') \\
q_r(1 + \alpha'_r) & \text{if } y > q_r(1 + \alpha'_r),
\end{array} \right.
\]

\[
E(R) = \int_{0}^{\infty} \left[ q_r(w + w\alpha'_r - w')(p - w') f(y)dy \right] + \int_{q_r(1 + \alpha'_r)}^{\infty} wq_r(1 + \alpha'_r)f(y)dy
\]

\[
= q_r(1 + \alpha'_r) - \left( p - w' \right) \int_{0}^{\infty} (w + w\alpha'_r)/(p - w') F(y)dy
\]

The commercial bank estimates the loss from the supplier’s bankruptcy depends on:

- Whether the retailer is bankrupt or not
- If the retailer bankrupt as well, how much money the supplier recovers from the retailer

Note that EBL_r and EBL_m increase with the manufacturer’s and the retailer’s bankruptcy probability and the order amount. After the above calculation, we can expect the supply chain total profit in the case of the manufacturer and the retailer direct financing:

\[
\prod_{m}^{D}(q_m) = \psi S(q_r) - c'q_m - mq_r - (\lambda c q_m EBL_m)
\]

Next, we consider the supply chain finance financing. The supplier as the core enterprise of the supply chain, financing from the commercial bank and then provides the funds to the downstream enterprises. The retailer purchases products with funds qrw, at the end of the sale period return the loans qrw(1+\r) to the supplier. The manufacturer purchases the raw materials with the funds qmw, at the end of the sale period return the loans qmw(1+\m) to the supplier. At the end of the sale period, the supplier will return qmc(1+\s)+qrw(1+\s) to the commercial bank. Suppose that the supplier goes bankrupt financially, the amount that the commercial bank recovers from the supplier’s bankruptcy depends on:

No matter whether the retailer bankrupt, when the retailer and the manufacturer trade each other, the retailer already paid the corresponding payment qrw. If the manufacturer bankruptcy as well, the supplier will recover \min[qmc(1+\s), qrw] from the manufacturer. Note that qw is always greater than qmc(1+\s), then no matter whether the manufacturer bankrupt, the supplier will recover qmc(1+\s), from the manufacturer. As for the retailer, if it not bankrupt, it will return qmc(1+\s), back to the supplier; if it bankrupt, then the supplier will receives:

\[
E(M) = \lambda q_r c (1 + \alpha'_m) - \int_{0}^{\infty} [\lambda q_r (1 + \alpha'_m) - w_q w'_r] F(y)dy
\]

Then, the commercial bank estimates the loss from the manufacturer’s bankruptcy is:

\[
EBL_m = \theta_{m} w_q (1 + \alpha'_m - E(M))
\]

\[
= \theta_{m} \int_{0}^{\infty} [\lambda q_r (1 + \alpha'_m) - w_q w'_r] F(y)dy
\]
In summary, in the case of the supplier bankruptcy, no matter whether manufacturer bankruptcy or not, if the retailer operates well, the commercial bank receives:

\[ E(B) = q_m c(1 + \lambda_r) + q_r w(1 + \alpha_r) \]

if the retailer bankruptcy, then the commercial bank expects recovery amount from the retailer’s bankruptcy is:

\[ E(B) = \min[q_m c(1 + \lambda_r), q_r w(1 + \alpha_r)] \]

\[ = q_m c(1 + \lambda_r), \text{ if } q_m c(1 + \lambda_r) \geq q_r w(1 + \alpha_r) \]

\[ = q_r w(1 + \alpha_r), \text{ if } q_m c(1 + \lambda_r) < q_r w(1 + \alpha_r) \]

\[ \int_{0}^{\alpha_r} F(y) dy \]

\[ \int_{0}^{T} \left( w + w_r - w \right) dy \]

\[ + \left( p - w \right) \int_{0}^{T} \left( w + w_r - w \right) dy \]

\[ F(y)dy \]

In the case of the supplier bankruptcy, the commercial bank expects recovery amount is:

\[ E(B) = (1 - \theta_r) D_1 + \theta_r D_2 \]

the commercial bank’s loss is:

\[ EBL_q = \theta_r [D_1 - (1 - \theta_r) D_2 = \theta_r \theta_s (D_1 - D_2) \]

(4)

The supply chain total profit in the case of supply chain finance financing is:

\[ \Pi_f(q_r) = pS(q_r) - \lambda q_r c - mq_r - (\lambda q_r c' - \alpha_s - EBL_s) \]

(5)

Let,

\[ \Delta \Pi_f(q_r) \]

be the difference of the above two financing methods in Eq. (3) and (5):

\[ \Delta \Pi_f(q_r) = \lambda \Pi_f(q_r) + \lambda c q_r c' - \lambda q_r c' - \alpha_s \]

\[ q_r w \alpha_r + EBL_s - EBL_m - EBL_\alpha \]

With the Eq. (1) (2) (4), Let:

\[ \lambda_1 = (\alpha_c + \lambda c \alpha_m - w + w') / w' \]

\[ \lambda_1 = (w + w_r - w') / (p - w') \]

We derive the first and second derivatives of \( \Delta \Pi_f(q_r) \) with respect to \( q_r \):

\[ \frac{\partial \Delta \Pi_f(q_r)}{\partial q_r} = wa' + \lambda c \alpha_m - \lambda c' \alpha_s - wa', \]

\[ = - \theta_r w_r \lambda f(q_r, \lambda_r) - \theta_r (p - w') \lambda f(q_r, \lambda_r) > 0 \]

\[ \frac{\partial^2 \Delta \Pi_f(q_r)}{\partial q_r^2} = - \theta_r w_r \lambda f(q_r, \lambda_r) - \theta_r (p - w') \lambda f(q_r, \lambda_r) < 0 \]

Hence, \( \Delta \Pi_f(q_r) \) is a convex function with respect to \( q_r \). When \( q_r = 0 \), \( \Delta \Pi_f(q_r) \) ; since, the function \( \Delta \Pi_f(q_r) \) is a monotone increasing function at the initial stage. Therefore, we can conclude the inference as follow:

- Through the calculation, the supply chain finance financing may be better than the direct financing for the participations of the supply chain.
- When \( q_r \leq y \), the profit of the supply chain finance financing achieve maximum.
- With the increasing of the size \( q_r \), the growth rate of the total profit become smaller, that is, the marginal profit growth rate decreases. When \( q_r \) is small, the scale of both the manufacturer and the retailer is small, hence, the growth rate of the total profit in the case of supply chain finance financing is bigger than direct financing, as a result, the supply chain finance financing is more beneficial to the supply chain. However, when the scale of the manufacturer and the retailer become bigger, \( q_r \) increases too. The difference between the two financing methods decreases. Although the supply chain finance financing still better than direct financing, with the scale of the downstream enterprises expanding and good reputation, the commercial bank will provide lower loan interest rate to the manufacturer and the retailer, the costs of direct financing reduce, hence it is very hard to decide which financing model is well.
- The bankruptcy probability of the manufacturer and the retailer, which are in good financial situation, is lower. As a result, the second order derivative of the profit closes to zero. That is, the marginal profit growth rate reduction.
INFERENCE AND CONCLUSION

In summary, as the participation of the supply chain, in order to promote the development of the supply chain and achieve the maximize profit; there will be the following decision conclusions:

- The commercial bank from the perspective of risk aversion will choose the supply chain finance financing; even though provide loans at lower loan interest rate to promote financing.
- Owing to the scale and reputation, the manufacturer and the retailer are very hard to obtain loans from the commercial bank, eventually; they have to seek the support of the large supplier, choosing the supply chain finance financing.
- The supplier through the supply chain finance financing, choosing more robust downstream enterprises, optimizing the supply chain configuration.
- The small enterprises which are attached the core supplier, with the development; accumulate a certain ability to resist risks. Thus they are more easily to obtain the financing from the commercial bank and not necessarily through the supply chain finance financing.

All in all, the supply chain finance financing reduce the risk of the commercial bank, at the same time, the core supplier achieves more profit through its own reputation. Although small and medium-sized enterprises are facing fierce competition, ultimately the survival will face a better financing environment.

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