The impact of market structure on the rate of transportation cost

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기업이 운송비용을 내생변수로 처리할 수 있고 산출량에 대한 한계비용이 일정하다면 장기의 경우 운송비용은 시장구조와 관계없이 동일할 수 있다는 것을 증명하였다.

I. Introduction

While the idea that products differ in quality is accepted in economic literatures, two subjects are open to considerable debate: the one is what constitutes "quality", the other is the relationship between the level of product quality and the type of market structure.

Even though there is a difficulty in defining the exact nature of quality, the product quality in economic literature is simply allowed to assume characteristics which increase or decrease the preference of consumer. This type of treatment about product quality allows the scope of product quality analysis to include not only the pure product quality but also the more general case where the aspect of quality under consideration was not restricted to pure quality. For example, waiting time or the rate of transportation cost is different from the pure quality in the sense that these factors do not give a direct effect to the utility level of product itself; however, these factors are a kind of product attributes which give a effect to the preference of consumers in choosing a product through budget constraint or opportunity cost.

Even though the nature and scope of quality is defined, there exists another difficulty. The problem is that some of characteristics are measurable but the others are not measurable on an absolute scale. When the quality is countable, the problem is simple because the more quality can be treated as the more quantity. However, there is a solution for the non-measurable case: certain market assumptions can results in an absolute scale for quality in much the same way that the
assumption that consumers are price takers results in an absolute scale for the differences between
the marginal values that consumers place on different goods.

The issue of the effect of market structure on the level of product quality is still an open
question. This paper has two purposes. First, the theory of product quality has been extended to
incorporate the general attributes of product quality. Second, we find out the conditions under which
product quality is independent of market structure. We choose the rate of transportation cost of
product as a product attribute. Hence this study is to figure out the impact of market structure on
the rate of transportation cost and the conditions under which the rate of transportation cost is
independent of market structure.

II. A general analysis of product quality model

We can consider a demand for product \( x \), with variable quality factor \( t \), where \( t \) is a kind of
attribute of the good \( x \) that is supplied simultaneously with \( x \). Let demand for \( x \) be written as

\[
x = f(P, P_y, t)
\]  \hspace{1cm} (1)

where \( P \) is the price of good \( x \), \( t \) is the quality variable, and \( P_y \) is the price of composite
commodity \( y \). This type of demand curve with quality variable can be derived in two situations. The
first is the case in which product itself contain a quality variable. Hence, a quality variable is
directly shown in utility function. The second is the case in which a quality variable is appeared at
budget constraint(not at utility function). This two cases are different each other in the
characteristic sense of quality analysis. However, these are identical in the sense that quality
variables affect the net marginal value of product, which yields the identical form of demand curve
as equation(1). For example, two identical products can not be treated equally when one of them
requires, for example, a transportation cost to obtain. On the other hands, as far as we concern only
marginal value of product, the one product yielding high utility can be equally treated as the other
product yielding low utility if we have to pay more to obtain the product yielding high quality. This
type of approach can extend the quality analysis to the various area which is similar to traditional
quality model. Now, let's show that two approach brings about an identical demand curve as
equation(1). First, we consider the first case.

Consider a product, with variable quality \( t \), where quality is attribute of the good \( x \) that is
supplied with \( x \). Let utility be a function of ordered pair \((x, t)\) such that the following utility function
is quasi-concave in \( x \) and \( y \) for every \( t \).

\[
U = U(x, y, t)
\]  \hspace{1cm} (2)

Where \( x \) is the quantity of good \( x \) consumed, \( t \) is the quality per unit of \( x \), \( y \) is a composite
commodity.
\[ M = P_x + P_y Y \]  \hfill (3)

Where the \( P \) is the price of ordered pair \((x, t)\) and \( P_y \) is the price of \( y \). From (2) and (3) demand for \( x \) can be written as equation (1).

Now, let consider the budget constraint case to show that an identical form of demand curve will appear as the first case (utility function case). Let utility be a function of \( x \) and \( y \) which is quasi-concave in \( x \) and \( y \) only.

\[ U = U(x,y) \]  \hfill (2)'

Which is identical to equation (2) without the quality variable \( t \). We assume the budget constraint

\[ M(x; t) = P_x + P_y Y \]  \hfill (3)'

Where the \( P \) is the price of good \( x \) and \( P_y \) is the price of \( y \), and \( t \) is a kind of attribute of good \( x \) which requires a certain rate of cost in obtaining a unit of good \( x \). For example, \( t \) can be a transportation cost, or waiting time. From (2) and (3)' demand for \( x \) can be also written as equation (1). As long as the value of \( t \) affects the budget constraint, which cause to change the consumer's choice set and, after all, the level of utility obtained, \( t \) can be treated as a kind of quality attribute. Hence, equation (1) can be derived form two different approaches.

It will prove useful in the following to consider the inverse demand function of equation (1)

\[ P = h(x, t, P_y) \]  \hfill (4)

Where it can be shown that \( h_x < 0 \), but \( h_t > 0 \) or \( h_t < 0 \) depending on the definition of \( t \): if \( t \) is a kind of traditional quality variable, \( h_t > 0 \), but if \( t \) is a kind of attribute with disutility factor, for example, a transportation cost or waiting time, \( h_t < 0 \).

Now consider the supply side. On the supply side assume that there are \( n \) identical firms each with cost functions that depend on the quantity of output produced and the quality of that output. Write this cost function as

\[ C = C(x, t) \]  \hfill (5)

and assume that \( C(\ ) \) is strictly convex in its argument\(^1\). Let the domain of the function \( C(\ ) \) be defined as the set of ordered pairs \((x, t)\) such that \( x \geq 0 \) and \( t \geq m \geq 0 \), so that the minimum of \( x \) is zero and the minimum quality is \( m \) which is non-negative.

Assume further that the industry in question is characterized by a form of constant cost such that each entrant has the same cost as existing firms, i.e., the function \( C(\ ) \) is independent of

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\(^1\) Here, if \( t \) is a transportation cost or waiting time, firm is assumed to try to reduce the value of \( t \) up to a certain level to increase consumer demand.
industry size. In other words, the function $C(\ )$ is independent of the amount of output of $x$ at given quality level. Thus, the entry or exit of firms will not change industry costs. The relevant costs, therefore, are those costs associated with producing output of a given quality. This type of assumption about cost function implies that each new firm entering the industry has available the same cost function as existing firms, which further implies that industry trade-off between quantity and quality is independent of industry size.

Each firm in competition takes market price as a parameter for any given quality. Competitive equilibrium for any quality implies that

$$C_x(x, t) = C(x, t)/x$$

(6)
i.e., marginal cost equals average cost. Industry total cost is

$$C = nC(x^*, t)$$

(7)
Where $C(x^*)$ is the level of firm total cost and $x^*$ is the level of output when (6) holds. But since no economies or diseconomies of scale exist at the industry level. Industry total cost is homogeneous of degree one in $n$ which also implies that industry total cost is homogeneous of degree one in industry output $X = nx$.

For any given level of quality long run industry average cost is constant as long as freedom of entry is assumed. In fact the constant level of industry average cost depends only on the level of quality, $t$. From (6) and (7)

$$LIAC = \frac{C^*(X, t)}{X} + nC(x^*, t)/n x^* = C(x^*, t)/x^* = L(t)$$

(8)
Where LIAC is long run industry average cost. Because of the constant cost assumption we made, changes in quality, $t$ alter the entire structure of costs.\(^2\) Form (8) and the convexity of costs it follows that $L^{' > 0}$ and $L^{' > 0}$ (or $L^{' < 0}$ and $L^{' < 0}$, if $t$ is a kind of waiting time or transportation cost). In this study, we assume that $t$ represents a kind of transportation cost, and $t$ is a decision variable of firm itself.

**III. Industry equilibrium**

Since the monopolist is the entire industry, comparison of equilibrium conditions for the monopoly firm versus the competitive firm will not yield meaningful differences between the two polar forms

\(^2\) For example, an increase in quality simply shifts upward(downward) the cost function for each firm if $C^t > 0 (C^t < 0)$. Note that if $t$ is a kind of waiting time or transportation cost, $C^t < 0$. 

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of market organization. We should, therefore, compare monopoly equilibrium to the equilibrium of the competitive industry.

i) Competition

As we have pointed out in the discussion of supply, long run average cost for any given quality is constant with freedom of entry when each firm can enter with the same costs as existing firms, which forms the basis for the definition of constant cost when quality is variable. In competitive equilibrium price must equal long run average cost for any given quality. In particular, for that quality that is optimal in equilibrium, industry price will equal the long run average cost associated with optimal quality.

Using this condition long run equilibrium price can be written as a funtion of quality.

\[ P = L(t) \]  \hspace{1cm} (9)

Given increasing marginal cost for quality, \( t \), the price quality relation implied by (9) will be convex to the horizontal axis. This equilibrium is the supply side price-quality frontier and is depicted in Figure 1, as the schedule SS. Since constant costs are assumed for any given quality, the schedule SS is independent of industry output and depends only on quality.

Aggregating across consumers yields the market inverse demand function

\[ P = H(X, t, P_y) \]  \hspace{1cm} (10)

From this inverse demand function the output constant price-quality relation can be derived. This schedule is negatively sloped since \( H_t < 0 \). In addition these schedules are concave to the horizontal if diminishing returns to quality is assumed.

In Figure 1, we have drawn a set of iso-quantity demanded price-quality schedules DiDi. Each of these iso-demand schedules is consistent with a fixed level of quantity demanded and the higher the DiDi schedule from the horizontal the lower the quantity demanded. Competitive equilibrium occurs at point \( E_c \) where the marginal value of quality for consumers is equal to the marginal cost of quality for the industry. Any lower schedule lies below the price-quality fronties SS and hence is unobtainable. Any higher iso-demand schedule would imply that price could be reduced with no change in quality and hence utility was not being maximized.

ii) monopoly

For the monopolist the assumption of constant costs implies that the long run cost function is

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3) Since we consider the case in which \( t \) represents the attribute yielding disutility, for example, the rate of transportation cost, \( L' (t) < 0 \). That is, the high value of \( t \) implies a lower quality, which implies the negative slope of schedule SS.
homogeneous of degree one in output for any given quality. This result follows since the monopolist can add plants each of which will have the cost function of a competitive firm. Cost minimization for the monopolist then implies that each plant will be operated where marginal cost equals average cost, i.e., at the competitive firm’s equilibrium output, for any given quality.

Profit maximization for the monopolist requires that marginal revenue equal long run marginal cost which, because of constant cost, equals long run average cost for any given quality. In particular, for the quality that is optimal, marginal revenue, MR, will equal the long run industry average cost associated with optimal quality so that MR=L(t). It follows then that the relation between marginal revenue and quality that is imposed by the cost conditions facing the monopolist is exactly the schedule SS, in Figure 1, since L(t) is independent of market organization.

From the definition of total revenue it follows that

\[ TR = XH(X, t, P, t) \] (11)

so that marginal revenue is

\[ MR = P + X H_X \] (12)

For any given output a locus of points of marginal revenue and quality can be derived that satisfy (12). The slope of these loci are

\[ \frac{\partial MR}{\partial t} = H_t + H_{Xt} \] (13)

Which must be negative if the market is stable. Stability also requires that the monopoly iso-demand loci be decreasing at a higher rate than cost determined locus SS, i.e.,
\[ \frac{\partial^2 MR}{\partial t^2} L''(t) \]  

(14)

The monopoly iso-demand schedules are shown in Figure 1 as schedules MiMi. For purposes of clarity we have drawn these loci concave to horizontal axis. The profit maximization point for the monopoly firm is point \( E_m \) in Figure 1. At this point the monopolist's marginal cost of quality is equal to the marginal revenue from additional quality. Furthermore, monopoly equilibrium requires that the marginal revenue of output equal the marginal cost of output. The first condition (quality condition) requires that the slope of the iso-demand schedule with respect to quality equal the slope of the long run average cost curve with respect to quality. The second condition (output condition) requires that marginal revenue equal long run average cost. Both of these conditions can only be simultaneously satisfied at point \( E_m \).

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**IV. Market organization and the rate of transportation cost as a quality variable**

As shown in Figure 1 monopoly and competition will produce goods of the different quality whenever the slopes of the demand price-quality and marginal revenue-quality contours are not the same at their respective equilibrium output for any given quality. This result is true whenever \( H_{Xi} \) is not equal to zero: the reason is that if \( H_{Xi} \) is equal to zero, \( \partial MR/\partial t \) is \( H_t \) from equation (13), which is identical to the slopes of the demand price-quality from equation (10). Hence, as long as \( H_x \) is independent of the value of \( t \), monopoly and competition will produce goods of the same quality. \( H_x \) is the money value of marginal utility of \( x \), which implies that \( H_m \) is equal to zero if the quality attribute \( t \) is not contained in the utility function. This means that monopoly and competition will produce goods of the same quality whenever the variable \( t \) is in the budget constraint instead of being contained on the utility function.

A characteristic common to many products is that their acquisition requires freight cost (transportation cost). Whatever the type of freight cost is, freight cost is reflected on the budget.
constraint through the full price of product. Hence the rate of transportation cost is independent of market structure when variable t is taken as decision variable by the firms which sell the product the spatially dispersed market.

V. Conclusion

This paper has treated the determination of optimal quality of product as a special case of the theory of joint supply and demand. For purposes of analysis, it was assumed that industries exhibit constant cost. In fact, a particular form of constant costs for jointly supplied goods was assumed. Specifically, any firm that enters the industry can have the same cost function as existing firms. But that cost function does not exhibit constant costs of both quantity and quality. Rather, I have assumed that the industry cost function exhibits constant cost for any given quality but that such cost functions exhibit increasing cost of quality.

The constant costs assumption implies that the supply frontier between quality and price or marginal revenue is independent of output. Thus both monopoly and competition have the same supply quality frontier, on the demand side monopoly and competition clearly differ. But are these differences critical for the quality decision? To answer this question, the trade-off schedules for competition(between price and quality) and monopoly(between marginal revenue and quality) was constructed. Then, because of the common supply condition, any differences in equilibrium quality are the result of differences in the effect of quality on price and marginal revenue.

Based on these demand side conditions, I showed that monopoly and competition charge the identical rate of freight cost(transportation cost) when firms choose the rate of transportion cost as decision variable of product quality.

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