ISSN : 0974 - 7435 Volume 10 Issue 18

2014

BioTechnology

An Indian Journal

FULL PAPER

BTAIJ, 10(18), 2014 [10459-10465]

Research on the cooperative operation mechanism of logistics service supply chain based on fairness preference theory

Yan Fei

School of Management, Xi'an Polytechnic University, 710048, (P.R.CHINA)

ABSTRACT

The agent has fairness preference will influence its behavior decision, which is often ignored nowadays. In the paper, the cooperative operation mechanism of double principal-agent mode of logistics service supply chain is investigated based on the fairness preference theory. The unique double principal-agent mode of logistics services supply chain is defined and its characteristics are analysed in depth. A double principal-agent model of logistics services supply chain is built in the paper based on fairness preference theory. Some useful conclusions are drawn which could provide a new idea for the incentive mechanism design and management in logistics service supply chain.

KEYWORDS

Supply chain management; Logistics service supply chain; Cooperative operation mechanism; Double principal-agent; Fairness preference.

INTRODUCTION

As one of modern management ideas and modes, supply chain management has experienced rapid development not only in theory, but also in practice in recent years. However, a substantial amount of research has focused on manufacturing and retail industry, and service industries are just now recognizing the value of successfully implementing it[1]. Service supply chain is a new research focus, which more and more scholars and practitioners have been directed towards nowadays[2-6]. The logistics industry is a classic example of the birth and development of a vital new service-based industry[7]; therefore, logistics service supply chain (LSSC) is one of the important forms in service supply chain and a focus in service supply chain research.

LSSC is a kind of socialized and industrialized logistics service operation mode, the structure of LSSC is generally considered as: functional logistics providers (referred to as providers)-integrative logistics providers (referred to as integrators)-logistics customers[8,9]. Every member affects and is affected by others. According to the degree of synergy among those members, three collaborative operation modes are available: point–chain coordination, line–chain coordination, and chain–chain coordination[10,11]. Those collaborative modes form a deepening process of collaborative operation.

In the paper, one kind of collaborative operation modes of LSSC, the double principal-agent mode which is the main form of the point–chain coordination mode, will be analyzed. The author of the paper has conducted some research on double principal-agent mode of LSSC[11,12], yet they are just based on the assumptions that members are pure self-interest preference and psychological factors are ignored. In recent years, many experimental study shows, agents also have fairness preference besides self-interest preference[13,14]. People will concern about the fairness of income distribution and behavior which will influence their behavior decision. Therefore, the paper tries to investigate the cooperative operation mechanism of double principal-agent mode of LSSC based on the fairness preference theory in order to provide a new idea for the incentive mechanism design and management in LSSC. Considering the fairness preference, there are two cases: one is the agent compares with the principal, another is one agent compares with other agents. In the paper, the former is conducted.

STRUCTURE AND CHARACTERISTICS OF DOUBLE PRINCIPAL-AGNET MODE OF LSSC

The basic structure of the double principal-agent mode of LSSC is showed in Figure 1. In this mode, the customer commissions the integrator to complete logistics activities. Generally, it is difficult for the customer to control the logistics services process and get specific information about the efforts level of the integrator and providers. The asymmetry of information between the customer and the integrator will inevitably lead to moral hazard problems in the operation process of LSSC. It is clear that the principal-agent relationship is between the customer and the integrator. The integrator is mainly responsible for integrated design of logistics activities, and some professional operation are outsourced to providers. The asymmetry of information is also exists between the integrator and providers, thus the integrator and providers also develop a principal-agent relationship.

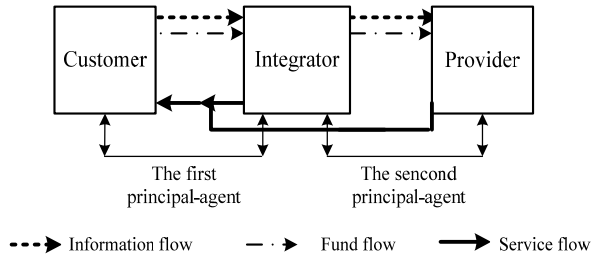

Figure 1 : The basic structure of double principal-agent mode of LSSC

The characteristics of double principal-agent mode of LSSC are as follows:

(1) The logistics service output is a kind of integrated service, which must be completed under the joint efforts of the integrator and providers. Therefore, although the first principal-agent interface is between the customer and the integrator, the integrator is not only an agent but also the representative of supplier (the integrator and providers).

(2) In LSSC, the integrator plays a "pivotal" role. From the view of funds flows, the integrator involves not only in the initial profits distribution with the customer, but also in the profits redistribution with providers. From the view of risk, the integrator not only takes risks from the customer, but also shares risks with providers. From the view of task, the integrator does not outsource logistics activities completely, and at least it needs to plan, organize and coordinate different logistics activities. Therefore, on one hand, as an agent for the customer, the integrator is a designer and organizer of logistics activities; on the other hand, as a principal for providers, the integrator is also a supervisor.

(3) LSSC is essentially a collaborative operation system through sharing and optimal allocation of resources. Double principal-agent relationship of LSSC is different from pure market transaction relations or internal relations in an enterprise. Every member in LSSC is economically independent and affects and is affected by each other.

(4) The principal-agent relationship between the members in LSSC is a long-term, dynamic and multi-stage process. Compared with the traditional short time principal-agent relationship, the cooperation between the members in LSSC will be more stable, therefore, the degree of information asymmetry and moral risk will decrease.

MODEL FOR DOUBLE PRINCIPAL-AGENT MODE OF LSSC BASED ON FAIRNESS PREFERENCE THEORY

Model assumptions

Assumption 1: For a simple analysis, there are just one integrator, one provider and one customer in a LSSC. The customer and the integrator are pure self-interest preference, while the provider also has fairness preference. Assume that the provider will be jealous when his income is lower than the integrator, and he will be proud when his income is higher than the integrator. The jealousy is a kind of negative utility and the pride is a kind of positive one. g_1 describes the degree of jealousy; g_2 describes the degree of pride; $g_1,g_2 \geq 0$, $g_1 > g_2$, $0 < g_2 < 1$.

Assumption 2: As the logistics service output is a kind of integrated service, both the integrator and the provider input relative elements (including human, technology, and material, etc.). Then, logistics service output in a circle time can be expressed as follows:

$$\pi(\alpha, \beta) = p\alpha + q\beta + \varepsilon \quad \textbf{(1)}$$

where π is logistics service output; α is the integrator's effort level, $\alpha > 0$; β is the provider's effort level, $\beta > 0$, suppose no game relationship among providers. The effort is various behaviors to ensure the quality of logistics services, such as planning, implementation, management, coordination, information sharing and staff training, etc. Assume 2-dimensional continuous variable $g = (\alpha, \beta)^T$ represents a specific behavior of logistics services supply, which decided by joint efforts of the integrator and providers. The greater the g the higher effort level and better logistics service is. p is the contributing coefficient of the integrator's efforts to logistics service output which is decided by the integrator's asset size, technical facilities and equipment, the degree of information, market reputation, etc., $p > 0$; q is the contributing coefficient of the provider's efforts to logistics service output, $q > 0$; ε is a random variable, decided by external uncertainties, $E(\varepsilon)=0$, $Var(\varepsilon)=\sigma^2$.

Assumption 3: The linear mixed incentive contract is adopted. In the first principal-agent, suppose the linear mixed incentive contract is:

$$s(\pi) = w + \lambda\pi \quad \textbf{(2)}$$

In the second principal-agent, suppose the linear mixed incentive contract is:

$$f(s) = s + \theta\lambda\pi \quad \textbf{(3)}$$

where w and s are fixed reward, which have nothing to do with the output; λ represents the initial profit distribution coefficient; θ represent the second profit distribution coefficient, $0 \leq \lambda \leq 1, 0 \leq \theta \leq 1$.

Assumption 4: Suppose fixed cost of the effort is zero. The effort cost function of the integrator is C_I, and the effort cost function of the provider is C_F. No consider the impact of the random variable. C_I, C_F could be described as follows:

$$C_I(\alpha) = \frac{1}{2}k_1\alpha^2 \quad \textbf{(4)}$$

$$C_F(\beta) = \frac{1}{2}k_2\beta^2 \quad \textbf{(5)}$$

where k_1 and k_2 represent the cost coefficient, $k_1 > 0$, $k_2 > 0$. It is easy to get $C_I(\alpha) > 0$, $C_I'(\alpha) > 0$, $C_I''(\alpha) > 0$, that is the higher lever of effort the greater cost of effort, which is reasonable. The same explanation is for $C_F(\beta)$.

Assumption 5: Assume the customer is risk neutral; the integrator and the provider are risk averse. Define the degree of risk aversion based on Arrow-Pratt absolute risk aversion. ρ_1 represents the amount of risk aversion of the integrator; ρ_2 represents the amount of risk aversion of the provider.

Modeling

According to the above model assumptions, the expected utility of the customer is equal to the expected income. The expected income of the customer is:

$$E(U_C) = \pi_C = -w + (1-\lambda)(p\alpha + q\beta) \quad (6)$$

The expected utility of the integrator and the provider are equal to the maximum certainty equivalent income. The certainty equivalent income of the integrator can be expressed as:

$$E(\pi_I) - \frac{1}{2}\rho_1(1-\theta)^2\lambda^2\sigma^2 = w - s + (1-\theta)\lambda(p\alpha + q\beta) - \frac{1}{2}k_1\alpha^2 - \frac{1}{2}\rho_1(1-\theta)^2\lambda^2\sigma^2 \quad (7)$$

The actual income of the provider who has fairness preference is:

$$\pi_F = s + \theta\lambda(p\alpha + q\beta + \varepsilon) - \frac{1}{2}k_2\beta^2 - g_1\max[(\pi_I - \pi_F), 0] + g_2\max[(\pi_F - \pi_I), 0] \quad (8)$$

For a simple analysis, assume $g_1=g_2=g$. g refers to the fairness preference coefficient. When $\pi_I > \pi_F$, g reprensents jealousy preference; otherwise, g reprensents pride preference.

Them, (8) could be expressed as:

$$\begin{aligned}\pi_F &= s + \theta\lambda(p\alpha + q\beta + \varepsilon) - \frac{1}{2}k_2\beta^2 - g(\pi_I - \pi_F) \\ &= (1+2g)s - gw + [(2\theta-1)g + \theta]\lambda(p\alpha + q\beta + \varepsilon) + \frac{1}{2}k_1g\alpha^2 - (1+g)\frac{1}{2}k_2\beta^2\end{aligned} \quad (9)$$

The certainty equivalent income of the provider can be expressed as:

$$\begin{aligned}&E(\pi_F) - \frac{1}{2}\rho_2[(2\theta-1)g + \theta]^2\lambda^2\sigma^2 = (1+2g)s - gw + [(2\theta-1)g + \theta]\lambda(p\alpha + q\beta) \\ &+ \frac{1}{2}k_1g\alpha^2 - (1+g)\frac{1}{2}k_2\beta^2 - \frac{1}{2}\rho_2[(2\theta-1)g + \theta]^2\lambda^2\sigma^2\end{aligned} \quad (10)$$

Then, the double principal-agent mode of LSSC can be modeled as follows:

$$\max_{\lambda} E(U_C) = \max_{\lambda}[-w + (1-\lambda)(p\alpha + q\beta)] \quad (11)$$

$$\text{s.t.(IR)}\ w - s + (1-\theta)\lambda(p\alpha + q\beta) - \frac{1}{2}k_1\alpha^2 - \frac{1}{2}\rho_1(1-\theta)^2\lambda^2\sigma^2 \geq \pi_{I0} \quad (12)$$

$$\text{(IC)}\ \max_{\alpha,\theta}[w - s + (1-\theta)\lambda(p\alpha + q\beta) - \frac{1}{2}k_1\alpha^2 - \frac{1}{2}\rho_1(1-\theta)^2\lambda^2\sigma^2] \quad (13)$$

$$\begin{aligned}\text{s.t.(IR)}\ &(1+2g)s - gw + [(2\theta-1)g + \theta]\lambda(p\alpha + q\beta) + \frac{1}{2}k_1g\alpha^2 - (1+g)\frac{1}{2}k_2\beta^2 \\ &- \frac{1}{2}\rho_2[(2\theta-1)g + \theta]^2\lambda^2\sigma^2 \geq \pi_{F0}\end{aligned} \quad (14)$$

$$\begin{aligned}\text{(IC)}\ &\max_{\beta}\{(1+2g)s - gw + [(2\theta-1)g + \theta]\lambda(p\alpha + q\beta) + \frac{1}{2}k_1g\alpha^2 \\ &-(1+g)\frac{1}{2}k_2\beta^2 - \frac{1}{2}\rho_2[(2\theta-1)g + \theta]^2\lambda^2\sigma^2\}\end{aligned} \quad (15)$$

π_{I0} is the retained profit of the integrator, π_{F0} is the retained profit of the provider.

Solution

According to the principle of profit maximization The first-order and the second-order partial derivative for β of (15) are

$$\frac{\partial\pi_F}{\partial\beta} = [(2\theta-1)g + \theta]\lambda q - (1+g)k_2\beta \quad (16)$$

$$\frac{\partial^2 \pi_F}{\partial \beta^2} = -(1+g)k_2 \tag{17}$$

As the second-order partial derivative is less than zero, set (16) equal to zero, we get

$$\beta^* = \frac{[(2\theta-1)g+\theta]\lambda q}{(1+g)k_2} \tag{18}$$

As $\beta > 0$, then $(2\theta-1)g+\theta > 0$.

According to the individual rationality constraint (IR, or participation constraint), when the expected utility of the agent is no less than its retained profit, it is willing to accept the commission. From the view of the principal, the better the smaller the payment is to the agent. Therefore, the actual participation constraint (14) is

$$\begin{aligned}&(1+2g)s - gw + [(2\theta-1)g+\theta]\lambda(p\alpha+q\beta) + \frac{1}{2}k_1 g\alpha^2 - (1+g)\frac{1}{2}k_2\beta^2 \\ &-\frac{1}{2}\rho_2[(2\theta-1)g+\theta]^2\lambda^2\sigma^2 = \pi_{F0}\end{aligned} \tag{19}$$

According to (13), (18) and (19), we can caculate the derivative for α and θ. Then, we get

$$\alpha^* = \frac{\lambda p}{k_1} \tag{20}$$

$$\theta^* = \frac{\rho_1(1+g)k_2\sigma^2 + (1+2g)q^2 + \rho_2 g(1+g)k_2\sigma^2}{\rho_1(1+g)k_2\sigma^2 + (1+2g)q^2 + \rho_2(1+g)(1+2g)k_2\sigma^2} \tag{21}$$

Similarly,according to (11), (12), (18) and (20), we can caculate the derivative for λ. Then, we get

$$\lambda^* = \frac{\frac{p^2}{k_1} + \frac{[(2\theta-1)g+\theta)]q^2}{(1+g)k_2}}{\frac{(1+2g)(1-\theta)^2}{1+g}\rho_1\sigma^2 + \frac{[(2\theta-1)g+\theta)]^2}{1+g}\rho_2\sigma^2 + \frac{p^2}{k_1} + \frac{[(2\theta-1)g+\theta)]^2 q^2}{(1+g)^2 k_2}} \tag{22}$$

If g=0,that is the provider has not the fairness preference, then

$$\alpha_0^* = \alpha^* = \frac{\lambda p}{k_1} \tag{23}$$

$$\beta_0^* = \frac{\theta\lambda q}{k_2} \tag{24}$$

$$\theta_0^* = \frac{\rho_1 k_2\sigma^2 + q^2}{\rho_1 k_2\sigma^2 + q^2 + \rho_2 k_2\sigma^2} \tag{25}$$

$$\lambda_0^* = \frac{\frac{p^2}{k_1} + \frac{\theta q^2}{k_2}}{\rho_1(1-\theta)^2\sigma^2 + \rho_2\theta^2\sigma^2 + \frac{p^2}{k_1} + \frac{\theta^2 q^2}{k_2}} \tag{26}$$

RESULT AND DISSCUSS

According to the above calculation results, some conclusions can be drawn.

Result 1: According to (18), $\frac{\partial \beta}{\partial \lambda} > 0$, $\frac{\partial \beta}{\partial \theta} > 0$, it means the provider will improve its efforts level with the increase of the initial profit distribution coefficient and the second profit distribution coefficient. $\frac{\partial \beta}{\partial k_2} < 0$, it means the provider will reduce its efforts level with the increase of the cost coefficient. $\frac{\partial \beta}{\partial q} > 0$, it means the provider will improve its efforts level with the increase of the contributing coefficient of the provider's efforts to logistics service output. $\frac{\partial \beta}{\partial g} = \frac{[(2\theta - 1)g + \theta]\lambda q}{(1+g)k_2} = \frac{(\theta - 1)\lambda q}{(1+g)^2 k_2} < 0$, it means the provider will reduce its efforts level with the increase of its fairness preference. The provoder's effort level has nothing to do with the degree of risk aversion and the external uncertainties on logistics service output.

Result 2: According to (20), $\frac{\partial \alpha}{\partial \lambda} > 0$, it means the integrator will improve its efforts level with the initial profit distribution coefficient. $\frac{\partial \alpha}{\partial k_1} < 0$, it means the integrator will reduce its efforts level with the increase of the cost coefficient. $\frac{\partial \alpha}{\partial p} > 0$, it means the integrator will improve its efforts level if it possesses the bigger asset size, the higher integrated technical capacity, and the higher degree of information. Compared (20) and (23), we can see that the integrator's effort level has nothing to do with the provoder's fairness preference, and some traditional factors, including the degree of risk aversion and the external uncertainties on logistics service output.

In order to get further conclusions, a numerical experiments are designed (see Figure 2 and Figure 3). Then, we can get the following conclusions.

Result 3: The initial profit distribution coefficient and the second profit distribution coefficient will decrease with the increase of degree of the provoder's fairness preference.

Result 4: The expected utility of the customer and the integrator will decrease with the increase of degree of the provoder's fairness preference. On the contrary,the expected utility of the provider will increase with the degree of its fairness preference.

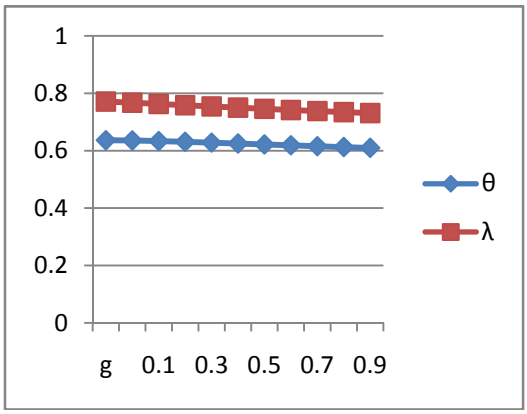

Figure 2 : Variation of *θ*, *λ* with *g*

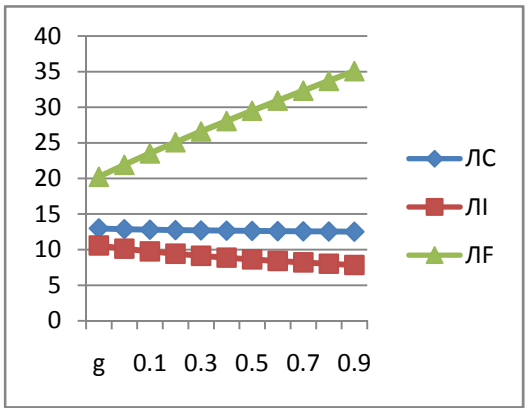

Figure 3 : Variation of π_c, π_I, π_F with *g*

CONCLUSIONS

The agent has the fairness preference is an important problem which has to be considered when making incentive policy. In ISSC, the fairness preference of the provider will affect the effort level of both the integrator and the provider, even the performance in the ISSC. The exist of fairness preference will lead to efficiency loss, reduce the expected utility of the principal. The greater the degree of fairness preference, the less the expected utility of the customer and the integrator, and the integrator need to pay more for the provider to compensate the negative utility caused by fairness preference.

Fairness preference has extensive influence on social and economic activities. The relationship between the integrator and the provider in LSSC is different from traditional transactions, therefore, it is important to consider both fairness preference and efficiency in practical operation and management of LSSC. It is a tempt to introduce the fairness preference theory into the LSSC research, there are still exist a lot of problems to be solved. It should be noted that the principal-agent problem of one agent and a single task is analyzed in the paper. In practice, it is common that there is more than one provider in a LSSC, then it is a multi-agent and multi-task principal-agent problem. Therefore, the fairness preference exists not only between the integrator and the provider, but also among providers, which is the future research.

ACKNOWLEDGEMENT

This work is supported by the Social Science Project of Shaanxi Province (13SC012) and Dr. Scientific Research Fund of Xi'an Polytechnic University (BS1007).

REFERENCES

[1] S.Jack Cook, Kathy De Bree, Amie Feroleto; From Raw Materials to Customers: Supply Chain Management in the Service Industry. SAM Advanced Management Journal, **66(4)**,14-21 **(2001)**.

[2] Kevin Poole; Seizing the potential of the service supply chain. Supply Chain Management Review, **7(4)**, 54-61 **(2003)**.

[3] Henk Akkermans, Bart Vos; Amplification in service supply chain: an exploratory case study. Production and Operations Management, **12(2)**, 204-223 **(2003)**.

[4] Dirk De Waart, Steve Kemper; 5 Steps to service supply chain excellenc. Supply Chain Management Review, **8(1)**, 28-35 **(2004)**.

[5] M.Lisa Ellram, L.Wendy Tate, Corey Billington; Understanding and managing the service supply chain. Journal of Supply Chain Management, **40(4)**, 17-32 **(2004)**.

[6] Tuncdan Baltacioglu, Erhan Ada, D.Melike Kaplan, Oznur Yurt, Y.Cem Kaplan; A New Framework for Service Supply Chains. The Service Industries Journal, **27(2)**, 105-124 **(2007)**.

[7] L.Ross Chapman, Claudine Soosay, Jay Kandampully; Innovation in logistic services and the new business model: a conceptual framework. International Journal of Physical Distribution and Logistics Management, **33(7)**, 630-650 **(2003)**.

[8] Tian Yu; Supplier selection in constructing logistics service supply chain. Systems Engineering Theory and Practice, **23(5)**, 49-53 **(2003)**.

[9] Liu Weihua; Research on the coordination of capacity cooperation in logistics service supply chain. Ph D dissertation, Shanghai Jiao Tong University (**2007)**.

[10] Yan Fei; Research on the Collaboration Mechanism of Logistics Service Supply Chain. Ph D dissertation, Chang'an University **(2009)**.

[11] Yan Fei; Three Collaborative Operation Modes of Logistics Service Supply Chain. The 3rd International Conference on Engineering Management and Service Sciences, Beijing, China **(2009)**.

[12] Fei Yan, Yunfei Li; Double Principal-agent Mechanism of Logistics Service Supply Chain. International Conference on Management Science & Engineering, Moscow, Russia **(2009)**.

[13] G.Charness, P.J.Kuhn; Do co-workers' wages matter? Theory and evidence on wage secrecy, wage compressionand effort. Institute for The Study of Labor, **(2004)**.

[14] E.Fehr, M.Schmidt; Theory of fairness, competition and cooperation. Quarterly Journal of Economics, **114(3)**, 817-868 **(1999)**.