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Social Desirability of Uniform Delivered Pricing

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There is more than one price policy in a spatial market. Three main spatial price policies are: (1) *uniform mill price* under which the seller chooses a constant f.o.b. price and transportation costs are paid by consumers; (2) *spatial price discrimination* (hereafter, SPD) under which different and location-specific prices are selected over space; and (3) *uniform delivered price policy* (UDP) under which consumers at different market sites pay the same delivered price. Among these price polices, price discrimination is treated by antitrust authorities of many countries being illegal *per se,* but uniform mill price is often appealing because of "its imitation of the spatial structure of marginal costs" (Hobbs, 1986). Perhaps because of this, much efforts in the literature has been devoted to the socially superiority of SPD as compared with uniform mill price.[1] The main conclusion hereupon is that in some cases, SPD is socially preferable as compared with uniform mill price. This implies that as compared with uniform mill price, the social superiority of SPD is model specific.

Uniform delivered pricing is also appealing as compared with SPD, and often tolerated by antitrust authorities. But there is a paucity of research that seeks to provide a theoretical justification for firms practicing UDP, another type of

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[1] The first attempt to examine the economic benefit of movement from SPD to uniform mill price is made by Greenhut and Ohta (1972) with the focus on monopoly output, and Holahan (1975) then extends the analysis to include some additional economic benefit comparisons such as profits, aggregate consumers' benefit, and social welfare. Subsequent researches revisited the issue by relaxing some of assumptions postulated by Greenhut and Ohta (1972) and Holahan (1975), including (GHO1) consumers are *uniformly* distributed over the space; (GHO2) the market area, the space the firm actually serves, is *endogenously* determined by the prices charged (hereafter the *variable market area* case); (GHO3) demands at different site are *identical* and *linear*, (GHO4) the firm's mill is *pre-determined*, and (GHO5) the firm is a *monopolist*. In the famous paper, Beckmann (1976) relaxed (GHO1) by (B2), but assumed instead (B3). Hsu (1983a) examined the spatial setting in which both (GHO2) and (B3) are possible. Some studies relaxed (GHO3) by assuming identical demands being nonlinear (see, for example, Hsu (1979), Greenhut (1977), Ohta and Wako(1988)) while some recent attempts are to relax (GHO4) by that the firm's location is an endogenous choice, including Hwang and Mai (1990), and Claycombe (1996).

discrimination.[2] Only two papers, as far as we know, appeared in the literature, but their conclusions are in sharply contrasted. In the pioneering paper, Beckmann (1976) shows that (BC1) the movement from UDP to SPD has no monopoly output effect; and (BC2) the firm's profits, consumers' benefits and social welfare all are greater under SPD than those under UDP. These results are in sharp contrast to the common wisdom that UDP is more socially preferable since in appearance, discrimination under UDP appears less serious. Nevertheless, Tan (2001) has recently shown instead that UDP is socially superior to SPD in a model[3] differing from Beckmann (1976). In other words, the social desirability of UDP, as compared to SPD, is model specific, too.

The model examined by Beckmann (1976) is the conventional one in the literature of spatial price theory. Nevertheless, it consists of a set of assumptions, including (B1) demand is identical and linear; (B2) the spatial consumer distribution can be of any form; (B3) the extent of the *market areas*-- the boundary of the space over which the firm actually serves--are exogenously fixed and same under alternative price policies, (hereafter, the *fixed market area* assumption); and (B4) competition is insignificant. The cautious reader might then wander whether the above-mentioned findings by Beckmann (1976) is justifiable in a more general content. This paper attempts to re-examine the issue in a generalized model of Beckmann (1976). Much is to say, this paper relax assumptions (B3) and (B4) but keeps (B1) in order to highlight the pure impact of economic space.

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[2] In the literature, some efforts have been devoted to the study of resultant economic benefits of another pair of price policies, namely, uniform mill price and UDP (See, for example, Beckmann (1976), Hsu (1983b), and Cheung and Wang (1996))

[3] To be precise, Tan (2001), similar to Hwang and Mai (1990), attempts to re-confirm one of conclusions made in a excellent review paper by Beckmann and Thisse (1986, p. 69), namely that the social superiority of one price policy maybe altered when the firm chooses its price policy and plant location simultaneously. Moreover, Tan's above-mentioned result holds only for cases that the constant transport rate is rather small (see Table 4 in Tan (2001) and the relevant discussion hereupon).

The organization of this paper is as follows: In Section 1, we first present the basic model. The model is same as that studied by Beckmann (1976) except that the fixed market area assumption, that is, (B3), is relaxed. We assume instead that the *market size*—the length of the space over which consumers are dispersed—can take various values. We show that the extent of the market area maybe determined exogenously by the fixed market size, or endogenously by the price charged, depending on the size of market. In Section 2, we first derive the optimal prices and market areas of alternative pricing policies, and then explore their properties. Efforts of Section 3 are devoted to the economic benefit effects of movement from SPD to UDP. We show that the finding (BC2) by Beckmann (1976) holds despite of the length of the market size, but (BC1) cannot hold in some cases. In Section 4, we examine the issue in a world without the assumption (B4), namely, the case of spatial competition under free entry--a neglected aspect in the literature of spatial price theory. We show that neither (BC1) nor (BC2) remain true when competition is so significant as to drive the firm's profit to zero. Some concluding remarks are provided in Section 5.

1. Basic Model

Consider a line market in which a spatial monopolist sells a homogeneous product subject to a strictly positive and constant freight, say t. The consumer's demand is linear:

(1) $$q(x) = f(p) = a - bp,$$

where x denotes distance from the seller's mill, $q(x)$ = the quantity demanded at the market site x, and p = the delivered price, the amount a consumer shall pay for a unit of commodity. Marginal cost of production, say c, is constant. Thus, the firm's profit under SPD, ®_d, is

(2) $$\text{®}_d = \int_0^{B_d} (m - c) f(p) r(x) dx - F$$

where B_d = the boundary of the market area under SPD, $m = p - tx$ = the *mill price*, that is, the amount the seller can receive by selling one unit of product, and F = total fixed costs. On the other hand, the profit under UDP, ®_u is:

(3) $$\text{®}_u = \int_0^{B_u} [(p_u - c - tx)q(x)]\text{¥}(x)dx - F = f(p_u)\int_0^{B_u} (p_u - c - tx)\text{¥}(x)dx - F$$

where p_u = the uniform delivered price charged under UDP, and B_u = the boundary of the market area under UDP.

About the extent of the market area, the fixed market area assumption postulated by Beckmann (1976) is that $B_d = B_u$. Another specification in the literature of spatial price theory is that the extent of the market area is endogenously determined by the price charged (see, for example, Beckmann (1968), Greenhut and Ohta (1972), and Holahan (1975)). Thus, the following relationship holds at the market boundary point under SPD

(4) $$q(B) = f(p_{\max}) = a - bp(B) = 0\,,$$

where $p_{\max}$ = the reservation price--the maximum price a consumer is willing to pay for a unit of commodity, and $p(B)$ = the delivered price charged at the market boundary under SPD. Based on the belief that a consumer will refuse to buy any quantity if the selling price is more than the maximum he is willing to pay, the above relation tells us that, under mill price, the market area equals the distance from his site to the point at which the delivered price equals the consumer's reservation price. Instead, the profit-maximizing UDP firm will refuse to sell beyond the market point at which the amount he receives for a unit of commodity equals the average variable cost (Beckmann (1968), and Hsu (1983b)). Thus, the following relation is used to determine the boundary of the market area under UDP

(5) $$(p_u - c - tB) = 0\,.$$

In the real world, the firm often confronts a spatial market over which consumers are dispersed within a finite length. It is worthy pointing out that in a market with varying size, (3) or (5) might over-estimate the extent of the market area. What (3) actually states is that once we know specific form of demand, costs of transportation and production, and the optimal price, the value of B can then be determined, regardless of whether there are any consumers locating at those market sites, and so does (5). It is clear that if there is no buyer at those market sites, the extent of the market area should equal the market size S. Accordingly, the following rule should be used to determine the extent of the market area

(6) $$B_i = \min(S, S_i),$$

where S_i stands for the distance satisfying (3) and (5) respectively under alternative pricing policies. Moreover, for any extent of market size, the equality holds for SPD:

(7) $$f[p\ (B)](\partial B / \partial m) = 0$$

and for UDP ,

(8) $$(p_u - c - tB)(\partial B / \partial p_u)$$

2. Optimal Prices and Market Areas

The marginal profit under UDP is

(9) $$d®_u / dp = f' \int_0^B (p - c - tx)¥(x)dx + f\int_0^B ¥(x)dx + (p - c - tB)¥(B)(dB/dp)$$

$$= f' \int_0^B (p - c - tx)¥(x)dx + f\int_0^B ¥(x)dx$$

where the second equality is based on (8). Thus, the optimal price under UDP is:

(10) $$p_u = c - f / f' + t\bar{x}$$

where $\bar{x} = \int_0^{B_u} x¥(x)dx / N_u$. The term $\bar{x}$ is the simple spatial mean of consumer distribution, or the *average distance* since $N_u = \int_0^{B_u} ¥(x)dx$, the total population served by the firm under UDP, and $¥(x)/N_u$ is the probability density of consumer locating over space. For our case of linear demand, the optimal delivered price under UDP is:

(11) $p_u = (a + bc + bt\bar{x}) / 2b$

By substituting (11) in (5), we find

(12) $S_u = (a - bc) / 2bt + \bar{x} / 2$

A function of mill prices is chosen to maximize profits under SPD. Since the first derivative of m_d with respect to the distance, that is, dm_d / dx, does not enter the integrand in (2), the variation problem is equivalent to an unconstrained classical programming problem. Thus, the optimal mill price schedule under SPD derived from the first-order condition of the optimization can be generally expressed as[4]

(13) $m_d = c - f(p_d) / f'(p_d)$

where $p_d = m_d + tx$ = the optimal delivered price schedule under SPD. In the case of linear demand, one find:

(14) $m_d = (a + bc - btx) / 2b$

By substituting (14) in (4), we find:

(15) $S_d = (a - bc) / bt$

Consider first the extent of the market area under alternative pricing policies. Note first that $S_d - S_f = (a - bc) / 2bt - \bar{x} / 2 = m_d(\bar{x}) > 0$ where $m_d(\bar{x})$ = the mill price charged at the market site $x = \bar{x}$ under SPD. It follows that

(16) $B_d > B_u$ when $S > S_u = (a - bc) / 2bt + \bar{x} / 2$

(17) $B_d = B_u$ if and only if $S \leq S_u$

Equation (16) indicates that in a market with varying size, the fixed market area assumption made by Beckmann (1976), in turn, requires the market is small, that is,

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[4] The formal derivation is available upon request from the author

$S \leq S_u$. On the other hand, if the market is not small, then the firm serves a larger market area under SPD than it would be under UDP.

The optimal prices under two pricing policies can be depicted as Figure 1. Both delivered prices under alternative pricing policies are equal at the market site $x = \bar{x}$. Thus, $p_d \geq p_f$ accordingly as $x \leq \bar{x}$, and vise versa (see Figure 1). That is, relative to UDP, SPD imposes a welfare loss on nearby buyers in the region ($\bar{x}$, B_d), and results in a welfare gain on buyers in region (0, $\bar{x}$). Moreover, when the market is not small as Beckmann's, SPD results in extra welfare gains by serving new buyers in region (S_f, B_d) (see Figure 1).

3. Economic Benefits

Consider first the total output sold, or monopoly output--the first measure used in the literature of spatial price theory to evaluate the economic benefit effect of movement from UMP to SPD. It can generally be defined for linear demand by $Q = \int_0^B (a - bp) r(x) dx$. Thus, for SPD

(18) $$Q_d = \int_0^{B_d} (a/2 - bc/2 - btx/2) r(x) dx$$

and for UDP,

(19) $$Q_u = \int_o^{B_u} (a/2 - bc/2 - bt\bar{x}/2) ¥(x) dx$$

By utilizing the definition the average distance, Equation (18) can be rewritten as

(20) $$Q_u = \int_o^{B_u} (a/2 - bc/2 - btx/2) ¥(x) dx.$$

Thus, the difference in monopoly outputs between SPD and UDP is:

(21) $$DQ = Q_d - Q_u = \int_{B_u}^{B_d} (a/2 - bc/2 - btx/2) r(x) dx.$$

Equation (21) indicates that SPD yields a larger monopoly output than UDP if and only if it enlarges the extent of the market area. If the market is small, then $B_d = B_u$, and thereby, one obtains the finding hereupon by Beckmann (1776). One the other hand, if the extent of the market size is $S > S_u$, then $B_d > B_u$, and thereby, $Q_d > Q_u$.

Formally,

PROPOSITION 1: *When individual demand is linear, monopoly output is greater under SPD than it would be under UDP only if it enlarges the extent of the market area or the market size is large.*

Proposition 1 shows that the output effect of SPD as compared to UDP, shown by Beckmann (1976) cannot remain valid in a large market

Another measure to evaluate the economic benefit effects of SPD in the literature of spatial price theory is social welfare, the sum of consumers' surplus and profits. Consumers' surplus as a whole can generally be defined for linear demand by $CS = \int_0^{B_f} (a - bp)^2 (1/2b) r(x) dx$. Accordingly, for SPD

(22) $$CS_d = \int_0^{B_d} (a - bc - btx)^2 (1/8b) r(x) dx$$

and for UDP,

(23) $$CS_u = \int_0^{B_f} (a - bc - bt\bar{x})^2 (1/8b) r(x) dx \; .$$

By utilizing the definition of the average distance, (23) can be rewritten as

(24) $$CS_u = \int_0^{B_u} (1/8b)[a - bc - btx + bt(x - \bar{x})]^2 r(x) dx$$

$$= \int_0^{B_f} (1/8b)(a - bc - btx)^2 r(x) dx + Var(x)(N_u bt^2/8)$$

$$+ 2\int_0^{B_f} (1/8b)(a - bc - btx) bt(x - \bar{x}) r(x) dx$$

$$= \int_0^{B_f} (1/8b)(a - bc - btx)^2 r(x) dx + Var(x)(N_u bt^2/8)$$

$$+ 2\int_0^{B_f} (bt^2/8)(-x + \bar{x})(x - \bar{x}) r(x) dx$$

$$= \int_0^{B_f} (1/8b)(a - bc - btx)^2 r(x) dx - Var(x)(N_u bt^2/8)$$

where $Var(x) = \int_0^{B_f} (x - x^*)^2 r(x) dx / N_f$. The term $Var(x)$ in (24) is nothing but the spatial *variance* of buyer density, or the variability of distance since it is defined by the second moment about the mean of x, exactly the same as the variance in statistics. Thus, the difference in aggregate consumers' surplus of two pricing policies is:

(25) $$DCS = CS_d - CS_u = (A/2) - (G/8)$$

where $A = \int_{B_u}^{B_d} (1/4b)(a - bc - btx)^2 r(x)dx$. It is clear that when the market size is small as that imposed by Beckmann (1976), then $DCS = -G/8 < 0$

Consider next the firm's preference. By substituting (14) in (2), the firms' profit under SPD is:

(26) $$®_d = \int_0^{B_d} (1/4b)(a - bc - btx)^2 r(x)dx - F .$$

Similarly, the firm's profit under UDP is:

(27) $$®_u = \int_0^{B_u} (a/2b - c/2 + t\bar{x}/2 - tx)[a - b(a/2b + c/2 + t\bar{x}/2)]¥(x)dx$$

By utilizing the definitions of the average distance and spatial variance, (27) becomes

(27') $$®_u = \int_0^{B_u} (1/4b)(a - bc + bt\bar{x} - 2btx)(a - bc - bt\bar{x})¥(x)dx$$

$$= \int_0^{B_u} (1/4b)[(a - bc - btx) + bt(\bar{x} - x)][(a - bc - btx) + bt(x - \bar{x})]¥(x)dx$$

$$= \int_0^{B_f} (1/4b)(a - bc - btx)^2 r(x)dx - Var(x)(N_u bt^2/4) .$$

Accordingly, the difference in the firm's profit of two pricing policies is:

(28) $$D® = ®_d - ®_u = (G/4) + A > 0$$

Therefore, the welfare difference between SPD and UDP is:

(29) $$DW = W_d - W_u = (3A/2) + (G/8) > 0$$

Equation (29) holds for any shape of spatial consumer distribution. It holds also despite of the extent of the market size since $DW = G/8 > 0$ when the market size is small and $A. > 0$ for a large market. Accordingly, we can conclude

PROPOSITION 2: *When demand is linear, SPD is socially superior to UDP, despite of both the shape of the spatial consumer density and the extent of the market size.*

Proposition 2 generalizes the finding obtained with the fixed market area assumption by Beckmann (1976) to any extent of the market size.

4. Spatial Competition

To justify the finding obtained by Beckmann (1976) in a market with the assumption that competition is insignificant, we consider the case of spatial competition under free entry. It is one of oft-studied topics in the literature of spatial price theory (see, for example, Holahan (1975), Capozza and Van Order (1978), and Gronberg and Meyer (1981)), and the focus has been on that entry drives the firm's profits to zero, the so-called zero-profit equilibrium.

There is no difference in the firm's profits under alternative pricing policies at zero-profit equilibrium under spatial competition. It follows from (28) that the value A must be negative of G is always positive, that of G is always positive. This, in turn, requires that $B_d < B_u$, and $A = -G/4$. Thus, the monopoly output is greater under UMP than that under SPD (see (20)). Moreover, it follows from (24) and (29) together with $A = -G/4$ that $DCS = -3G/8$, and $DW = -G/2$. Therefore, we can conclude

PROPOSITION 3: *In zero-profit equilibrium under spatial competition, UMP is social superior to SPD, in terms of monopoly output, consumers' surplus as a whole or social welfare.*

Proposition 3 shows that both Beckmann's (BC1) and (BC2) cannot hold when competition is significant. Note also that Proposition 3 holds for any shape of spatial consumer distribution.

5. Concluding Remarks

We have found in a generalized model of Beckmann (1976) that when a spatial monopoly is free from competition, social welfare is greater under discriminatory pricing than it would be under uniform delivered pricing for any shape of the spatial consumer density with various market sizes. Spatial price discrimination can also result in larger monopoly output than uniform delivered pricing when it serves larger market area. This, as shown in this paper, is the case that the market size is not small as that postulated by Beckmann (1976). Nevertheless, in regions where competition is so significant as to drive the firm's profits to zero, uniform delivered pricing is always social superior to discriminatory pricing, either in terms of monopoly output, consumers' surplus or social welfare. This result holds for any shape of buyer density. The findings of this paper, we believe, may provide the theoretical justification for antitrust authorities-- their main job is to promote competition--often appealing uniform delivered pricing as compared to spatial price discrimination.

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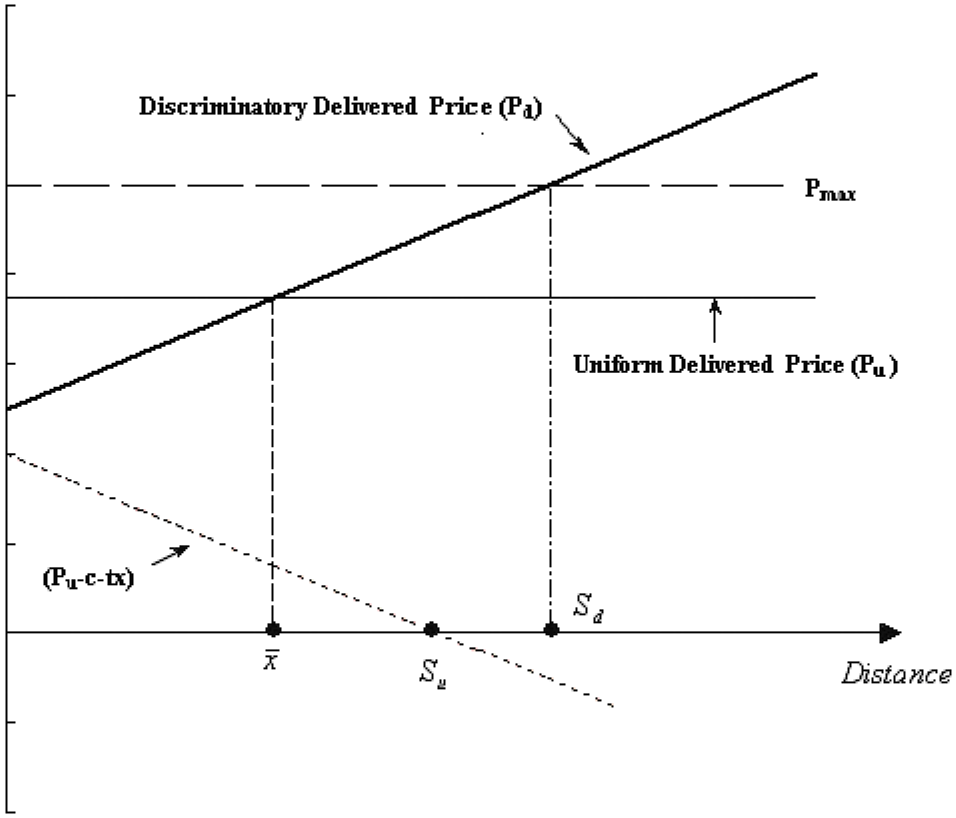
Figure 1: Optimal Prices and Market Areas



Social Desirability of Uniform Delivered Pricing

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Abstract: This paper attempts to examine the social desirability of uniform delivered pricing as compared to spatial price discrimination in a generalized model of Beckmann (1976). It shows that when a spatial monopoly is free from competition, social welfare is greater under discriminatory pricing than it would be under uniform delivered pricing for any shape of the spatial consumer density with various market sizes. Spatial price discrimination can also result in larger monopoly output than uniform delivered pricing when it serves larger market area. Nevertheless, in regions where competition is so significant as to drive the firm's profits to zero, uniform delivered pricing is always social superior to discriminatory pricing, either in terms of monopoly output, consumers' surplus or social welfare. The findings of this paper, we believe, may provide the theoretical justification for antitrust authorities-- their main job is to promote competition--often appealing uniform delivered pricing as compared to spatial price discrimination.

Key words: Uniform delivered pricing, spatial price discrimination, social desirability, spatial monopoly, spatial competition