95-F-5

NON-PRICE COMPETITION AND SOCIAL WELFARE IN OLIGOPOLY

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February 1995

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Current Version: 1995/2/27

Abstract

In oligopolistic markets, firms compete on not only product prices but also various non-price factors, such as quality and accompanying service. However, relatively little attempt has been made to delineate their welfare implications. This paper fills this gap. It is shown that the government can improve social welfare in an oligopolistic market by imposing higher quality/service standard than the laissez-faire level under following two conditions in addition to minor technical conditions. First, consumers' preferences are solely based on quality/service-adjusted prices. Second, quality/service-adjusted prices are strategic complements.

*I am indebted to seminar participants at Nanzan University for their comments on an earlier draft. This research is partly supported by the Zenkoku Ginko Gakujutu Kenkyu Shinko Zaidan.

1. INTRODUCTION

In oligopolistic markets, firms compete on not only product prices but also various non-price factors. Among such non-price factors, product variation has been attracted much attention, and the incentive to differentiate products in order to ease price competition has been intensively investigated.[1] However, the choice of product types is only one mode of non-price competition. Given product variation, product quality is also an important variable for firms to differentiate themselves from their competitors.[2] Moreover, firms also compete on the quality of broadly-defined "service" such as prompt delivery, provision of information, flexible payment terms, and after-sale service. Such non-price competition is not confined to manufacturing. In financial service industries such as banking, financial firms have attempted to differentiate themselves by providing more services (e.g., more convenient hours, bank-by-phone, friendly tellers, shorter response time on loan applications), in addition to create new financial products.

Despite its importance of non-price competition, relatively little attempt has been made to delineate welfare implications of non-price competition in oligopoly.[3] The purpose of this paper is to fill this gap. Specifically, I ask whether the government can improve social welfare by imposing higher quality/service standard in oligopoly, *given the number of firms and the product variation.* This "short-run" assumption of the fixed number of firms and the fixed product variation is made here because this makes social welfare calculation simple and transparent. The short-run case will be the reference point in the long-run analysis of product choice and entry.

There are two basic problems in determining oligopolistic bias in non-price competition. The first concerns imperfect competition in general, and the second is related to oligopolistic competition. In this paper, I use "service" as a stand-in of non-price factors.

It is well-known (see Tirole [12, pp.100-104]) that the monopoly service may be too high or too low compared with the first best, depending on specifications of preferences and costs. Here the first best service is the choice of the social planner who can control both price and service. There are two kinds of ambiguity about possible monopoly bias. First, for the same given output, the service may be too high or too low depending on a particular shape of the demand curve. Second,

[1] See Shaked and Sutton [10]. See also Tirole [12, Chapter 7] for a survey of this literature.

[2] Recent studies on product differentiation investigate the effect of product quality competition on the product-type differentiation. See Economides [5], [6] and Neven and Thisse [8].

[3] But see Economides [6] for a related attempt in a specific cicular model of product differentiation assuming uniform distribution of consumers, unit quantity purchase, zero marginal cost, quadratic quality costs, and sequential decision of location, quality, and price.

even in the case where we have a definite answer about the bias for the same output level, price is not the same between the first best and the monopoly, so that the "same output" condition does not hold.

The problem is further aggravated in oligopoly by the existence of strategic interaction among firms. Oligopolistic firms take account of not only the demand response but also their rival's strategy, in determining prices and non-price factors. The direction of oligopolistic bias is in general ambiguous, depending on demand, cost and market structure.

In this paper, I thus search for reasonable restrictions on preferences, technology, and strategic interdependence, which are general enough to be satisfied in many markets, and are still sufficient to obtain a definite result about the oligopoly bias. I make three basic assumptions.

First, I consider as a reference point the second best in which the social planner can control only service by imposing the minimum (or maximum if necessary) service standard, instead of the first best in which the planner can control both price and service. Thus, I ask in this paper whether the social planner can improve the oligopolistic outcome by intervening service provision. This is a practical criterion, since there have been lively debates in many countries over the imposition of such standard.[4]

Second, I assume that consumers evaluate in monetary terms service that firms provide, and calculate the "service-adjusted prices." It is further assumed that consumers have the same monetary evaluation of service, so that the service-adjusted price of a firm is the same among consumers. Their demand depends solely on this service-adjusted price.[5]

Third, service-adjusted prices are assumed to be strategic complements, in which an increase [decrease] in one firm's service-adjusted price induces an increase [decrease] in the other firms' service-adjusted price. This is also a natural assumption, since prices are strategic complements in many cases.

I show in this paper that under these assumptions together with minor technical ones, the social planner can improve social welfare by imposing minimum service standard which is higher than the laissez-faire service level. The intuition behind this result is based on the fact that price is higher that marginal cost in imperfect competition. In the framework of this paper, the service-adjusted price is higher than the marginal cost of "producing" service-adjusted product, so that an increase in the production of service-adjusted quantity is socially desirable.

Suppose that the social planner imposes a higher service standard on firms.

[4]For example, the government can set the minimum length of free after-sale service. Similarly, the minimum product-quality standard is often argued to improve social welfare in general.

[5]However, there are exceptions. For example, Japanese computer firms sell their differentiated products (not compatible with one another) , and at the same time offer free (or token-fee) lessons of using computers. Since skill obtained in these lessons can be used for other firms' computers, this service spills over to other firms' products. Then, separability in product-service mixes implicitly assumed in the service-adjusted price is not likely to hold.

There are direct and indirect effects. The direct effect is that the imposition of higher service standard reduces the service-adjusted price for a given unadjusted price (price of the physical product) . The indirect effect is that the imposition may induce firms to raise their unadjusted price to cover the cost increase, which increases the service-adjusted price. However, under general conditions on technology, the direct effect dominates the indirect effect, so that the service-adjusted price is reduced. Since service-adjusted prices are strategic complements, strategic interaction in oligopoly further reduces service-adjusted prices. Therefore, the production of service-adjusted products increases, which leads to welfare improvement.[6]

The organization of this paper is as follows. In Section 2, I explain the basic logic behind the result of this paper in the well-known durability model of Swan [11] in a monopoly setting. In Section 3, the model of oligopoly with non-price competition is presented, and the main theorem is explained. The generality of assumptions is also investigated by examining representative-consumer models and location models, which are standard models of differentiated-product oligopoly. I show in Section 4 that there is a convenient characterization of the optimum (second-best) service standard, which is based on demand elasticities. The proof of the theorems is found in Appendix. Section 5 concludes the paper.

2. A MONOPOLY EXAMPLE

In this section, I briefly explain in a simple example why the imposition of higher quality/service standard improves social welfare. The example is an extension of Swan [11]'s optimal durability model. The model is a monopoly model, so that strategic interaction is absent making the basic structure simple.

Let us consider, for example, the market of light bulbs. The monopolist's strategic variables include not only the price p of the light bulb but also its durability q. A consumer who buys D bulbs gets qD hours. The demand for the bulbs depends on p and q. In order to produce the light bulbs with durability q, the monopolist incurs the fixed cost $h(q)$, and constant marginal cost $c(q)$ for producing one bulb. The cost functions h and c satisfy $h(0) \geq 0$, $h' \geq 0$, $h'' \geq 0$, $c(0) > 0$, $c' > 0$, and $c'' > 0$. In the original Swan model, there is no fixed cost, so that $h(q) = 0$. The importance of $h(q)$ will become clear in the subsequent discussion.

Durability-Adjusted Price. Assume that consumers care only about the total number of hours, and not about the way these hours are obtained. Then, it

[6] In addition, we must take into account the cost increase due to higher service standard. It turns out that its importance is of the second order, so that it can be ignored for practical purposes. See Sections 2 and 3.

is possible to reformulate the demand for the bulbs and the revenue of the monopolist in terms of ***durability-adjusted quantity*** $X = qD$ and ***durability-adjusted price*** $z = p/q$. The demand is $X(z)$, and the revenue is zX. The cost is then reformulated accordingly: cost function is now $G(X, q) = h(q) + (c(q)/q)\,X$. Then, the monopolist's problem is to maximize

$$zX - G(X,q) = zX - \left[h(q) + \frac{c(q)}{q}X\right] \tag{2.1}$$

I assume "regularity" of the monopoly durability-adjusted price in which a reduction in the marginal cost reduces the monopoly durability-adjusted price.[7]

The social welfare is the sum of consumers' and producer's surplus such that

$$\int_z^{\infty} X(s)ds - G(X,q) = \int_z^{\infty} X(s)ds - \left[h(q) + \frac{c(q)}{q}X\right] \tag{2.2}$$

Swan shows that the monopoly durability coincides with the first-best (command optimum) durability if $h(q) = 0$.[8] This result is well-known as Swan's Invariance Theorem. But we generally have $h(q) > 0$, so that the monopoly durability is not equal to the first-best durability.

However, ***if the durability-adjusted quantity level is the same and given, the monopoly durability and the planner's durability coincide with each other.*** This is because the durability q appears only in cost both in the monopolist's profit and the social welfare in the durability-adjusted framework.

The Second-Best Planner: Market-Structure-Constrained Optimum. Let us consider the social planner who does not have power to impose price. But he can impose a durability standard, by setting the minimum (or maximum if necessary) durability. The Second-Best social planner thus takes the market structure as given, and maximizes social welfare by determining durability. I show that in the durability-adjusted framework, the social planner ***always*** increases social welfare by imposing a durability standard higher than the monopoly durability.

Let us start from the monopoly durability-adjusted price and the monopoly durability. On the one hand, for the given durability-adjusted quantity, the monopoly durability minimizes the cost. Thus, the marginal increase in the cost due to the marginal increase in the durability is of the second-order, and thus can be ignored. On the other hand, regularity implies marginal increase in durability decreases the durability-adjusted price (that is, the durability increase exceeds

[7]Let $c(q;\xi)$ be the marginal cost, where ξ is a shift parameter such that $c_\xi < 0$, where $c_\xi = \partial c/\partial \xi$. Since $dz/d\xi = [1 - \eta_z(c/q)]^{-1}\,(c_\xi/q)$, the regularity assumption implies $1 - \eta_z(c/q) > 0$.

[8]The monopoly and the first-best durability are q minimizing $c(q)/q$.

the corresponding price increase)[9] so that it increases the durability-adjusted quantity. Monopoly means that the durability-adjusted quantity is always too small and that an increase in durability-adjusted quantity leads to a first-order improvement in social welfare. Therefore, marginal increase in durability unambiguously improves social welfare.[10]

In extending the analysis from monopoly to oligopoly in realistic setting, three problems must be addressed. First, strategic interaction between producers must be taken into consideration. Thus, explicit game-theoretic framework is needed. Second, since products are differentiated and that demand of one product depends on prices of other products, simple summation and integration of demand functions become intractable. Third, in many cases, the expenditure share of the industry's products is not small and thus the income effect of price change must be explicitly taken into consideration. In order to take the latter two into account, we have to assume some form of aggregated preferences. The model of the next section deals with these issues.

3. THE INSUFFICIENT-SERVICE THEOREM

3.1. THE MODEL

Consider an industry consisting of n firms, each producing one differentiated product. I assume that the number of firms, n, is given.

The firms compete with each other not only on price but also on providing "service", which must be interpreted in a broad context. It includes various modes of non-price competition. To provide a high physical quality of products may also be a part of service considered here as in the case of light bulbs. In this section, I first present the model in a general setting in Section 3.1, and then explain specific assumptions in Section 3.2. Examples are given in Section 3.3.

Let p_i and q_i be the ith firm's product price and its service level. Here I assume that q_i is a scaler variable for simplicity, but the analysis below can be easily extended without no substantial change to the case that q_i is a vector of various services. The demand for the ith firm's product, D_i, depends on its price

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[9]The monopoly price is determined by $z = \eta(c(q)/q)$, where η is the price elasticity of the demand. The monopoly durability is determined by $\partial G/\partial q = 0$, which implies $d(c(q)/q)/dq < 0$ at the monopoly durability since $h'(q) > 0$. Therefore, $dz/dq = [1-\eta_z(c(q)/q)]^{-1}[d(c(q)/q)/dq] < 0$ at the monopoly price and durability, because $1 - \eta_z(c(q)/q) > 0$ from the regularity.

[10]The firm's maximization of (2.1) implies $X + \{z - (c/q)\}X_z = 0$. Differentiating the social surplus (2.2), and using the above expression and $z = \eta(c/q)$, we have

$$\frac{dSS}{dq} = (\eta - 1)\frac{c(q)}{q}X_z\frac{dz}{dq} - \frac{\partial G}{\partial q}$$

It is evident that $dSS/dq > 0$ at the monopoly price and quality so long as $dz/dq < 0$ and $\partial G/\partial q = 0$.

and service, as well as other firms' price and service: $D_i = D^i(p, q)$, where $p = (p_1, ..., p_n)$ is the price vector and $q = (q_1, ..., q_n)$ is the service vector. Similarly, I use the following definitions throughout this paper: $p_{-i} = (p_1, ..., p_{i-1}, p_{i+1}, p_n)$ and $q_{-i} = (q_1, ..., q_{i-1}, q_{i+1}, q_n)$.

The ith firm's profit Π^i is $\Pi^i = p_i D^i - C^i(D^i, q_i)$ where C^i is the cost function. The cost depends not only on the quantity produced, but also on the level of service. I consider a simultaneous-move Nash game. That is, firms simultaneously determine price and service taking other firms' price and service as given.[11]

If the government imposes the service-standard q_i^g, then the market equilibrium with the service requirement is p^g such that p_i^g maximizes $\Pi^i = p_i D^i - C^i(D^i, q_i)$ with respect to p_i, where $D^i = D^i(p_{-i}^g, p_i, q_{-i}^g, q_i)$.

In the no-intervention market-equilibrium in which there is no service control by the government, the market equilibrium is (p^m, q^m) such that (p_i^m, q_i^m) maximize $\Pi^i = p_i D^i - C^i(D^i, q_i)$ with respect to (p_i, q_i) where $D^i = D^i(p_{-i}^m, p_i, q_{-i}^m, q_i)$. In both cases, I assume unique interior equilibrium in which $\Pi^i > 0$ throughout this paper.

3.2. RESTRICTIONS ON PREFERENCES, TECHNOLOGY, AND STRATEGIC INTERACTION

In this section, I specify restrictions on preferences and technology which enable us to determine oligopolistic bias in non-price competition. The first assumption of service-adjusted price is the extension of the durability-adjusted price in the monopoly model considered in Section 2.

Assumption 3.1 (Service-Adjusted Price). *There exist the service-adjusted quantity X^i and the service-adjusted price z_i such that $X^i = X^i(D^i, q_i)$ and $z_i = z_i(p_i, q_i, D_i)$, which satisfy the following two conditions: (a) Consumers' total welfare W is an indirect utility function of the service-adjusted price z_i and the total income Y such that $W = W(z_1, ..., z_n, Y)$ and the demand for the service-adjusted quantity X^{Di} satisfies Roy's identity $X^{Di}(z_1, ..., z_n, Y) = -(W_{z_i}/W_Y)$; where $W_{z_i} = \partial W/\partial z_i$ and $W_Y = \partial W/\partial Y$. (b) Producers' profits Π^i can be re-written as the function of z_i, X^{Di} and q_i: $\Pi^i = z_i X^{Di} - G^i(X^{Di}, q_i)$, where $z_i X^{Di}$ is the revenue, and $G^i(X^{Di}, q_i)$ is the generalized cost function.*

The first part of the next assumption implies that when the service-adjusted price increases, the marginal utility of income decreases or at least unchanged.

[11] If one interpret q as product quality, then the sequential-move model in which quality is determined first and then price is decided may be more appropriate, since the decision of product quality is likely to be an investment decision. This is the line taken by Economides [6]. However, if q is service, then to change the level of service is not hard in many cases, so that the simultaneous determination is not unrealistic. Moreover, even if quality is determined first, the simultaneous-determination model gives a convenient reference point (see Chu and Nishimura [3]).

The second part assumes downward-sloping "market demand" curve. They are fairly standard assumptions.

Assumption 3.2 (Regular Utility and Demand). *Marginal utility of income W_Y is non-increasing in service-adjusted prices: $\partial^2 W/\partial Y \partial z_i \leq 0$. The demand decreases if all service-adjusted prices in this market increases by the same amount, i.e., $\sum_{j=1}^{n} \partial X^{Di}/\partial z_j < 0$.*

The third assumption is that if the level of service increases, the marginal cost of "producing" service-adjusted quantity decreases. This may seem a little bit counter-intuitive, but it is in fact a natural assumption.

Assumption 3.3 (Cost Curvature). *Marginal generalized cost of "producing" service-adjusted quantity is decreasing in service. That is, $MGC^i = \partial G^i/\partial X^{Di}$ satisfies*

$$\partial MGC^i/\partial q_i < 0. \tag{3.1}$$

In many cases, service provision and production are independent activities. Most service such as prompt delivery, specific product information, and after-sale service seems to satisfy this independence. In this case, the marginal production cost depends only on physical quantity, and is increasing with physical quantity. Consider an increase in service. Now smaller physical quantity is needed to "produce" the same level of service-adjusted quantity. This implies the marginal production cost is lower at the same level of service-adjusted quantity, when service is increased. Then, Assumption 3.3 is satisfied.

In the case of product quality, however, the marginal production cost is likely to depend positively on product quality (see the durability of model of Section 2). In this case, Assumption 3.3 requires that the MGC-decreasing effect of increased service explained in the previous paragraph dominates its MGC-increasing direct effect. This additional constraint is generally met as in the durability model of Section 2, in which Assumption 3.3 always holds around the equilibrium.[12]

Under the above assumptions, the market equilibrium can be characterized in terms of the service-adjusted price z_i and service q_i. In the following, $z = (z_1, .., z_n)$ is the vector of service-adjusted prices.

Market Equilibrium with Service Requirement. Let us first consider the case in which the government sets the service standard. In this case, the government determines q_i^g. Let

$$z = h(q, Y) \text{ implicitly defined by } z_i = \eta^i(z, Y) G_X^i \left(X^{Di}(z, Y), q_i\right) \text{ for all } i, \tag{3.2}$$

[12]In the durability model, we have $MGC = c(q)/q$. The monopolist's optimum requires $dMGC/dq = d(c/q)/dq < 0$.

where η^i is the mark-up rate such that

$$\eta^i(z,Y) = \left[1 + \left(\frac{X^{Di}(z,Y)}{z_i}\right)\left(\frac{\partial X^{Di}(z,Y)}{\partial z_i}\right)^{-1}\right]^{-1}.$$

Then, the market equilibrium $z^g = (z_i^g, ..., z_n^g)$ is determined by $z^g = h(q^g, Y)$.

Market Equilibrium without Service Requirement. In this case, firms choose their own level of service. Thus, the market equilibrium without the government's service requirement is (z^m, q^m) satisfying $G_q^i = 0$and $z_i^m = \eta^i G_X^i$ where $G_q^i = \partial G^i / \partial q_i$.

It is convenient to re-formulate the equilibrium conditions as follows. Let

$$q^i = f^i(X^{Di}) \text{ implicitly defined by } G_q^i(X^{Di}, q_i) = 0. \tag{3.3}$$

Then, the equilibrium z^m are determined by

$$z = h\left(f(z,Y), Y\right) \text{ for all } i,$$

where $f = (f^1, ..., f^n)$ while the equilibrium q^m is such that $q_i^m = f^i\left(X^{Di}(z^m, Y)\right)$.

It should be noted that the government can duplicate the no-intervention market equilibrium by setting the service standard equal to the no-intervention service, that is, $q_i^g = q_i^m$.

Let us now specify assumptions on strategic interaction. I assume symmetry, regularity, strategic complementarity, and stability. They are fairly standard in the game-theoretic analysis of imperfect competition (see Bulow, Geanakoplos, and Klemperer [1]), although they are somewhat strong assumptions.

Assumption 3.4 (Symmetry). *Demand functions and cost functions are symmetric so that $\eta^i = \eta^j$; $G^i = G^j$ for all $i \neq j$.*

We hereafter consider symmetric equilibrium. Let us implicitly define the service-adjusted price reaction function $z_i = R^i(z_{-i}; q_i, Y)$ for given service q_i in the following way:

$$R^i(z_{-i}; q_i, Y) = \eta^i\left(R^i(z_{-i}; q_i, Y), z_{-i}, Y\right) G_X^i\left(X^{Di}\left(R^i(z_{-i}; q_i, Y), z_{-i}, Y\right), q_i\right).$$

The following assumptions are on the characteristics of this reaction function. The first assumption implies that a shift in the marginal cost of producing service-adjusted quantity *ceteris paribus* reduces the service-adjusted price. That is, a favourable change in the cost function reduces the best-response price, which is a natural assumption. This assumption is the generalization of the regularity condition in Section 2.

Assumption 3.5 (Regularity). *Let ξ_i be the shift parameter in the generalized cost function $G^i(X^{Di}, q_i; \xi_i)$ such that $G^i_{\xi_i} = \partial G^i / \partial \xi_i < 0$. Then, the service-adjusted-price reaction function $z_i = R^i(z_{-i}, q_i, Y; \xi_i)$ is decreasing in ξ_i.*

The next assumption is crucial in this paper, which implies that the best response to a decrease in the competitors' service-adjusted prices is to cut the firm's service-adjusted price to meet competition, but the decrease is less than proportional.

Assumption 3.6 (Strat. Comple. and Stability). *If all the other firms increase their service-adjusted price by the same amount, then the best-response service-adjusted price of the firm also increases or unchanged. However, the price increase is less than proportional to the other firms' price increase. That is, $0 < dz^i/dy < 1$ for all i, where $z^i = R^i(y, ..., y, q_i, Y)$.*

In many cases, prices are strategic complements. Since the basic structure of the game assumed in the literature is the same as the one I consider here for given service levels, the assumption of strategic complementarity is justified. Similarly, the stability assumption is justified since otherwise oft-assumed "tatonnement process" does not converge (see Tirole [12]).

Government's Objective Function. Let us now consider the government's objective function. I assume the government maximizes the following social surplus:

$$SS(q, Y) = W(z, Y) + W_Y(z, Y) \sum_{i=1}^{n} \Pi^i(z_i, Y, q_i)$$

$$= W\left(h(q, Y), Y\right)$$

$$+ W_Y\left(h(q, Y), Y\right) \sum_{i=1}^{n} \left[h^i(q, Y) X^{Di}\left(h(q, Y), Y\right) - G^i(X^{Di}\left(h(q, Y), Y\right), q_i)\right]$$

where h is defined in (3.2). Here, Π^i (profits) is multiplied by W_Y (marginal utility of income) in order to get producers' surplus in utility terms. The intervention equilibrium's social surplus is $SS(q^g)$ while the no-intervention equilibrium social surplus is $SS(q^m)$.

I hereafter consider symmetric equilibrium in which all firms have the same service-adjusted price and the same level of service in equilibrium. I also assume interior equilibrium in which firms' profits are non-negative. The following is the main theorem of this paper.

THEOREM 3.1 (Insufficient Service). *Assume Assumptions 3.1 through 3.6. Let q^g be the government-controlled service quality and q^m be the no-intervention market-equilibrium service quality. Then, an increase in q^g always increases social surplus SS at $q^g = q^m$.*

The main theorem shows that the government can increase social surplus by imposing higher service standard than the laissez-faire level. The proof of this theorem is somewhat technical and thus relegated to Appendix. However, the basic logic behind this theorem is simple and natural extension of the monopoly argument in Section 2.

Suppose first that the service is exogenously determined by the government. Then, the model is exactly the same as the textbook differentiated-product imperfect competition model (price game) if we simply replace price by service-adjusted price. It is well-known that in the imperfectly competitive market price exceeds marginal cost, so that the equilibrium quantity is too low (and price is too high). The same is true in this service-adjusted price game: the service-adjusted price exceeds corresponding marginal cost, so that the equilibrium service-adjusted quantity is too low. Thus, any market intervention that increase the quantity increases social surplus so long as it does not change other variables in the game.

Suppose that the government first mimics the no-intervention market equilibrium, that is, it sets its service standard at the no-intervention level. Consider then an increase in the service standard. Under Assumptions 3.3, 3.5, and 3.6, an increase in the imposed service standard reduces the equilibrium service-adjusted price (Lemma 2 in Appendix). That is, although the equilibrium unadjusted price may increase, its reaction to the service change is small enough to make the service-adjusted price decreases. So long as the industry demand is not completely inelastic, a decrease in the service-adjusted price increases the equilibrium service-adjusted quantity, and thus increases social surplus. An increase in the imposed service standard, however, increases the cost, and thus the gain from the increased service-adjusted quantity must be compared with the loss due to the increase in the cost of providing service. However, the social marginal cost of service increase is zero at the no-intervention market equilibrium under Assumption 3.1. This is because under Assumption 3.1, the social cost is equal to the generalized cost G^i, which is also the private cost of the firm. Thus, the individual optimization implies that the private marginal cost of increasing service is zero at the individual optimum so that the social cost of increasing service is also zero. Therefore, social surplus is unambiguously increased when the government increases its service standard over the no-intervention market equilibrium level.

3.3. EXAMPLES

In this section, I consider two major models of imperfect competition with product differentiation, *i.e.*, the representative consumer model and the location model. Using the theorem obtained in the previous section, I examine conditions under which the government can improve social welfare by imposing high service standard.

Example 1: A Representative-Consumer Model. The representative consumer model of product differentiation has been extensively discussed in the literature. The model has been used not only in the analysis of industrial organization, but also in macroeconomics (see, for example, Weizman [13] and Nishimura [9]). However, the issue of non-price competition has not been fully analysed in this framework.

Let us incorporate service into the model of Dixit and Stiglitz [4]. Let D^i be the consumption of the ith firm's physical product, and p_i its price. The service q_i the firm provides is assumed to be "consumption-augmenting", so that the service-adjusted quantity X^i is such that $X^i = q_i D^i$ as in the Swan durability model.

The representative consumer's utility is

$$U = \phi V^\alpha B^{1-\alpha}$$

where $\phi = \alpha^{-\alpha} 1 - \alpha^{-(1-\alpha)}$ is a normalizing factor, V is the sub-utility based on this industry's products such that

$$V = \left[\frac{1}{n} \sum_{i=1}^{n} (q_i D^i)^{(k-1)/k} \right]^{k/(k-1)},$$

and B is the consumption-composite of the other industries' products, which is taken as a numeraire. The representative consumer maximizes U with respect to D^i subject to the budget constraint

$$\sum_i p_i D^i + B = Y \tag{3.4}$$

where Y is income.

Let $X^i = q_i D^i$ be the service-adjusted quantity, and z_i be the service-adjusted price such that

$$z_i = \frac{p_i}{q_i}. \tag{3.5}$$

Then, individual demand for service-adjusted products is

$$X^{Di} = \left(\frac{z_i}{z^*} \right)^{-k} \frac{1}{n} \frac{\alpha Y}{z^*} \text{ where } z^* = \left[\frac{1}{n} \sum_{i=1}^{n} z_i^{1-k} \right]^{1/(1-k)}$$

It is straightforward to show that this example satisfies the consumer part of Assumption 3.1 and Assumption 3.2.

Next, consider the ith firm. I assume a similar cost structure as in Section 2. The fixed cost of providing service q_i is $(1/2)q_i^2$, and variable cost of producing D^i with service is $(s + rq_i)\, D^i$. Then, the ith firm's total cost is

$$C^i(D^i, q_i) = \frac{1}{2}q_i^2 + (s + rq_i)\, D^i \tag{3.6}$$

The definition of z_i and X^i implies $p_i Di = z_i X^i$. Thus, the generalized cost function is

$$G^i(X^i, q_i) = \frac{1}{2}q_i^2 + \left(\frac{s}{q_i} + r\right) X^i. \tag{3.7}$$

Then, the ith firm's profit Π^i is

$$\Pi^i = z_i X^i - G^i(X^i, q_i). \tag{3.8}$$

Therefore, the producer-part of Assumption 3.1 is satisfied. Since

$$\frac{\partial MGC^i}{\partial q_i} = \frac{\partial^2 G^i}{\partial X^i \partial q_i} = -\frac{s}{q_i^2} < 0.$$

Assumption 3.3 is satisfied.

In order to make analysis simple, I assume the monopolistically competitive assumption in the strong form (Nishimura [9]) in which the firm takes z^* as given in their calculation of the optimal price. Then, the individual service-adjusted price z_i for given q_i is a mark-up over the marginal service-adjusted production cost $r + (s/q_i)$, *i.e.*,

$$z_i = \omega\,[r + (s/q_i)] \text{ where } \omega = k/(k-1),$$

so that it is straightforward to show that Assumptions 3.5 and 3.6 hold in this ease. Therefore, the theorem asserts that the government can improve social welfare by imposing higher service standard than the market-equilibrium service level.

Example 2: A Location Model. The second example is the location model of product differentiation. The following model and its variants (including circular city models) have been extensively discussed in the recent literature of price and quality in the differentiated product industry (see, for example, Neven and Thisse [8], Economides [5], [6], and Chu and Nishimura [3]).

The model follows Economides [5] and Chu and Nishimura [3]. Assume that two firms are located at the opposite ends of a linear city stretching from 0 to 1 (Firm 1 at 0 and Firm 2 at 1). The marginal cost of producing D^i is constant and set to be zero, while there is a fixed cost cq_i^2 of providing service q_i. Then, the profit function of firm i is

$$\Pi^i = p_i D^i - cq_i^2$$

Consumers are assumed to be distributed uniformly along this linear city. They are otherwise homogeneous. They incur a linear transportation cost and buy one unit of the product, if they want it.

A consumer is assumed to get the following utility from purchasing product i:

$$U^i = M + kq_i - dt + Y - p_i,$$

where M is the monetary value of the product at zero quality; k is the consumer's monetary valuation of unit quality; d is the distance from the consumer to firm i; and t is the monetary unit transportation cost, while Y is income and p_i is the price of the product. Thus, $M + kq_i - dt$ is the utility from consuming this product, while $Y - p_i$ is utility from consuming other commodities than this market's.

The consumer always chooses a product with a higher U^i, and if U^i of the chosen product exceeds his own reservation utility (which is Y in this example), he actually buys the product. I consider two cases. In the first case, M is sufficiently small so that consumers located at the centre of the linear city do not buy products. In the second case, M is so large that all consumers buy products from either firm 1 or 2.

In the first case, demand for the firm i's products is determined by

$$M + kq_i - \lambda t + Y - p_i = Y,$$

where λ is the distance of the marginal consumer from the firm. Thus, demand for firm i's products is

$$D^i = \lambda = \frac{M + kq_i - p_i}{t} \tag{3.9}$$

Consumers' total utility U is then

$$U = \int_0^{\lambda} (M + kq_1 - st + Y - p_1)\, ds + \int_{\lambda}^{1-\lambda} Y ds$$

$$+ \int_{1-\lambda}^{1} (M + kq_2 - (1-s)t + Y - p_2)\, ds.$$

Let $z_i = p_i - kq_i$, and $X^i = D^i$. By definition, the ith firm's profit Π^i is

$$\Pi^i = p_i D^i - cq_i^2 = z_i X^i - G(X^i, q_i), \tag{3.10}$$

where

$$G(X^i, q_i) = cq_i^2 - kq_i X^i. \tag{3.11}$$

Therefore, Assumption 3.3 is satisfied.

In this case, define $W(z_1, z_2, Y)$ such that

$$W(z_1, z_2, Y) = Y + \frac{(M - z_1)^2 + (M - z_2)^2}{2t}$$

Then we have

$$U = W(z_1, z_2, Y),$$

$$-(\partial W/\partial z_i)/(\partial W/\partial Y) = (M - z_i)/t = X^i,$$

It is straightforward to show that Assumptions 3.1 through 3.6 are satisfied. Therefore, the government can improve social surplus by imposing high service standard.

Let us now consider the second case in which M is sufficiently small so that all consumers buy the product. To compute demand, let us find a consumer who is indifferent between buying from firm 1 and firm 2. The boundary consumer is the one located at θ, where

$$M + kq_1 - \theta t + Y - p_1 = M + kq_2 - (1-\theta)t + Y - p_2.$$

Demand of firm i is thus

$$D^i = \frac{p_j - p_i + k(q_i - q_j) + t}{2t}.$$

Consumers' total utility U is then

$$U = \int_0^\theta (M + kq_1 - \theta t + Y - p_1)\, dt + \int_\theta^1 (M + kq_2 - (1-\theta)t + Y - p_2)\, dt.$$

Let

$$W(z_1, z_2, Y) = Y + M + \frac{z_1^2 + z_2^2 - 2z_1z_2 - 2(z_1+z_2)t + t^2}{4t}$$

Then, we have

$$U = W(z_1, z_2, Y),$$

$$-(\partial W/\partial z_i)/(\partial W/\partial Y) = (z_j - z_i + t)/(2t) = X^i.$$

Then, it can be shown that Assumption 3.2 is violated although all other assumptions are satisfied.

In fact, it can be shown that the government cannot increase social surplus by imposing service standard in this example. To see this, let us compute social surplus. In the symmetric equilibrium, consumers' welfare is equal to $Y + M - z - (1/4)t$. The sum of the firms' profits are $z - 2c(q^g)^2 - kq^g$. Therefore, since marginal utility of income is unity by assumption, social welfare SS is $SS = M - (1/4)t - 2c(q^g)^2 - kq^g$. Thus, the service-adjusted price z is irrelevant in social surplus.

By maximizing SS with respect to q^g, we obtain $q^g = k/(4c)$. On the other hand, straightforward equilibrium calculation shows that $z^m = t - k^2/(4c)$ and $q^m = k/(4c)$, so that $p^m = 1$. Thus, the optimal q^g is equal to q^m.

In this case, the market equilibrium is the first best (command optimum) in which the government cannot improve social surplus by imposing both price and service. This is because price does not have any allocational role between this market and the other ones. The total demand is exogenously given, and the marginal utility of income is always unity. Therefore, price determination simply determines how social surplus is divided between consumers and firms, so that price is completely irrelevant in resource allocation.

4. THE OPTIMUM SERVICE STANDARD

In this section, I give a convenient characterization of the optimal service standard q^* which maximizes social surplus SS, in the special case of constant marginal utility of income, constant elasticity of demand, and constant returns to scale in production. The optimum standard here is the second best one, since price is set by firms. In this section, it is assumed that all Assumptions in the previous section are satisfied.

Individual and Industry Demand Functions Before proceeding with analysis, It is convenient to define individual demand and industry demand. Under the symmetry assumption (Assumption 3.4), $X^{Di} = X^{Dj}$ so that we hereafter omit superscript i and j. In this section, I use z and y as scalers for expositional simplicity, although they are vectors in the previous section. This should not cause any confusion in the following analysis.

Let the individual demand function $X^D(z, y, Y)$ be

$$X^D(z, y, Y) = X^{Di}(z_1, ..., z_n, Y) \text{ where } z_i = z \text{ and } z_j = y \text{ for all } j \neq i \quad (4.1)$$

and the industry demand function $X^*(z)$ be

$$X^*(z, Y) = X^{Di}(z_1, ..., z_n, Y) \text{ where } z_i = z \text{ for all } i. \quad (4.2)$$

I make the following additional assumptions in this section.

Assumption 4.1 (Constant Demand Elasticity). *The service-adjusted price elasticity of individual demand is constant and equal to ε, and that of industry demand is also constant and equal to ε^*, i.e.,*

$$-\frac{z}{X^D} X_z^D = \varepsilon \text{ and } -\frac{z}{X^*} X_z^* = \varepsilon.$$

Assumption 4.2 (Constant Returns to Scale). *The generalized cost function $G(X,q)$ is such that $G(X,q) = A(q) + B(q)X$, where $A' > 0$; $A'' > 0$; $B' < 0$; and $B'' > 0$. That is, The fixed service cost $A(q)$ and the marginal cost of producing the service-adjusted quantity $B(q)$ are both convex.*

Assumption 4.3 (Constant Marg. Utility of Income). *The marginal utility of income M_Y is constant and equal to unity.*

Note that we have $B' < 0$ in order to satisfy Assumption 3.3. Because of this constant elasticity assumption, the firm's optimal price is a function of its quality q such that $z = h(q) = \eta B(q)$, where $\eta == [1 - \varepsilon^{-1}]^{-1}$.

Assumption 4.4 (Small Industry-Demand Elasticity). *The elasticity of industry demand is sufficiently small compared with convexity of service costs, such that*

$$\frac{A''}{A'} + \frac{B''}{-B'} > \varepsilon^* \frac{-B'}{B}. \tag{4.3}$$

THEOREM 4.1 (Optimal Service Standard). *Assume Assumptions 4.1, 4.2, 4.3, and 4.4, in addition to Assumptions 3.1 through 3.6. Let q^o be the optimum service standard that the government imposes. Then, the optimum service standard* increases *if the* industry *demand is more elastic, while the optimum service standard* decreases *if the* individual *demand is more elastic, that is, $dq^o/d\varepsilon^* > 0$ while $dq^o/d\varepsilon < 0$.*

THEOREM 4.1 provides a convenient characterization of the relationship between demand elasticities and the optimum service standard.

Here we see a large effect of oligopolistic negative externality. Suppose that industry demand becomes more elastic. For each individual firm, there is no change in their strategy. However, for an industry as a whole, to increase the service standard (and thus to reduce the service-adjusted price) increases the demand and thus social welfare more than before. The discrepancy between social gain and private gain from increasing service is larger.

In contrast, an increase in the individual demand elasticity decreases the optimum service standard. An increase in the individual demand elasticity implies the mark-up is now smaller. This means the oligopolistic bias is smaller, so that we need less corrective action in the form of the service standard.

5. CONCLUDING REMARKS

I have shown in this paper that the government can improve social welfare by imposing higher service standard than the laissez-faire level, under two plausible conditions in addition to minor technical conditions: (1) consumers' preferences and firms' profit functions can be re-formulated in terms of service-adjusted products and prices, and (2) service-adjusted prices are strategic complements.

In this paper, I have assumed that the number of firms and their product choice are given. Thus, the result obtained in this paper is the short-run characteristic of oligopoly. In the long run, firms adjust their product choice and entry of new firms occurs. However, there is a good reason that insufficient service theorem still holds in the long run.

Suppose that firms' profits are higher under no intervention (which is likely). If profits are higher under no intervention, more new firms have incentive to enter, and free entry entails more firms. This is not desirable because of the fixed cost of production. This effect is emphasized by Economides [6] in the context of a circular model of product differentiation. Consequently, the government is likely to improve social welfare by imposing higher service standard than the laissez-faire level, even in the long run.

There are several ways to extend the analysis. First, this paper has assumed that price and service are simultaneously determined. However, there is no *a priori* reason of simultaneity. In the case of product quality, it is natural to assume that quality is determined before price. In the other services such as prompt delivery, there is strong evidence that firms change them more often than prices (Carlton [2]). The sequential choice introduces strategic interaction not only among firms but also between strategies (price and service/quality) (Chu and Nishimura [3]). So far, welfare implications of cross-strategic interaction are sketchy and not fully understood.

Second, the assumption of service-adjusted products implies one firm's service does not spill over to the other firms' products. Although this is a natural assumption in many cases, this does not hold, for example, for free lessons of using computers provided by computer companies. Skill obtained in these lessons can be used for other companies computers. However, since this externality is a positive externality, intuition suggests that insufficient service theorem holds true even if we allow spillovers.

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Appendix

A.1. PROOF OF THEOREM 3.1

It is worthwhile to rewrite the market equilibrium condition using individual demand function X^D (see (4.1)) and industry demand function X^* (see (4.2)) for given q. Equilibrium conditions have two parts. First, the individual optimality condition is

$$(z - G_X)X_z^D + X^D = 0, \text{ where } X^D = X^D(z, y, Y) \text{ and } G = G(X^D, q).$$

Second, under symmetry, market equilibrium requires

$$y = z.$$

In the following, all expressions are evaluated at $z = z^m$ and $q = q^m$.

LEMMA A.1. *Under Assumptions 3.1 and 3.4, we have*

$$\frac{dSS}{dq^g} = n\left[\frac{X^D}{-X_z^D} X_z^* \frac{dz}{dq^g} - G_q\right] \\ +n\sum_{i=1}^n \frac{dW_Y}{dz_i}\frac{dz}{dq^g}\left[zX^D - G(X^D, q^g)\right]. \tag{A.1}$$

Proof. Since $SS = W + W_Y n\left(zX^D - G(X^D, q^g)\right)$ and that $X^D = -W_{z_i}/W_Y$ (see Assumption 3.1), we have, using (4.1) and (4.2),

$$\frac{dSS}{dq^g} = \sum_{i=1}^n \left[W_{z_i}\frac{dz}{dq^g}\right] + W_Y n\left[\left((z - G_X)\, X_z^D + X^D\right)\frac{dz}{dq^g} + (z - G_X)\, X_y^D \frac{dz}{dq^g} - G_q\right] \\ +n\sum_{i=1}^n\left[\frac{dW_Y}{dz}\frac{dz}{dq^g}\left(zX^D - G(X^D, q^g)\right)\right]$$

$$= W_Y n\left[-X^D\frac{dz}{dq^g} + (z - G_X)\, X_y^D\frac{dz}{dq^g} - G_q\right] + n\sum_{i=1}^n \frac{dW_Y}{dz_i}\frac{dz}{dq^g}\left[zX^D - G(X^D, q^g)\right]$$

From (4.1) we have $z - G_X = -X^D/X_z^D$. Moreover, $X_z^{D*}(z) = X_z^D(z,z) + X_y^D(z,z)$. Substituting these relations into the above expressions, and rearranging terms, we obtain Lemma 1. □

In order to prove the subsequent lemma, an alternative expression of individual optimality condition (4.1) is useful.

$$z = \eta G_X \text{ where } \eta(z, Y) = \left[1 + \frac{X^D}{z}\left(\frac{\partial X^D}{\partial z}\right)^{-1}\right]^{-1}. \tag{A.2}$$

LEMMA A.2. *Assumptions 3.3, 3.5 and 3.6 imply that an increase in the required service standard* decreases *the service-adjusted price, i.e., $dz/dq^g < 0$.*

Proof. Let us consider a shift parameter ξ in G explicitly such that $G(X, q; \xi)$. Then we have from (A.2)

$$\frac{dz}{d\xi}\left(1 - \eta_z G_X - \eta G_{XX} X_z^D\right) = \eta G_{X\xi} < 0,$$

because of Assumption 3.3. Moreover, Assumption 3.5 implies that $dz/d\xi < 0$. Consequently, we have $1 - \eta_z G_X - \eta G_{XX} X_z^D > 0$.

Next, (A.2) implies

$$\frac{dz}{dy}\left(1 - \eta_z G_X - \eta G_{XX} X_z^D\right) = \eta_y G_X + \eta G_{XX} X_y^D.$$

Assumption 3.6 implies that $0 \leq dz/dy < 1$. Therefore, from the above expression of dz/dy and $1 - \eta_z G_X - \eta G_{XX} X_z^D > 0$, we have

$$1 - \eta_z G_X - \eta G_{XX} X_z^D > \eta_y G_X + \eta G_{XX} X_y^D \geq 0. \tag{A.3}$$

Let us now consider dz/dq^g. From (A.2) and (4.2), we have

$$\frac{dz}{dq^g}\left[1 - (\eta_z + \eta_y) G_X - \eta G_{XX}\left(X_z^D + X_y^D\right)\right] = \eta G_{Xq}.$$

Since (A.3) implies the term in the bracket on the left-hand side of the above expression is negative under Assumption 3.3, we have $dz/dq^g < 0$. □

PROOF OF THEOREM 3.1 Note first that we have $dz/dq^g < 0$ from Lemma 2. Since the service-adjusted price is always higher than the marginal cost, we have $z - G_X = X^D/(-X_z^D) > 0$. Assumption 3.2 implies $X_z^* < 0$. In addition, in the no-intervention market equilibrium $G_q = 0$. Therefore, the term in the first brackets of the right-hand side of (A.1) is positive at $q^g = q^m$. Next, consider the term in the second brackets (A.1). It is non-negative since $dW_Y/dz_i \leq 0$ (Assumption 3.2), $zX - G = \Pi > 0$ and $dz/dq^g < 0$. Consequently, we have $dSS/dq^g > 0$ at $q^g = q^m$. □

A.2. PROOF OF THEOREM 4.1

LEMMA A.3. *We have the following relation between the elasticities and the optimum service standard:*

$$E(q^0) \equiv \frac{A'(q^o)}{-B'(q^o)X^*(h(q^o), Y)} = \frac{\varepsilon^*}{\varepsilon - 1} + 1. \tag{A.4}$$

Proof. Under Assumptions 4.1, 4.2, and 4.3, the socially optimal service standard is determined by

$$\frac{dSS}{dq^g} = n\left[\frac{X^D}{-X_z^D}X_z^*\frac{dz}{dq^g} - G_q\right] = 0,$$

where equation (A.1) is utilized. Therefore, q^o satisfies

$$\frac{\varepsilon^*}{\varepsilon}X^D\left(-\frac{dz}{dq^g}\right) = G_q. \tag{A.5}$$

This characterizes the optimal service standard q^o. Note that under Assumption 4.1, the mark-up rate $\eta = \left[1-\varepsilon^{-1}\right]^{-1}$ is constant. Under Assumption 4.2, we have $G_q = A' + B'X^D$, $G_{Xq} = B' < 0$, and $G_{XX} = 0$. Moreover, since $z = \eta B(q)$, we have $dz/dq^g = \left[1-\varepsilon^{-1}\right]^{-1} B' < 0$. Substituting this into (A.5) , we have

$$\frac{\varepsilon^*}{\varepsilon - 1} = \frac{A'(q^o)}{-B'(q^o)X^*} - 1,$$

where $X^D\left(z(q^0, Y), z(q^o, Y), Y\right) = X^*\left(z(q^o, Y), Y\right)$ is used. From this expression, we obtain the desired result. □

PROOF OF THEOREM 4.1 We have

$$E'(q) = \frac{A''\left[-B'X^*\right] - A'\left[(-B'')X^* + (-B')X_z^*\eta B'\right]}{\left[-B'X^*\right]^2}.$$

Note that the numerator is positive if

$$\frac{A''}{A'} - \frac{(-B'')}{-B'} - \frac{X_z^*\eta B'}{X^*} = \frac{A''}{A'} - \frac{(-B'')}{-B'} - \frac{zX_z^*}{X^*}\frac{\eta}{\eta B}B' = \frac{A''}{A'} + \frac{B''}{-B'} - \varepsilon\frac{-B'}{B} > 0.$$

Assumption 4.4 implies this is the case. Therefore, we have $E' > 0$.

Since (A.4) implies that $E(q^o) = [\varepsilon^*/(\varepsilon - 1)] + 1$, we have

$$E'\frac{dq^o}{d\varepsilon^*} = \frac{1}{\varepsilon - 1} > 0 \text{ and } E'\frac{dq^o}{d\varepsilon} = -\frac{\varepsilon^*}{(\varepsilon-1)^2} < 0.$$

Thus, we obtain THEOREM 4.1. □