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Equilibrium Conditions In Service Supply Chain

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Abstract

Service supply chain features human players as service vendor, service integrator, customer and service resource. It tends to be digitally connected, such as consulting, e-business and integrated enterprises. Our study uses a formal model and simulations to develop the effect of a service supply chain on equilibrium computation. Two insights arise on how a network can obtain equilibrium computation: forming the network structure of service supply chain; exploring entities behavior and equilibrium conditions. These results highlight the importance for service supply chain of adapting its network structure to equilibrium and application.

Keywords: *service supply chain; service volume; equilibrium*

1. Introduction

With the ever-growing importance of the service sector in economies, the notion of service supply chain (SSC) has obtained a more prominent role in contemporary operations management. As more and more traditionally product based companies like IBM, Cisco and Pitney Bowes garner increasing proportions of their revenues from services. How can partners of service supply chain form temporary alignments to quickly respond to market/customer requirements as well as effectively utilize their

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competencies? The ability to select suitable partners and effectively utilize their resources throughout the chain is a key to successful supply chain networks. The uncertainties and constraints may result in dynamisms and difficulties in searching, selecting, and coordinating the services. Relevant literature in this area can be found in workflow or business process management, where problems in managing activities under various resource and operational constrains are being investigated.

Equilibrium is pervasive in service supply chain. The equilibrium state of service supply chain is an ideal and optimal state. Examples include development of decentralized models that allow for a generalized network structure and simplicity in computation in regards to the study of supply chains [1], modeling the competition among firms that produce services for customers who are sensitive to delay time [2, 3], and equilibrium conditions [4, 5]. Equilibrium may contain integrated dynamic models [6-8]. Generally, it is equilibrium and not optimization that dominates service supply chain network problem solving.

2. Model set up

We build a model of a service supply chain that engages in equilibrium computation to solve a complex supply chain with many interdependent entities. Our model explicitly captures two fundamental characteristics of complex equilibrium: (1) service supply chain network equilibrium conditions, the customers take into account their consumption decision not only the price charged for the service by the integrators or service brokers but also the service volume to obtain the service, and (2) variation inequality formulation, the equilibrium conditions governing the supply chain network may be equivalent to the solution of the variation inequality problem, which coincides with the equilibrium service flow and price pattern. We consider N service vendors, with a typical service vendor denoted by n; M service integrators, with a typical service integrator denoted by m; X service brokers, with a typical service broker denoted by x; and customers associated with Y demand markets, with a typical demand customer or market denoted by y, as depicted in Fig. 1. The Service integrators have enormous influence over all of the activities involved in the service supply chain network. The Service brokers and the service integrators can be the same or separate business entities. The Service brokers are service branches of service products, and deal with service integrators and customers. Since service brokers do not make service change fundamentally, they are not explicitly represented by nodes in this network model. An implicit assumption is that the service integrators need to cover the direct service cost and consider whether service brokers should be used and how much service volume should be delivered. Here, however, we will assume that, because services cannot be stored, the service volume available at each service vendor is equal to the service volume transmitted. The links in the service supply chain network denote transaction links.

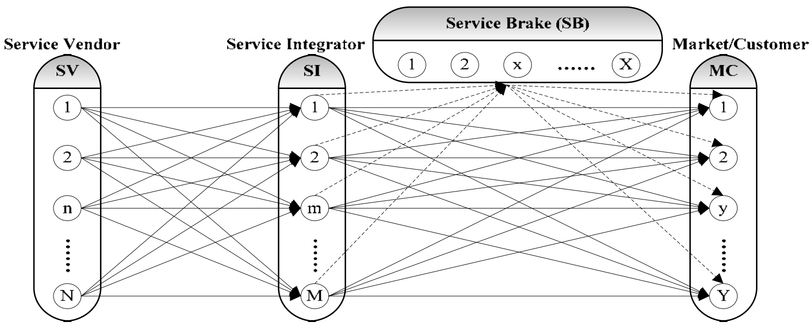

Figure 1: Research Conceptual Framework

Now, for definiteness and easy reference, we explore the behavior and optimality conditions of the service vendors, the service integrators, and the customers at the demand markets. Meanwhile, we describe the service supply chain network equilibrium conditions and propose the equilibrium computation formulation.

3. Entities behavior and optimality conditions

Let $\boldsymbol{\delta_{nm}}$ denote the service volume for service transaction by service vendor n to service integrator m. Since for each service vendor the total amount of service volume sold must be less than the total service volume of service products, the following conservation of service flow equation express relationship between the quantity of service transaction by service vendor n and the transmitted chains to service integrators: $\boldsymbol{\delta_n = \sum_{m=1}^{M} \delta_{nm}, n = 1, 2, \cdots, N.}$ (1)

Let $\boldsymbol{\mathcal{P}_{nm}}$ denote the unit price charged by service vendor n for service transaction with service integrator m, which is an endogenous variable and can be determined (i.e. the wholesale price). Due to (1) and note the assumption that individual service vendor is a profit-maximize people; we may express service generating cost associated with service vendor n, namely, $\boldsymbol{\mathcal{C}_n}$ as follows: $\boldsymbol{\mathcal{C}_n(\mathcal{H}) \equiv \mathcal{C}_n(\mathcal{S})}$ for all $\boldsymbol{n = 1, 2, \cdots, N.}$ where $\boldsymbol{\mathcal{H}}$ is nm-dimensional vector of service transaction between service vendors and service integrators, $\boldsymbol{\mathcal{H} \subseteq \{\delta_{nm} | n = 1, 2, \cdots, N; m = 1, 2, \cdots, M\}}$. $\boldsymbol{\mathcal{S}}$ is the service volume for service vendors sold, $\boldsymbol{\mathcal{S} = \sum_{n=1}^{N} \delta_n}$. Therefore, the optimization case of service vendor n can be expressed as follows: $\textbf{Opt.} \boldsymbol{\sum_{m=1}^{M} \mathcal{P}_{nm}\delta_{nm} - \mathcal{C}_n(\mathcal{H}) - \sum_{m=1}^{M} \mathcal{T}_{nm}(\delta_{nm})}$ (2)

where $\boldsymbol{\mathcal{T}_{nm}(\delta_{nm})}$ is service transaction cost incurred by service vendor n in dealing with service integrator m. According to the existing literature [9-11], we can assume that the service generating cost and the service transaction cost functions for each service vendor are convex and continuously differentiable. Given $\boldsymbol{\mathcal{H}^*}$ and $\boldsymbol{\delta_{nm}^*}$ in a non-cooperative game, the optimality conditions for all service vendors simultaneously may be expressed as the following formulation:

$$\sum_{n=1}^{N} \sum_{m=1}^{M} \left[\frac{\partial \mathcal{C}_n(\mathcal{H}^*)}{\partial \delta_{nm}} + \frac{\partial \mathcal{T}_{nm}(\delta_{nm}^*)}{\partial \delta_{nm}} - \mathcal{P}_{nm}\right] \times \ [\delta_{nm} - \delta_{nm}^*] \geq 0 \qquad (3)$$

Since service generating cost $\boldsymbol{\mathcal{C}_n}$ is a function of the total service volume, we can obtain that the marginal service generating cost with respect to $\boldsymbol{\delta_n}$ is equal to the marginal generating cost with respect to $\boldsymbol{\delta_{nm}}$, namely, $\boldsymbol{\frac{\partial \mathcal{C}_n(\mathcal{S})}{\partial \delta_n} \equiv \frac{\partial \mathcal{C}_n(\mathcal{H})}{\partial \delta_{nm}}}$. We can, thus, transform (3) into the following equivalent expression with respect to determine $\boldsymbol{\mathcal{H}^*}$ and $\boldsymbol{\mathcal{S}^*}$:

$$\sum_{n=1}^{N} \frac{\partial \mathcal{C}_n(\mathcal{S}^*)}{\partial \delta_n} \times [\delta_n - \delta_n^*] + \sum_{n=1}^{N} \sum_{m=1}^{M} [\frac{\partial \mathcal{T}_{nm}(\delta_{nm}^*)}{\partial \delta_{nm}} - \mathcal{P}_{nm}] \times [\delta_{nm} - \delta_{nm}^*] \geq 0 \qquad (4)$$

The service integrators, in turn, are involved in transactions both with the service vendors since they wish to obtain the services for their integration service outlets, as well as with the customers, who are the ultimate purchasers of the services at demand markets. Since service cannot be stored, it is rational hypothesis that the total amount of the services sold by a service integrator is equal to the total service volumes that he ordered from the service vendors. This assumption can be represented as:

$$\boldsymbol{\sum_{y=1}^{Y} \sum_{x=1}^{X} \delta_{my}^{x} = \sum_{n=1}^{N} \delta_{nm} = \delta_m} \qquad (5) \quad \boldsymbol{m = 1, 2, \cdots, M.}$$

Here $\boldsymbol{\delta_{my}^{x}}$ denotes the service volume for service transaction by service vendor n in transaction with demand market $\boldsymbol{y}$ via service broker $\boldsymbol{x}$.

Let $\boldsymbol{\wp_{my}^{x}}$ denote the unit price charged by service integrator m for service transaction with demand market $\boldsymbol{y}$ via service broker $\boldsymbol{x}$, which is an endogenous variable and can be determined (i.e. the retail price). Due to (5) and note the assumption that individual service integrator seeks to maximize his own profit; we can express the optimization case of service integrator m as follows:

$$\textbf{Opt.} \sum_{y=1}^{Y}\sum_{x=1}^{X} \wp_{my}^{x}\, \delta_{my}^{x} - \mathcal{T}_m(\mathcal{H}) - \sum_{n=1}^{N} \mathcal{P}_{nm}\delta_{nm} - \sum_{n=1}^{N} \mathcal{I}_{nm}(\delta_{nm}) - \sum_{y=1}^{Y}\sum_{x=1}^{X} \mathcal{J}_{my}^{x}(\delta_{my}^{x}) \qquad (6)$$

Here $\mathcal{T}_m(\mathcal{H})$ denotes the operating cost of service integration by service integrator m, which is a function of the total service flows to the service integrator, that is, $\mathcal{T}_m(\mathcal{H}) \equiv \mathcal{T}_m(\mathbb{S})$, $\mathbb{S} = \sum_{m=1}^{M} \delta_m$ $\mathcal{I}_{nm}(\delta_{nm})$ denotes the transaction cost incurred by service integrator m in transaction with service vendor n. $\mathcal{J}_{my}^{x}(\delta_{my}^{x})$ denotes the transaction cost incurred by service integrator m in transaction with demand market y via service broker x.

As mentioned, thinking of the literature [12, 13], we assume that the transaction costs and operating costs are all convex and continuously differentiable. Meanwhile, the service integrators compete in a non-cooperative game. Therefore, the optimality conditions for all service integrators simultaneously may be expressed as the following formulation with respect to determine $\wp_{my}^{x*}$ δ_{my}^{x*} and $\mathbb{S}^*$:

$$\sum_{m=1}^{M} \frac{\partial \mathcal{T}_m(\mathbb{S}^*)}{\partial \delta_m} \times [\delta_m - \delta_m^*] + \sum_{m=1}^{M}\sum_{y=1}^{Y}\sum_{x=1}^{X} \left[\frac{\partial \mathcal{J}_{my}^{x}(\delta_{my}^{x*})}{\partial \delta_{my}^{x}} - \wp_{my}^{x*}\right] \times \left[\delta_{my}^{x} - \delta_{my}^{x*}\right]$$

$$+ \sum_{n=1}^{N}\sum_{m=1}^{M} \left[\frac{\partial \mathcal{I}_{nm}(\delta_{nm}^*)}{\partial \delta_{nm}} + \mathcal{P}_{nm}\right] \times [\delta_{nm} - \delta_{nm}^*] \geq 0 \qquad (7)$$

Here, the marginal cost with respect to δ_m is equal to the marginal cost with respect to δ_{nm} , namely, $\frac{\partial \mathcal{T}_m(\mathbb{S})}{\partial \delta_m} \equiv \frac{\partial \mathcal{T}_m(\mathcal{H})}{\partial \delta_{nm}}$.

We now discuss the optimality conditions for the customers located at the demand markets. The customers care about two aspects for making their consumption decisions. One side is price charged for services by the service integrators or service brokers, the other is the service transaction cost to obtain the services. In our model, we assume that the demand for the services at each demand market is determinacy, which is denoted by the term ϱ_y. Hence, the following conservation equations must hold: $\varrho_y = \sum_{m=1}^{M}\sum_{x=1}^{X} \delta_{my}^{x}$. In the optimality conditions, when the service volume purchased from the service integrators via service brokers is positive ($\delta_{my}^{x*} > 0$), the optimality prices the customers are willing to pay for the services at the demand market will be precisely equal to the sum of the price charged by the service integrator and the unit transaction cost incurred by the customers. Namely, $\mathfrak{p}_y^* = \wp_{my}^{x*} + \mathbb{T}_{my}^{x}(\mathcal{Q}^*)$. Where $\mathfrak{p}_y^*$ denotes the demand price of the service at demand market y. $\mathbb{T}_{my}^{x}(\mathcal{Q}^*)$ denotes the unit transaction cost incurred by the customers located at the demand market y associated with service integrator m via service broker x . $\mathcal{Q}^*$ is mxy-dimensional vector of service $\mathcal{Q}^* \subseteq \{\delta_{my}^{x} | y = 1, 2, \cdots, Y; m = 1, 2, \cdots, M; x = 1, 2, \cdots, X\}$. Otherwise, if the price charged by the service integrator plus the unit transaction cost exceed acceptable price by the customers, then there will be no service transaction ($\delta_{my}^{x*} = 0$) between the service integrators and the customers. Therefore, the optimality conditions for all demand markets simultaneously may be expressed as the following formulation with respect to determine $\mathcal{Q}^*$: $\sum_{m=1}^{M}\sum_{y=1}^{Y}\sum_{x=1}^{X} [\wp_{my}^{x*} + \mathbb{T}_{my}^{x}(\mathcal{Q}^*)] \times \left[\delta_{my}^{x} - \delta_{my}^{x*}\right]$ (8)

4. Conclusion

This study will look at how the internet is creating a new wave of business and technical models, which promise to boost productivity in the service sector. Service supply chain encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all service management activities. We use a formal model to explore the effects of network structure on equilibrium computation with respect to entities behavior and equilibrium conditions. Previous work has explored that understanding of random networks (a node connects to other nodes by equal chance), regular networks (a node connects to other nodes by explicit design), and semi-regular networks (in between these two) and raises numerous topological patterns from various connection rules. This work has illuminated important managerial trade-offs, but it has represented network only in its limited form---with N service vendors (SV), M service integrators (IS), X service brokers (SB), and Y markets/ customers (MC) ---and has focused on equilibrium computation.

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