Strategic Outsourcing with Delay-Sensitive Customers

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Abstract: This paper investigates the impact of customers' delay sensitivity on the pricing and capacity strategy of supply chain, in which a provider (or a supplier) provides a service or distributes a product to an independent outsourcer (or a retailer). The problem is modeled as a Stackelberg game in the context of a simple queuing system, where the provider, as the leader of the game, determines the capacity and the service price charged to the outsourcer. Reacting to the provider's decisions, the outsourcer sets the market (service) price to provide the service to the customers who incur the delay cost if the waiting time exceeds a certain tolerance level. Our result indicates that although the outsourcer does not incur a capacity cost, the outsourcing strategy is not always optimal. We show that the outsourcing strategy should be adopted only when the customer required activity performance is higher than a certain threshold. In an oligopolistic setting, the value of threshold decreases with the number of outsourcers in the market.

Keywords: outsourcing, price- and delay sensitive customers, tolerance threshold, game theory

I. Introduction

This paper investigates pricing and capacity strategy of a supply chain, where a provider (or a supplier) offers a service or a product to an independent outsourcer (or a retailer). The vertical competition is raised by the operation decisions made by two firms individually, especially when they are facing price- and delay-sensitive customers. In that case, how they adopt appropriate strategies to maximize their profits respectively; how would these operation factors influence the firms' decisions and the channel performance? All these questions are interesting and important for the managers and remained to be addressed.

The above characteristics commonly existed in the real outsourcing business activities. In the after-sale industry, a customer may go to a digital device retailer bringing his breakdown Nikon camera without a warranty. Then the camera is probably repaired by an outside repair center but not the retailer itself, thus the retailer can't control the whole service time very well which includes the shipping time, assembly delivery time and fixed repair time. Considering the customer's impatience, both the charge for the maintenance and waiting time would definitely affect the customer's purchase decision. In the call center industry, nowadays global organizations have always preferred outsourcing call center services to India. Joinedup thinking is a contact centre consultancy that provides a range of services to assist clients to establish new call centre Services or improve their existing contact centre services. Its clients come from both the Corporate and Public Sectors spanning the media and financial services business sectors which are all household names in the UK such like freesat, sky, digitaluk and Virgin Health bank (http://joinedup-thinking.com/default.htm). Referring to the call service, the telephone fee and the waiting time needed to get through the phone are two critical operation factors impacting the customer's choice of making a call or not. According to Zohar et al (2002), 38% of the customers would abandon this service within the delay time of 110, 140, 180, 240 seconds during different periods of the day with the assumption that the customers' patience is unrelated to the system performance.

While outsourcing has been widely adopted by the firms to cut costs, improve performance, and refocus on the core business, however, some outsourcers experience deterioration in profit and performance due to losing control over the outsourced activity. These firms pay little time and effort on investigating the features of the business they intend to outsource (Barthelemy, 2003). The above examples exhibit some characteristics common to an outsourcing environment: Firstly, the outsourcer and the supplier are mutually independent and purchase for the maximum profit respectively; Then the outsourcer focuses more on market while the supplier should guarantee a good operational performance level; Lastly, The demands are affected by the price and expected waiting time.

The strategy and competition in the outsourcing supply chain are strongly influenced by the customers react to the actual performance level. Anderson et al (1997) demonstrated that customer satisfaction is correlated with capacity utilization based on the evident from empirical marketing research. We measure the activity performance by using the utilization rate that can be observed by the customers and related with the provider's capacity. Also in some situations, a common threshold always exists that the insufficient performance level has a negative influence on customers, incurring the delay cost only if the utilization rate of the activity falls short that threshold (e.g., Jahnke et al, 2005 or Zohar et al., 2002). For example, sometimes delaying a routine maintenance for a certain time period has no cost consequences for the customers due to the consideration of the service complexity or difficulties such like the risk of a machine failure. However, after this allowed delay, the customer has to bear monetary cost associated with the delay. By combining such cost structure into the model, we make a direct connection between operations and marketing.

The above issues make the problem much more complicated. Adopting a well-organized pricing and capacity strategy is a key step for successes of outsourcing business activities. Hence, with such a circumstance mentioned above, our work tries to explore some insights and offer managerial guidance by developing an explicit model.

Some existed literatures investigate the outsourcing competition with the outsourcer usually acts as a game leader (Cachon and Harker (2002), Ren and Zhou (2008)). However, with supply firm grows by taking more advanced technology or taking advantage of the lower cost of raw material and human resources, he becomes much more competitive in the industry. It would be true that many firms decide to outsource some kind of business activity to the same supply firm. For example, it's possible that different agents receive their OEM orders and outsource to the same qualified manufacturer. Thus, we assume supplier has the bargaining power. In this paper, we firstly consider a single firm who intends to outsource a delay sensitive activity to an outside provider and formulate a familiar Stackelberg game, where the provider acts as a leader to set the intermediate price and capacity for this outsourcing activity and then the outsourcer follows to set the sales price. We compare the outcomes of the outsourcing strategy with the in-house operation. Despite lower the capacity cost, outsourcing is not always performing better which incentive us to study the relation between customers' satisfaction and cost reduction from outsourcing. The result indicates that under some conditions, the firm can exert outsourcing as a powerful tool to enhance their net profit. Apart from these, in our oligopolistic model considering N competitive firms outsource the same business activity to a same provider, we demonstrate with more outsourcers competition in the environment, it requires a more strict condition that a smaller threshold to carry out the strategy. At last, with perfect competition, the value of outsourcing strategy diminishes.

Another significant contribution of our paper is that we explore the optimal pricing and capacity strategy of the firms in an outsourcing environment when they face both price- and delay-sensitive customers with a tolerance threshold. Imagine the situation that the customers' tolerance level for a certain activity becomes lower, the demand for this activity decreases. In order to increase the demand, the two parties would exert some effort that the outsourcer lowers his sales price while the provider increases his capacity to improve the performance level. Therefore, the pricing and capacity strategies making should be adaptive and based on the customers' tolerance level. Applying such strategy, we find an interesting result that the provider would always chooses the intermediate price and capacity which just enough fulfill the customer requirement. That means it is efficient for the outsourcer to control over their activity performance level. Our results can help firm to clarify how to make the decision of outsourcing, and also how to exert the adaptive pricing and capacity strategies to master the outsourced activity performance.

II. Model

1. The Kinked Demand Curve with Service-level Sensitive Customers

A simple queuing system is often applied to model the interaction between available capacity and the stochastic demand .The arrival rate of the customers or the demand is noted by $\lambda > 0$ every customer orders just one product unit and then served by the FIFO discipline. For example, when a product unit is ordered, it immediately starts to complete the job and increases the queue length by one. The time needed to serve a single product unit hence is an independent variable with a random distribution and can be noted with a mean of $1/\mu$. The provider's capacity per time unit on average will be denoted by $\mu > 0$. Therefore the provider's utilization rate is $\rho = \lambda/\mu$.

The utilization rate is the most important factor should be considered in modeling the relationship between the customers' demand and provider's capacity as it shows the activity intensity or performance efficiency of the whole system in a certain situation. To guarantee the queue length is limited, the assumption $\rho < 1$ has to be made. Then ρ means the probability of a server is being busy and $1 - \rho$ means the probability of being served by a free server at once. In a $M / M / 1$ model, the expected number of customers in the queuing system is an increasing function of ρ. Thus the utilization rate ρ would be considered as the uniform factor to describe the every aspect of a whole system.

However, there always exists a delay threshold in customer's mind which has a negative influence on the performance level. For examples, Hui and Tse (1996) find that 5 minutes of waiting time is critical for computerized service while Taylor (1994) observed half hour is the threshold for the airline service. Once the waiting time exceeds the threshold, it drives the customer away. For convenience in the following discussion, $\theta(0 < \theta < 1)$ is given to describe the specified threshold of measuring the performance level including waiting time, queue length and the probability of free server. Therefore θ means the maximal load of the system. The customers can enjoy a sufficient service when the actual utilization rate exceeds the threshold value, otherwise incur a delay cost. As a result, we should consider two different scenarios while considering the level of demand faced by the provider.

In the first scenario, the minimal performance level is achieved, which means the provider can satisfy customer's demand, then a standard linear price-demand-rate function should be introduced, which demand is a decreasing function of the price:

$$\lambda(p) = \alpha - \beta p \quad (1)$$

In the second scenario, the minimal performance level is lower than the threshold which will cause a certain number of customers decide to not buy the product or enjoy the service then leave the queue because of the insufficient performance. In such a case, an extra virtual price should be introduced to measure the loss due to the long waiting time. Hence, the total price for a single customer π consists of two parts: the actual price p and the monetary equivalent price caused by the dissatisfaction of the long waiting time. To simplify the representation of the two respective scenarios, an expression taking the extra charge into consideration is given to fit the two sets of the customers in the model rather than two individual ones. More concretely with a certain capacity μ, the extra charge is assumed to be related of the price difference between the system' utilization rate and maximal load $\rho - \theta$. Thus the full price π can be given as follow:

$$\pi(p, \mu) = p + \varepsilon\, max\{0, \rho - \theta\} \quad (2)$$

where ε represents the responsiveness for the poor performance. To ensure the response is strong enough that have a significant impact on the purchase choice for customers, we assume $\varepsilon \geq 1/2\theta^2$. Equation (2) relates to both p and μ with a constraint $\lambda(p) \,/\, \mu \leq \theta$, then the demand will be represented by a standard price-demand-rate function (1), implying $\rho = \lambda(p)/\mu$. In the other case, for $\theta < \lambda(p) \,/\, \mu < 1$ we suppose the customers would perceive this poor performance, then they are able to figure out whether the provider reaches the required performance level or not. However, in the real world, the idea to measure the performance level by the combination of the price p and capacity μ comes from the rich experience.

According to the insufficient performance level, the customers' service utility is denoted by the full price π, implying $\rho = \lambda(\pi(p, \mu))/\mu$ .Since in this scenario $\pi(p, \mu) = p + \varepsilon(\alpha - \beta\pi(p, \mu))/(\mu + \varepsilon\theta)$, we can conclude

$$\pi(p, \mu) = \frac{\varepsilon(\alpha - \mu\theta)}{\mu + \varepsilon\beta} + \frac{\mu p}{\mu + \varepsilon\beta} \quad (3)$$

Under all there assumptions and deduction, we finally get the relationship between the actual paid price and the demand rate when there exists a given capacity μ and can be described by the following kinked demand curve.

$$D(p, \mu) = \begin{cases} \alpha - \beta p, & 0 < \frac{\alpha - \beta p}{\mu} \leq \theta \\ \frac{\mu(\alpha + \varepsilon\beta\theta - \beta p)}{\mu + \varepsilon\beta}, & \theta < \frac{\alpha - \beta p}{\mu} \leq 1 \end{cases} \quad (4)$$

$D(p, \mu)$ is a kinked price-demand-rate function as depicted by the solid line in the Figure 1. For a given capacity μ, the kinked point is denoted by the highest demand rate while the minimal service level is reached, that is, $D_\theta = \mu\theta$ with the corresponding price of $p_\theta = a - b\mu\theta$. While the price exceeds p_θ, the demand rate is represented in the first part of (4), otherwise, it's denoted by the second part.

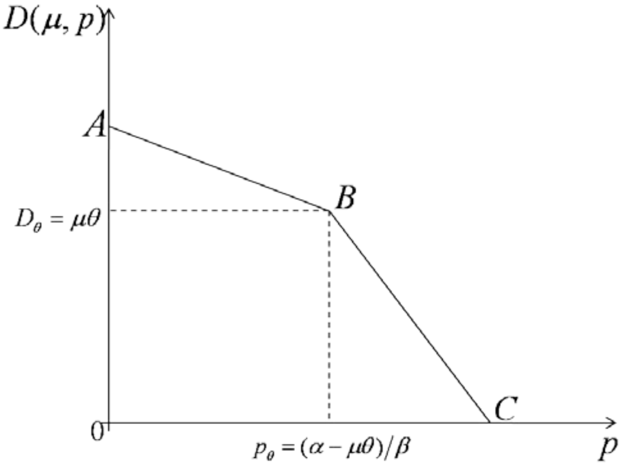

Figure 1 Kinked Demand Curve

Facing the delay-sensitive customers, the firms always worry about their responsibility to this performance, which is essential for their reputation. As a result, more and more large firms choose outsourcing part or all activities to an outside provider to reduce their delay risk and save capacity cost.

The monopolist provider supplies the outsourcer the activity for each customer at intermediate price w, and incurs a direct operating cost per unit c, maybe for a raw material cost or telephone fee. We assume there's no cost discrimination between the outsourcer and the supplier. Besides, as the capacity size of the provider is μ, the corresponding linear capacity cost per unit time is $z\mu$, usually this is for salary paid for the employees, where z measures the capacity cost level for outsourcer. For analytic simplicity, we assume $z = 1$.

Therefore, for each of them, the outsourcer's profits are determined by

$$\Pi_o = (p - w)D(\mu, p) \quad (5)$$

And the provider's profits are determined by

$$\Pi_p = (w - c)D(\mu, p) - z\mu \quad (6)$$

2. Benchmark: Integrated Outsourcing Supply Chain

While the outsourcer chooses an in-house operation, he should make centralized decision on the sales price and capacity. We first consider this integrated situation as a benchmark. The system's expected profit could be described by

$$\Pi_I(p, \mu) = (p - c)D(\mu, p) - k\mu \quad (7)$$

Here we assume $k \geq z = 1$, which implies that the outside provider has a lower capacity cost than the integrated outsourcer.

As the target is to maximize the profit demonstrated above, this problem is similar to that in Jahnke and Chwolka (2005) which solves the following profit maximization problem for the integrated system:

$$\mathrm{Max}_{p,\mu}\, \Pi_I(p,\mu). \quad (8)$$

We have the following proposition.

Proposition 1 *The profit-maximizing ssles price and capacity for the integrated system should be* $p^I = \frac{\alpha\theta + k\beta + \beta\theta c}{2\beta\theta}$ *and* $\mu^I = \frac{\alpha\theta - \beta\theta c - k\beta}{2\theta^2}$.

As Jahnke and Chwolka pointed out, while the customer's response to a deteriorating activity is sufficiently strong, the system's optimal solutions should satisfies $(\alpha - \beta p)/\mu = \theta$, which means the integrated system would determine the capacity just enough to meet customer's demand. Therefore in steady state, there is no customer abandonment or waiting. This result is similar with the one in Ren and Zhou (2008) and Whitt (2006). The solution also indicates that the system optimally balances the cost and benefit of capacity. For example, when the capacity cost per unit k increases, the provider would optimally increase the sales price and exert less capacity for this activity.

With the best choices of both price and capacity, the optimal profit of integrated system could be calculated, i.e. $\Pi_I^* = (\alpha\theta - \beta\theta c - k\beta)^2/4\theta^2\beta$. To ensure the capacity is strictly positive, we assume $\theta > k\beta/(\alpha - \beta c) = \hat{\theta}$, where $\hat{\theta}$ is a lower bound for a firm to take such a business, which means as the customers become too impatient or the capacity cost is too high that the firm can't afford, hence it's unnecessary to enter such a market. Then it's clearly seeing the profit function is monotonically increasing with θ. However, the capacity is strictly concave with the maximum point $\theta = 2k\beta/(\alpha - \beta c)$. As the threshold θ decreases, that means the customer becomes more impatient, the provider should increase the capacity to improve the service quality as to satisfy the customers' requirement. However, the capacity should not increase with θ decreases continuously because of the huge cost caused by the increasing capacity.

After investigating the integrated model as a benchmark, we now introduce the case of the decentralized outsourcing supply chain.

3. Decentralized System: Non-cooperative Outsourcing

In decentralized outsourcing system, the provider and outsourcer are mutually independent without cooperation. We model the interaction between the outsourcer and the provider as the familiar Stackelberg Game with two stages. The provider is the price leader, deciding the intermediate price w and capacity μ before the outsourcer sets the sales price p to customers. For the outsourcer, as the intermediate price w and demand can be predetermined, he can maximize profit given in (5) with respect to the sales price p. The provider estimates the outsourcer's response and then maximizes her profit given in (6) according to choose the optimal intermediate price and capacity.

In the first stage of this game, the provider considers its operating cost c for the activity and then acts as the price leader in setting both the intermediate price w and capacity μ. In the second stage, given the intermediate price w and capacity μ, the outsourcer decides the sell price p to maximize his profit. These ensure the perfect of the subgame and to confirm this point, we first analyze the outsourcer's decision in the second stage followed by the discussion of the first stage decisions.

Proposition 2 (the Provider's Pricing Strategy) *The optimal intermediate price and the capacity is the corresponding value of the demand at the kinked point. Specifically*

$$w^* = \frac{\alpha\theta + \beta\theta c + \beta}{2\beta\theta}, \mu^* = \frac{\alpha\theta - \beta\theta c - \beta}{4\theta^2}$$

And the optimal sales price for the outsourcer is $p^* = \frac{3\alpha\theta + \beta + \beta\theta c}{4\beta\theta}$.

Substituting the results of proposition 3 into (5) and (6) yields the optimal profit of the outsourcer and provider: $\Pi_o^* = \frac{(\alpha\theta - \beta\theta c - \beta)^2}{16\theta^2\beta}$ and $\Pi_p^* = \frac{(\alpha\theta - \beta\theta c - \beta)^2}{8\theta^2\beta}$.

The outsourcing decision is reasonable only when the outsourcer's profit in decentralized system is higher than the profit in integrated system. That is to say only when the inequation $\Pi_I^* \le \Pi_o^*$ holds, the company would outsource the business.

Proposition 3 *If and only if* θ *is below the threshold* $\tilde{\theta} = (2k-1)\beta/(\alpha - \beta c)$, *the inequation* $\Pi_I^* \le \Pi_o^*$ *holds which means the company with higher capacity cost prefers to outsource the activity to lower cost company.*

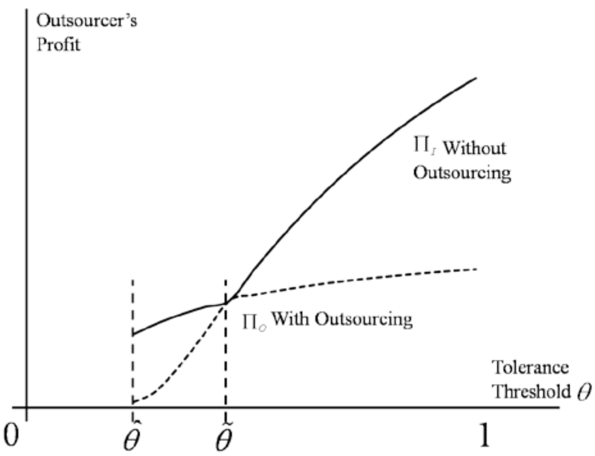

Figure 2 Outsourcer's Profit with and without outsourcing

Proposition 3 demonstrates the threshold $\tilde{\theta}$ which should be an upper bound for the company to determine whether adopt the activity outsourcing as a strategy to increase profit or not. In Figure 2, the outsourcer's profit is drawn as a function of customers' tolerance threshold towards the insufficient performance level. When the customers' tolerant level of this activity is above this threshold which means customers have lower expectation for the activity performance and are more patient for the delay, outsourcing brings less revenue than his loss through outsourcing. Therefore, outsourcing is not beneficial for the firm. On the other hand, instinctively, when the customer requires higher activity performance, i.e. higher capacity utilization, the party who operates the activity should increase the capacity to fulfill customers' request. In this environment, the outsourcer would be more eager to outsource this activity to a provider, who has lower capacity cost per unit. Thus when the performance level becomes more and more significant for an activity, the outsourcer prefers to assign it to an outside provider to gain extra profit or vice versa. Here $\tilde{\theta} - \hat{\theta} = \frac{(2k-1)\beta}{\alpha-\beta c} - \frac{k\beta}{\alpha-\beta c} = \frac{(k-1)\beta}{\alpha-\beta c}$, this is called the tolerance threshold value interval. From this simple expression, with a greater cost advantage (k increases), or a higher price sensitivity (β increases), or a smaller market size (α decreases), the outsourcer has a greater possibility to outsource its service business. The first two issues are intuitive, for the market size, we may explain that a smaller market generates a fiercer competition but a lower profit which incentives the outsourcer to strategically abandon the business.

Then based on the value of the tolerance threshold, the outsourcer can adopt different appropriate strategy to maximize its profit. The related outcomes as well as the comparative result are provided in Table 1.

Table 1 Outcomes of the competition between outsourcer and provider

	Integrated System: Benchmark	Decentralized System: Outsourcing	Comparative Statics when Outsourcing	
	$\theta \geq \tilde{\theta}$	$\theta \leq \tilde{\theta}$	Derivative w.r.t. θ	Sign
Sales price	$p^I = \frac{\alpha\theta + k\beta + \beta\theta c}{2\beta\theta}$	$p^o = \frac{3\alpha\theta + \beta + \beta\theta c}{4\beta\theta}$	$-\frac{1}{4\theta^2}$	–
Demand	$D^I = \frac{\alpha\theta - \beta\theta c - k\beta}{2\theta}$	$D^o = \frac{\alpha\theta - \beta\theta c - \beta}{4\theta}$	$\frac{\beta}{4\theta^2}$	+
performance	θ	θ		
Profit	$\Pi_I^* = \frac{(\alpha\theta - \beta\theta c - k\beta)^2}{4\theta^2\beta}$	$\Pi_o^* = \frac{(\alpha\theta - \beta\theta c - \beta)^2}{16\theta^2\beta}$	$\frac{-\alpha\theta + \beta c\theta + \beta}{8\theta^3}$	–
		$\Pi_p^* = \frac{(\alpha\theta - \beta\theta c - \beta)^2}{8\theta^2\beta}$	$\frac{-\alpha\theta + \beta c\theta + \beta}{4\theta^3}$	–

From the Table 1, we also find an interesting phenomenon that the final activity performance level equals to customers' tolerance threshold θ no matter outsourcing or not. That means if the outsourcer and provider both put customers impatience into consideration, the performance level for the activity would be equal to the in-house operation level. Actually, when the customers are delay-sensitive to the activity, both parties would incur much delay cost if performance level falls below the required one. In order to satisfy customers' requirement, the outsourcer charges a lower sales price, i.e. $p^o \leq p^I$ when $\theta \leq \tilde{\theta}$; the provider chooses enough capacity μ^o. Therefore, the subgame perfect equilibrium of Stackelberg game describes that adopting the optimal price and capacity strategy which is related with θ, both parties would achieve their optimal profit and the performance level would be sufficient to meet customers' need. Therefore, it is unnecessary for the outsourcer to worry about the actual performance level in the outsourcing environment although he loses the direct control.

4. Oligopolistic Provider

In this section, as the provider adopts a pooling strategy that it can serve several outsourcers at the same time, we extend our model by investigating the case of n outsourcers who are identical and directly compete with each other. We intend to see how the profits of provider and outsourcers change and influence the choice of whether to outsource or not. In the first stage, the provider still acts as a Stackelberg game leader and set intermediate price w and its capacity μ based on the market size. Then the outsourcers learn the information and set the sales price p to customers independently and simultaneously.

In such a way, we can find the optimal solution for the provider by choosing appropriate intermediate price w and its capacity μ and the maximum profits are as follow: $\Pi_p^{n*} = \frac{n}{(n+1)} * \frac{(\alpha\theta-\beta\varepsilon\theta-\beta)^2}{4\beta\theta^2}$, $\Pi_o^{n*} = \frac{1}{(n+1)^2} * \frac{(\alpha\theta-\beta\varepsilon\theta-\beta)^2}{4\beta\theta^2}$ (9)

From these two representations, we can see clearly that with more outsourcers, the provider's profit increase and is more eager to adopt a pooling strategy due to the scale of economic and an even stronger bargaining power. The outcomes of the outsourcers and provider in an oligopolistic setting are shown in Table 2.

Table 2 Outcomes in Monopolistic and Oligopolistic settings

	Decentralized Outsourcing with N competitors	Decentralized Outsourcing
Service price	$p^n = \frac{(n+2)\alpha\theta+n\beta+n\beta\theta c}{2(n+1)\beta\theta}$	$p^o = \frac{3\alpha\theta+\beta+\beta\theta c}{4\beta\theta}$
Real demand	$D^n = \frac{n}{n+1} * \frac{\alpha\theta-\beta\theta c-\beta}{2\theta}$	$D^o = \frac{\alpha\theta-\beta\theta c-\beta}{4\theta}$
Service capacity	$\mu^n = \frac{n}{n+1} * \frac{\alpha\theta-\beta\theta c-\beta}{2\theta^2}$	$\mu^o = \frac{\alpha\theta-\beta\theta c-\beta}{4\theta^2}$
Wholesale price	$\frac{\alpha\theta+\beta\theta c+\beta}{2\beta\theta}$	$\frac{\alpha\theta+\beta\theta c+\beta}{2\beta\theta}$
Profit	$\Pi_o^{n*} = \frac{n}{(n+1)^2} * \frac{(\alpha\theta-\beta\theta c-\beta)^2}{4\theta^2\beta}$	$\Pi_o^* = \frac{(\alpha\theta-\beta\theta c-\beta)^2}{16\theta^2\beta}$
	$\Pi_p^{n*} = \frac{n}{n+1} * \frac{(\alpha\theta-\beta\theta c-\beta)^2}{8\theta^2\beta}$	$\Pi_p^* = \frac{(\alpha\theta-\beta\theta c-\beta)^2}{8\theta^2\beta}$
	$\Pi_T^{n*} = \frac{n^2+2n}{(n+1)^2} * \frac{(\alpha\theta-\beta\theta c-\beta)^2}{4\theta^2\beta}$	$\Pi_T^* = \frac{3(\alpha\theta-\beta\theta c-\beta)^2}{16\theta^2\beta}$

From Table 2, with $n > 1$ we can see the retail price is lower than that in the scenario with only one retailer and hence the demand increases. Then we see the total profit is larger than that in a single retailer case. Interestingly, we find

$$lim_{n\to\infty} \Pi_T^{n*} = \frac{n^2+2n}{(n+1)^2} * \frac{(\alpha\theta-\beta\theta c-\beta)^2}{4\theta^2\beta} = \frac{(\alpha\theta-\beta\theta c-\beta)^2}{4\theta^2\beta} = \Pi_I^* \quad (10)$$

Thus, we can say with more and more outsourcer competitors, it can dampen the double marginalization effect to some extent. When the number of outsourcers goes to infinity which means the perfect competition, the double marginalization disappears.

Still we use an integrated system as a benchmark to see under what situation the outsourcers are willing to adopt the outsourcing strategy.

$$\Pi_I^{n*} = \frac{(\alpha\theta-\beta\theta c-k\beta)^2}{4n\theta^2\beta} \quad (11)$$

Proposition 4 *When the service provider serve n outsourcers concurrently, if and only if* θ_n *is below the threshold* $\tilde{\theta}_n = \frac{[k(n+1)-\sqrt{n}]\beta}{(n+1-\sqrt{n})(\alpha-\beta c)}$ *, the inequation* $\Pi_I^{n*} \geq \Pi_o^{n*}$*, holds which means the companies with higher service cost prefers to outsource the service to lower cost company.*

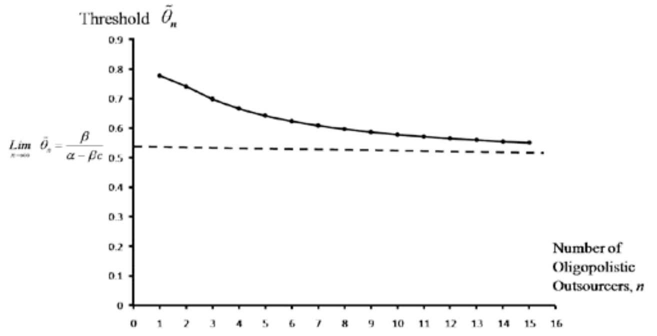

Figure 3 Tolerance Threshold decreases with more outsourcers

So if there's only one outsourcer chooses to build the business partnership with the supplier, the customer's tolerance threshold is just like we present in Proposition 4. And we can find from Figure 3, the value of the tolerance threshold increases with more outsourcers involved in the market, that is $\theta_{n+1} < \theta_n$ for all $n \geq 1$, and it finally approaches to $\hat{\theta}$ when the number of outsourcers goes to infinity, which means there always exists a threshold interval for the outsourcer to adopt an outsourcing strategy. However, with more outsourcers competition in the environment, it requires a more strict condition that a smaller threshold to carry out the strategy. At last, with perfect competition, the value of outsourcing strategy diminishes.

III. Conclusion

In this paper, we consider a model of outsourcing with where the firm outsources the activity that has price- and delay-sensitive customers to an outsider provider. With powerful marketing position, the provider firstly sets the intermediate price as well as his capacity for this business activity, and then the outsourcer follows to set the price for the customers. While the outsourcer loses his direct control over this activity, he may wonder how to make the right outsourcing decision under such an environment. Is outsourcing a helpful strategy for the firm to gain more profit and improve the performance? How and why? Our model provides an explicit answer focusing on what proper price and capacity strategies would be adopted by the outsourcer and provider.

The strategy in the outsourcing environment is strongly affected by the customers' reaction to the actual performance level, which is measured by the utilization rate. We also show that a customers' tolerance threshold always exists and their delay costs incurs only when the actual performance level falls below this threshold. Such characteristics lead us to develop a kinked demand curve to represent this customer behavior.

Given our model, we compare the pricing and capacity solutions in the integrated system with the outsourcing case. Although outsourcing can decrease the capacity cost, it is not always an optimal choice for the firm because the profit is also influenced by customers' impatience. We investigate the relation between customers' satisfaction and cost reduction benefited from outsourcing. The results suggest that when the customer required activity performance is higher than a certain level, the firm should outsource this activity to the outside provider for gaining more net profit. And in the opposite situation the firm prefers integrated control. The similar phenomenon also extends to an oligopolistic setting where the provider faces several outsourcers. Besides, the result indicates that when the number of outsourcers served by the same provider increases, the value of outsourcing mitigates.

Referring to outsourcing, the firm worries about losing direct control over how the activity performance meets the customers' requirement. In our paper, we explore the optimal pricing and capacity strategy which is related to the customers' tolerance level. An interesting finding is that the provider would always chooses the intermediate price and capacity that just enough fulfill the customers' satisfaction, which makes the actual performance level in outsourcing the same with the integrated system. Therefore with the optimal strategy, it is unnecessary for the outsourcer to worry about the actual performance although he can't control directly.

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