Capacity Manipulation and Menus of Two Part Tariff Contract in Supply Chain

Guojun Ji, Guangyong Yang

***Abstract*—In a decentralized supply chain, raw material supply uncertainty, phantom orders of downstream firm as well as huge investment sunk costs leads to supplier's production capacity manipulation behavior. A supply chain consisting of a supplier and a retailer who faces a newsvendor problem is considered. The impact of supplier's production capacity manipulation on retailer's purchase decision is discussed. The retailer can adopt a menu of two part tariff contract regarding the terms of trade and capacity. Both supplier and retailer have prior belief about counterpart decision behavior. Then, we construct menus of two part tariff contract offered by the retailer to the supplier who has production capacity manipulation and type dependent reservation profits. Our results show that when capacity difference between type H supplier and type L supplier is higher than a critical threshold, the retailer offers two kinds of optimal menus of two part tariff contract in view of reservation profits difference between the type H supplier and type L supplier, and that both supplier and retailer's prior belief about counterpart decision behavior affect optimal menus of two part tariff contract. Finally, a case study shows our conclusions.**

***Index Terms*—** Asymmetric information, Bullwhip effect, Capacity manipulation, Menus of two part tariff contract, Prior belief, Reservation profit.

I. Introduction

In a decentralized supply chain, the supplier often has better production capacity information because of its proximity to the upstream raw material supplier. This capacity information asymmetry creates an incentive problem, i.e., the supplier can influence the downstream firm's production or assembly decision by cheating his forecast. Anticipating this, the downstream firm does not consider the capacity information to be credible. This improper action leads to significant profit losses for both parties. Finally, the consumer also suffers from higher retail's price and lack of product availability.

Capacity manipulation is also bound up with the downstream firm purchase decision. Personal computer (PC) and electronics manufacturers often submit "phantom orders" to induce their suppliers to secure more component capacity (Lee *et al.* 1997). In 2001, Solectron, a major electronics supplier, had $4.7 billion in excess component inventory because of inflated forecasts provided by its customers (Engardio 2001). Analyzing such forecast inflation, the supplier may discount the forecast provided by its customers. Furthermore, huge capacity investment sunk costs can also further deteriorate capacity manipulation. As a result, raw materials supply uncertainty, phantom orders of downstream firm and huge sunk investment costs lead to importance of study of supplier production capacity manipulation.

The purpose of this paper is to show the impact of supplier production capacity information on retailer's purchase decision. We study a supply chain consisting of a supplier and a retailer who faces a newsvendor problem. The supplier has better knowledge of his production capacity than the retailer has. We model this problem as a game of adverse selection. In this model, the retailer (principal) offers a menu of two part tariff contracts, each of which consists of two parameters: the slotting payments and wholesale price. The supplier (agent), who has alternative opportunities and associated reservation profits, either chooses one from the menu of contracts or rejects them all. Generalizing the traditional contracts, we consider type dependent reservation profits for type L and type H suppliers. We derive an optimal two part tariff contract menu for the retailer under this generalization.

Both supplier and retailer have prior belief about counterpart decision behavior. We start with a newsvendor retailer offers deterministic two part tariff contract to supplier under symmetric production capacity case. Retailer receives slotting payments and places an order at the wholesale price. Then we construct menus of two part tariff contract offered by the retailer to the supplier who has production capacity manipulation. We show that when ratio capacity of type H supplier to capacity of type L supplier is higher than a critical threshold, the retailer offers two kinds of optimal menus of two part tariff in view of reservation profits difference between the type H supplier and type L supplier. We also show that both supplier and retailer's prior belief about counterpart decision behavior affect optimal menus of two part tariff contract. Finally, we identify characteristics of the business environment that make menus of two part tariff contract particularly valuable.

Two-part tariffs are widely used in business-to-business contracts, where their popularity is second only to linear prices. Two-part tariffs can be categorized to two following types: the dominant supplier (upstream) and the dominant buyer (downstream). The literatures on a dominant-supplier supplying a regular product have considered in detail the two-part tariffs contract with format (F, w); i.e., supplier

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charges a lump-sum side (or franchising) payment F besides wholesale price w. It is easy to know that, under information symmetry, two part tariff contract enables a dominant-supplier to perfectly coordinate the channel (Hua,H 2008). In a newsvendor-product context, Weng (1999), Ha (2001), Cachon and Lariviere (2005) have considered two part tariff contract. In contrast, there are few literatures of two part tariff contract focusing on dominant-buyer (downstream). In the game theory literatures, Lau,A (2008) is closely related to our problems in that they consider two part tariff contract from buyer perspective, but their focus is on a dominant retailer purchases a newsvendor-type product from a manufacturer under asymmetric unit manufacturing cost, our results will imply that supplier has production capacity manipulation behavior and type-dependent reservation profits.

One of major difficulties on supply chain management is bullwhip effect. Lee *et al.* (1997) provided four reasons for distortion of demand forecasts, such as the rationing game and order batching; they don't mention the player's artificial manipulation as a reason for forecast inflation, which give rise to asymmetric information. Asymmetric information results from demand uncertainty, supply uncertainty, lead time uncertainty and so on, but another reason is member artificial manipulation based on individual benefits. At present, some considered artificial manipulation, such as Özer, Ö (2006), Terry A. Taylor (2007), Anand.K. *et al*. (2008), Cakanyildirm M (2007) and Su (2008). Özer, Ö (2006) characterized that the manufacturer often manipulate demand forecast information because of her better belief about consumers in a decentralized supply chain, and can affect the supplier's capacity decision by phantom orders. Thus, the supplier does not consider the forecast information provided by the manufacturer to be credible and offers nonlinear capacity reservation contract and advance purchase contract to obtain credibly manufacturer's forecast information. Anand K. *et al.* (2008) studied that the buyer purchases component from supplier and may control inventories from the first period to the later period. The strategic inventories are a powerful technique in the hands of the buyer in which serve as a deterrent to the supplier's monopoly power in later periods, but, this threat is inversely proportional to his holding costs. Su (2008) summarized that the seller can do better by creating artificial shortages in view of seasonal products, and argued that scarcity also serves as a marketing tool in generating hype and allure, which further increases the desirability of the product. Taylor A T (2007) shown that a firm developing an innovative product, due to market pressures, cannot supply a precise, court enforceable contract of product and production process. Without this contract, the supplier faces a classic hold-up problem and may underinvest in capacity. Thus, the buyer can offer relational contract to supplier, but he must procure more than his demand to indirectly monitor the supplier's capacity investment. We also study downstream firm purchases product from upstream firm, but we consider menus of two part tariff contract offered by buyer to supplier who has capacity manipulation to maximize firm's expected profits. Cakanyildirm M.(2007) shown that type-dependent reservation profits of supplier influence the buyer behavior under asymmetric production cost information, their focus is deterministic or menus of revenue sharing contracts. Our paper will study deterministic or menus of two part tariff contracts.

This paper is organized as follows: In Section II some assumptions are analyzed; In Section III, we will solve the retailer's profit maximization problem under symmetric capacity information case; In section IV, we will deal with the retailer's profit maximization problem when the supplier holds capacity manipulation behavior, and the case that retailer War-mart purchases apparel from upstream L.L.Bean is also discussed, The paper is concluded in Section V.

II. ASSUMPTIONS

Consider a supply chain with a risk-neutral supplier (denoted by "S") and a risk-neutral retailer (denoted by "R"). The retailer faces a newsvendor problem and makes a single purchase of a product from the supplier. The supplier's capacity is not known before offering a two part tariff contract because of uncertainty of raw material supply. However, the supplier knows more about his production capacity than the retailer does.

Let the random variable ξ denotes the supplier's production capacity. We assume for simplicity that ξ is a discrete random variable with two possible outcomes: ξ_l and ξ_h with $\xi_l < \xi_h$. We consider only two types of suppliers, namely high capacity supplier and low capacity supplier denoted by L and H, respectively. The supplier will be type L if he knows that he will get his raw materials from the low provider, i.e., his production capacity will be ξ_l. Otherwise, he is of type H, and his production capacity will be ξ_h.

Initially, neither the supplier nor the retailer knows which type the supplier is. By the time of choosing a contract, however, the supplier's type is realized and observed by the supplier whereas the retailer does not still observe supplier's type, and has belief about her supplier's type L with probability α and type H with probability $1-\alpha$. α and $1-\alpha$ are common knowledge.

Let $\pi_l^{\min}$ ($\pi_h^{\min}$) denote the supplier's reservation profit when she is type L (H), this reservation profit is the minimum gain of supplier's alternate opportunity. Profits $\pi_l^{\min}$ and $\pi_h^{\min}$ are not necessarily equal.

Let r be the retail price per unit. $f(\ )$ and $F()$ be the density and cumulative distribution functions of the retailer demand, respectively. Assume $F()$ is continuous, s denotes the salvage value and c denotes supplier's unit production cost.

Under asymmetric capacity information, let β and $1-\beta$ denote supplier learn about information probability of retailer's purchase quantity ξ_l and ξ_h. Furthermore, β and $1-\beta$ are also common knowledge between S and R.

III. SYMMETRIC CAPACITY INFORMATION SCENARIO

In this section, we will analyze the case when both the R and the S have the same production capacity information. Assume that R is stackelberg leader. Known probability of type L and type H supplier, R can offer a two part tariff contract to S, in

which specified lump-sum side or "slotting" payment *F* and purchase at the wholesale price *w*. This contract can be represented by a pair of parameters (*F, w*). Then, we have the following theorem 1.

THEOREM 1 *Under symmetric capacity information, R offer optimal two part tariff contract* (F_l^*, w_l^*) *to type L supplier when the supplier type is L; R offer optimal two part tariff contract* (F_h^*, w_h^*) *to type H supplier when the supplier type is H, where*

$$w_l^* = r-(r-s)\xi_l f(\xi_l),$$
$$F_l^* = (r-c)\xi_l - (r-s)\xi_l^{\,2} f(\xi_l) - \pi_l^{\min},$$
$$w_h^* = r-(r-s)\xi_h f(\xi_h),$$
$$F_h^* = (r-c)\xi_h - (r-s)\xi_h^{\,2} f(\xi_h) - \pi_h^{\min}.$$

PROOF. Let F_l denotes the R receive slotting payment from S when the supplier type is L and purchase at the wholesale price w_l. The retailer want to maximize his expected profit, while ensuring that the supplier's expected profit is higher than his reservation profit. The retailer's optimal two part tariff contract can find (F_l, w_l) as follows.

$$\max_{(F_L, w_l)} r\xi_l - w_l\xi_l + F_l - (r-s)E(\xi_l - d)^+ \qquad (1)$$

$$s.t.\ \ w_l\xi_l - c\xi_l - F_l \ge \pi_l^{\min}, \qquad (2)$$
$$F_l, w_l \ge 0,$$

Note that $(\xi_l - d)^+ = \max(\xi_l - d, 0)$.

As receiving slotting payment F_l under the two part tariff contract (F_l, w_l), R will offer the optimal wholesales price w_l^* for the channel by solving the newsvendor problem. Considering $\partial[r\xi_l - w_l\xi_l - (r-s)E(\xi_l - d)^+]/\partial\xi_l = 0$, we have $w_l^* = r-(r-s)\xi_l f(\xi_l)$. Under symmetric capacity information, type L supplier only capture reservation profits, it is easy to see that the solution of the problem is $F_l^* = (r-c)\xi_l - (r-s)\xi_l^{\,2} f(\xi_l) - \pi_l^{\min}$.

The retailer problem for type H supplier, we can use similar procedure to prove. □

IV. CAPACITY MANIPULATION SCENARIO

In the case of asymmetric information, the retailer does not know if the supplier will be of type L or type H, but knows that the supplier is of type L with probability *α* and of type H with probability 1-*α*. So the menus of two part tariff contracts offered by the retailer can be represented by $\{(F_l, w_l), (F_h, w_h)\}$, where (F_l, w_l) (resp. (F_h, w_h)) is designedly for the supplier of type L (resp. H).

The sequence of events is as follows:

(1) The R provides a menu of two part tariff contracts $\{(F_l, w_l), (F_h, w_h)\}$ to the S. Here, the R's objective is to find the optimal menu of two part tariff contract that maximizes his profit.

(2)Given this menu, the supplier then either accepts a contract (F_i, w_i) or rejects both contracts, where $i = h, l$.

(3)If the supplier accepted contracts, she will choose a particular contract that maximizes her profit. Specifically, if the S declares his capacity information to be ξ_h, then the retailer receives the payments F_h and purchase quantity either ξ_h or ξ_l at wholesale price w_h.

(4)The S produces quantity either ξ_l or ξ_h and delivers to R.

(5)The retailer receives the order and sells at unit price *r>0*. Leftover units can be sold in an exogenous salvage market at *s* per unit.

PROPOSITION 1. *Suppose that the supplier learns about probability of retailer's purchase quantity* ξ_l and ξ_h *with probability* β and 1-β. *If the supplier chooses contract* (F_l, w_l) *when he is of type H, his expected profits will be* $\pi_{LSh} = w_l\xi_l - F_l - c\xi_h$*; if the supplier chooses contract* (F_h, w_h) *when he is of type L, his expected profit is as follows:*

$$\pi_{HSl} = \beta[(w_h - c)\xi_l - F_h] + (1-\beta)[(w_h - c)\xi_l - F_h - (\xi_h - \xi_l)\lambda_2]. \qquad (4)$$

PROOF. (1) When supplier declares her choice of contracts to the buyer of type *H*, due to retailer's order quantity of ξ_h or ξ_l, supplier could produce ξ_l to deal with R's low purchase quantity. If R's order quantity is higher than S's products, S will pay to R λ_1 per unit, on the other hand, if R's order quantity is less than S's products, S will charge λ_2 per unit, this compensation of capacity can help to prevent S from cheating. Furthermore, the supplier learn about probability of retailer's purchase quantity ξ_l and ξ_h with probability β and $1-\beta$, where β and $1-\beta$ are common knowledge between S and R. If the supplier is of type *L*, the expected profits of S is as follows:

$$\pi_{HSl} = \beta[(w_h - c)\xi_l - F_h] + (1-\beta)[(w_h - c)\xi_l - F_h - (\xi_h - \xi_l)\lambda_2].$$

(2) When supplier declares his choice of contracts designedly for the supplier of type *L*, the R argues that the S's product quantity only for ξ_l, so order quantity is ξ_l. If the supplier is type *H*, expected profits of S satisfies:

$$\pi_{LSh} = w_l\xi_l - F_l - c\xi_h.$$

Based on the *revelation principle* (Fudenberg and Tirole (1991)), there is an optimal contract menu of the supplier will

choose the contract that is intended for his type. The supplier, by choosing a contract, truthfully reveals his production capacity information. According to the revelation principle, the retailer will solve the following problem to maximize her expected profit.

$$\max_{\{(F_l,w_l),(F_h,w_h)\}} \alpha H_1 + (1-\alpha)[\beta(\alpha H_2 + (1-\alpha)H_3) + (1-\beta)(\alpha H_4 + (1-\alpha)H_5)]$$

$$s.t.\quad PC.\quad \pi_{LSl} \ge \pi_l^{\min}, \tag{5}$$

$$\pi_{HSh} \ge \pi_h^{\min}, \tag{6}$$

$$IC.\quad \pi_{LSl} \ge \pi_{HSl}, \tag{7}$$

$$\pi_{HSh} \ge \pi_{LSh}, \tag{8}$$

$$F_l, w_l, F_h, w_h \ge 0, \tag{9}$$

where $H_1 = rE\min(\xi_l, d) + F_l - w_l\xi_l$,

$H_2 = rE\min(\xi_l, d) + F_h - w_h\xi_l$,

$H_3 = rE\min(\xi_l, d) + F_h - w_h\xi_l - (\xi_h - \xi_l)\lambda_2$,

$\pi_{LSl} = (w_l - c)\xi_l - F_l$,

$H_4 = rE\min(\xi_l, d) + F_h - w_h\xi_l + (\xi_h - \xi_l)\lambda_1$,

$H_5 = rE\min(\xi_h, d) + F_h - w_h\xi_h$,

$\pi_{HSh} = \beta[(w_h - c)\xi_l - F_h + (\xi_h - \xi_l)\lambda_2] + (1-\beta)[(w_h - c)\xi_h - F_h$.

Constraints (5) and (6) are called *participation* constraints (PC). They guarantee that each type of supplier earns at least his reservation profit when he chooses the designed contract for his type. The left side of constraint (7) is the expected profit of the type L supplier when he chooses the designed contract for his type, while the right side is his profit when he chooses the designed contract for the supplier of high type. The explanation of (8) is similar to that of (7). Constraints (7) and (8) are called *incentive compatibility* constraints (IC). These constraints state that each supplier type prefers the contract that is designed for his type. The following theorem characterizes optimal menus of two part tariff contract offered by R when supplier has capacity manipulation behavior.

THEOREM 2. *Suppose that the ratio capacity of type H supplier to capacity of type L supplier is higher than a critical value, namely,*

$$\frac{\xi_h}{\xi_l} > \frac{\alpha^2(1-\beta) - (1-\alpha)\beta}{(1-\beta)(3\alpha - 1 - \alpha^2)}$$

(i) *If* $(\pi_h^{\min} - \pi_l^{\min})/(\xi_h - \xi_l)^2 \ge c\beta + \beta\lambda_2 + \lambda_1$,

the optimal menus of two part tariff contract offered by the retailer is $\{(F_l^{/}, w_l^*), (F_h^{/}, w_h^{/})\}$, *where*

$$w_h^{/} = c - (\beta\lambda_2 + \lambda_1)/(1-\beta) + (\pi_h^{\min} - \pi_l^{\min})/[(1-\beta)(\xi_h - \xi_l)],$$

$$F_l^{/} = (w_l^* - c)\xi_l - \pi_l^{\min},$$

$$F_h^{/} = -\frac{(\beta\lambda_2 + \lambda_1)}{1-\beta} + \beta\lambda_2(\xi_h - \xi_l) - \pi_h^{\min} + \frac{(\pi_h^{\min} - \pi_l^{\min})(\beta\xi_l + (1-\beta)\xi_h)}{(1-\beta)(\xi_h - \xi_l)},$$

(ii) *If* $(\pi_h^{\min} - \pi_l^{\min})/(\xi_h - \xi_l)^2 < c\beta + \beta\lambda_2 + \lambda_1$,

Then, the optimal menus of two part tariff contract offered by the retailer is $\{(F_l^{\wedge}, w_l^*), (F_h^{\wedge}, w_h^{\wedge})\}$, *where*

$$w_h^{\wedge} = (c\beta + \beta\lambda_2 + \lambda_1)/[(1-\beta)(\xi_l + \xi_h)],$$

$$F_h^{\wedge} = [(\xi_h - \xi_l)(c\beta + \beta\lambda_2 + \lambda_1) + \beta(\xi_h - \xi_l)\lambda_2 - c(1-\beta)(\xi_h + \xi_l)] \times \frac{\beta\xi_l + (1-\beta)\xi_h}{(1-\beta)(\xi_h + \xi_l)} - \pi_h^{\min},$$

$$F_l^{\wedge} = (\xi_h - \xi_l)^2(c\beta + \beta\lambda_2 + \lambda_1)/(\xi_h + \xi_l) - c(\beta\xi_l + (1-\beta)\xi_h) + (\xi_h - \xi_l)(\beta\lambda_2 + \lambda_1) - \pi_h^{\min} + w_l^*\xi_l.$$

PROOF. We consider S's manipulation behavior, namely, supplier declares her choice of contracts designedly for the supplier of type *H*. Therefore, the supplier aims to increase his expected profits. Since the retailer does not want to pay more than the high type's reservation profit, i.e., constraints (6) should be binding in the optimal solution of R. To meet the low type from choosing the designed contract for high type, the retailer must therefore increase the low type supplier's expected profit and thus decrease her own profit. However, the retailer only increases the low type supplier's expected profit as much as necessary, until constraints (7) becomes binding. Furthermore, when the supplier declares her choice of contracts designedly for the supplier of type *L*, retailer only orders quantity of ξ_l at wholesale price w_l^*. In other words, order quantities under this situation are equal to amount of purchase under symmetric capacity information case because the retailer only purchase quantity of ξ_l. The optimization of R's problem above can be reflected to following problem in which supplier has capacity manipulation behavior:

$$\max_{\{F_l,F_h,w_h\}} \alpha F_l - \alpha w_l^*\xi_l - (1-\alpha)[(\beta + (1-\beta)\alpha\xi_l + (1-\alpha)(1-\beta)\xi_h]w_h + \Delta$$

$$s.t.\ (w_l^* - c)\xi_l - F_l \ge \pi_l^{\min}, \tag{10}$$

$$(w_h - c)(\beta\xi_l + (1-\beta)\xi_h) - F_h = \pi_h^{\min} - \beta(\xi_h - \xi_l)\lambda_2, \tag{11}$$

$$(w_h - w_l^*)\xi_l + F_l - F_h = (\xi_h - \xi_l)\lambda_1, \tag{12}$$

$$(w_h - c)(\beta\xi_l + (1-\beta)\xi_h) - w_l^*\xi_l \geq -\beta(\xi_h - \xi_l)\lambda_2 - c\xi_h + F_h - F_l \ , \quad (13)$$

where,

$$\Delta = [\alpha + (1-\alpha)\beta + \alpha(1-\beta)(1-\alpha)]rE\min(\xi_l, d) + (1-\alpha)^2(1-\beta)rE\min(\xi_h, d) + \alpha(1-\alpha)(1-\beta)(\xi_h - \xi_l)\lambda_1 - \beta(1-\alpha)^2(\xi_h - \xi_l)\lambda_2$$

To substitute (11) and (12) into the objective function and rearrange equation, we can obtain the following optimization problem:

$$\max_{w_h} \alpha F_l - (1-\alpha)[(\beta + (1-\beta)\alpha\xi_l + (1-\alpha)(1-\beta)\xi_h]w_h + \Delta$$

$$s.t. \quad w_h \leq \frac{(c\beta + \beta\lambda_2 + \lambda_1)(\xi_h - \xi_l)}{(1-\beta)(\xi_h + \xi_l)}, \quad (14)$$

$$w_h \leq c(1-\beta) - \beta\lambda_2 - \lambda_1 + \frac{(\pi_h^{\min} - \pi_l^{\min})}{(1-\beta)(\xi_h - \xi_l)}, \quad (15)$$

Where Δ equals to the above mentioned expression.

When,

$$\frac{\xi_h}{\xi_l} > \frac{\alpha^2(1-\beta) - (1-\alpha)\beta}{(1-\beta)(3\alpha - 1 - \alpha^2)}$$

the objective function is increasing in w_h. Thus,

$$w_h^{\wedge} = \max\{\frac{c\beta + \beta\lambda_2 + \lambda_1}{(1-\beta)(\xi_l + \xi_h)}, c - \frac{\beta\lambda_2 + \lambda_1}{1-\beta} + \frac{\pi_h^{\min} - \pi_l^{\min}}{(1-\beta)(\xi_h - \xi_l)}\},$$

Considering $w_h^{\wedge}$ in constraints (11) and (12), we can obtain $F_h^{\wedge}$ and $F_l^{\wedge}$.

Remarks: The aforementioned theorem characterizes that when capacity difference between type H supplier and type L supplier is increasing and higher than a critical threshold, due to phantom orders of retailer, as well as huge sunk cost, supplier manipulate capacity to gain from cheating and avoiding order shrinkage of the downstream firm. In other words, capacity difference greatly influences buyer purchase decision via supplier's manipulation behavior. If reservation profits difference between type L supplier and type H supplier is increasing, type L supplier can obtain more gains from pretending to announce selection of contract designedly to type H supplier, which result to manipulation behavior.

At a result, both capacity difference and reservation profits difference affect supplier manipulation behavior, further influence the downstream retailer purchase decision, namely, $\frac{\pi_h^{\min} - \pi_l^{\min}}{(\xi_h - \xi_l)^2}$ determines that the retailer offers two kinds of optimal menus of two part tariff. The following corollary illustrates that both supplier and retailer's prior belief about counterpart decision behavior affect optimal menus of two part tariff contract.

COROLLARY 1

If $(\pi_h^{\min} - \pi_l^{\min})/(\xi_h - \xi_l)^2 \geq c\beta + \beta\lambda_2 + \lambda_1$,

$$\frac{\xi_h}{\xi_l} > \frac{\alpha^2(1-\beta) - (1-\alpha)\beta}{(1-\beta)(3\alpha - 1 - \alpha^2)},$$

then, $\partial w_h^{/} / \partial\beta < 0$.

PROOF Based on

$$\frac{\partial w_h^{/}}{\partial\beta} = -\frac{\lambda_2(1-\beta) + \beta\lambda_2 + \lambda_1}{(1-\beta)^2} - \frac{\pi_h^{\min} - \pi_l^{\min}}{(\xi_h - \xi_l)(1-\beta)^2} < 0,$$

the result is clear.

According to expression of ξ_h / ξ_l, both supplier and retailer's prior belief about counterpart decision behavior affect optimal menus of two part tariff contracts, i.e., α, β greatly affect optimal contracts and expected profits. Corollary 1 shows that wholesale price offered by the retailer is decreasing in β, illustrating supplier who has better belief about R's purchase behavior prefers more production manipulation, thus, wholesale prices is lower. On the other hand, slotting payments have closely related to α, β, but not explicit variable relationship.

In summary, capacity difference, reservation profit difference, both supplier and retailer's belief about counterpart decision behavior which reflects private information game will influence optimal menus of two part tariff contracts offered by the retailer to the supplier.

For example, in the past decades many powerful retail chains have appeared around the world, owners of many major international brands outsource much of their manufacturing activities to independent upstream firms. Thus, the dominant retailer scenario, such as Wal-mart, Carrefour, becomes increasingly prevalent and important. We study the case that Wal-mart purchases apparel from L.L.Bean. Due to components of apparel supply uncertainty, phantom orders of Wal-mart as well as huge R&D costs leads to L.L.Bean's production capacity manipulation behavior. Wal-mart offers menus of two part tariff contract to L.L.Bean in order to maximize her profits.

Two-part tariffs are composed of two components, lump-sum side (or ''franchising'') payment *F* as well as wholesale price *w*, where franchising payment is equivalent to site lease fees in Wal-mart locations. On the other hand, Wal-mart is a stackelberg leader because of powerful sale amounts and sophisticated information networks, offering wholesale price to L.L.Bean based on prior belief about counterpart's capacity difference, reservation profit difference and current sale position.

V. CONCLUSIONS

The purpose of this paper is to show the impact of supplier production capacity information on retailer's purchase decision. One of major difficulties on supply chain management is bullwhip effect. Asymmetric information and artificial manipulation result in mismatch between supply and demand, which giving rise to market mediation costs, namely, cost of overstocking or understocking products. But, there are few literatures on the player's artificial manipulation as a reason for forecast inflation and capacity deception, which give rise to asymmetric information. Practitioners and theoretical literatures increasingly focus on asymmetric information resulting from member artificial manipulation based on individual benefits in supply chain.

Two-part tariffs are widely used in business-to business contracts, where their popularity is second only to linear prices. They have been extensively studied by researchers in economics and business. We use two part tariff contract to study that dominant downstream firm offers to upstream firm. We construct menus of two part tariff contract offered by the retailer to the supplier who has production capacity manipulation and type dependent reservation profits. We conclude that when capacity difference between type H supplier and type L supplier is higher than a critical threshold, the retailer offers two kinds of optimal menus of two part tariff in view of difference between reservation profits of the type H supplier and type L supplier. In other words, menus of two part tariff contract are influenced by capacity difference and reservation profits between type L and type H supplier. At the same time, both supplier and retailer's prior belief about counterpart decision behavior affect optimal menus of two part tariff contract.

Further study will extend risk-neutral supplier to bounded rationality to illustrating the impact of manipulation of risk aversion of supplier to downstream firm purchase decision. Another perspective is that explore downstream firm purchase decision by relational contracts based on long term trust and coordination. Furthermore, further research is needed to identify simple-yet-effective menus of two part tariff contracts in the presence of such asymmetries. Another avenue is accounted for strategic downstream firm behavior. We also note that most related academic studies on the dominant-supplier scenario consider contract formats that are already in use in the real-world. In contrast, practical dominant-retailer implemented contract formats are not yet widely enacted.

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REFERENCES

[1] Lee, H., P. Padmanadbhan, S. Whang. Information distortion in a supply chain: The bullwhip effect. Management Science, 43, pp.546–558, 1997.

[2] Engardio, P. Why the supply chain broke down. Business Week March 19 2001.

[3] Weng, Z.K. The power of coordinated decisions for short-life-cycle products in a manufacturing and distribution supply chain. IIE Transactions, 31 (11), pp.1037–1049,1999.

[4] Ha, A.Y., Supplier–buyer contracting: Asymmetric cost information and cutoff level policy for buyer participation. Naval Research Logistics, 48 (1), pp.41–64, 2001.

[5] Cachon, G.P. Lariviere, M.A. Supply chain coordination with revenue-sharing contracts: Strengths and limitations. Management Science, 51 (1), pp.30–44, 2005.

[6] Lau, A, H, L,. Lau Hon-Shiang. Wang, Jian-Cai. How a dominant retailer might design a purchase contract for a newsvendor-type product with price-sensitive demand. European Journal of Operational Research, 190, pp.443–458, 2008.

[7] Özer, Ö., W. Wei. Strategic commitment for optimal capacity decision under asymmetric forecast information. Management Science, 52(8), pp.1238–1257, 2006.

[8] Taylor, T. A., E. L. Plambeck. Supply chain relationships and contracts: The impact of repeated interaction on capacity investment and procurement. Management Science,53(10), pp.1577-1593, 2007.

[9] Anand K, Anupindi. R, Bassok. Y. Strategic inventories in vertical contracts. Management Science, 54(10), pp.1792–1804, 2008.

[10] Cakanyildirim, M., Gan, X., Sethi, S.P. Contracting and coordination under asymmetric production cost information. Working paper, The University of Texas at Dallas, USA., 2008.

[11] Su,X., Zhang,F. Strategic customer behavior, commitment, and supply chain performance. Management Science, 54(10), pp.1759-1773, 2008.

[12] Fudenberg, D. and J. Tirole. 1991. Game Theory. MIT press Cambridge, MA.

[13] Ho Teck-Hua, Zhang Juanjuan. Designing pricing contracts for boundedly rational customers: does the framing of the fixed fee matter? Management Science, 54(4), pp. 686-700, 2008.