Perfect Competition and Quality Variation

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I. Introduction

Underlying the discussion of the concept of quality in the existing literature is the implicit reasoning that introducing a quality variable violates a crucial assumption of the competitive model – the assumption of "parametric pricing." Consequently, the monopolistic, the monopolistically competitive or the oligopolistic models are usually utilized to analyze the quality-related issues. This situation is evidenced by the line of researchers analyzing the level of quality offerings under different market structures[1] as well as under different regulatory constraints.[2] In a few exceptional cases dealing with product quality in a competitive framework, the structures of models are incomplete and the readers are left with a feeling of disjointedness.[3] This paper is intended to correct the dominance of the

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1) See, for instance, a survey of the literature done by Schmalensee [1979], and also Dixit [1979] and Lancaster [1980].

2) See Stigler [1968a], White [1972], Rosse [1972], Douglas and Miller III [1974], Spence [1975], Sheshinski [1976] and Vander Weide and Zalkind [1981].

3) Some of the works cited in footnote 2 also discuss competitive models as well as monopolistic models. However, in any case, the so-called competitive models are simply ad hoc amendments to monopolistic models and/or have incomplete structures. See, for instance, White [1972], Rosse [1972], Pazner [1974] and Spence [1976]. Closest to the current effort is the recent contribution by Leffler [1982]. While some of his conclusions turn out to be similar to the ones discussed later in this paper, among others, his way of deriving a market equilibrium based on the maximization of the sum of consumers and producers surpluses (by some omnipotent planner) is different from the one taken here. Most importantly, missing in his model are the analysis of individual firm

noncompetitive approach to the quality-related issues.

In Section II, a full-fledged competitive model of quality variation in the context of a variable quality product is developed. It is shown that upon introduction of product quality variable, the firm and industry equilibria cannot be logically separated as in the standard competitive industry model. It turns out that an industry equilibrium is underdetermined and consequently, individual firms play a very significant role in structuring the industry equilibrium. The only role given to the industry is to generate a possible relationship between quality and price, which, in turn, is perceived as a market-determined constraint by the profit maximizing firms. As a result, quality level is determined as a firm's choice variable, simultaneously with a firm's output decision. The market equilibrium price, through the perceived quality-price relationship, and industry output are determined given the quality level chosen by individual firms. In this framework, product differentiation among firms in a given industry is not allowed, assuming that there exist no natural or legal barriers to perfect imitation. Conseqently, competition among a large number of identical firms effectively establishes a single equilibrium level of variable quality. "One" is a virtue of competition, not a symptom of monopoly.

Section III discusses some interesting comparative statics exercises. Since the framework provides for a complete and endogenous specification of the perceived quality-price relationship, the comparative statics exercises can be easily performed without the ad hoc and arbitrary assumptions on the shape of the relationship which often are made in the literature. The results have shown that a demand increase or a costreducing technology is not always quality-improving. Effect of entry barrier on quality turns out to be ambiguous.

The concluding remarks appear in Section IV.

II. Product Quality and Perfect Competition

It is assumed that all characteristics embodied in a commodity can be represented by a single scalar measure q, which will be subsequently

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equilibrium and the treatment of entry or exit. It is also observed that Hashimoto [1982] relies on a model similar to the Leffler's one in analyzing the effects of minimum wage on the amount of on-the-job-training offered. Leland [1977] also discusses quality choice in a general equilibrium context, treating the number of firms fixed but addresses a rather different set of issues than those considered in this paper. In terms of a methodology taken, the current approach is close to Rosen [1974], while he discusses a differentiated product which is different from a variable-quality product assumed in this paper.

called "quality level."[4] Hence, q is assumed to be an increasing function of and to be suitably indexed according to the embodied characteristics. The term "quality" is to be interpreted in a generic sense, such that quality is exclusively associated with characteristics which are costly to and variable by the firm, and are valued in one way or another by consumers.

For consistency with the standard competitive model, both product differentiation among firms and quality differentiation within a firm are not allowed, while product quality can be varied. Thus, along with the standard competitive assumptions of perfect information and atomistic, identical firms, we introduce the following assumption: there exist no natural or legal barriers to perfect imitation.[5] In addition, we will assume that a given firm will choose only one quality level for its product out of the large feasible set of all different quality levels; thereby, quality differentiation within a firm is not allowed. Underlying this assumption is the plausible *a priori* assumption that market and/or technological conditions prevent the profitable production of more than one quality level, without reducing the feasible set to just one. Hence, any new developments in market and/or technological conditions may alter the profitability perception, resulting in a new quality product being produced. With these assumptions, one may reason that effective competition among firms will establish a single equilibrium level of quality in a variable-quality product market.

In addition, the concept of perfect knowledge is somewhat broadly interpreted such that individual firms also know the market demand parameters. This assumption will serve for an experiment adopted in this framework.

1. A Conceptual Experiment and the Perceived Price Function

Suppose a competitive firm's profit function can be represented as follows:

4) Some limitations of this assumption were discussed by Schmalensee [1979]. The main problem is that this assumption has somewhat limited applicability. Here, I make this assumption only for convenience of model presentation, noting that its relaxation does not affect the substance of conclusions. However, it is worthwhile to mention two different approaches that deal with quality. The first one, the Lancasterian approach, breaks down the community into its embodied characteristics which are the main substance analyzed rather than the commodity itself. The second approach parameterizes the quality level as the argument which enters the utility and cost functions. In this case, the commodity is preserved as the main analytical substance (see Houthakker [1952], Fisher and Shell [1975] and Sheshinski [1976]). The former fits better in the household production framework. In this study the latter perspective is adopted.

5) The violation of this assumption will imply a negatively sloped demand curve for an individual firm and hence the monopolistically competitive firms. See Demsetz [1982] for this point.

$$\Pi = p \cdot x - c(x, q; \alpha) \tag{1}$$

where p is unit revenue, q is quality level and x is physical quantity. $c(x, q; \alpha)$ is total cost, derived from cost minimization subject to a production function constraint relating x, q and factors of production. The parameter, α reflects the underlying variables in the cost minimization problem, namely, the production function parameters and factor prices. It is assumed that c is convex with $c(o,q) = O$ and c_x, c_q and $c_{qx} > O$.

Introducing quality in the cost function also requires taking account of its effect on the revenue side. In this framework, the main deviation from the classical competitive firm will turn out to consist of recognizing the dependence of revenue as well as cost on product quality level. The oligopolistic and monopolistic models usually identify this dependence of revenue on quality level through incorporating a market sharing demand curve and a market demand curve (or their inverses), respectively. However, in this competitive framework, a different conceptual experiment is adopted. The dependence of revenue on quality level is assumed to be perceived as a result of individual firms' extensive information search in the relevent product market.

A hypothetical question faced by an individual firm contemplating the introduction of a new variety is how much it can gain or lose from varying the level of quality. Given the situation in which all the other firms have an equal access to the same technology and market condition, the answer to this question can only be obtained by looking at the possible change in the market equilibrium configuration, especially in the market equilibrium price, resulting from quality variation made by all firms in the industry including the firm, itself. The logic behind this is as follows. Any event perceived to be favorable to this firm should also be regarded equally favorable to all the other firms under the given assumption. Therefore, it will be reasonable to conjecture that any individual firm contemplating quality variation must consider that the same action is also available to its rivals. Hence, individual firms will perceive that the dependence of revenue on quality level is substantiated by the competitive movement of all firms in the same direction. Now, the relevant question becomes how the market equilibrium configuration will change due to a unit change in quality level. Given the information on cost and demand parameters, individual firms can easily solve this problem. Notice that underlying this experiment is an important assumption that the best source of information on the profitability of the new variety is the *observed product market*. There may exist (conceptually or in actuality) a quality (characteristics) market. However, it is assumed that to obtain information from the latter market is more costly.

Here, I claim that, as a result of this experiment, ***unit revenue***, **p is given** by some positive function of quality level which is perceived to be determined by a ***market equilibrium*** in the product market and can be called as the perceived price function for the quality embodied per unit of physical quantity. Furthermore, the price function is independent of quantity. Furthermore, the price function is independent of quantity supply x, and so, is consistent with the spirit of competitiveness (i.e., "parametric pricing"). The individual firm is a price taker in the sense that only if it maintains the existing quality level can it sell any amount of physical quantity at the prevailing market price. When this firm alters the quality level it supplies, new market demand and supply curves for the changed quality product become relevant and a new market price will be determind on the basis of the newly established quality level. Hence, the observed market price is perceived as if it were dependent only on the quality level supplied.

A clarification of the assertion that the perceived price function is determined by a market equilibrium is now in order. As suggested earlier, this industry is assumed to consist of the large number of identical firms supplying a single variable quality product. In addition, consumers are assumed to be identical and take as a parameter the quality level supplied in the market.

The market demand for the product, X^D can be represented as:

$$X^D = \phi\ (p,q;\beta) \tag{2}$$

where β is the demand shift parameter, and $\phi_q > 0$ and $\phi_p < 0$ are assumed, recognizing that quality improvement will always raise the consumer's utility level.[6] Also, the usual negatively sloping demand curve is still preserved here. The exact location of this demand curve in quantity-price plane will be determined by the quality level supplied in the market.

Viewing this industry as a representative firm, the quantity supply decision will be made based on the equality of price and marginal cost. To derive an industry marginal cost function, first, notice that an industry cost can be seen as a sum of all individual firm's costs.

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6) In the current context, a necessary and sufficient condition for $\phi_q > 0$ is a diminishing marginal rate of substitution of the variable quality good for the aggregate of traditional market goods with respect to quality improvement. Suppose identical consumers have a utility function as follows:

$$u = U(y,x:q) \tag{a}$$

where x and q are variable quality good and its quality level, respectively, and y is an aggregate expenditure on traditional market goods. Given the suitably defined budget constraint, a utility maximization will imply the following comparative statics result,

$$\frac{dx}{dq}\Big|_{dp^x=0} = \frac{p^y(U_{xq} \cdot p^y - U_{yq} \cdot p^x)}{D} \tag{b}$$

$$C = n \cdot c\,(X/n, q; \alpha) = C(X, q; n, \alpha) \tag{3}$$

where C denotes an industry cost, n is the number of firms in this industry and X is the industry output which is the sum of individual firm's outputs. The functions, $c(\cdot)$ and $C(\cdot)$ denote the individual firm's cost curve which is the same as the one in equation (1) and the industry cost curve, respectively. From this formulation, one can easily show that $C_X = c_x$, $C_{XX} = c_{xx} / n$, $C_{XXX} = c_{xxx} / n^2$, $C_q = nc_q$ and $C_{qX} = c_{qx}$ in which n is treated as a parameter and the subscripts denote partial derivatives. A marginal condition, the equality of price and marginal cost, can now be written as follows:

$$p = C_X\,(X, q; b, \alpha) \tag{4}$$

which is the condition to force this industry to behave competitively. Notice, also that equation (4) describes the inverse industry supply curve corresponding to the quality level.

Now, an industry equilibrium will be determined by adding the market clearing condition to conditions (2) and (4). This equilibrium can be expressed by the following system of equations:

$$X^D = \phi(p, q; \beta) \tag{2}$$

$$p = C_X\,(X, q; n, \alpha) \tag{4}$$

$$X = X^D \tag{5}$$

where equation (5) is the market clearing condition. This three-equation system can be reduced to the following two-equation system:

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where D is the determinant of bordered Hessian being positive as a second-order condition, and p^x and p^y are prices for x and y, respectively. To get a positive sign of this expression (b), hence of o_q, the numerator should be positive, which, in turn, implies the following condition:

$$d\,(-\frac{dx}{dy})/dq < 0. \tag{c}$$

However, in the context of the simple repackaging type of quality variation in which the characteristic defined as $q \cdot x$ directly enters a utility function, the condition for $\phi_q > 0$ is an elastic demand for the characteristic with respect to its price defined as p^x/q, which is also implied by the condition (c). Researchers following this formulation have been critical of assuming $\phi_q > 0$. See Murphy [1980]. Leffler [1982], being also critical of quality being parameterized in demand function, specifies a utility function such that priced and unpriced attributes enter separately the utility function, thereby implying consumers' preference depends on market environment. See also Leland [1977] for a more general specification in the context of characteristics approach. In a stricter sense, this issue may not be much relevant here. A more important and general requirement for the current framework is to ensure a positive quality level. As long as this condition is ensured to be satisfied, it does not matter what specification of consumer preference is adopted. If the demand specification in the text is adopted, $\phi_q > 0$ is a sufficient but not necessary condition for the positive quality level (as will be seen later in equations (9) and (12)).

$$p = C_X \ (X, q; n, \alpha) \tag{4}$$

$$X = \phi \ (p, q; \beta). \tag{6}$$

Note that this system is different, in a very important respect, from the usual formulation. Here we have two equations with three unknowns, p, X and q treating n as a parameter.[7] Hence, the industry equilibrium is underdetermined and can be defined only up to a given quality level. Conceptually, this result simply reaffirms that the usual textbook exposition of a competitive industry equilibrium is void of quality variable. Notice, however, that the current approach begins from the very recognition of this underdeterminacy.

To further characterize the nature of this underdeterminacy and the experiment adopted here, I will introduce a definition and related remarks.

Defination 1. *Market equilibrium locus.* Suppose that there exists a continuum of potential (or historical) market equilibria depending on the relevant quality levels supplied. Then, a locus of those market equilibrium points exists in X - p plane and is defined as a market equilibrium locus. In Figure 1, the dotted line is a possible market equilibrium locus.

Remarks. The underdetermined system of equations (4) and (6) can define only a market equilibrium locus. The experiment adopted in this framework hypothesizes that individual firms choose a single point along this locus. Therefore, what individual firms search for is information on the shape of this locus. The feasibility of the experiment is guaranteed by the fact that, given the assumption that individual firms have perfect knowledge (or can gather information) about cost and demand functions, a single equilibrium point observed in the relevant product market is sufficient to identify the whole locus. To retrieve a specific relationship between unit revenue and quality level from this locus is simply to derive a reduced form equation for the price from the system of equation (4) and (6). One may also realize that this conceptual experiment is similar in spirit to the one usually assumed in Rational Expectations literature [see Muth (1961)].

Using equations (4) and (6), we can here derive reduced form equations for price and quantity in terms of equality. Substituting equation (6) in

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7) At this point, one may be tempted to apply a freeentry condition (or zero-profit condition) to nail down the number of firms, n. However, the imposition of this condition is logically premature since a well and correctly specified profit function is yet to be defined. Notice that the profit function (1) given earlier is not fully defined. Hence, until the correctly specified profit function is defined and the long-run equilibrium condition can be introduced, the number of firms will be treated as a parameter. Notice, however, that the number of firms is not a firm's choice variable in any cases.

place of X in equation (4) we have $p = C_X(\phi(p,q;\beta), q;n,\alpha)$, which can be solved for price. This reduced form of price in terms of quality is, here, defined as the parceived price function for the quality level embodied per unit of physical quantity and can be written as follows:

$$p = p(q; n, \alpha, \beta) \tag{7}$$

As claimed earlier, this perceived price function defined here does not depend on the individual firm's physical quantity supplied and therefore, is consistent with a parametric pricing. Any firms, incumbent or intending to enter this product market, will implicitly observe this price function and should take account of this relationship in making their optimization decisions on quality and quantity supplied.

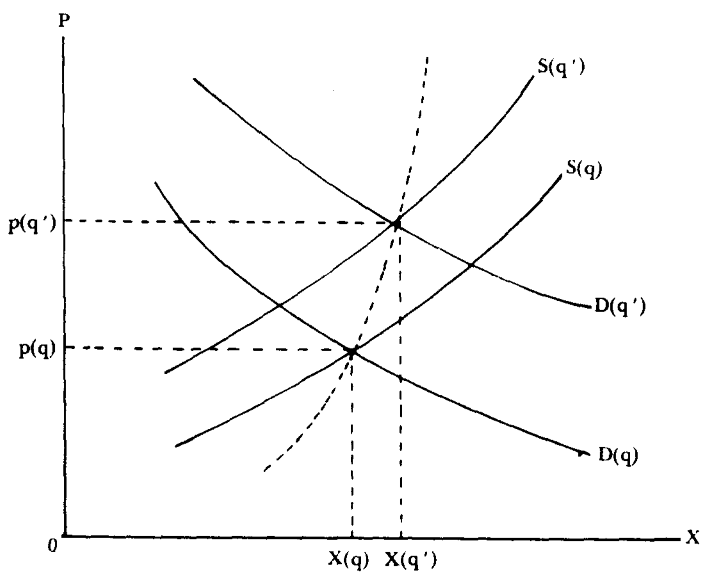
On the other hand, substituting equation (4) for p in equation (6), we have $X = \phi(C_X(X,q;n,\alpha), q;\beta)$ which can be solved for X as follows:

$$X = h(q; n, \alpha, \beta) \tag{8}$$

which determines the industry size in terms of the quality level supplied and the number of firms.

Differentiating equations (4) and (6) with respect to q and solving for $\frac{dp}{dq}$ and $\frac{dX}{dq}$, (i.e., applying the implicit function theorem to the system of equations (4) and (6), we can derive the slopes of equations (7) and (8):

[Figure 1] A Market Equilibrium Locus (q' > q)



$$\frac{dp}{dq} \equiv p_q = \frac{\phi_q C_{XX} + C_{Xq}}{1-\phi_q C_{XX}} > 0 \tag{9}$$

$$\frac{dX}{dq} \equiv h_q = \frac{\phi_q + \phi_p C_{Xq}}{1-\phi_q C_{XX}} \gtrless 0 \tag{10}$$

The slope of the perceived price function, p_q will be determined by the demand and supply parameters evaluated at the chosen quality levels and is always positive with the assumed properties of the demand and cost functions. this result confirms the earlier claim that unit revenue is a positive function of quality level. A positive value of h_q implies that industry size is an increasing function of quality, and vice versa. Note further that all the relevant parameters of the perceived price function can also be easily derivable by utilizing the implicit function theorem.

Remarks. Notice that all the relevant parameters of the perceived price and industry size functions depend on the shape of the market equilibrium locus. The positivity of p_q is implied by the fact that the equilibrium point moves upwardly along the locus with quality improvement. Also, a positively (negatively) sloping locus implies $h_q > 0$ ($h_q < 0$). In addition, the effects of entry on the price and industry size, namely, p_n and h_n can be easily derivable, and $p_n < 0$ and $h_n > 0$ as shown in the next section. Intuition is that, for any given quality level, more firms will imply an outward shift of the supply curve and so the lower price and increased quantity supplied. In this case, the market equilibrium locus also shifts outwardly. However, the signs of the second derivatives of these functions cannot be easily determined as shown later.

2. An Equilibrium and the Optimal Choice of Quality Level

With the well-defined perceived price function in hand, one can now fully specify a firm's profit function. An individual firm can be visualized to maximize profit given by equation (1) subject to the perceived price function, equation (7). In this framework, the price function plays a role similar to the production function constraint in the cost minimization problem. Putting it another way, this firm can choose the price it charges for the product supplied, but only to the extent that it satisfies the market constraint, namely, the market determined perceived price function, which is analogous to the output decision being subject to production technology in the cost minimization problem.

Now the new profit function can be constructed, through the direct substitution of equation (7) into equation (1), as follows:

$$\Pi = p(q; n, \alpha, \beta)x - c(x, q; \alpha). \tag{11}$$

The first- and second-order conditions for profit maximization are:

$$p(q) - c_x(x, q) = 0 \tag{12}$$

$$x\, p_q - c_q(x, q) = 0 \tag{13}$$

and

$$c_{xx},\ c_{qq} - x \cdot p_{qq},\ c_{xx}(c_{qq} - xp_{qq}) - (p_q - c_{xq})^2 > 0 \tag{14}$$

where the subscripts denote the partial derivatives and the parameters, n, a and B are temporarily suppressed. Equation (12) implies a classical result that the firm will produce output up to the point where unit revenue is equal to marginal cost of physical quantity, given the optimally chosen quality level. Equation (13) indicates that the firm will supply the quality level such that the compensation for quality improvement is just equal to the marginal cost of quality supplied per unit of physical quantity.

This system of equations (12) and (13) will describe an individual firm's short-run equilibrium with a given number of firms, n. With the chosen optimal levels of quantity, x and quality, q, the equilibrium price will be determined from the perceived price function (7). For the equilibrium industry output, one can utilize the relationship, $X = n \cdot x$ or the industry-size equation (8) which, however, is not independent from the condition (12).[8]

However, we do not really take the number of firms as given. The competitive industry is characterized by unrestricted free entry in the long run. So, there is an entry condition as follows

$$\Pi = 0 \tag{15}$$

where Π is given by equation (11). The condition (15) will help determine the number of firms in the industry which has been treated as a parameter. Hence, the long-run equilibrium will be described by the system of equations (12), (13) and (15). We have three equations with three unknowns, x, q and n. Given x, q and n, the price will be determined from the equation (7) and the industry output is obtained from $X = n \cdot x$ or the equation (8). One possible solution state is depicted in Figures 2a through 2c, where superscript "*" denotes equilibrium value. Figure 2a, related to equation (12) explains quantity determination given p^* or q^* and n^* in the x-p

8) Notice that this dependence of equation (8) on the condition (12) is not confined only to the short-run context. Given the relationship, $X = n \cdot x$, the industry-size equation (8) will be automatically reduced to the condition (12), or vice versa. This can be readily seen by realizing that the derivation of equation (8) is same as substituting $x = X$ for x in condition (12) and solving for X.

plane. Figure 2b related to equations (7) and (13), explains quality and price determination simultaneously, given x* and n*. Figure 2c depicts the industry equilibrium.

III. Comparative Statics Properties

1. A General Result

This section presents some comparative statics results of the model and is meant to show a general applicability to a wide variety of problems.

Explicitly incorporating the shift parameters in the long-run equilibrium system, we will have:

[Figure 2] Illustration of a Full Equilibrium

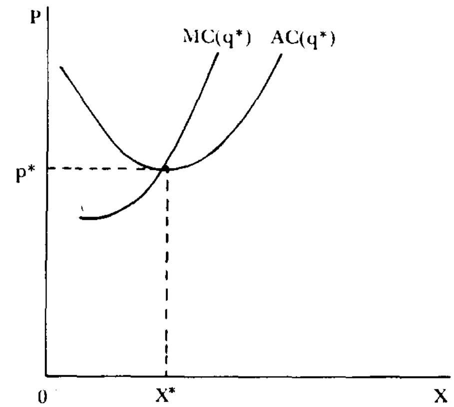


Figure 2a
Firm Equilibrium

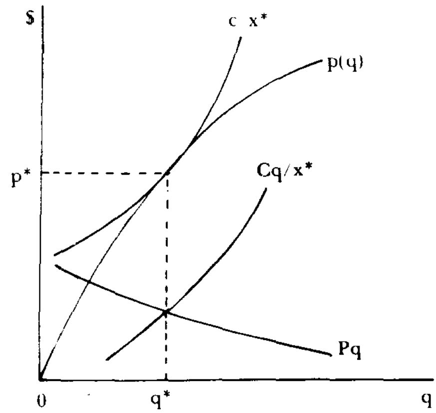


Figure 2b
Quality Provision

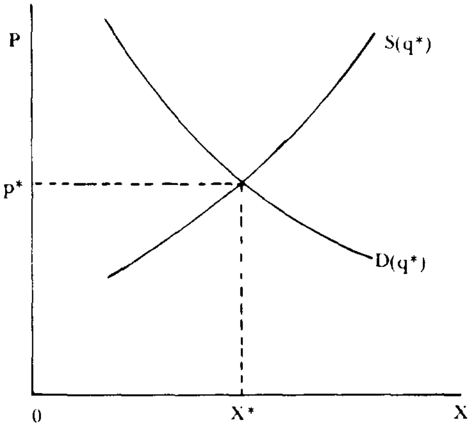


Figure 2c
Industry Equilibrium

$$p\,(q;n,\alpha,\beta)-c_x\,(x,q;\alpha)=0 \tag{12}$$

$$xp_q\,(q;n,\alpha,\beta)-c_q\,(x,q;\alpha)=0 \tag{13}$$

$$p\,(q;n,\alpha,\beta)\,x-c(x,q;\alpha)=0\,. \tag{15}$$

One may add equation (7) to this system to determine the equilibrium price. However, to avoid the complexity, we will work with this three-equation symtem. To be general, we will adopt the letter δ as representing relevant parameters α and β in this system. The results of the specific exercises with respect to α and β will be automatically obtained by replacing δ in the general results by α and β, respectively.

Differentiating the above system with respect to δ, we obtain the following system of equations:

$$\begin{bmatrix} -c_{xx} & p_q-c_{xq} & p_n \\ p_q-c_{xq} & xp_{qq}-c_{qq} & xp_{qn} \\ 0 & 0 & xp_n \end{bmatrix}\begin{bmatrix} dx/d\delta \\ dq/d\delta \\ dn/d\delta \end{bmatrix}=\begin{bmatrix} c_{x\delta}-p_\delta \\ c_{q\delta}-xp_{q\delta} \\ c_\delta-xp_\delta \end{bmatrix} \tag{16}$$

Solutions for this system can be obtained as follows:

$$\frac{dx}{d\delta}=[(c_\delta-xp_\delta)\{xp_{qn}(p_q-c_{xq})-p_n(xp_{qq}-c_{qq})\}+$$
$$xp_n\{(c_{x\delta}-p_\delta)(xp_{qq}-c_{qq})-(p_q-c_{xq})(c_{q\delta}-xp_{q\delta})\}]/xp_n(\Delta) \tag{17}$$

$$\frac{dq}{d\delta}=\{(xp_\delta-c_\delta)(-xc_{xx}\,p_{qn}-p_n\,(p_q-c_{xq})\}+$$
$$xp_n\{c_{xx}\,(xp_{q\delta}-c_{q\delta})+(p_q-c_{xq})(p_\delta-c_{x\delta})\}]/xp_n\,(\Delta) \tag{18}$$

$$\frac{dn}{d\delta}=\frac{c_\delta-xp_\delta}{xp_n} \tag{19}$$

where $\Delta=-c_{xx}(-c_{qq}+xp_{qq})-(p_q-c_{xq})^2>0$ and $xp_{qq}-c_{qq}<0$ as long as the second-order conditions are satisfied. To evaluate the signs of these solutions, the relevant parameters of the perceived price function, p_q p_{qq}, p_n, p_{qn} p_δ and $p_{q\delta}$ should be known in advance, while p_q is already derived in equation (9). Notice, also, that these parameters describe the impact effects on the level and the slope of the price function. At this point, one may realize that an important virtue of this framework is to help derive *endogenously* all the relevant parameters of the perceived price function, which is the necessary requirement for the well-defined comparative statics exercise.

The most important underlying reasoning in this framework is that any changes in the market equilibrium configuration will be perceived by the individual firms through the effects on the perceived price function. Hence, in deriving the relevant price function parameters, we will make use of the market equilibrium conditions, equations (4) and (6), to which the implicit function theorem will be applied. We will reproduce these conditions for convenience.

$$p = C_X\,(X, q; n, \alpha) \tag{4}$$

$$X = \phi\,(p, q; \beta) \tag{6}$$

where, as before, the letter δ will also be adopted to represent the parameters α and β.

Differentiating these equations with respect to the relevant parameter δ, holding n and quality level (q) constant and solving for $\left.\frac{dp}{d\delta}\right|_{\substack{dq=0\\dn=0}}$ and $\left.\frac{dX}{d\delta}\right|_{\substack{dq=0\\dn=0}}$ we have:

$$\left.\frac{dp}{d\delta}\right|_{\substack{dq=0\\dn=0}} \equiv p_\delta = \frac{\phi_\delta\, C_{XX} + C_{X\delta}}{1-\phi_p\, C_{XX}} \tag{20}$$

$$\left.\frac{dX}{d\delta}\right|_{\substack{dq=0\\dn=0}} \equiv h_\delta = \frac{\phi_\delta + C_{X\delta}}{1-\phi_p\, C_{XX}} \tag{21}$$

On the other hand, differentiating equations (4) and (6) twice, first with respect to q holding all parameters and n constant and second with respect to δ holding q and n constant, we have after some manipulations:

$$\left.\frac{d^2 p}{dq d\delta}\right|_{dn=0} \equiv p_{q\delta}$$

$$= [C_{XXX}\cdot h_q \cdot h_\delta + C_{XX}(\phi_{q\delta} + \phi_{qp}\cdot p_\delta + \phi_{pp}\cdot p_q \cdot p_\delta + \phi_{p\delta}\, p_q) + C_{XqX}\cdot h_\delta + C_{XX\delta}\cdot h_q + C_{Xq\delta}\,]/(1-\phi_p \cdot C_{XX}). \tag{22}$$

$$\left.\frac{d^2 X}{dq d\delta}\right|_{dn=0} \equiv h_{q\delta} =$$

$$[\phi_p\cdot C_{XXX}\cdot h_q \cdot h_\delta + (\phi_{q\delta} + \phi_{qp}\cdot p_\delta + \phi_{pp}\cdot p_q\cdot p_\delta + \phi_{p\delta}\cdot p_q) + \phi_p\cdot C_{XqX}\cdot h_\delta + \phi_p\cdot C_{XX\delta}\cdot h_q + \phi_p\cdot C_{Xq\delta}\,]/(1-\phi_p C_{XX}). \tag{23}$$

Equations (20) and (22) amount to the impact effects of changes in a parameter on the level and the slope of the price function, respectively. Equations (21) and (23) give the impact effects on the industry size. Signs of p_δ and h_δ can be easily determined but the determination of the signs $P_{q\delta}$ and $h_{q\delta}$ requires some information on the higher order derivatives of the cost and demand functions.

Concerning p_n, p_{qn} and p_{qq}, notice that, in the system of equations (4) and (6), n and q are actually treated as parameters and so, the results of equations (20) to (23) can also be taken as a general formula for these values. Setting $\delta = n$ in these results and realizing some derivatives will vanish, we will have (and ignore h_{qn}):

$$p_n = \frac{C_{Xn}}{1-\phi_p C_{XX}} = \frac{-x(C_{XX})}{1-\phi_p C_{XX}} < 0 \tag{24}$$

$$h_n = \frac{\phi_p C_{Xn}}{1-\phi_p C_{XX}} = \frac{-x\phi_p (C_{XX})}{1-\phi_p C_{XX}} > 0 \tag{25}$$

$$\begin{aligned} p_{qn} = [&C_{XXX} \cdot h_q \cdot h_n + C_{XX} \cdot \phi_{pp} \cdot p_q \cdot p_n + C_{XX} \cdot \phi_{qp} \cdot p_n + \\ &C_{XqX} \cdot h_n + C_{XXn} \cdot h_q + C_{Xqn}] \,/\, (1-\phi_p C_{XX}). \end{aligned} \tag{26}$$

where the second equalities is equations (24) and (25) hold by virtue of the definition of the industry cost curve, equation (3) in the previous section.[9] Setting this time $\delta = q$ in equation (22), we will have:

$$\begin{aligned} p_{qq} = [&C_{XXX} \cdot h_q^2 + C_{XX} (\phi_{qq} + 2\phi_{pq} \cdot p_q + \phi_{pp} \cdot p_q^2) + \\ &2h_q \cdot C_{XqX} + C_{Xqq}] /(1-\phi_p C_{XX}). \end{aligned} \tag{27}$$

Now, substituting the values of p_q, p_{qq}, p_n, p_{qn} p_δ and $p_{q\delta}$ obtained from equations (10), (27), (24), (26), (20) and (22), respectively into equations (17), (18) and (19), we can complete our comparative statics exercises. In general, it seems difficult to sign unambiguously this comparative statics results including the values of p_{qq}, p_{qn} and $p_{q\delta}$, while p_q, p_n and p_δ can be relatively eassily signed. This issue will be dealt with the depth in the following section.

In addition, effects on the price and industry output can be expressed, respectvely, as follows:

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9) From equaiton (3), $C_X = c_x (X/n, q)$. Therefore, $C_{Xn} = -x(c_{xx})/n = -x\, C_{XX}$.

$$\frac{dp}{d\delta} = p_q \frac{dq}{d\delta} + p_n \frac{dn}{d\delta} + p_\delta \tag{28}$$

$$\frac{dX}{d\delta} = h_q \frac{dq}{d\delta} + h_n \frac{dn}{d\delta} + h_\delta \text{ or } x \frac{dn}{d\delta} + n \frac{dx}{d\delta} \tag{29}$$

2. Specific Examples Examined

Three specific examples will be considered as the specific comparative statics exercises. First and second ones are concerned with the changes in demand and cost conditions, respectively. In the third example, and effects of entry barrier will be discussed. To facilitate the discussion, we will state a definition and related remarks.

Definition 2. *Output-enhancing-quality versus output-decreasing-quality markets.* As output-enhancing-quality (output-decreasing-quality) market is the market which is characterized by a positively (negatively) sloping market equilibrium locus. The case assumed in Figure 1 is an output-enhancing-quality market.

Remarks. In an output-enhancing-quality market, the following is true: $|\phi_q/\phi_p| > p_q > c_{xq}$ and $h_q > 0$. In an output-decreasing-quality market the converse is true: $|\phi_q/\phi_p| < p_q < c_{xq}$ and $h_q < 0$.

To prove these, realize that one can deduce the following relationship from equation (9), through some manipulation,

$$p_q = |\phi_q/\phi_p| \left[\frac{C_{XX} + C_{Xq}/\phi_q}{C_{XX} - 1/\phi_p}\right] \tag{9-1}$$

This implies that $p_q \lessgtr |\phi_q/\phi_p|$ if $|\phi_q/\phi_p|$. Furthermore, equation (9) also produces the following relationship,

$$p_q = C_{Xq} \left[\frac{1 + (\phi_q/C_{Xq})C_{XX}}{1 - \phi_p C_{XX}}\right. \tag{9-2}$$

which suggests that $p_q \lessgtr C_{Xq}$ if $|\phi_q/\phi_p| \lessgtr C_{Xq}$. Hence, collectively, either $|\phi_q/\phi_p| > P_q > C_{Xq}$ or $|\phi_q/\phi_p| < p_q < C_{Xq}$ must hold. In addition, equation (10) produces the following relationship,

$$h_q = \frac{-\phi_p \left[\left|\frac{\phi_q}{\phi_p}\right| - C_{Xq}\right]}{1 - \phi_p C_{XX}} \tag{10-1}$$

which suggests that $h_q \lesseqgtr 0$ if $|\phi_q/\phi_p| \lesseqgtr C_{Xq}$. Therefore, $|\phi_q/\phi_p| > p_q > C_{Xq}$ ($|\phi_q/\phi_p| < p_q < C_{Xq}$) implies $h_q > 0$ ($h_q < 0$) which, by definition, holds only in an output-enhancing-quality (output-decreasing-quality) market. Note further that $C_{Xq} = c_{xq}$ by virtue of equation (3) in the previous section.

Remarks. Now with this information, one can further characterize these two markets. Intuitively, a higher value of $|\phi_q/\phi_p|$ implies that demand is highly sensitive to quality, relative to price. On the other hand, a lower value of c_{xq} means an efficient firm. Hence, one can imagine that quality-sensitive consumers and efficient firms will tend to make an output-enhancing-quality market, while, in an output-decreasing-quality market, quality-insensitive consumers and inefficient firms will tend to get together.

To simplify the discussions further, linear supply and demand curves will be adopted. Specifically, the cost function takes the following form.

$$c = Ax^2 + Bq^2 + Dqx \tag{30}$$

where A, B and D are parameters and positive. For the demand curve, we assume the following form.

$$X^D = -ap + bq + dpq \tag{31}$$

where a, b and d are positive parameters and $-a + dq < 0$ is assumed.[10] With these assumed curves, one can easily show p_{qn} and p_{qq} reduce to the following expressions:

$$\begin{aligned} p_{qn} &= [C_{XX}(\phi_{qp}\cdot p_n) + C_{XXn}\cdot h_q + C_{Xqn}]/(1-\phi_p C_{XX}) \\ &= [C_{XX}(\phi_{qp}\cdot p_n) - (C_{XX}/n)\cdot h_q]/[1-\phi_p C_{XX}) \end{aligned} \tag{26-1}$$

$$p_{qq} = [2C_{XX}(\phi_{qp}\cdot p_q)]/(1-\phi_p C_{XX}) > 0 \tag{27-1}$$

where the second equality in equation (26-1) hold by virtue of equation (3). One may realize that $p_{qn} < 0$ in an output-enhancing-quality market.

Case 1. Demand increase specific only to quality.

Consider a case in which demand parameter, β acts only on quality. In terms of the demand curve, we will assume $b = b(\beta)$ and $b_\beta > 0$ and so $\phi_{p\beta} = 0, \phi_{q\beta} > 0$ and $\phi\beta > 0$. From equations (20) and (22), one can easily show that $p_\beta > 0$ and $p_{q\beta} > 0$ in this case. The comparative statics results

10) With these demand and cost curves, $\phi_{pp} = \phi_{qq} = 0$ and $c_{xxx} = c_{xxq} = c_{qqx} = 0$ and hence $C_{XXX} = C_{XXq} = C_{qqX} = 0$.

11) From equation (3), $C_{Xq} = c_{xq}(X/n, q)$ and $C_{XX} = c_{xx}(X/n, q)/n$. Hence, $C_{Xqn} = -x(c_{xqx}/n) = 0$ and $C_{XXn} = [-xc_{xxx} - c_{xx}]/n^2 = -C_{XX}/n$.

with parameter, β can also be obtained by setting $\delta = \beta$ in equations (17), (18) and (19).

$$\frac{dx}{d\beta} = [x^2 (p_q - c_{xq})(p_n p_{q\beta} - p_\beta p_{qn})]/xp_n(\Delta) \tag{17-1}$$

$$\frac{dq}{d\beta} = [x^2 c_{xx} (p_n p_{q\beta} - p_\beta p_{qn})]/xp_n(\Delta) \tag{18-1}$$

$$\frac{dn}{d\beta} = (-p_\beta)/p_n > 0 \tag{19-1}$$

where the sign of $\frac{dq}{d\beta}$ depends on the sign of $(p_n p_{q\beta} - p_\beta P_{qn})$ which is ambiguous with $p_n < 0$, $p_{qn} \leq 0$, $p_\beta > 0$ and $p_{q\beta} > 0$. The sign of $\frac{dX}{d\beta}$ and $\frac{dq}{d\beta}$ are ambiguous, in general.

In an output-enhancing-quality market both of quality and firm's output may increase or decrease. However, in an output-decreasing-quality market with $p_{qn} > 0$ assumed, quality increases but firm's output decreases. In general, it is possible that both of quality and firm's output reduce after demand increases. Also, the effects on the industry output and price turn out to be ambiguous while, in any case, more firms enter the market.[12)]

Case 2. Technological change specific only to quality.

We will consider the case in which technological innovation occurs only on quality production. This case amounts to assume $B = B(\alpha)$ and $B_\alpha < 0$ in terms of the cost function introduced earlier and so $c_{x\alpha} = 0$, $c_\alpha < 0$ and $c_{q\alpha} < 0$. In this case, it turns out that $p_\alpha = 0$ and $p_{q\alpha} = 0$. Setting $\delta = \alpha$ in equations (17), (18) and (19), the results will be:

$$\frac{dx}{d\alpha} = [-c_\alpha \cdot p_n (xp_{qq} - c_{qq}) + x(p_q - c_{xq})(c_\alpha \cdot p_{qn} - p_n \cdot c_{q\alpha})]/\Delta \tag{17-2}$$

$$\frac{dq}{d\alpha} = [c_\alpha \cdot p_n (p_q - c_{xq}) + xc_{xx} (c_\alpha \cdot p_{qn} - p_n c_{q\alpha})]/\Delta \tag{18-2}$$

$$\frac{dn}{d\alpha} = (c_\alpha / x \cdot p_n) > 0 \tag{19-2}$$

where, in general, the signs of $\frac{dq}{d\alpha}$ and $\frac{dX}{d\alpha}$ are ambiguous.

12) Effects on the industry output and price are expressed as follows:

$$\frac{dX}{d\beta} = X\frac{dn}{d\beta} + n\frac{dx}{d\beta} = (+) + (+) \text{ or } (-).$$

$$\frac{dp}{d\beta} = p_q\frac{dq}{d\beta} + p_n\frac{dn}{d\beta} + p_\beta = (+) \text{ or } (-) + (-) + (+).$$

In an output-enhancing-quality market, both of firms output and quality can increase or decrease, while, in an output-decreasing-quality market with $P_{qn} > 0$ assumed, quality level decreases but firm's output increases after cost-reducing technology is introduced. In any case, more firms will enter this market but the effects on the industry output and price are ambiguous.

Case 3. Effects of entry barrier.[13]

Economists are accustomed to think of entry barrier as leading to an oligopolistic industry structure. Hence, effects of entry barrier have usually been analyzed in relation to specific collusion hypothesis. Instead of following this tradition, we will assume a special case of entry barrier in which the initial competitive nature of rivalry remains intact even with entry barrier and the initial assumption of no barrier to perfect imitation is maintained. Therefore, the market is the one in which the number of firms are still large enogh, even after entry barrier imposed, to negate any oligopolistic collusion and an individual firm still faces a horizontal demand curve.[14]

To discuss effects of entry barrier, a zero-profit condition (equation (15)) should be dropped and hence we will work with the system of equations (12) and (13) only. Treating n as a parameter, and performing a comparative statics exercise with respect to n, we have:

$$\frac{dx}{dn} = [-p_n\ (xp_{qq} - c_{qq}) + xp_{qn}\ (p_q - c_{xq})]\ /\Delta \tag{32}$$

$$\frac{dq}{dn} = (xc_{xx}\ p_{qn} + p_n\ (p_q - c_{xq}))\ /\Delta. \tag{33}$$

In general, it is not clear whether entry barrier will lead to more quality competition and hence to higher quality level.

To make some specific statements, we will adopt the same cost and demand curves introduced earlier. In an output-enhancing-quality market, all of quality, price and firm's output increase after entry barrier is imposed, while effect on the industry output is ambiguous. However, in an output-decreasing-quality market with $p_{qn} > 0$ assumed, an entry barrier

13) Entry or exit has not been adequately dealt with in literatures similar in spirit to the current framework. Either the number of firms is assumed to be given (Leland [1977] and Leffler [1982]) or treated in an ad hoc manner (Rosen [1974]). Therefore, effects of entry barrier cannot be systematically analyzed in those frameworks.

14) An example of this type of market may be the banking market with rate regulations lifted off but entry barrier still imposed.

brings forth a lower quality level, while the effects on firm's output, price and industry output are ambiguous.

IV. Concluding Remarks

It is shown that the model developed in Section 2 can be easily applicable to a wide variety of quality-related issue, in explaining the effects on the relevant choice variables, especially on the quality level, of various events experienced by firms. The main difficulty in determining the direction of the relevant effects turns out to stem from the fact that a single event may shift both the price and cost functions, and change the slope of the price function simultaneously. However, even in ambiguous cases, the framework allows one to sufficiently nail down the range of ambiguity, or some simplifying assumptions will be enough to help determine the direction of adjustments.

I will conclude this paper by discussing some unresolved issues.

Consider first an issue of short-run versus long-run versus long-run variation in quality level. It seems that the classical approach implicitly assumes the concept of quality is associated only with some long-run factors such as technological innovation. However, it is also plausible to define the concept of quality as broadly as possible including even advertising expenditures which might increase consumer's utility. Note also that "quality" itself might be nothing more than the consumer's perception, and firms can simply replace plain parts with ornate ones. However, having said this and incorporated the quality variation also into the short-run context impose one penalty blurring the very distinction between two runs.

Here, I will attempt to describe one possible scenario on this issue. Suppose that the products are initially introduced as various "models." Then, product quality changes can be made in two alternative ways: the quality content (or characteristics) of a given product model specification can be varied or the model specification itself can be changed. For the former case, one can say that a new "variety" of a given model has been introduced. Note that, in this case, it is quite possible to have more than one variety under a single model specification. Also, if two different models embody the same quality level, they may be said to be of the same variety.[15] The distinction between long-run and short-run analysis can be made by assuming that the quality change per se occurring through variety change is costless but that there exists some production specificity in model

15) See Triplette [1971] for similar discussions.

specification. Variety change can be made, for example, by simply replacing expensive parts with cheap parts, but new models can only be introduced with different techniques, altering the model specification. Suppose, further, that the model change is the relatively more efficient way to change the product quality than the variety change, in terms of quality production efficiency. In the short run, the cost of model change will be perceived as prohibitive due to its specificity even if this is the most efficient way to change quality. Hence, the natural alternative to change quality is through variety changes. However, in the long run, this specificity can be easily overcome through the entry of new models into this industry and quality variation will be made through model changes. Therefore, under these assumptions, the short run can then be described as a situation in which quality variation can only be introduced through variety changes. In the long run, quality change will result from model changes (e.g., the proliferation of new brands through entry into this industry).

Consider now an issues of a variable-quality product versus differentiated products market. As already seen in the analysis on the industry level, this model suggests a variable-quality product market rather than differentiated products market. The basic approach taken here, an inference of the price and quality relationship from the market equilibrium concept, is the same as the approach taken is the hedonic price literature, while it can be reasoned that the envelope function, an interpretation given to the implicit price function derived from market clearing conditions in the differentiated products market,[16] will be collapsed to a single point in the context of a variable-quality product market. Hence, the perceived price function defined here is invoking the idea that there exists an infinite set of potential equilibria rather than actual equilibria, depending on the quality levels supplied, and hence a potential market equilibrium locus. Concerning the applicability of this model to the differentiated products market, one can reason that if a differentiated products market, one can reason that if a differentiated products market breaks down into well-defined segments with low cross-elasticity of demand between different quality products, for example, economy cars and luxury cars, then this model may be applicable to this market. In this context, the

16) The hedonic price function in the context of Rosen's competitive approach to the differentiated products market has the property of a joint envelope function of a family of demand price functions and another family of supply price functions. See Lucas [1975] and Rose [1974]. However, one should notice that Rosen's reasoning that the implicit price function is independent of individual firm's quantity supplied is shown to be unclear by Lucas [1975].

following observation might be taken as reasons supporting the analysis doen here. First, the theoretical analysis of the differentiated products market exhibit natural tendencies toward market segmentation.[17] Second, on the very primitive level of analysis of the hedonic price function, the assumption of a simple repackaging case is the same as implicitly assuming market segmentation.[18] Finally, the empirical studies of hedonic prices generally support the market segmentation hypothesis in that the pooled regression over the whole market gives F-statistics[19] which are too low.

An alternative approach to the price-quality relationship is the treatment of price as a signal of product quality under imperfect information.[20] This notion may be helpful in further characterizing the perceived price function. The following conjectures are made on intuitive grounds without any rigorous proof. The consumer's poor information on quality will result in a higher price, other things being equal. Hence, the perceived price function will shift down but the slope will get steeper with better information. An intuitive reason for this is that better information will reduce the consumer's search costs and, at the same time, make consumers more responsive to the given quality change.

In conclusion a theoretical framework can be sufficiently simplified to yield many interesting and refutable implications, while its usefulness can only be judged by the validity of its predictions. Most deviations from the competitive framework in dealing with quality-related issues seem to stem from the mistaken demand for correspondence between reality and assumptions. In this context, the following quotation, taken from Stigler [1968b], may be revealing.

"Should monopoly or competition be used to analyze the New York housing market? The answer is: both. If we are interested in the effects of rent ceilings and inflation, the theory of competition provides informative predictions. If we are interested in why one location rents for more than another, the theory of monopoly may be an informative guide. Different theories, each with its particular assumptions, can be applied to the same phenomena to answer different question." (p. 320)

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17) See Rosen [1974] and Deaton and Muellbauer [1981].
18) See Deaton and Muellbauer [1981].
19) See Griliches [1971] and Deaton and Muellbauer [1981].
20) See Klein and Leffler [1981], Nelson [1970], Scitovsky [1944] and Wolinsky [1983].

REFERENCES

1. Barzel, Y., "An Alternative Approach to the Analysis of Taxation." *Journal of Political Economy*, vol. 84. 6, 1976
2. Deaton, A., and J. Muellbauer., *Economics and Consumer Behavior*, Cambridge University Press, New York, 1981, Chapter 10.
3. Demsetz, H., "Barriers to Entry," *American Economic Review*, March, 1982, pp. 47-50.
4. Dixit, A., "Quality and Quantity Competition," *Review of Economic Studies* October 1979.
5. Douglas, G. W., and J. C. Miller III., "Quality Competitin, Industry Equilibrium, and Efficiency in the Price Constrained Airline Market," *American Economic Review*, September 1974, pp. 657-69.
6. Fisher, F. M., and K. Shell., *The Economic Theory of Price Indices: Two Essays on the Effects of Taste, Quality, and Technological Change*, Academic Press, New York, 1972.
7. Gabor A., and C. W. J. Granger., "Prices as an Indicator of Quality: Report on an Enquiry," *Economica* February, 1966, pp. 43-70.
8. Griliches, Z. ed., *Price Indexes and Quality Change: Studies in New York Methods of Measurement*, Cambridge: Harvard University Press, 1971.
9. Hashimoto, M., "Minimum Wage Effects on Training on the Job," *AER*, December 1982, pp. 1070-87.
10. Houthakker, H. S., "Compensated Changes in Quantities and Qualities Consumed," *Review of Economic Studies*, #3, 19, 1952, pp. 155-64.
11. Jwa, Sung H., *Towards an Equilibrium Approach to the Effects of Price Controls: A Theoretical and Empirical Analysis of the Effects of Price Controls on Quality Offerings*, unpublished dissertation, Department of Economics, UCLA, 1983.
12. ________, "Quality Variation Under Price Controls," Working paper, Financial Studies Section, Federal Reserve Bank of Minneapolis and to be presented at the SEA meeting in Atlanta, Georgia in November 1984.
13. Klein, B. and K. B. Leffler, "The Role of Market Forces in Assuring Contractual Performance," *Journal of Political Economy*, August 1981, pp. 615-41.
14. Lancaster, K., "A New Approach to Consumer Theory," *Journal of Political Economy*, April 1966, pp. 132-57.
15. ________, "Competition and Product Variety," *Journal of Business*, vol. 53, #3 Pt. 2, 1980.
16. Leffler, K. B., "Ambiguous Changes in Product Quality," *AER*, December 1982, pp. 956-67.
17. Leland, H. E., "Quality Choice and Competition," *American Economic Review*, vol. 67, No. 2, March 1977, pp. 127-37.
18. Lucas, R. E. B., "Hedonic Price Functions," *Economic Inquiry*, vol. June 1975, pp. 157-58.
19. ________, "Hedonic Wage Equations and Psychic Wages in the Return to Schooling," *American Economic Review*, June 1977, pp. 549-58.
20. Murphy, M. M., "Quality and Consumer Demand," *The American Economist*, vol. 24, No. 1, Spring, 1980, pp. 42-45.
21. Muth, J. F., "Rational Expectations and the Theory of Price Movements," *Econometrica*, vol. 29, #6, 1961, pp. 315-35.
22. Nelson, P., "Information and Consumer Behavior," *Journal of Political Economy*, March-April 1970, pp. 311-29.
23. Pazner, E., "Quality Choice and Monopoly Regulation," in Richard Caves and Marc Roberts, eds., *Regulating the Product*, Ballinger Cambridge, 1975.
24. Rosse, J. N., "Product Quality and Regulatory Constraint," Memorandum No. 137, Research Center in Economic Growth, Standford University, 1972.

25. Rosen, S., "Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition," *Journal of Political Economy*, vol. 82, #1, 1974, pp. 34-55.

26. Schmalensee, R., "Market Structure, Durability, and Quality: A Selective Survey," *Economic Inquiry*, vol. 17, April 1979.

27. Scitovsky, T., "Some Consequences of the Habit of Judging Quality by Price," *Review of Economics and Statistics*, vol. 12, 1944, pp. 100-05.

28. Sheshinski, E., "Price, Quality and Quantity Regulation in Monopoly Situations," *Economica*, vol. 43, No. 2, 1976, pp. 127-37.

29. Spence, M. A., "Monopoly, Quality, and Regulation," *Bell Journal of Economics*, vol. 6, #2, Autumn 1975, pp. 417-29.

30. Stigler, G. J., "Price and Nonprice Competition," in G. J. Stigler ed., *The Organization of Industry*, Richard D. Irwin, Inc., Illinois, 1968a.

31. ________, "Monopolistic Competiton in Retrospect," in G. J. Stigler ed., *op cit*, 1968b.

32. Triplett, J. E., "Quality Bias in Price Indexes and New Methods of Quality Measurement," in Z. Griliches ed., 1971.

33. Vander Weide, J. H. and J. H. Zalkind, "Deregulation and Oligopolistic Price-Quality Rivalry," *American Economic Review*, March 1981, pp. 144-54.

34. White, L. J., "Quality Variation When Prices are Regulated," *Bell Journal of Economics*, Autumn 1972, pp. 425-36.

35. ________, "Price Regulation and Quality Rivalry in a Profit-Maximizing Model: The Case of Bank Branching," *JMCB*, February 1976, pp. 97-106.

36. Wolinsky, A., "Price as Signals of Product Quality," *Review of Economic Studies*, No. 163, 1983, pp. 647-658.