ON TRANSACTION COST SHARING BETWEEN BUYER AND SELLER

by

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1. INTRODUCTION

This paper investigates how a transaction cost encountered by potential customers might affect the price schedule quoted by a seller. It is shown using basic microeconomics that the seller will compensate buyers for the transaction expense through a form of rebate, provided that the transaction cost, consumer surplus, and production cost take on suitable values. The firm can afford to pay the rebate because the marginal cost of inframarginal units is assumed to be lower than the per-unit selling price. Customers enjoy gains from trade because the rebate and consumer surplus together outweigh the transaction expense. With regard to exchange between a firm and a single large buyer, actual contracts sometimes specify only the quantity of output and money compensation. But if the product is divisible, it is customary for even two parties to utilize a price schedule such as a two-part tariff, which is the situation studied below. In this case the rebate formally appears as a "negative entrance fee." By way of analogy to transaction cost sharing, utility companies extract a hook-up fee as compensation for the fixed component of production cost.

Section 2 presents utility and cost functions that characterize consumers and the single producer. It is assumed throughout that potential buyers treat the price schedule as given and, consequently, that the seller chooses a price schedule that maximizes profit. Various properties of the profit-maximizing schedule are established, such as, providing the quantity of product at which marginal utility equals marginal cost, and setting per-unit price equal to marginal cost. These properties are formally derived by adapting Oi's (1971)
well-known analysis of two-part tariffs (consisting of an entrance fee and a per-unit price) to the current situation. In Section 3, a first example demonstrates how the seller who faces a single potential customer must offer a rebate in order to induce the customer to shop. In a second example, the seller faces many potential customers but is allowed to exclude any subset of them from participating in exchange. This privilege allows the firm to limit the total transaction cost that otherwise exceeds the social surplus created by production. The seller maximizes profit by including a "door prize" in the price schedule quoted to the customers served. In the final example, a door prize is again profit-maximizing when the assumption of market segmentation is omitted. Applicability of the model to Marketing is considered in Section 4.

2. FORMULATION

It is imagined that a single producer and a single consumer are considering the manufacture and sale of a quantity of Good X. Money, a proxy for all other commodities, measures various costs, payments between the parties, and the consumer's endowment of wealth. The seller can manufacture Good X according to a cost function \( C(X) \), where \( C(0) = 0 \), \( C'(X) \geq 0 \), and \( C''(X) > 0 \). With profit maximization as the objective, the firm specifies a price schedule consisting of two parts, a lump-sum payment \( T \) and a per-unit price \( P \). The buyer thus pays to the seller \( T + PX \) dollars in exchange for \( X \). The condition \( T > 0 \) means that the buyer pays an entrance fee, and the condition \( T < 0 \) indicates a rebate.

The buyer (or consumer, or potential customer) has a utility function \( U(X,Y) \) defined over Good X and money consumption Y. The buyer begins with an endowment of \( M \) dollars. In order to obtain Good X, the consumer must first
pay a transaction cost $A$ then pay the seller according to the announced price schedule. This potential customer purchases Good $X$ if the final utility exceeds the utility of the endowment $M$. That is, the customer determines $(X^*, Y^*)$ that maximize $U(X, Y)$ subject to $Y = M - A - T - PX$, then purchases $(X^*, Y^*)$ if $U(X^*, Y^*)$ indeed exceeds $U(0, M)$. Because of the transaction expense, a decision to enter the market might require a rebate besides a low per-unit price.

It is expedient to borrow from Qi’s (1971) paper to analyze the seller’s behavior. Although the transaction cost introduces a slight modification of Qi’s expressions, a clear comparison can be drawn between the entrance fee and the per-unit price of this discussion to those derived by Qi. In fact, per-unit price again equals marginal cost (at the output level induced by the per-unit price) and, for suitable transaction cost, the optimal entrance fee is negative. As an introduction to the expressions presented below, it might be noted that Qi’s approach transforms the seller’s two-variable problem involving $T$ and $P$ into a one-variable problem in $P$ alone. Since the profit-maximizing $T^*$ extracts all of the buyer’s surplus, it can be expressed as $T^*(P)$. The next step is the determination of $P^*$, given that $T = T^*(P)$. Whereas $T^*(P) > 0$ in Qi’s analysis, it is possible now for $T^*(P) < 0$ because of the customer’s transaction cost and the producer’s low marginal cost of inframarginal units.

The consumer considers buying $X$ that solves the problem

$$U = \max_{x > 0} U(X, Y),$$

where $Y = M - A - T - PX$. This optimization defines two demand functions linking $X$ and $Y$ to the per-unit price $P$ and wealth $M-A-T$,

$$X = X(P, M-A-T),$$


Letting \( X_1(\ldots) \) and \( Y_2(\ldots) \) denote partial derivatives, it is reasonable to assume that \( X_1(\ldots) \geq 0, X_2(\ldots) \geq 0, \) and \( Y_2(\ldots) > 0. \) For future reference, differentiation of (2.2) with respect to its second argument gives

\[ Y_2(\ldots) = 1 - PX_2(\ldots) \quad (2.3) \]

The seller selects \( T \) and \( P \) that maximize profit \( \pi, \)

\[ \pi = PX(P, M-A-T) + T - C(X(P, M-A-T)) \quad (2.4) \]

At any \( P, \) the partial derivative of \( \pi \) with respect to \( T \) is simply

\[ \frac{\delta \pi}{\delta T} = -PX_2(P, M-A-T) + 1 + C'(X) \cdot X_2(P, M-A-T) \]

\[ = Y_2(P, M-A-T) + C'(X) \cdot X_2(P, M-A-T) \quad (2.5) \]

where the last expression is obtained using (2.3). Since \( Y_2(\ldots) > 0 \) by assumption, it is evident that \( \frac{\delta \pi}{\delta T} > 0. \) That is, the monopolist always prefers a larger entrance fee, subject to the condition that the customer purchases a positive amount of Good X. The result is that \( T \) and \( P \) award the consumer final utility equal to \( U(0, M). \) The property \( \frac{\delta \pi}{\delta T} > 0 \) found here is the same as Di's, even though there is a transaction expense in the present situation.

As stated earlier, (2.1) and (2.2) are applicable if \( U(X(P, M-A-T), Y(P, M-A-T)) \geq U(0, M). \) Letting \( T^* \) denote the entrance fee that the seller would utilize in conjunction with any \( P, \) it follows that \( T^*(P) \) satisfies the constraint

\[ U(X(P, M-A-T^*(P)), Y(P, M-A-T^*(P))) = U(0, M) \quad (2.6) \]

Since \( T = T^*(P), \) demand for Good X can be written as a function of \( P \) alone, \( \xi(P). \) In terms of \( \xi(P), \) profit becomes

\[ \pi(P) = P \cdot \xi(P) + T^*(P) - C(\xi(P)) \quad (2.7) \]

Differentiation of (2.7) gives the first-order-condition (FOC) for \( P \) under the
assumption that $T = T^*(P)$, to appear below as (2.11). Before examining that
FOC, a link between $dT^*(P)/dP$ and $\xi(P)$ should be deduced from the identity

$$U(\xi(P), M - A - T^*(P) - P \cdot \xi(P)) = U(0, M).$$

(2.8)

Differentiation here with respect to $P$ leads to

$$dT^*(P)/dP = -\xi(P).$$

(2.9)

(That is, differentiation of (2.8) first gives

$$U_1(\cdot, \cdot)\xi'(P) + U_2(\cdot, \cdot)[-dT^*/dP - P \cdot \xi'(P) - \xi'(P)] = 0.$$  \hspace{1cm} (2.10)

Since $U_1(\cdot, \cdot) = P$ and $U_2(\cdot, \cdot) = 1$ at a consumer optimum, (2.10) becomes

$$P \cdot \xi'(P) + [-dT^*/dP - P \cdot \xi'(P) - \xi'(P)] = 0.$$  \hspace{1cm} (2.11)

This yields (2.9).

The seller's FOC pertaining to $P^*$ is now found. From (2.7),

$$d\pi/dP = P \xi'(P) + \xi(P) + dT^*(P)/dP - C'(\cdot)\xi'(P).$$

With the help of (2.9), it follows that

$$d\pi/dP = [P - C'(\cdot)] \xi'(P).$$

(2.11)

Since profit is maximized when $d\pi/dP = 0$, the firm selects $P^*$ such that

$P^* = C'(X)$, where $X$ is the quantity demanded at price $P^*$. Even when the
customer bears a transaction cost $A$, the seller sets per-unit price equal to
marginal cost. In the following examples, the seller sets $T^* < 0$ in order to
grant the consumer non-negative net benefit from shopping.

3. EXAMPLES

Example 1. The seller faces a single customer who starts with an
endowment $M = (0,4)$ that contains none of Good $X$ and 4 dollars. $U(X,Y)$, the
consumer's utility function, is given by

$$U(X,Y) = 4X - X^2 + Y.$$  \hspace{1cm} (2.12)

The provision of Good $X$ in this economy entails two costs, a transaction cost
A = 2 and a manufacturing cost C(X),

\[ C(X) = X^2 \]

These formulas are responsible for certain aspects of Figures 1 and 2. Any combinations (X,Y) that award the consumer as much utility as (0,M) form the indifference curve \( U_a \), a parabola. Curve C, also a parabola and having Y-intercept equal to 2, illustrates production possibilities that the economy can achieve after both costs A and C(X) are assessed. Curves \( U_a \) and C are tangent at \( E = (1,1) \). At E the slope equals 2, indicating that marginal utility and marginal cost equal 2 dollars when \( X = 1 \).

Two pricing schedules are illustrated. In Figure 1, setting \( T = 0 \) and \( P = 4 - 2 \cdot \sqrt{2} \) corresponds to the budget line \( P_e \) having Y-intercept equal to 2. Although point E is acceptable to the consumer, the producer would suffer a loss under this contract. More generally, no price line generated by setting \( T = 0 \) can pass through E and be tangent to \( U_a \) and C.

In Figure 2, setting \( T = -1 \) and \( P = 2 \) corresponds to the budget line \( P_e \) passing through E. Since \( U(1,1) = U(0,4) = 4 \), the consumer is willing to surrender 3 dollars in exchange for one unit of Good X. The seller willingly manufactures Good X in exchange for 1 dollar since \( C(1) = 1 \). The remaining 2 dollars are absorbed by the consumer’s transaction expense. In summary, a rebate must be used if the consumer’s optimum is to occur at E and if the seller maximizes profit over all two-part tariffs.

In Figures 1 and 2, E is “just as desirable” as \( (0,M) \). However, if the transaction cost were slightly smaller than 2 dollars, then the curves \( U_a \) and C should be shifted vertically so that they overlapped. In that situation there would exist outcomes that are strictly preferable to \( (0,M) \) in a social sense. Attaining these outcomes would also require a rebate, \( T < 0 \), if
exchange conforms to a linear price schedule.

Figure 3 displays the preceding conditions using a demand curve (plot of marginal utility) and marginal cost curve, labelled DEMAND and MC, respectively. Since the consumer expends $A$ before obtaining any Good $X$, there is a price $P_a$ at which DEMAND is discontinuous. At prices above $P_a$ the buyer refrains from trading. However, if the transaction expense is ignored for the moment, the dashed portion of DEMAND indicates that there exists a quantity $x_e$ at which marginal utility equals marginal cost.

The quantity $x_e$ should be produced because consumer's utility, measured in dollar terms, exceeds $A + C(x)$. As shown in Figure 3, the seller will set per-unit price equal to $P_e$. Producer surplus will equal the area $OPE_e$ if the customer enters the market. Unfortunately, $A$ exceeds consumer surplus by the area $P_bP_eEB$. Therefore, exchange at $P_e$ occurs if the seller compensates the buyer for $P_bP_eEB$ out of producer surplus $OPE_e$ through a rebate. Finally, if $A$ rises, then $P_e$ falls, and $P_bP_eEB$ eventually exceeds $OPE_e$. In this instance the seller can no longer profitably offer a rebate, and no exchange occurs.

**Example 2.** In this example the seller may decide how many customers to serve, out of an infinite pool of potential buyers. For the sake of simplicity, it is assumed that consumers have identical utility functions and transaction expense. The profit-maximizing number of customers and price schedule are found. Intuitively speaking, serving a single customer generates too little surplus from which to extract profit, and serving very many customers nullifies social surplus through the burden of multiple transaction costs. The seller offers a door prize when parameters have suitable values.

Of the infinitely many consumers interested in the seller's product, each begins with a generous endowment of money and faces an exogenously determined
transaction cost $A$. An individual's utility function of Good X and of final money consumption is $u(x,y) = 4x - x^2 + y$. This expression yields a person's demand for Good X, conditional on shopping, given by

$$x = \frac{(4-P)}{2} . \quad (3.1)$$

A consumer's surplus from exchanging money for this amount of Good X is simply

$$c.s. = 4x - x^2 - $P$x, \text{ or in terms of P,}$$

$$c.s. = \frac{(4-P)x^2}{4} . \quad (3.2)$$

The seller's manufacturing cost for serving N customers is quadratic,

$$C(Nx) = (Nx)^2 . \quad (3.3)$$

In addition to selecting N, the seller determines the profit-maximizing entrance fee T and per-unit price P. Since the optimal T extracts all consumer surplus, $T = c.s. - A$, or

$$T = \frac{(4-P)x^2}{4} - A . \quad (3.4)$$

For any N, the firm's profit is

$$\pi_N = NT + P \cdot Nx - C(Nx) . \quad (3.5)$$

Variable $\pi_N$ can be written in terms of P alone by using (3.1) to replace x and (3.4) to replace T. Simple calculations determine the profit-maximizing price schedule and output when N customers are served,

$$P_N^* = \frac{4N}{(1+N)} \quad (3.6)$$

$$T_N^* = \frac{4}{(1+N)^2} - A \quad (3.7)$$

$$x_N^* = \frac{2}{(1+N)} \quad (3.8)$$

$$\pi_N^* = \frac{4N}{(1+N)} - NA \quad (3.9)$$

The firm's last task is to choose the optimal value for N. Differentiation of (3.9) with respect to N permits solving for the optimal N,

$$\frac{\delta \pi_N^*}{\delta N} = \frac{4}{(1+N)^2} - A = 0 \quad (3.10)$$

$$\frac{\delta^2 \pi_N^*}{\delta N^2} = -\frac{8}{(1+N)^3} < 0 . \quad (3.11)$$
(It is imagined here that \( A < 2 \); the case in which \( A = 2 \) is covered in Example 1, above.) Since \( N \) is restricted to the set of integers, a final comparison between two profit figures is generally necessary.

The results of some computations are given below. It is supposed that
\[
A = 4/(1+10)^2 + \epsilon ,
\]
in which \( \epsilon \) is small but positive. This particular formula for \( A \) is motivated by the FTC in (3.10) and the expression for \( T_n^* \) in (3.7). For example, if \( \epsilon = 0 \), then \( N = 10 \) and \( T_{10}^* = 0 \) immediately. If \( \epsilon > 0 \), the firm's profit should be examined for several nearby values of \( N \),
\[
\begin{align*}
\pi_{10}^* &= 3.3025 - 9\epsilon \\
\pi_{11}^* &= 3.3058 - 10\epsilon \\
\pi_{12}^* &= 3.3030 - 11\epsilon .
\end{align*}
\]
It is clear that the firm selects \( N = 10 \) for sufficiently small \( \epsilon \). Also,
\[
\begin{align*}
P_{10}^* &= 3.6364 \\
T_{10}^* &= -\epsilon .
\end{align*}
\]
This demonstrates that the seller offers a door prize to several customers. It is necessary, however, that the number of customers can be limited by the seller. If the seller were required to serve the entire set of interested customers, rising marginal cost would eliminate profit. It is also emphasized that these calculations apply to a seller who cannot discriminate among the \( N \) customers admitted.

Example 3. The objective is to demonstrate that a door prize may occur when transaction costs are not identical. The preceding example is altered very slightly, i.e., it is assumed that
\[
A_j = 4/(1+10)^2 + \epsilon_j ,
\]
where \( \epsilon_j > 0 \) are again small. Consumers are indexed so that \( \epsilon_j < \epsilon_{j+1} \).
Suppose now that the firm calculates the highest profit attainable from serving the first \( N \) consumers, \( N = 1,2,... \). For any \( N \), the variables \( P_N^* \) and \( x_N^* \) are still given by (3.6) and (3.8) from Example 2. \( T_N^* \) must be chosen so that these \( N \) customers are willing to enter the market. Consequently,

\[
T_N^* = c.s. - \max (A_j), \quad \text{or} \quad T_N^* = 4/(1+N)^2 - 4/(1+10)^2 - \epsilon_N.
\]

The maximal profit for several values of \( N \) are shown here,

\[
\begin{align*}
\pi_1^* &= 3.3025 - 9\epsilon_0 \\
\pi_{10}^* &= 3.3058 - 10\epsilon_{10} \\
\pi_{11}^* &= 3.3030 - 11\epsilon_{11}
\end{align*}
\]

It is clear that, for sufficiently small \( \epsilon_{10} \), the firm again elects to serve 10 consumers. This is not surprising because \( A_j \approx 4/(1+10)^2 \) for \( j = 1,...,10 \), as in Example 2. In addition, consumers sort themselves into the two groups intended by the firm. Only the first 10 consumers wish to enter the market because \( c.s. - A_{10} - T_{10}^* = 0 \). In summary, the presence of identical transaction costs used in Example 2 is not a necessary condition for observing a door prize.

4. REMARKS

The one-customer model seems to be applicable to several situations described in the Marketing literature. In International Marketing, traders encounter large transaction costs arising from geographical separation, language differences, and unfamiliar business practices. Luqmani et al. (1988), in a study of US corporations that sell to governments of less-developed countries, report that a $100,000 fee must accompany bids submitted on Saudi Arabian government contracts. One might interpret this practice as a
means of sharing the transaction cost in such a proportion that both parties will realize gains after final payments are made, with consideration given to quantity delivered and marginal cost. (The authors do point out that the submission fee eliminates small, unreliable suppliers.) The reader is also reminded of Houston's (1986) definition of "Marketing" as the costly search for potential exchange partners. The US corporations in Luqmani et al. are shouldering more of the Marketing burden by paying the submission fee.

White (1986) and Lachica (1988) report that the US Department of Defense seems to have adopted a new policy that requires a defense contractor to pay the R&D expense for a new weapons system. Previously, the Department shared heavily in this fixed cost. One interpretation of the new policy is that division of a transaction cost has been reeported, and that both parties will reap gains from exchange at a somewhat higher per-unit price. Although a "price schedule" might seem superfluous when only two agents are trading, the Department and defense contractor can quote a "per-unit price" that approximates marginal cost for the scrutiny of critics, say.

In Industrial Marketing, Bost and Kahle (1985) reaffirm the importance of vendor's marketing communications in promoting the vendor's market share. That is, it is crucial for an industrial supplier to pay for this transaction cost. Samli and Kosenko (1982) stress that US contractors delivering high-tech goods to the People's Republic of China should provide ample support services. Otherwise, the exchange would no longer be attractive to this buyer. One might say that these papers emphasize the importance of properly sharing a transaction cost, so that both parties can reap gains from trade.

With regard to Examples 2 and 3, the negative entrance fee becomes a "door prize" awarded to a limited number of customers when underlying parameters
have appropriate values. In fact, one does hear of door prizes being given to “the first N customers.” At this point it might be informative to comment on the design of the examples. The objective is to find the profit-maximizing T and P when there are (countably) infinite consumers, while explicitly attending to each consumer's decision to enter the market or not. The market demand function in terms of T and P is discontinuous as each person enters. As seen in D1 (1971, Section II), it is difficult to characterize optimal T and P when utility functions vary in random ways, without even considering transaction costs or attempting to get T < 0. To avoid complicated market demand functions, it is first imagined that transaction costs are identical. However, this assumption causes consumers to respond to T and P en masse, leaving the seller with no opportunity for profit at infinite output since marginal cost is rising. If the seller limits the number of customers, it becomes possible for a door prize to be profit-maximizing, as shown in Example 2. A revision with unequal transaction costs appears in Example 3.
REFERENCES


FIGURE 1.