Study on Finance Procedure Optimization of Small-Medium Logistics Enterprises Based on Bayesian Game

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Abstract

Bayesian game is employed to study the applicability of modern financial products for small-medium logistics enterprises, analyze the roles and service procedure of innovative financial products in logistics industry. In loan market, product competitiveness affects market behaviors significantly, while market information asymmetry weakens small-medium logistics enterprises in the game of the market, making them pay more for loans than others. As revealed in Nash equilibrium solution, small-medium logistics enterprises can achieve the fund for their development through innovative financial products including logistics finance and network finance. After the model and procedure of financial service for the small-medium logistics enterprises was changed, the fund needed for their development was the most optimal way. These products include market network design, competition, information technology, perceived risk, trust , information, and process design. Based on the framework, a case study was carried in logistics field.

Keywords: Bayesian game, small-medium logistics enterprises, finance procedure optimization

1 Introduction

Small-medium logistics enterprises provide a variety of differentiated logistics service for the society, making people's everyday life much more convenient. However, they often face the dilemma of Macmillan Gap resulted from their inferior market position with regard to size, fund, reputation and competitiveness. This is mainly attributed to the defective finance model caused by information asymmetry and product invisibility. Hence, it has become a hot topic now about how to effectively eliminate financial shortage experienced by small and medium logistics enterprises , help them provide better, efficient, convenient, safe and differentiated logistics services for the society, effectively improve the added value of industries and the quality of economic growth and lower the operating cost of logistics.

In this process, Modigliani and Miller (1958) brought forth the MM theory from the approach of finance model and concluded the weak correlation of finance structure and model with enterprise value. In a seminal article published in 1958 Franco Modigliani and Merton Miller proved under very restrictive assumptions that a firm's value was independent of its capital structure. Assuming no corporate or personal taxes or bankruptcy costs, the increase in return to shareholders in a firm using leverage is exactly offset by the risk associated with this debt financing. However, subsequent research relaxing these limiting assumptions showed that capital structure was not irrelevant, but indeed affected firm value. The Modigliani-Miller study proved very important though as it helped to reveal what was required for capital structure to be relevant and hence affect a firm's value. From the approach of finance risk, Stiglitz and Weiss (1981) proposed a credit rationing model and claimed the existence of moral risk and adverse selection in the credit market. Focusing on relationship between bank and enterprise, Carey and Flynn (2005) conducted an empirical analysis and put forth the dependence function of bank's fund supply to SMEs (small and medium enterprises). Tagoe, Anuwa-Amarh and Nyarko (2008) studied the relationship between information management level and finance level of SMEs and the correlation of their credit history and information level with finance efficiency, and discovered their strong correlation. Popescu (2008) delved into the finance problem of innovation-focused SMEs and the main reasons for their difficulty in finance, and put forward some solutions. Irwin and Scott (2010) employed the method of statistical analysis to unveil the noticeable distinctions among owners of SMEs in their finance capacity, such as, race and gender, etc., and pointed out that education background has relatively low impacts on finance capacity. Kundid and Ercegovac(2011) studied the features of credit rationing to SMEs in Croatia under the background of financial crisis, but failed to draw some general conclusions.

Lots of achievements have been made in the research on the finance of SMEs0. Nevertheless, there is not any specific research on the economic behaviors and causes driving players in finance. Also, attention is only paid to individual's loan behavior with regard to finance, while network under this behavior and interactions caused thereby are not studied in depth 00. In addition, the uniqueness of industry is overlooked, so there is no specific solution proposed for logistics industry. By analyzing the approach to economic behaviors in microscopic Bayesian game under networked relationship, this paper studies and solves the problem of finance channel optimization for small and medium logistics enterprises.

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Jianjun Xu, et al. generalize the Bayesian game approach by considering to minimize the weighted sum of the difference between the return and the sum of each portfolio return 0. They suppose that the decision-maker is ambiguous about the choice of weights and he choose a robust optimization approach to cope with this ambiguity. Then they aim at minimizing the maximization of the weighted sum of the difference between the return and the sum of each portfolio return, where the maximization is to be taken in all the possible distributions of the weights. They call this generalization as worst-case discounted regret portfolio optimization. In general the solution for this problem is NP hard and some approximation method is often proposed. In this paper, they supposed that the decision maker get across some parts of information about the uncertain distributions of the weights, for example the first-order, support set and affine first-order information. By applying the duality of the semi-infinite programming, the worst-case discounted regret portfolio optimization problem with the uncertain distributions can be equivalently reformulated to a linear optimization problem, then, the established solution approaches for linear optimization can all be applied to our setting. An example of a portfolio optimization problem is given to show the efficiency of our methods and the results demonstrate that our methods can satisfy the diversified property under the uncertain distributions of the weights.

The economic crisis that is experienced in Europe has a large influence on transport and logistics companies. Since turnover typically drops strongly during a crisis, companies try to reduce costs in order to survive. The study reported in this paper has investigated how manpower planning in warehouses has been used to counter effects of the funds' lack and what the results are of the measures taken for the small-medium logistics enterprise. A survey was carried out among warehouses run by money suppliers and logistics service providers. The results of the survey show that there is a significant relation between a decrease in turnover and the four investigated manpower planning strategies. Furthermore, the most effective manpower planning strategies are flexible planning of employees and balancing the workload. Hence, some studies concluded that in particular better operational planning was a key strategy to counter the effects of the financial crisis, which was an important insight for the management of warehouses.

Historically, despite positive production growth projections and the associated benefits of local market entry, many foreign companies have experienced significant difficulties gaining desired market access in China. The Chinese Government and already established companies have not extended an overly welcoming hand for foreign investments into China. To explore this unique situation, we use a Japanese company (renamed ABC Company in this research) to illustrate the entry of a foreign automaker to the Chinese automotive manufacturing market. We examine ABC's SC development and its integration into the Chinese business environment.

The remainder of this paper is organized as follows. A brief literature review is presented, followed by a description of research methodology. Then, three sections are presented which introduce the major stages of SC adaptation: market entry preparation, supplier network establishment, and logistics integration, respectively. Analyses and implications and future study are presented, and the paper concludes with a summary and limitations of the research.

The logistics performance of a firm's SC has been indirectly linked to positive financial performance. Logistics integration reflects the perspective that a manufacturing entity extends beyond its mere physical site boundaries to include its suppliers interactions. Supplier inclusion results in greater cooperation and coordination between the manufacturer and supplier partners, as well as more shared information and blurred boundaries between entities. Most research on SC integration agrees that SC integration results in improved and sustained firm performance. Therefore, by integrating and improving logistics processes, firms are able to enhance their SC processes and create efficiencies, which in turn ultimately improve firm performance.

2. Analyses on Loan Network of Parties Involved in Finance

In an attempt to sort through these problems and inefficiencies, the small-medium logistic enterprise (SMLE) was currently in the process of working with suppliers to reduce the number of supplier logistics partners, including eliminating those considered unqualified due to safety concerns, delivery variability, etc. Through these efforts, SMLE has effectively cut back its number of supplier logistics partner companies from more than 20 to ten for local suppliers within the city, and SMLE continues to work on improving its logistics integration from the current city to other cities. However, SMLE's efforts must continually be balanced with the sensitive local official and supplier relationships it has carefully cultivated.

In finance, decision risk is mostly burdened by lender in the end. Hence, the decision in the game is approached only from the perspective of lender to simplify the analysis of loan network model.

Modelling assumptions:

(1) A small and medium logistics enterprise L has a prior probability of default P_0, which is known to all players in the market.

(2) A lender S_0 evaluates the lending risk before making a decision, and rectifies his prior judgment as he may be affected by others $S_1,S_2,\ldots\ldots,S_n$.

(3) If $(S_1,S_2,\ldots\ldots,S_n)$ are independent from each other, the enterprise L's possibility of default is $(C_1,C_2,\ldots\ldots,C_n)$ and $C_1UC_2U\ldots\ldots UC_n=\Omega$.

SY_n stands for the strength of L's default if C_n is true. The higher SY_n, the more possible default. SN_n stands for the strength of L's default if C_n is not true. The higher SN_n, the more possible default.

Based on these assumptions, when a natural person S_0 consults with S_1, S_1 will judge L's default risk (SY_1, SN_1) according to C_1. Based on the (SY_1, SN_1), S_0 will rectify the value of the prior probability P_0. Using the subjective Bayesian formula, the posterior probability of default S_0 is calculated as follows:

$$P_1 = P(S_0 / C_1) = SY_1 * P_0 / \left[(SY_1 - 1) * P_0 + 1\right] \quad (1)$$

Likewise, when a natural person S_0 consults with S_n, S_n will judge L's default risk (SY_n, SN_n) according to C_n. Based on the (SY_n, SN_n), S_0 will rectify the value of the prior probability P_0. Thus, there will be0:

$$P_n = P(S_0 / C_n) = SY_n * P_{(n-1)} / \left[(SY_n - 1) * P_{(n-1)} + 1\right] \quad (2)$$

In a specific market process, all players in finance form a specific loan network on the basis of risk probability.

The most general form of analysis in paired experiments investigates whether within-pair differences are stochastically positive, and the most natural measure of stochastic positivity is θ, the expected sign of Walsh averages. The estimate of this effect size measure is asymptotically equivalent to the generalized Wilcoxon signed rank test statistic. Its non null variance can be estimated, leading to formulation of Wald confidence intervals, but to find more accurate score-type, boundary-respecting intervals, some conceptual and technical difficulties must be overcome. This is achieved firstly by a transformation result stating that any continuous stochastically positive variable D can be transformed by a smooth odd function g so that the method came from a symmetric location shift model. In turn, this allows the rank method assumption that observed differences have a symmetric distribution. The further assumption that this is from an extended logistic family, covering a wide range of shapes ranging from heavy to light tailed, along with some accurate functional approximations, enables a simple iterative method to be developed for confidence intervals for the effect size measure θ. Simulation studies show that the proposed method performs better than other existing confidence interval methods.

Requests for monographs generated within an interlibrary loan network are analyzed for statistics data. It is suggested that demand represents use of the literature more completely than satisfied requests or circulation statistics. Demand in this study is characterized as either regional demand or state-wide demand and is related to the level of the network where final processing of the request occurs. A negative exponential distribution is found to adequately characterize both levels of demand as a function of publication date for four subject categories. Corrected demand data is obtained by removing the growth rate of most of the available literature represented by American book publisher output. Based on over 10,000 interlibrary loan requests, negative exponential distributions describe the raw data as well as the corrected data.

An integrated model of rough set and neural network for five-category classification of loan risk is proposed. The financial data are discretized by using the self-organizing mapping neural network; and the evaluation indices are reduced without information loss through a genetic algorithm. The reduced indices are used to develop the rules for the five-category classification of loan risk, and to train the neural network. The rough set theory is used to determine the category for the test sample which matches all rules in the rule-base. The neural network is applied to separate those test samples which do not match any one rule in the rule-base. 698 loan firms of five-category are selected as test samples.

The objective of the proposed study is to explore the performance of credit scoring using a two-stage hybrid modelling procedure with artificial neural networks and multivariate adaptive regression splines (MARS). The rationale under the analyses is firstly to use MARS in building the credit scoring model, the obtained significant variables are then served as the input nodes of the neural networks model. To demonstrate the effectiveness and feasibility of the proposed modelling procedure, credit scoring tasks are performed on one bank housing loan dataset using cross-validation approach. As the results reveal, the proposed hybrid approach outperforms the results using discriminant analysis, logistic regression, artificial neural networks and MARS and hence provides an alternative in handling credit scoring tasks.

3. Game Analyses on All Players in Finance

In a specific game process, the following reasonable assumptions must be taken with regard to market players for better analysis:

(1) Every player in Bayesian game is entirely rational, and their economic behaviours are always for the purpose of own maximum benefits.
(2) No player is able to access the counterpart's strategic choice and income function as well as the entire information of other players, and they can only obtain the perfect information. In other words, every player experiences incomplete information symmetry and knows only some behaviours of counterpart in the game.
(3) The game is classified into single-player Bayesian game and multi-player Bayesian game under networked structure to describe different rational decision-making processes of players respectively. In a single static game, a player makes a judgment based on the current information on hand. In repeated games, the choice is made finally based on the judgment of total income within the future time period t (month, quarter, year) through mutual effect of all players in the games.

Thus, the procedure of Bayesian game is as follows: When the contract chooses one-time repayment of principal, the impacts of time t on both parties can be overlooked. Hence, only their selection in a single game is taken into account.

Lender: If S_0 has a discretionary fund M_0 and two options: investing in bank for riskless fixed income r_0; lending to L for floating income subject to certain risks.
Mortgagor: The logistics enterprise L borrows M_0 for providing logistics service to gain the income r_x.

The game matrix of both players in the market is presented in Table 1.

TABLE 1 Game Matrix

Ender / Mortgagor	Loan	Non-Loan
Loan	$(M_0(r_x-r_1-r_0), M_0(r_0+r_1)*(1-P_t))$	$(0, M_0*r_0)$
Non-Loan	$(0, M_0*r_0)$	$(0, M_0*r_0)$

As shown in the game matrix, when $M_0(r_x-r_1-r_0)\geq 0$, the enterprise L's future expected income r_x is higher than r_1+r_0, so L wants to borrow money. The lender S_0 requires satisfying $M_0(r_0+r_1)*(1-P_t)\geq M_0*r_0$, so there is:

$$P_t \leq 1-r_0/(r_0+r_1) \tag{3}$$

In other words, the lender may lend money only if posterior probability must be higher than $r_0/(r_0+r_1)$. Otherwise, the lender may select the fixed income without risk.

Based on Table 1, the Nash equilibrium solution of single static Bayesian game is obtained: $(M_0(r_x-r_1-r_0), M_0(r_0+r_1)*(1-P_t)$. Under the equilibrium condition, the logistics enterprise L can obtain the total income $M_0(r_x-r_1-r_0)$, while the lender can gain the expected income $M_0(r_0+r_1)*(1-P_t)$ at the rate of income $(r_0+r_1)*(1-P_t)$.

When the contract chooses the payment of interests in multiple stages, time t will affect the selection of both parties. Hence, both parties in the game will require different incomes and take different game strategies compared to the previous condition. Due to the existence of time t, the previous results of game will make investors rectify their posterior probability through the network structure of relationship, and affect the final choices of all market players.

If the lender S_0 obtains the income in stage T, he will change the default probability of the logistics enterprise L in stage T+1. If the default probability in stage T is judged to be P=0.5, the default probability judged by S_0 in stage T+1 will decrease (or increase) since the lender gains (loses) the income, so it will further affect the lender's posterior probability in the next stage. This causes that some lenders keep entering and leaving the game even in the same period.

In addition, the income of both parties changes as well due to the existence of time t. To the lender S_0, the expected income within time t is changed to:

$$E_0 = M_0(1+r_0+r_1)^t*(1-P_n) = M_0(1+r_0+r_1)^t*(1-P_{T+1}) \tag{4}$$

The money lent by S_0 in the end must satisfy $E_0 \geq M_0*r_0$, so there is:

$$P_{T+1} \leq 1-\left[(1+r_0)/(1+r_0+r_1)\right]^t \tag{5}$$

To the logistics enterprise L, the income to be obtained within time t is:

$$E_1 = M_0(r_x-r_0-r_1)^t \tag{6}$$

Along with the increase of time t, the value of $(1+r_0+r_1)^t$ is higher, so the default probability judged by the lender is higher. Hence, the lender will have higher and higher requirements. Thus, small and medium logistics enterprises have to well perform the contract in all stages as much as they can and improve the probability of their credibility, so as to obtain constant financial support.

4. Empirical Analyses

The enterprise J is a logistics service provider specialized in refrigerated storage at ports. To improve the quality of logistics service and the competitiveness of refrigeration business, the enterprise needs to borrow money for new equipment in refrigerating compartments. Based on the current condition of J (annual turnover is less than 5 million USD and there are no assets available as collateral), it is impossible to raise money from bank. It is assumed that the enterprise J's prior probability of default is 0.2. The enterprise J has close business relationship with a large port enterprise J, which can easily obtain a loan from bank for its good liquidity. In order to solve the problem of finance for the enterprise J, the enterprise H consults with five other enterprises in the relevant industry and judges the default risk related to the business, that is, (SY_1,SN_1), (SY_2,SN_2),……, (SY_n,SN_n) with the results $(2,SN_1)$, $(1,SN_2)$, $(0.5,SN_3)$, $(2,SN_4)$, $(1,SN_5)$. Thus, the corresponding network of loan is as follows:

$$P_1 = P(X_0/C_1) = SY_1*P_0/\left[(SY_1-1)P_0+1\right] = 0.39$$

Likewise,

$P_2 = 0.39$;

$P_3 = 0.24$;

$P_4 = 0.39$;

$P_5 = 0.39$.

To the enterprise H, the enterprise J's posterior probability of default is 0.39.

(1) In a single game, as shown in Equation (3), the enterprise H is willing to lend money only if $P_J \leq 0.39$. Assuming that the term of loan is 3 years and the loan interest rate of bank for the same term is 5%, the lending will be realized only if the enterprise J accepts the rate of above 8.2%.

(2) In repeated games, if interests are paid in stages, as shown in Equations (2), (4), (5) and (6), there is $f(t)= 1-[(1+r_0)/(1+r_0+r_1)]^t$. Along with the elapse of time, f(t) gets closer to 1 gradually, while P_T is closer to 0 gradually. The union of f(t) and P_T will be the time of lending. When $P_T < f(t)$, the enterprise H burdens higher pressure. When $P_T > f(t)$, more pressure goes to the enterprise J. Therefore, whether the enterprise J can obtain a loan successfully is not only affected by its own profitability, but also depends much on the model of loan (lending platform).

As shown in the above analysis, successful finance is affected not only by profitability of small and medium logistics enterprise, but also by market information gathering and finance platform (innovation of financial products), etc. compared with both exogenous finance and endogenous finance. On one hand, existing channels can be utilized to solve the problem of financial shortage, or innovative financial products can be also provided for enterprises with good liquidity in order to realize the win of two or multiple parties. For example, when a port enterprise needs to borrow money, a logistics financial platform can be designed for the port enterprise based on its advantages, in order to solve the problem of financial shortage. On the other hand, existing network finance platform may be utilized to optimize own procedure of finance. For instance,

the enterprise may employ the business procedure of network finance based on fixed platform and the business procedure of network finance based on mobile client. In this way, small and medium logistics enterprises can spend more time and energy on the innovation and development of logistics services, not the establishment and maintenance of social network.

Financial problem of small-medium logistics enterprises exists in the industrial society for a long time, so it cannot be thoroughly eliminated by taking a new approach or technology. During the modern revolution of information technology, computer technology and electronic technology, these technologies must be combined with small and medium logistics enterprises to constantly explore the innovative model of network finance and the optimization of its procedure and widen the channel and way of finance for small and medium logistics enterprises, so as to guarantee the healthy and sustainable development of logistics industry.

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