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An Incentive Payment Solution for Service Providers in Service Supply Chains

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Abstract: To achieve the maximized benefit in service supply chains, an effective incentive to influence service provider's behavior is indispensable. This incentive could be implemented via the payment to suppliers. In this study, the optimal incentive payment solution for service suppliers in service supply chains is considered and the impacts of relevant parameters analyzed. The study of incentive payment includes optimal incentive payment function, the precondition of incentive, profit allocation control, etc. The results show that an effective incentive payment will bring additional benefits for the whole supply chain. And the higher the cost of the service provider's high effort is the less effective the incentive payment solution is. Also the bigger the sensitivity of market demand to service provider's effort level is the further the originator need to implement such incentive solution.

Key words: Supply chain, service operation, incentive payment, optimization

INTRODUCTION

The service economy is becoming the backbone of global economic growth. With market competition becoming fiercer, service companies are seeking core competitive advantages through sophisticated restructuring. Service outsourcing and supply chain alliances are becoming the key factors to further development of service industries. Therefore, knowledge of service and service supply chain management is urgently needed. Service is a special kind of goods which differs from material products with distinct features of behavior processing, intangibility, heterogeneity, non-storability, simultaneity between production and consumption, customer participation, etc. The first three features indicate that it is far more difficult to measure the quality of service products than material products and the last three features show that the service providers mostly need to make direct contacts with end customers without effective supervision. Therefore, a moral risk problem will appear that is to say, the service providers (Fig. 1) tend to negatively serve end customers in order to lower their costs. The reason lies on that the service provider, as a supplier, obtains his income from the service originator, however his direct serving object is not the service originator but end customers. What's more, the measure and supervision on that serving operation is quite difficult. For this reason, an effective incentive to service providers is indispensable to achieve the maximized benefit of a service supply chain.

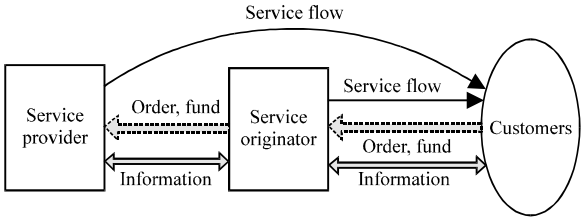

Fig. 1: Model of service supply chains

Service supply chains have been studied by several researchers (Ellram *et al*., 2004; Sengupta *et al*., 2006; Baltacioglu *et al*., 2007). proposed a framework for service supply chains in which the service supply chain is defined as "the network of suppliers, service providers, consumers and other supporting units that performs the functions of transaction of resources required to produce services; transformation of these resources into supporting and core services and the delivery of these services to customers. And service supply chain management is the management of information, processes, resources and service performances from the earliest supplier to the ultimate customer".

The service supply chain consists of three basic stages: The service provider, the service originator and the customer, as shown in Fig. 1. To improve efficiency and benefits, the service originator outsources several parts of the business to the supplier. Thus the service provider is the company which supplies professional services to the service originator and/or directly to the end customers. These activities contribute directly to the production of the core service in the chain. In this way, the service provider is usually involved in the delivery of these services. For example, in a logistics service supply chain, the service originator, as the core enterprise, is the so-called integrated logistics service subcontractor and

the service provider refers to some functional logistics companies, such as transportation firms, warehouse firms, etc., which provide corresponding logistics services to the customer which can be manufacturing or retail enterprises.

In the above service supply chain model, several key activities can be identified (Ellram *et al*., 2004; Baltacioglu *et al*., 2007): demand management; capacity and resources management; customer relationship management; supplier relationship management; order process management; service performance management and information and technology management.

These activities, Supplier Relationship Management (SRM) is critical to service supply chain management. Because in the service delivery process, the service providers contribute directly to service delivery and are usually in direct contact with the ultimate customers which means they are more influential on the customers' buying behavior than those in the product supply chain. Therefore, a failure in the supply side may simultaneously turn into a failure in the performance of the entire supply chain. To prevent such an occurrence, sustainable relationships with the suppliers built on coordination, collaboration, responsiveness and trust should be maintained. This is the focus of supplier relationship management.

Supplier relationship management, as explained in Ellram *et al*. (2004), involves a process in which a supplier is selected and contracts are negotiated, signed and executed. The contracts should include clear Service Level Agreements (SLAs), based on the achievement of work. Good SLAs can reduce uncertainty in performance expectations. Service delivery management is closely intertwined with supplier relationship management and takes over to ensure that contractual demands and service level agreements are met. In contrast to manufacturing supply chains in which the quality of a product is measurable and pre-specified, a critical issue associated with the service supply chain is the difficulty for the service provider of measuring and controlling the quality of services supplied by a service provider, as the service commodity is invisible. A traditional way to measure and control the supplier's behavior is by site supervision. However, in the practical operation of service supply chain, service providers offer services to customers independently from the originator. In addition, the services of a provider, are often large and distributed widely which makes site supervision costly. Therefore, the site supervision is usually not worthwhile in practice. Another important reason for the ineffectiveness of site supervision is that some services cannot be measured, even under site supervision, such as service of consultation and scheme design. However, economic incentives is quite feasible to influence service providers to reach a more optimal performance of supply chains.

The core problem of an incentive is to seek for an optimal payment mode so as to improve the benefit of the whole supply chain. To analyze this, some questions have to be answered: What is the optimal form of incentive payment to service providers? When is it necessary to implement such incentive? How to adjust the allocation of the profit between members?

In the study, some related literatures are reviewed in section 2. An incentive model in service supply chains is described in section 3. The detailed premises of the incentive implementation and profit allocation adjustment are discussed in Section4. The conclusion and the future research are mentioned in the fifth section.

RELATED LITERATURES

Related studies include those of Sengupta *et al*. (2006) who compared the product supply chain with the service supply chain in the contract of supply chain performance. Ahlstrom and Nordin (2006) analyzed several problems of establishing service supply relationships from the viewpoint of a high-tech manufacturing company. Demirkan and Cheng (2008) set up a service supply chain model consisting of one ASP (Applied Service Provider) and one AIP (Applied Instrument Provider) and studied the problems of supply chain performance with various coordination strategies. Marlow and Nair (2008) study the service contracts as an instrument of international logistics supply chain. Baltacioglu *et al*. (2007) put forward a service supply chain model which was applied to a healthcare industry. Akkermans and Vos (2003) reported on a case study from the telecommunication industry and aimed to analyze relevant root causes and associated countermeasures of the amplification phenomenon in service supply chains. Veronneau and Roy (2009) conduct an empirical study of current practices and challenges of a cruise line service supply chains. Youngdahl and Loomba (2000) analyze the service-driven global supply chains.

From the view of service outsourcing, Ren and Zhang (2009) studied how to design service outsourcing contracts. Their work mainly discuss the affection of the service provider's capacity cost and quality cost. Akan *et al*. (2011) we advance a unifying model covering call center and order fulfillment operations and study the associated contracting problem under information asymmetry. Kim *et al*. (2007) introduced a multitask principal-agent model to support resource allocation and use it to analyze commonly observed contracts. The

results show that the first-best solution can be achieved if channel members are risk neutral. When channel members are risk averse, the second-best contract combines a fixed payment, a cost-sharing incentive and a performance incentive.

Bottani and Rizzi (2006) present a multi-attribute approach for the selection and ranking of the most suitable 3PL service provider based on the TOPSIS technique (Technique for Order Preference by Similarity to Ideal Solution) and the fuzzy set theory. Jackson and Pascual (2008) develop a model and report results to determine the agent's optimal strategy for a given type of contract. The model derives in a non-cooperative game formulation in which the decisions are taken by maximizing expected profits. Bustinza *et al.* (2010) believed that researchers undervalued the impact that outsourcing decisions have on our competitive capabilities and found that there is a relationship between outsourcing decisions and company performance which is articulated via the impact of outsourcing decisions on the firm's competitive capabilities. Forslund (2009) explored how the performance management process may be affected by the design and contents of logistics service performance contracts between customer and supplier. He discussed the different design and contents of contracts, containing some patterns related to industry, company size and degree of formalization.

INCENTIVE MODEL

An originator and a service provider compose a service supply chain and they face an uncertainty market demand x represented by distribution function of F(x) and density function of f(x). The expected demand is E. The originator offer part of the service to the customers by himself, in the meantime he subcontracts some professional service to the service provider. The degree of the provider's effort can be of two types: high or low, indexed by H and L, respectively. The high effort could make the customers more satisfactory and accordingly the expected demand would increase that is to say, $E_H > E_L$.

Assumption 1: xH is equal in distribution to ax_L for some constant $\alpha \geq 1$, i.e., $E_H = aE_L$ and $F_H(x) = F_L(x/a)$ for $x \geq 0$.

Before the operation starts, the originator invests C_{10} to prepare his service capacity which could meet the demand of q_0 at most. Correspondingly the service invest C_{1P} to meet the maximum demand of q_P. In this work, we make the assumption that both the originator and service provider have enough capacity to meet all the market demand. Thus will help us focus our analysis further on the key problem, i.e., incentive mechanism.

Assumption 2: The maximum service volume of the originator or the service provider is no less than the actual market demand x (neither x_H nor x_L), i.e., $q_0 \geq x_H$ and $q_P \geq x_H$. Here x_H is a stochastic variable.

Because $x_H = ax_L$ and $\alpha > 1$, we can get $q_0 > x_L$ and $q_P > x_L$. Assumption 2 implies that there is no stockout phenomena. Once customers come, their demand could fully be satisfied.

When demand commence, the originator offers a part of the total service to customers with the unit price of p and the unit cost of c_0 while the service provider offers another part of the service with the unit cost of c_P. If the service provider is in high effort (indexed byH), he will face the additional cost of ψ and the demand distribution function $F_H(x)$. On the other hand, low effort (indexed byL) induces the demand distribution function of $F_L(x)$ without any additional cost. For the service provider's service, the originator pays t(x) to him.

To the originator, $F_H(x)$ means more profits than $F_L(x)$, so he would like to use the payment of t(x) not only to pay for the service provider's work but also to make the service provider be in high effort. So, we call t(x) an incentive payment mode. From the view of practitioner, t(x) should not be complicated. The more simple the structure of t(x) is, the more feasibly practitioners could put it into practice. A simple and convenient form of t(x) is linear and in this study we adopt the following form to make further analysis:

$$t(x) = a + bx \ (b \geq 0) \tag{1}$$

The originator is the dominant firm in this supply chain. To maximize his own benefits, the originator would like to provide an optimal payment form of t(x) to the service provider who would make a decision whether he accept this payment form. The objective function can be given as follow:

$$\begin{aligned} &\text{Maximize } \pi_O = pE_H - c_O E_H - E[t(x)] - C_{IO} \\ &\Rightarrow \text{Maximize } [pE_H - c_O E_H - (a + bE_H) - C_{IO}] \end{aligned} \tag{2}$$

where, E[t(x)] represents the expected payment from the originator to the service provider.

To make the service provider accept the payment form t(x), two prerequisites are necessary. First the benefit of the service provider from high effort is no less than that from low effort. Second the benefit of the service provider is always non-negative. Therefore we could get two constraint conditions:

$$\begin{aligned} &\text{s.t.1:} \quad \pi_P(H) - \pi_P(L) \geq 0 \\ &\Rightarrow a + bE_H - c_P E_H - C_{IP} - \psi - (a + bE_L - c_P E_L - C_{IP}) \geq 0 \end{aligned} \tag{3}$$

and:

$$s.t.2: \quad \pi_P(H) \geq 0 \Rightarrow a + bE_H - c_P E_H - C_{IP} - \psi \geq 0 \tag{4}$$

Incentive model solving. Denoting λ_1 and λ_2 as the multipliers of Eq. 3-4, respectively, the Lagrangian function of the incentive model can be written as:

$$L = pE_H - c_O E_H - (a + bE_H) - C_{IO} + \lambda_1(a + bE_H - c_P E_H - C_{IP} - \psi - (a + bE_L - c_P E_L - C_{IP})) + \lambda_2(a + bE_H - c_P E_H - C_{IP} - \psi)$$

The necessary conditions of the optimal solution can be derived as follows:

- Derivative with respect to a:

$$\frac{\partial L}{\partial a} = -1 + \lambda_2 = 0$$

- Derivative with respect to b:

$$\frac{\partial L}{\partial b} = E_H + \lambda_1(E_H - E_L) + \lambda_2 E_H \leq 0,$$
$$b \geq 0, \quad b(E_H + \lambda_1(E_H - E_L) + \lambda_2 E_H) = 0$$

- Derivative with respect to λ_1:

$$\frac{\partial L}{\partial \lambda_1} = (b - c_P)(E_H - E_L) - \psi \geq 0, \ \lambda_1 \geq 0, \quad \lambda_1((b - c_P)(E_H - E_L) - \psi) = 0$$

- Derivative with respect to λ_2:

$$\frac{\partial L}{\partial \lambda_2} = a + bE_H - c_P E_H - C_{IP} - \psi \geq 0, \ \lambda_2 \geq 0,$$
$$\lambda_2(a + bE_H - c_P E_H - C_{IP} - \psi) = 0$$

And from assumption1, we know $E_H = aE_L$ and $\alpha > 1$. Summarizing all above equations, we could get the solution of a and b and get the optimal form of t(x):

$$\begin{cases} a = C_{IP} - \dfrac{\psi}{\alpha - 1} - \alpha E_L \\ b = 1 + c_P + \dfrac{\psi}{(\alpha - 1)E_L} \end{cases} \tag{5}$$

$$t(x) = C_{IP} - \frac{\psi}{\alpha - 1} - \alpha E_L + (1 + c_P + \frac{\psi}{(\alpha - 1)E_L})x \tag{6}$$

And correspondingly the maximum of the originator's benefit is:

$$pE_H - \psi - (c_O + c_P)E_H - (C_{IO} + C_{IP}) \tag{7}$$

In this incentive issue, it is impossible for the service provider to infinitely magnify his expected benefit through motivating the supplier as there is a maximized objective utility in real life. And, we only get one feasible solution from the above model. So according to the optimization theory, this feasible solution must be the maximum and also the global optimal solution.

DECISION AND CONTROL OF THE INCENTIVE PAYMENT SOLUTION

The precondition of incentive. From above, we presume that the supplier's high effort will improve the net profit of the supply chain and also we know it will induce additional cost. So to a manager it is necessary to understand when such incentive payment solution is valuable. In this section, we discuss about this question.

To make the incentive valuable requires that the supplier's effort could lead to a positive increment of supply chain profit. The supplier's effort will increase the expected demand. Namely, the probability of higher demand increases while the probability of low demand decreases.

The expected net profits of the supply chain due to the supplier's effort is:

$$\Delta\Pi = \Pi_H - \Pi_L = (p - c_O - c_P)E_H - \psi - (p - c_O - c_P)E_L$$

As $E_H = \alpha E_L$, we get:

$$\Delta\Pi = (\alpha - 1)(p - c_O - c_P)E_L - \psi \tag{8}$$

As long as the net revenue is positive, the incentive to the supplier is necessary. So, the precondition is $\Delta\Pi = (\alpha - 1)(p - c_O - c_P)E_L - \psi \geq 0$, that is:

$$(p - c_O - c_P) \geq \frac{\psi}{(\alpha - 1)E_L} \tag{9}$$

From the above analysis, it can be seen that Eq. 9 is the decision criteria whether to motivate the supplier or not. The left express of the in Eq. 9 equals the unit gross profit margin of the service. It tell us that managers should pay more attention to those service industry whose gross profit margin is quite low when he want to incentive his suppliers. And when he makes pricing decision he needs to take into account the criteria Eq. 9 if he is using such incentive payment solution.

And from the right part of the in Eq. 9, we could get several management inspirations. First, the cost of the service provider's high effort may make the incentive payment solution useless. The higher the cost is the less

effective the incentive solution is. The Second is about average market demand. If the demand is very small, for example a new service sector, managers should remain cautious about implementing incentive payment solution. Lastly the parameter α implies the sensitivity of market demand by altering from low effort to high effort. The in Eq. 9 tells managers that the bigger the sensitivity of market demand to service provider's effort is the further the originator need to implement such incentive solution.

Profit allocation control: When implementing the incentive payment of Eq. 6, the originator's profit reach its maximum and the provider's is zero. This incentive payment solution can only be available on the condition that the service provider has no bargaining power. However, the supplier often has bargaining power at least some extent and will not be satisfied with the lowest profit. Therefore we should offer an effective adjustment mechanism to alter the profit allocation between the originator and his supplier.

By introducing a profit control parameter of $w(w \geq 0)$, the incentive payment becomes:

$$t(x) = C_{IP} - \frac{\psi}{\alpha - 1} - \alpha E_L + w + \left(1 + c_P + \frac{\psi}{(\alpha - 1)E_L}\right)x$$

The upper bound of $\tilde{w}$ makes the originator's profit zero:

$$\pi_O = pE_H - (a + \tilde{w} + bE_H) - c_P E_H = 0$$

So, we get:

$$\tilde{w} = pE_H - \psi - (c_O + c_P)E_H - (C_{IO} + C_{IP}) \quad (11)$$

Thus, the range of profit control parameter w is:

$$0 \leq w \leq \tilde{w} = pE_H - \psi - (c_O + c_P)E_H - (C_{IO} + C_{IP}) \quad (12)$$

And the allocation ratio of two members' profit is:

$$\frac{\pi_O}{\pi_P} = \frac{pE_H - \psi - (c_O + c_P)E_H - (C_{IO} + C_{IP}) - w}{w} \quad (13)$$

By negotiating the appropriate profit control parameter w which is acceptable by both of the originator and the service provider, they could easily balance their profit according to their bargaining power. At the same time they make the whole supply chain gain the maximum profit by implementing the incentive payment solution.

CONCLUSION REMARKS

In a service supply chain, the originator needs to offer the incentive payment to the service provider. We examine why the incentive is necessary and what is the optimal payment solution. The Eq. 6 represents an effective and exercisable payment solution for the originators in service supply chains. Since, in some service industries, the cost of the supplier's effort is even higher than the increment of the supply chain's profits. The precondition of incentive and the profit allocation adjustment are also discussed.

For a manager of a certain service enterprise, when negotiating with supplier about the service outsourcing, he should consider the incentive to the service provider. When considering the incentive mechanism, he should judge the validity and necessity of the incentive in the view of certain service industry. For the service whose "demand-service sensitivity" is high, the incentive is more necessary. While in some service industries, the service providers face the ultimate users indirectly, the validity of incentive decreases.

Another important problem for the manager is negotiating on the profit allocation. After determining the profit allocation ratio, we can use parameters w to realize reasonable profit allocation. After these steps, the manager can ensure the profit maximization and effective operation of the service outsourcing.

Obviously, the problem of incentive for service supply chains is quite rich and our model is incomplete. One important dimension which was not considered is the situation that the originator or the service provider's capacity could not meet the market demand. If so, the originator should further consider the optimal capacity preparing decision while he is choosing the right parameters for payment form t(x). We do not investigate such situation because we want to make the result of incentive solution more concentrated and easier to analyze. However it is one of the main points which would be discussed in future.

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