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The Switching Decision between Pricing Strategies Based on Operation Efficiency

Yu Xia*

D'Amore-McKim School of Business, Northeastern University, Boston, MA 02115, U.S.A.

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Abstract — This research studies a supply chain with two competitive suppliers and many buyers. The suppliers compete in the market based on their operation efficiencies as well as their pricing strategies. We investigate the switching decisions between the short-term pricing strategy that expands market and the long-term strategy that maximizes profit. The suitable pricing strategies based on their operational efficiencies are suggested to the suppliers to act and react in the competitive market under different situations through Game Theory. Managerial insights and practical guidelines are provided to the suppliers to set their competing prices and find their market niches in a competitive market. The equilibrium price, the market segmentation, and the overall profit of each supplier that results from different pricing strategy combinations are obtained, compared and analyzed.

Keywords — Game theory, supplier competition, pricing strategy, market segmentation, logistics and operations management

1. INTRODUCTION

In the automobile industry, sales have been very volatile; firms are experiencing double-digit percentage declines and increases in sales. Manufacturers and dealers worldwide have been forced to implement creative marketing strategies to entice reluctant consumers to purchase vehicles. Major manufacturers, including the Big Three (General Motors, Ford Motors and Chrysler), have offered substantial discounts. Hyundai even allowed new cars to be returned if the customers lost their jobs. After the quality scandals and the massive recalls in early 2010, Toyota is offering big sales with significantly lowered prices in order to maintain market share. Advertisements from many dealerships, which promise a deep discount and financial help, occupy the best commercial time slots on television channels. In the retail industry, many retailers filed for bankruptcy during the last several months in recent years. Among them are some of the most well-known household names: Waterford Wedgwood, Circuit City, Goody's, Linens'n Things, and Sharper Image. The remaining retailers are fiercely battling in pricing strategy to survive. Similar situations are happening in other industries too. Suppliers in almost all supply chains are encountering brutal price competitions.

It seems that during a big economic downturn, suppliers, whether they are giant manufacturers, reputable retailers or smaller businesses, focus on, at least temperately, upholding the sale, cleaning inventory to stay lean, and trying to puncture into other competitors' market segments to survive the moment. In this type of environment, their pricing strategy of focusing on short-term sale promotion, we call it Sale Promotion (SP) strategy, prevails. On the other hand, there is no doubt that a supplier's long-term target is to maximize profit, which we will call Profit Maximization (PM) strategy. Actually, suppliers who constantly seek for higher efficiency in operations and operate with a stable long-term PM pricing strategy are the suppliers doing relatively better or even fairly well in this severe recession. Wal-Mart, the world's largest retailer, reported a 5.1% surge in its same-store sales in 2009. The company has followed the strategy "providing everything a consumer needs at the lowest possible price" (Mottner and Smith, 2009) for half a century. A fashion seller, "The Buckle," posted a 21% surge in its same-store sales. A teen clothier, "Hot Topic," logged a strong 10.8% sales gain at the same time (Kavilanz, 2009). Although the entire automobile industry is suffering in today's economy, companies such as Honda and Nissan are doing substantially better than their peers. Even among the "Big Three" automakers, Ford Motor, which has emphasized on long-term operation efficiency, has generated much better business results compared to GM and Chrysler (Xia and Tang, 2011).

This paper links the suppliers' operation efficiency to their market segmentation and pricing strategies. We try to answer the questions that how and when the competitive suppliers shall switch between difference pricing strategies in a competitive market based on their operation efficiencies. Both pricing strategies, the long-term PM strategy and the short-term SP strategy are considered and analyzed. Four different strategy combinations are studied while the suppliers'

* Corresponding author's email: y.xia@neu.edu

operation efficiency difference varies. We then suggest to the suppliers suitable action and reaction policies between the SP and PM strategies under different competitive situations of operation efficiency. Most importantly, we are able to find the exact switching points between the two pricing strategies, to predict the market segmentation and to estimate the profit margin for the competitive suppliers under different policy combinations.

The remainder of the paper is organized as follows. Section 2 briefly reviews the related literatures. Section 3 introduces the basic model. Section 4 finds the equilibrium prices, corresponding market segments, and profits when suppliers choose different strategy combinations. Section 5 compares the different strategy combinations and discusses the suitability of the two strategies. Section 6 concludes the paper with some final remarks.

2. LITERATURE REVIEW

Recently, supplier competition through pricing strategies has received more and more attention in supply chain management study. One stream of research focuses on the influence of pricing strategies banding with other factors under different competitive circumstances. Cruz and Tan (2005) investigated the interdependence of pricing mechanisms and strategy behaviors of the suppliers. Yue *et al.* (2006) studied the pricing strategies for complementary goods under information asymmetry. Haghighat *et al.* (2008) illustrated how a supplier's profit may be affected by the market pricing mechanism under imperfect competition. Shi *et al.* (2010) considered the setting of the profit target and the related pricing strategies for corporate divisions. Xia (2011) studied the competition of the suppliers and finds the equilibrium pricing strategy when they offer substitutable products. Shah *et al.* (2011) consider the deterioration of product and related optimal pricing policy.

Another stream of research emphasize on the importance of pricing strategy in market competition and segmentation. Oliva *et al.* (2003) studied firms following the market expansion strategy, and concluded that strategies which focus on market expansion cannot serve as a long-term strategy for a business, even for an e-business. Xia (2004) considered two different strategies, one for profit and another for market share, when suppliers compete for buyers. Lancioni (2005) discussed how to develop an effective pricing strategy in industrial marketing with profit and market share as the two major concerns in setting pricing strategies. Abramson *et al.* (2005) found that the availability of market share information leads to a more aggressive pricing strategy. Sterman *et al.* (2007) used a simulation of the duopoly case to show that switching between a strategy focusing on market share and a strategy focusing on profit is a rational decision for competing companies under different dynamic situations of market. Xia *et al.* (2008) studied the competition among multiple suppliers and found out the related market segmentation and equilibrium pricing strategy.

This research contributes to the literature by including ideas from both an operations management perspective and a marketing and economics perspective. It considers suppliers' choices between the PM and SP strategies in a competitive market place in relation to their relative operation efficiency in serving different buyers. In fact, Langlois (1997) studied how the Japanese auto industry used short-run market expansion pricing strategy to penetrate into the U.S. market while Detroit followed the traditional profit maximization pricing strategy. This case matches with the one supplier adopting long-term PM strategy and another adopting short-term SP strategy, which is discussed in this research. To better illustrate the literature, a table is included in the following.

Table 1. Literatures on pricing strategy and competition

Topics	Literatures
Pricing strategy and other factors	Cruz and Tan (2005), Yue *et al.* (2006), Haghighat *et al.* (2008), Shi *et al.* (2010), Xia (2011), Shah *et al.* (2011)
Pricing and market segmentation	Oliva *et al.* (2003), Xia (2004), Lancioni (2005), Abramson *et al.* (2005), Sterman *et al.* (2007), Xia *et al.* (2008)
Pricing strategy in practice	Langlois (1997), Mottner and Smith (2009), Kavilanz (2009), Xia and Tang (2011)

To study suppliers' pricing strategy choices in a competitive market, we use the Game Theory as the framework of this research. The equilibrium prices and the related market segments of the suppliers are found for different buyer order profiles as the suppliers' operation costs differ in serving the buyers; action and reaction pricing strategies are studied and suggested to suppliers under different situations.

3. MODEL DESCRIPTION

We study a marketplace with two suppliers offering a single non-differentiated product or substitutable products to multiple buyers. To avoid any further complexity on the supply side of the model, we assume that both suppliers order their needed inputs from a common or similar source, in all relevant dimensions (price, quality, lead-time, etc.), with unit product

cost C_0. This further upstream supply tier is assumed to have ample supply. The suppliers here can be manufacturers, wholesalers or retailers, as long as they provide products to a downstream entity in a supply chain. Similarly, the buyers here can be manufacturers, wholesalers, retailers or consumers, as long as they purchase products from an upstream entity in a supply chain. For reader's convenience, a list for all the notations is included as following.

Table 2. Notations

μ	Order frequency of a buyer
q	Order quantity of a buyer
x	Location of a buyer
K	Transportation cost factor
$x_o(\mu, q)$	Market segmentation point
C_o	Unit product cost, same for both suppliers
$C_i(\mu, q)$, $i = 1, 2$	Unit inventory cost for Supplier i
$\delta(\mu, q)$	Cost difference between the two suppliers. $\delta(\mu, q) = C_2(\mu, q) - C_1(\mu, q)$
$P_i(\mu, q)$, $i = 1, 2$	Unit price offered by Supplier i
x_{pp}, x_{ss}, x_{ps}, x_{sp}, $i = 1, 2$	Market separating location when suppliers choose difference pricing strategy combinations
U^i_{pp}, U^i_{ss}, U^i_{ps}, U^i_{sp}, $i = 1, 2$	The profit for Supplier i when suppliers choose difference pricing strategy combinations

Within this two-supplier multi-buyer marketplace, suppliers compete for buyer's market by offering competitive prices. Both suppliers offer the same product quality and service. However, they hold different operation parameters and therefore, the inventory cost for the suppliers to serve the same buyer is different. The suppliers, indexed by $i = 1, 2$ are located at the two ends of a line. Without loss of generality, we assume the length of the line equals 1. A buyer is distinguished by his operation efficiency (inventory cost) and location, which is described by the distance between the buyer and Supplier 1, x. When a buyer has more than one order profiles, each profile is viewed as a separate buyer.

The suppliers compete for a buyer's business by determining the price offered to the buyer $P_i(\mu, q)$, $i = 1, 2$. This offering price is based the supplier's own operation cost structure, the buyer's order profile, and the potential offering price of the other competing supplier. Furthermore, the suppliers may choose between two strategies in their pricing rivalry: one is the Profit Maximization (PM) strategy, the other is the Sale Promotion (SP) strategy. Whichever pricing strategy a supplier chooses, the price offered by her should be no less than her unit cost to generate profit and to avoid being sued for "dumping". More specifically, we assume that both suppliers have the flexibility to offer different prices to different buyers based on the buyers' order profiles (i.e., their order quantities and order frequencies). Notice that this pricing scheduling can be implemented through a price menu approach to avoid antitrust litigation under the Robinson-Patman Act.

Clearly, the lowest price a supplier can offer to a buyer depends on the supplier's product cost C_o and inventory cost $C_i(\mu, q)$, $i = 1, 2$ to serve the buyer. As C_o is the same for both suppliers, the difference between the suppliers' costs is really the difference between C_1 and C_2. Since buyers eventually pay for the product and the transportation cost, they choose a supplier based on the total cost of replenishing from the supplier (product cost + transportation cost). Although other issues exist, cost is still the primary reason for a buyer to choose a supplier, and it is also the mainstream in supply chain management papers whether they consider coordination or competition.

We propose a unit transportation cost which is linearly related to the distance between a buyer and a supplier. Thus, the unit cost for a buyer to buy from Supplier 1 is $P_1(\mu, q) + Kx$; and the unit cost to buy from Supplier 2 is $P_2(\mu, q) + K(1 - x)$. The market of the two suppliers geographically separates at a location, $x_o(\mu, q)$, on the demand line, where $P_1(\mu, q) + Kx_o = P_2(\mu, q) + K(1 - x_o)$. Therefore,

$$x_o(\mu, q) = \frac{P_2 - P_1 + K}{2K} \tag{1}$$

The buyers with $x < x_o$ belongs to Supplier 1's market segment, while other buyers belong to Supplier 2's market segment. x_{pp}, x_{ss}, x_{ps} and x_{sp} will be used to denote the market separating location for the situations when both suppliers choose the PM strategy, when both suppliers choose the SP strategy, when Supplier 1 chooses the PM strategy and

Supplier 2 chooses the SP strategy, and when Supplier 1 chooses the SP strategy and Supplier 2 chooses the PM strategy, respectively. Similarly, U_{pp}^1, U_{pp}^2, U_{ss}^1, U_{ss}^2, U_{ps}^1, U_{ps}^2, U_{sp}^1 and U_{sp}^2 are the profit functions for Supplier 1 and Supplier 2 under different strategy combinations.

4. MARKET SEGMENT, EQUILIBRIUM PRICE AND PROFIT UNDER DIFFERENT STRATEGY COMBINATIONS

Choosing between the SP and PM strategies has always been a difficult decision for a supplier. In this section, we describe the competition between the two suppliers, and find equilibrium profits as well as market segments for suppliers when they choose between the two strategies under different competitive circumstances.

For demonstration convenience, we denote $\delta(\mu,q) = C_2(\mu,q) - C_1(\mu,q)$. $\delta(\mu,q)$ is the unit cost difference between the two suppliers when they serve a buyer with order profile (μ,q). To simplify the analysis, without loss the generality of the research, we assume that $\delta \geq 0$ $(C_2 > C_1)$. Note that $\delta \geq 0$ assumes that Supplier 2 holds a higher operation cost. Since the whole system is symmetric, we can easily switch the results of Supplier 1 and 2 if Supplier 1 holds higher operation cost.

To better describe the profit of the two suppliers serving buyers on the line, we further assume that buyers holding the same operation behavior (order frequency μ and order quantity q) are uniformly distributed along the line between the two suppliers. We then define

$$U^1 = (P_1 - C_1)x_o \tag{2}$$

$$U^2 = (P_2 - C_2)(1 - x_o) \tag{3}$$

as the profit functions for Supplier 1 and Supplier 2, respectively.

In the above profit functions, $(P_i - C_i)$ is the unit profit of supplier $i = 1,2$. x_o and $1 - x_o$ are the market segments of Supplier 1 and 2 respectively. Since we assume the buyers with certain order profile (μ,q) are uniformly distributed along the locations between the two suppliers, the buyer demand $d = \mu q$ is uniformly distributed along the locations between the two suppliers. Therefore, Supplier 1 and 2's market shares can be illustrated by the geographic market segments, x_o and $1 - x_o$, respectively. We then are able to define a supplier's profit function as the multiplication of her market share and the unit profit as above.

4.1 Both Suppliers Choose Profit Maximization Strategy

In the long-term, both suppliers want their profits to be maximized. The PM strategy is a reasonable strategy to choose when suppliers accept their market segments and pursue long-term profit maximization.

Theorem 1.

When both suppliers choose the PM strategy, the equilibrium prices, corresponding market separating location and profits are:

(I) If $0 \leq \delta \leq 3K$

$$P_1^*(\mu,q) = K + \frac{2}{3}C_1 + \frac{1}{3}C_2, \tag{4}$$

$$P_2^*(\mu,q) = K + \frac{1}{3}C_1 + \frac{2}{3}C_2; \tag{5}$$

$$x_{pp}(\mu,q) = \frac{\delta}{6K} + \frac{1}{2}; \tag{6}$$

$$U_{pp}^1(\mu,q) = \frac{(3K+\delta)^2}{18K}, \tag{7}$$

$$U_{pp}^2(\mu,q) = \frac{(3K-\delta)^2}{18K}; \tag{8}$$

(II) If $\delta > 3K$,

$P_1^*(\mu,q) = C_2 - K$, $P_2^*(\mu,q) = C_2$; $x_{pp}(\mu,q) = 1$;

$U_{pp}^1(\mu,q) = \delta - K$, $U_{pp}^2(\mu,q) = 0$.

Proof:

The profit functions for both suppliers in (2) and (3) can be rewritten a

$$U_{pp}^1 = (P_1 - C_1)x_o = (P_1 - C_1)\frac{P_2 - P_1 + K}{2K} \tag{9}$$

$$U_{pp}^2 = (P_2 - C_2)x_o = (P_2 - C_2)\frac{P_1 - P_2 + K}{2K} \tag{10}$$

for $0 < x_o(\mu,q) = \frac{P_2 - P_1 + K}{2K} < 1$. U_{pp}^1 is a concave function of P_1 and a decrease function of P_2; U_{pp}^2 is a concave function of P_2 and a decrease function of P_1. By the definition of Nash equilibrium, given P_2, Supplier 1 chooses P_1 to maximize U_{pp}^1, which is equivalent to $\frac{\partial U_{pp}^1}{\partial P_1} = -2P_1 + P_2 + C_1 + K = 0$ or

$$P_1 = \frac{P_2 + C_1 + K}{2}. \tag{11}$$

Given P_1, Supplier 2 chooses P_2 to maximize U_{pp}^2, which is equivalent to $\frac{\partial U_{pp}^2}{\partial P_2} = P_1 - 2P_2 + C_2 + K = 0$ or

$$P_2 = \frac{P_1 + C_2 + K}{2}. \tag{12}$$

According to the Game Theory, Nash Equilibrium happens when both (11) and (12) are satisfied. Since we assume Supplier 2 has a higher operation cost in serving buyers with certain order profile ($\delta(\mu,q) = C_2(\mu,q) - C_1(\mu,q) > 0$), (4) and (5) are then generated under the condition $0 \le \delta \le 3K$. The market separating location x_o is calculated out accordingly in (6).

When $\delta > 3K$, $\frac{\partial U_{pp}^1}{\partial P_1} = 0$ $\frac{\partial U_{pp}^2}{\partial P_2} = 0$, and $0 \le x_{pp} \le 1$ cannot be satisfied if $P_2 \ge C_2$, Supplier 2 is not able to get any profit under PM strategy. However, to minimize its rival's profit, it offers the lowest price it can offer, $P_2 = C_2$; Supplier 1 is forced to offer a price that equals $C_2 - K$ to maximize its profit, and the corresponding $x_{pp} = 1$. ■

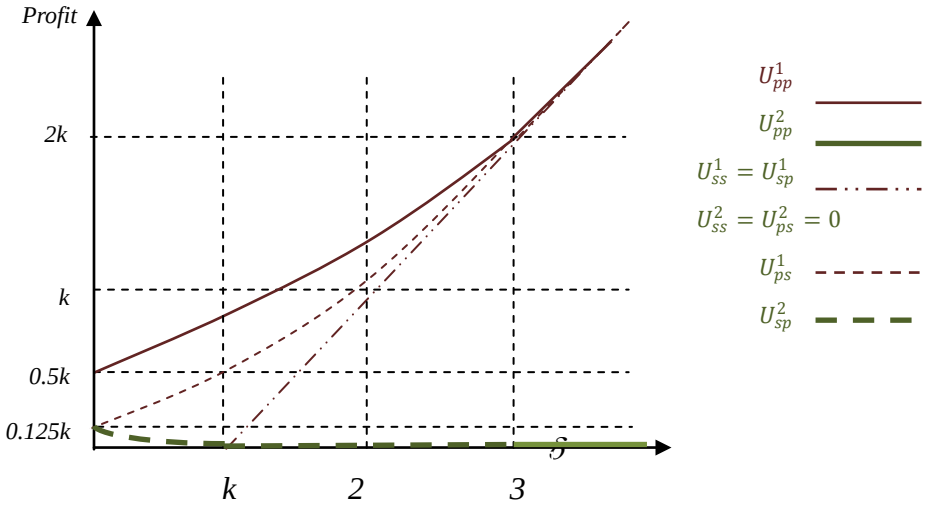

Figure 1. Supplier profits under different strategy combinations

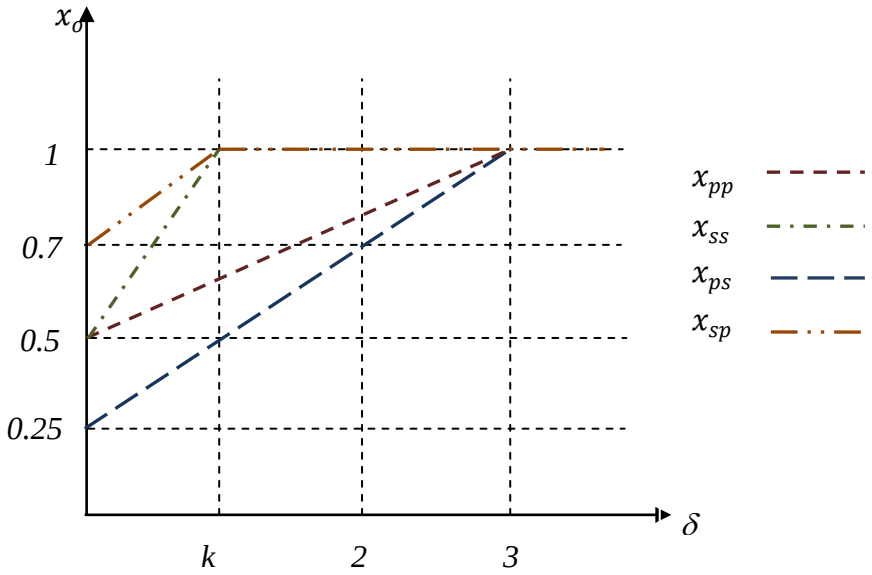

Figure 2. Market segmentation under different strategy combination

We notice that the equilibrium price for a supplier to offer a buyer is not only related with the supplier's own cost, but also related with her rival's cost. When the cost difference between two suppliers is limited ($0 \le \delta \le 3K$), both of them share the market and Supplier 1 has more than half of the market segment as she is the one who holds lower cost. While the cost difference is bigger ($\delta > 3K$), Supplier 1 dominates the market and can still generate profit. Supplier 2 loses the entire market share and holds no profit. Besides, the larger the difference between the suppliers' costs, the more the profit for the dominating supplier, Supplier 1. The U_{pp}^1 and U_{pp}^2 lines in Figure 1 show the profit changes for both suppliers as their cost difference δ varies when they both choose the PM strategy. The x_{pp} line in Figure 2 shows the market segmentation changes.

4.2 Both Suppliers Choose Sale Promotion Strategy

This section describes the corresponding prices offered by the suppliers, and the market segments and supplier profits when both suppliers choose the SP pricing strategy.

Theorem 2.

When both suppliers choose the SP strategy, the equilibrium prices, corresponding market separating location and profits are:

(I) *If* $0 \le \delta \le K$,

$$P_i^*(\mu, q) = C_i(\mu, q),\ i = 1,2;\quad x_{ss}(\mu, q) = \frac{\delta}{2K} + 0.5;$$

$$U_{ss}^1(\mu, q) = 0,\ U_{ss}^2(\mu, q) = 0.$$

(II) *If* $\delta > K$,

$$P_1^*(\mu, q) = C_2 - K,\quad P_2^*(\mu, q) = C_2;\quad x_{ss}(\mu, q) = 1;$$

$$U_{ss}^1(\mu, q) = \delta - K,\ U_{ss}^2(\mu, q) = 0.\ \blacksquare$$

The proof of the above theorem follows the same idea we used for the proof of Theorem 1 when both suppliers choosing PM strategy. The only difference is that the suppliers aim to maximize market segments instead.

The above theorem shows that the SP strategy results in a much more fierce competition between the suppliers compared to the PM strategy. Both suppliers can share the market only when their operation costs are very compatible ($0 \le \delta \le K$), although none of them is able to generate profit. Hence, the SP strategy shall only be used temporarily during the promotion and introduction stages of a product, to expand market segment, or to clean out inventory. It shall

never be a long-term strategy.

Note that once the suppliers' operation costs difference is $\delta > K$, Supplier 2 cannot hold any market share. This may result in temporary loss in profit for Supplier 2. If this situation continues, she may be kicked out of the market permanently. In either case, Supplier 2 should not actively choose the SP strategy unless she has to clean out inventory. Supplier 1 may actively choose the SP strategy if she intends to dominate the market (which is generally prohibited by law) or to keep her market segment maximized. The U_{ss}^1 and U_{ss}^2 lines in Figure 1 show the profit changes for both suppliers as their cost difference varies when they both choose the SP strategy. The x_{ss} line in Figure 2 shows the market segmentation changes.

4.3 One Supplier Chooses the PM Strategy, Another Chooses the SP Strategy

Sometimes, suppliers may choose different strategies based on their individual situations. When one supplier chooses the PM strategy, and another chooses the SP strategy, with the same idea we used in Theorem 1 and 2, we can prove the suppliers' market segments, equilibrium prices , and profits as below:

Theorem 3.
(I) If Supplier 1 chooses the PM strategy, Supplier 2 chooses the SP strategy, equilibrium prices, corresponding market separating location and profits are:

(I-1) *If* $0 \le \delta \le 3K$,

$$P_1^*(\mu, q) = (C_1 + C_2 + K)/2,\ P_2^*(\mu\ q) = C_2;$$

$$x_{ps}(\mu, q) = \frac{\delta}{4K} + 0.25;$$

$$U_{ps}^1(\mu, q) = (\delta + K)^2/(8K),\ \ U_{ps}^2(\mu, q) = 0.$$

(I-2) *If* $\delta > 3K$,

$$P_1^*(\mu, q) = C_2 - K,\quad P_2^*(\mu, q) = C_2;\quad x_{ps}(\mu, q) = 1;$$

$$U_{ps}^1(\mu, q) = \delta - K,\ \ U_{ps}^2(\mu, q) = 0.$$

(II) If Supplier 1 chooses the SP strategy, Supplier 2 chooses the PM strategy, equilibrium prices, corresponding market separating location and profits are:

(II-1) *If* $0 \le \delta \le K$,

$$P_1^*(\mu, q) = C_1,\ \ P_2^*(\mu, q) = (C_1 + C_2 + K)/2;$$

$$x_{sp}(\mu, q) = \frac{\delta}{4K} + 0.75\ \ ;$$

$$U_{sp}^1(\mu, q) = 0,\ \ U_{sp}^2(\mu, q) = (K - \delta)^2/(8K).$$

(II-2) *If* $\delta > K$,

$$P_1^*(\mu, q) = C_2 - K,\quad P_2^*(\mu, q) = C_2;$$

$$x_{sp}(\mu, q) = 1;$$

$$U_{sp}^1(\mu, q) = \delta - K,\ \ U_{sp}^2(\mu, q) = 0.\ \blacksquare$$

When Supplier 1 chooses the PM strategy, Supplier 2 can choose the SP strategy to continue to stay in the market unless the cost difference reaches $3K$, but she generates no profit in exchange for a possibly bigger market segment. From theorem 2 we know that she can stay in the market even if she chooses the PM strategy in the same situation.

When Supplier 1 chooses the SP strategy, Supplier 2 can choose the PM strategy to generate profit if the cost difference is less than K. She may lose some market share compared to choosing the SP strategy. We know from Theorem 2 that she will not generate any profit if she chooses the SP strategy. The U_{ps}^1, U_{ps}^2, U_{sp}^1, and U_{sp}^2 lines in Figure 1 show

the profit changes for both suppliers as their cost difference varies when one supplier chooses the PM strategy and another supplier chooses the SP strategy. The x_{ps} line and x_{sp} lines in Figure 2 show the market segmentation changes.

5. STRATEGY SUITABILITY ANALYSIS

This section compares and analyzes different pricing strategy combinations for the suppliers by their coexisting condition, market segmentation, equilibrium price and profit. It then suggests pricing strategy policies for the suppliers under different situations. Assume $\delta = C_2 - C_1 > 0$, we have the following table:

Table 3. Comparison of strategy combinations

		Both sup. choose PM	Both sup. choose SP	Sup. 1chooses PM, Sup. 2 chooses SP	Sup. 1 chooses SP, Sup. 2 chooses PM
$0 \le \delta \le K$	Equilibrium Price	$P_1 = K + \frac{2}{3}C_1 + \frac{1}{3}C_2$ $P_2 = K + \frac{1}{3}C_1 + \frac{2}{3}C_2$	$P_1 = C_1$ $P_2 = C_2$	$P_1 = \left(K + C_1 + C_2\right)$ $P_2 = C_2$	$P_1 = C_1$ $P_2 = \left(K + C_1 + C_2\right)$
	Market Segment	$x_{pp} = \delta / 6k + 0.5$	$x_{ss} = \delta / 2k + 0.5$	$x_{ps} = \delta / 4k + 0.25$	$x_{sp} = \delta / 4k + 0.75$
	Profit	$U_{pp}^1 = \left(3K + \delta\right)^2 / 18K$ $U_{pp}^2 = \left(3K - \delta\right)^2 / 18K$	$U_{ss}^1 = 0$ $U_{ss}^2 = 0$	$U_{ps}^1 = \left(K + \delta\right)^2 / 8K$ $U_{ps}^2 = 0$	$U_{sp}^1 = 0$ $U_{sp}^2 = \left(K - \delta\right)^2 / 8K$
$K \le \delta \le 3K$	Equilibrium Price	$P_1 = K + \frac{2}{3}C_1 + \frac{1}{3}C_2$ $P_2 = K + \frac{1}{3}C_1 + \frac{2}{3}C_2$	$P_1 = C_2 - K$ $P_2 = C_2$	$P_1 = \left(K + C_1 + C_2\right)$ $P_2 = C_2$	$P_1 = C_2 - K$ $P_2 = C_2$
	Market Segment	$x_{pp} = \delta / 6k + 0.5$	$x_{ss} = 1$	$x_{ps} = \delta / 4k + 0.25$	$x_{sp} = 1$
	Profit	$U_{pp}^1 = \left(3K + \delta\right)^2 / 18K$ $U_{pp}^2 = \left(3K - \delta\right)^2 / 18K$	$U_{ss}^1 = \delta - K$ $U_{ss}^2 = 0$	$U_{ps}^1 = \left(K + \delta\right)^2 / 8K$ $U_{ps}^2 = 0$	$U_{sp}^1 = \delta - K$ $U_{sp}^2 = 0$
$\delta > 3K$	Equilibrium Price	$P_1 = C_2 - K$ $P_2 = C_2$	$P_1 = C_2 - K$ $P_2 = C_2$	$P_1 = C_2 - K$ $P_2 = C_2$	$P_1 = C_2 - K$ $P_2 = C_2$
	Market Segment	$x_{pp} = 1$	$x_{ss} = 1$	$x_{ps} = 1$	$x_{sp} = 1$
	Profit	$U_{pp}^1 = \delta - K$ $U_{pp}^2 = 0$	$U_{ss}^1 = \delta - K$ $U_{ss}^2 = 0$	$U_{ps}^1 = \delta - K$ $U_{ps}^2 = 0$	$U_{sp}^1 = \delta - K$ $U_{sp}^2 = 0$

The above table lists equilibrium prices, market segmentation and profits for both suppliers when they choose four competition strategy combinations under three major situations. The first three rows show the equilibrium price, market segment and profit for both suppliers when the cost difference between them is small ($\delta \le K$). Similarly, the second three rows and the last three rows show the same information when the cost difference between the suppliers is medium ($K < \delta \le 3K$) and large ($\delta > 3K$) respectively. The four columns of the table represent four pricing strategy combinations: both suppliers choosing PM strategy, both suppliers choosing SP strategy, Supplier 1 choosing PM and Supplier 2 choosing SP strategy, and Supplier 1 choosing SP and Supplier 2 choosing PM strategy.

If $\delta \le K$, the two suppliers always share the market no matter which strategy they choose. If $\delta > 3K$, Supplier 1 dominates the market no matter which strategy Supplier 2 choose. If $K < \delta \le 3K$, the two suppliers can share the market only if Supplier 1 chooses the PM strategy. When suppliers' operation costs pole apart ($\delta > 3K$), Supplier 2 cannot survive the competition in the long-term, no matter which strategy she chooses, because she generates no profit after the competition. Supplier 1 therefore dominates the market with the advantage of lower cost. Under this situation, no matter

which strategy that Supplier 2 chooses, she cannot catch any market segment or generate any profit after competition. Price competition shall no longer be an option for Supplier 2 to survive long-term. She has to choose a different approach, e.g., customization, better service, or even a different product line to sustain development (which is not covered in this research). In the meantime, she may keep offering the lowest price possible C_2 to limit the competitor's profit. The suggestion for Supplier 1 is to keep a certain difference in pricing (offer the price lower than Supplier 2 offers by K). There is no need to further drop the price to compete.

Once the cost difference falls into the range of $K < \delta \leq 3K$, the lower cost supplier (Supplier 1) has the power to decide the market segment of the higher cost supplier (Supplier 2). If Supplier 1 chooses the PM strategy, she will coexist with Supplier 2, who also should choose the PM strategy. Supplier 2 should not challenge Supplier 1 by choosing the SP strategy if Supplier 1 chooses the PM strategy, since the choice will hurt Supplier 1 in terms of market segment. Supplier 1 can easily fight back by choosing the SP strategy and leave Supplier 2 no market and no profit. On the other hand, if Supplier 1 initiates the SP strategy, she can definitely push Supplier 2 out of the market with some profit loss $\left[\left(3K+\delta\right)^2 \Big/ 18K - \left(\delta - K\right)\right]$ no matter what strategy Supplier 2 chooses. Supplier 2 will not be able to gain profit or market share. This profit loss gets smaller as the cost difference δ approaches $3K$. Note that no matter how Supplier 2 reacts, Supplier 1's profit stays at $\delta - K$, and her market stays full if she chooses the SP strategy. Supplier 1 will earn less profit by choosing the SP strategy; however she may eventually enjoy the monopoly of the market after Supplier 2 is forced out and delisted. Note that this is also a very sensitive situation. Supplier 1 is suspected of being a "monopoly" if she chooses the SP strategy, and Supplier 2 can use the laws to protect herself. Therefore, Supplier 1 should be very careful in choosing the SP strategy. She may consider the SP strategy when Supplier 2 is weak in general and she will be able to eliminate Suppler 2 from the market permanently. Also, Supplier 1 can use the SP strategy to test her competitor or catch a temporary market opportunity, which is the reason that we see more sales when the market is very good (e.g., Christmas and Thanksgiving time). Besides, Supplier 1 can switch back to the PM strategy at any time. In reality, a lower cost supplier may choose more concealed ways to push her competitor out of the market; for example, binding the product into a package to conduct a price battle.

Table 4. Order of strategy combinations

	Both sup. choose PM	Both sup. choose SP	S1 choose PM, S2 chooses SP	S1 choose s SP, S2 chooses PM
$0 \leq \delta \leq K$	Supplier 1: (3,2) Supplier 2: (3,3)	(1,3) (1,2)	(2,1) (1,4)	(1,4) (2,1)
$K \leq \delta \leq 3K$	(3,2) (2,2)	(1,3) (1,1)	(2,1) (1,3)	(1,3) (1,1)
$\delta > 3K$	(1,1) (1,1)	(1,1) (1,1)	(1,1) (1,1)	(1,1) (1,1)

(*x, y*): *x* is the order of profit, with 1 the lowest; *y* is the order of market share, with 1 the smallest.

It is obvious that when the two suppliers are very compatible ($\delta \leq K$), none of them are capable to dominate the market. All four strategy combinations are discretionary, however, with both suppliers choosing the PM strategy as a stable situation. Suppose that Supplier 1 chooses the PM strategy. If Supplier 2 chooses the PM strategy in reaction, they share the market and both earn profit. If Supplier 2 chooses the SP strategy, she earns $0.25 - \delta/(12K)$ as market segment and loses all the profit. If, at this moment, Supplier 1 switches her strategy from PM to SP, then Supplier 2 will lose the entire market segment she earned and further lose $\delta/(3K)$ market segment. Therefore, as a rational decision maker, Supplier 2 will stay with the PM strategy as long as Supplier 1 chooses the PM strategy. With the similar argument, in the long-term, Supplier 1 will stay with the PM strategy as long as Supplier 2 chooses the PM strategy. Otherwise, if Supplier 1 starts the battle by switching to the SP strategy and aims at extending the market segment by $\delta/(12K) + 0.25$, Supplier 2 loses in both market share and profit. Supplier 2's profit decreases by $(3K+\delta)(9K-5\delta)/(72k)$. This decrease maximizes at $2K/9$ when $\delta = K$. Supplier 2 could seek revenge by adopting the SP strategy, and lowering Supplier 1's market gain to $\delta/(3K)$. Or, Supplier 2 may choose to continue with the PM strategy gaining little profit $(K-\delta)^2/(8K)$, while keeping Supplier 1 holding no profit. Either way, Supplier 1 cannot keep the SP strategy for long-term or keep her leading power in action. Therefore, the SP strategy shall only be used by Supplier 1 to invade Supplier 2's market segment temporarily since neither can dominate market share in this situation or earn any profit. After the competition battle, both

suppliers shall settle with the PM strategy in the long-term.

Based on the above observations and analysis, we have the following conclusion about the suitability of the strategies:

Proposition 1.

(I) When $0 \le \delta \le K$, both suppliers should choose the PM strategy in equilibrium and in long-term;

(II) When $K < \delta \le 3K$, Supplier 1 can choose the SP strategy to dominate the market or choose the PM strategy for a higher profit; supplier 2 shall choose the PM strategy if Supplier 1 chooses the PM strategy. Once Supplier 1 chooses the SP strategy, Supplier 2 holds no profit or market share, no matter which strategy she chooses.

(III) When $\delta > 3K$, pricing strategies make no difference in terms of equilibrium pricing, market segmentation and profit. Supplier 1 will always dominate the market share, no matter which strategy she chooses.

The above analysis shows the suitable strategies for both suppliers in the long-term. However, in the short-term, suppliers may choose a different strategy reaction to explore the market, promote sales, or generate additional profit. For example, when $\delta \le K$, if both suppliers choose the PM strategy, they can coexist and enjoy the profits. However, this balance can be broken. If Supplier 2 chooses the SP strategy, she can squeeze into the market that normally belongs to Supplier 1. But, this situation will not last long. If Supplier 1 fights back by switching to the SP strategy, Supplier 2 will lose all gained market share and profit. However, Supplier 2 can use this strategy to clean her inventory and move to another product line, or just to check her competitor's capability and explore new customer groups.

Generally speaking, the SP strategy is a double edged sword that will hurt both suppliers in terms of profit, and shall only be temporarily adopted under certain conditions.

6. CONCLUSION

The contribution of this paper lies in three major aspects. First, this research considers a competitive environment. Instead of focusing on vertical coordination between suppliers and buyers, this research focuses on a horizontal competitive relationship between suppliers. The ideas of the Game Theory are used and the equilibrium price and market segments are found. Second, this research integrates the supply chain operation efficiency along with the transportation cost by the Hotelling model. Therefore, both the operational and logistical costs are considered through the view of operations management; geographic market segmentation is measured. Most importantly, this paper compares and analyzes two common pricing strategies, the Profit Maximization (PM) strategy and the Sale Promotion (SP) strategy. It provides some managerial insights and practical guidelines for the competing suppliers to find their market niches and set their competing prices.

One particular assumption of the paper is the linear transportation cost function. In academic literatures, linear transportation cost is well accepted, especially by many articles adopt Hotelling model. This paper follows the same assumption to make the mathematic derivation approachable and the managerial insights clearly. In practice, within certain weight range, transportation cost is charged approximately linearly to the distance, which meets the assumption of the paper. When the weight of the cargo increases to over certain range, transportation cost increases with a concave function. The situation can be considered as a different order profile in this research and does not conflict with the results. Another limit is the assumption of uniform distribution of buyer demand. The assumption is reasonable for raw resource and daily necessities, but may not be suitable for all products. However, we believe the above managerial insights are adaptable to more practical situations. For different practical situations, other distributions or more uncertain factors may be a good extension of this research. The two-supplier system can be extended into a multiple-supplier system. The Hotelling model can be extended to the circle model in considering the transportation cost for multiple suppliers. We also can include more factors such as the inventory level, the stockpile of suppliers, and the no-purchase option for buyers to further study how these issues will stimulate suppliers' strategy decisions and influence the competition results in future research.

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