

Amacher, Gregory S.; Koskela, Erkki; Ollikainen, Markku

Working Paper

Quality competition and social welfare in markets with partial coverage: New results

ETLA Discussion Papers, No. 851

Provided in Cooperation with:

The Research Institute of the Finnish Economy (ETLA), Helsinki

Suggested Citation: Amacher, Gregory S.; Koskela, Erkki; Ollikainen, Markku (2003) : Quality competition and social welfare in markets with partial coverage: New results, ETLA Discussion Papers, No. 851, The Research Institute of the Finnish Economy (ETLA), Helsinki

This Version is available at:

<https://hdl.handle.net/10419/63696>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.

Keskusteluaiheita – Discussion papers

No. 851

Gregory S. Amacher* – Erkki Koskela**

Markku Ollikainen***

QUALITY COMPETITION AND SOCIAL WELFARE

IN MARKETS WITH PARTIAL COVERAGE:

NEW RESULTS

* Department of Forestry, Virginia Commonwealth University, and College of Natural Resources, Virginia Tech, Blacksburg, VA 24061 USA,

** Department of Economics, P.O. Box 54, FIN-00014 University of Helsinki, Finland

*** Department of Economics and Management, P.O. Box 27, FIN-00014 University of Helsinki, Finland.

E-mails: gamacher@vt.edu, erkki.koskela@helsinki.fi, markku.ollikainen@helsinki.fi.

We would like to thank Professor Luca Lambertini for useful discussions, and Ph.D. Chiara Lombardini-Riipinen for computational help and comments. Koskela thanks Department of Forestry of Virginia Tech and Research Department of the Bank of Finland for their hospitality. This paper is a part of the project "Studies in Environment and Resource Economics" financed by the Academy of Finland.

AMACHER, Gregory S. – KOSKELA, Erkki – OLLIKAINEN, Markku, QUALITY COMPETITION AND SOCIAL WELFARE IN MARKETS WITH PARTIAL COVERAGE: NEW RESULTS. Helsinki: ETLA, Elinkeinoelämän Tutkimuslaitos, The Research Institute of the Finnish Economy, 2003, 15 p. (Keskusteluaiheita, Discussion Papers, ISSN, 0781-6847; no. 851).

ABSTRACT: We use a vertical product differentiation model under partial market coverage to study the social welfare optimum and duopoly equilibrium when convex costs of quality provision are either fixed or variable in terms of production. We show that, under fixed costs, at the social welfare optimum only one quality variant of the good is provided, while both variants are optimal under variable costs. In the duopoly equilibrium the quality spread is too wide under variable costs, but too narrow under fixed costs, relative to the social optimum. Finally, in both the fixed and variable cost cases, average quality provided by the duopoly equilibrium is too low from the perspective of a social welfare maximizer.

Keywords: Product Differentiation, Partial Market Coverage, Social Welfare

JEL Classification: L13, D60

1 Introduction

A well-established result in vertical product differentiation models is that a duopoly consisting of high and low quality firms leads to product quality dispersion that is too high and average levels of quality that are too low, relative to the socially optimal outcome (see Crampes and Hollander 1995). This result has been established under the assumption that markets are fully covered, i.e., that all consumers purchase positive quantities of the good in question. A consequence of full market coverage is that, even though duopoly qualities differ from the socially optimal ones, the quantities produced by the firms are always equivalent.

The case of a partially covered duopoly is more appealing, in that it allows for some consumers who do not purchase from either firm but could potentially enter the market. In this case, if the duopoly and socially optimal outcomes differ, then not only the qualities but also the quantities differ. In the voluminous literature on partial market coverage, the social welfare outcome has mainly remained an open issue.

Our work fills an important gap in this literature. We characterize the properties of socially optimal qualities and solve for the divergence between duopoly and social outcomes when a market is partially covered. Unlike other work, we analyze and compare both cases of fixed and variable costs of production.¹ For variable costs we characterize the social optimum in the same way that Crampes and Hollander (1995) do for the fully covered market case. Ecchia et al. (2002) have argued that, under fixed costs, it is optimal to provide just one quality level. However, they do not study the problem of socially optimal price setting, nor do they show how the fixed cost case may differ from the variable cost case. Motta (1993) allows for both variable and fixed costs with partial market coverage but does not explicitly solve for the socially optimal outcome. Instead he uses numerical illustrations to compare consumer surpluses in the different equilibria.

Like most existing product differentiation models, we assume consumers derive utility from observed quality of products. Indeed, we retain this assumption because we seek to provide closure on the modeling of one class of product differentiation models

¹ Under the assumption of fixed costs, Ronnen (1991) considers minimum quality standards without analyzing the socially optimal quality provision. Lambertini (1996), in turn, considers the variable cost case but does not examine the socially optimal outcome.

under the assumption of partial market coverage. Also like other work, our duopoly outcome is solved as the subgame perfect equilibrium of a two-stage game. Firms maximize profits by first competing in qualities and then competing in prices.

Our characterization of the socially optimal outcome provides several new findings. Unlike in the duopoly equilibrium, it is socially optimal in the fixed cost case to provide only the high quality variant of a good, while the profit maximizing duopoly provides two variants. Moreover, provision of the socially optimal quality level is higher than the high quality variant provided by the market and, therefore, average quality provided by the market is lower than the socially optimal average quality. The social planner in this case is free to charge either a zero or positive price, and to service either some or all of the consumers in the market.

Under the assumption of variable costs the high quality firm in a duopoly will have higher profits but lower market share than the low quality firm. As a new result we show that the spread of product quality observed under a profit maximizing duopoly is too high relative to the socially optimal outcome. At the socially optimal outcome, both firms produce the same amounts, and total output is greater than with the duopoly outcome.

At the social optimum the major difference between fixed and variable cost cases is that, under fixed costs, only one product variant is provided, while both variants are optimal under variable costs. In duopoly equilibrium the quality spread is too wide under variable costs, while it is too narrow under fixed costs. Average product quality in both cases is too low compared to the socially optimal equilibrium.

We proceed as follows. Section 2 presents a basic duopoly model and the profit maximizing solution with partial market coverage for both fixed and variable costs of production. In Section 3 we compare the socially optimal and profit-maximizing qualities. Finally, we provide a brief conclusion.

2 A Duopoly Model of Vertical Product Differentiation with Partial Market Coverage

Under an assumption of partial market coverage, each consumer is typically assumed to purchase either one unit of the good or nothing. Let a consumer have a utility function u (see Tirole 1988, pp 96-97, 296-298),

$$u = \theta s_k - p_k, \quad (1)$$

where s_k and p_k are the quality and price of the k th good.² In (1), θ represents the consumer's taste parameter, so that the consumer derives a surplus equal to $\theta s_k - p_k$ from a good of quality s_k and price p_k . Assume there are two possible qualities of goods produced by two types of firms, $k = H$ (high quality) and $k = L$ (low quality). A standard assumption is that the consumers' taste parameters are uniformly distributed over qualities on a definite interval, $\theta \in [\underline{\theta}, \bar{\theta}]$ (see e.g. Motta 1993, or Cremer and Thisse 1999).

We assume that the high and low quality firms have quadratic and convex cost functions for providing quality,

$$c_k(s_k) = \frac{1}{2} b s_k^2 \quad \text{for } k = H, L. \quad (2)$$

Because consumers can purchase either one unit or nothing, the consumer who is indifferent between high and low quality goods has a threshold taste parameter defined by

$$\hat{\theta} = \frac{p_H - p_L}{s_H - s_L}. \quad \text{Under partial market coverage, some consumers do not enter the market.}$$

More specifically, the lowest marginal willingness to pay value can be defined for the consumer who is indifferent between buying and *not buying* the good, i.e., $\theta^c = \frac{p_L}{s_L}$.

Recalling the uniform distribution of consumer types, the demands for high and low quality

² Throughout the paper, derivatives of functions with one argument will be denoted by primes, while partial derivatives will be denoted by subscripts of functions with many arguments.

products then become $q_H = \bar{\theta} - \hat{\theta}$ and $q_L = \hat{\theta} - \theta^c$, where q_H and q_L are the number of consumers purchasing from the low and high quality firm, respectively.

Based on the above assumptions, we will focus on cases where the costs of providing quality are either fixed or variable with respect to output. The assumption of fixed costs has been widely applied in the literature. Kuhn (2000) recently argued that the variable cost case might be more appealing than the fixed cost case, because it avoids an implausible feature of fixed costs. This is that the high quality firm has both higher profits and a larger market share in equilibrium.³ In conformity with observations from practice, our variable cost case results in an equilibrium where the profits of the high quality firm are higher than those of the low quality firm. However, the market share of the high quality firm is lower than the low quality firm.

2.1 Price and Quality Games: Fixed costs

The analysis of duopoly competition under fixed costs of production was originally provided by Ronnen (1991). In what follows we develop the features of his model very briefly. When the cost of quality provision is fixed in terms of quantity produced, then given the demands q_k and the cost function in (2), the profit functions of the high and low quality firm are:

$$\pi_k = p_k q_k - c_k(s_k), \text{ for } k = H, L. \quad (3)$$

There are then two stages of the duopoly game: quality provision (stage 1), and price competition conditional on quality provided (stage 2). Firms move simultaneously in each stage.⁴ We can solve for the subgame perfect equilibrium of this game. This equilibrium relies, as usual, on commitment by firms in terms of quality. In the second stage, firms choose prices given the costs of quality production. From the first-order conditions, $\partial \pi^H / \partial p_H = 0$ and $\partial \pi^L / \partial p_L = 0$, we can solve for the optimal prices and their difference as follows,

³ This result was originally discovered by Lehmann-Grube (1997). He also showed that it holds irrespective of whether the firms choose their qualities simultaneously or sequentially.

$$p_H^* = \frac{2s_H(s_H - s_L)\bar{\theta}}{4s_H - s_L}; \quad p_L^* = \frac{s_L(s_H - s_L)\bar{\theta}}{4s_H - s_L}; \quad p_H^* - p_L^* = \frac{(2s_H - s_L)(s_H - s_L)\bar{\theta}}{4s_H - s_L} \quad (4)$$

Thus, duopoly prices depend on the quality differences and the upper bound of the consumer taste distribution. The lower bound of the taste distribution does not matter here, because in partially covered markets the lowest critical value of marginal willingness to pay is endogenous.

Inserting the above prices into the respective profit functions yields the indirect profit functions for each firm's choice of quality,

$$\pi_H^* = \frac{4s_H^2(s_H - s_L)\bar{\theta}^2}{(-4s_H + s_L)^2} - \frac{1}{2}bs_H^2; \quad \pi_L^* = \frac{s_H(s_H - s_L)s_L\bar{\theta}^2}{(-4s_H + s_L)^2} - \frac{1}{2}bs_L^2. \quad (5)$$

Differentiating equations in (5) with respect to qualities gives,

$$\frac{\partial \pi_H}{\partial s_H} = \frac{32\bar{\theta}^2 s_H^2 (s_H - s_L)}{(-4s_H + s_L)^3} + \frac{4\bar{\theta}^2 s_H^2 + 8\bar{\theta}^2 s_H (s_H - s_L)}{(-4s_H + s_L)^2} - bs_H = 0 \quad (6a)$$

$$\frac{\partial \pi_L}{\partial s_L} = \frac{2\bar{\theta}^2 s_H s_L (s_H - s_L)}{(-4s_H + s_L)^3} + \frac{\bar{\theta}^2 s_H (s_H - s_L) - \bar{\theta}^2 s_H s_L}{(-4s_H + s_L)^2} - bs_L = 0 \quad (6b)$$

Solving these first-order conditions for high and low quality and their difference with *Mathematica* yields,

$$s_H^* = \frac{0.253311\bar{\theta}^2}{b}; \quad s_L^* = \frac{0.0482383\bar{\theta}^2}{b}; \quad s_H^* - s_L^* = \frac{0.2050727\bar{\theta}^2}{b}. \quad (7)$$

Thus, the equilibrium duopoly qualities and the quality difference between firms depend positively on the square of the upper bound of taste distribution, $\bar{\theta}^2$, and negatively on the marginal cost parameter of quality provision b .

⁴ In fact, Lambertini (1996) has shown that the simultaneous move game is the only pure strategy equilibrium possible for a partial market coverage model with variable costs of producing quality.

Using these optimal qualities, we can now solve for the prices and demands of both quality variants as a function of exogenous parameters: $p_H^* = \frac{0.107662\bar{\theta}^3}{b}$; $p_L^* = \frac{0.010251\bar{\theta}^3}{b}$; $q_H^* = 0.524994\bar{\theta}$; $q_L^* = 0.262497\bar{\theta}$. The overall demand, which indicates the resulting coverage in the market, is therefore given by $q_H^* + q_L^* = 0.787491\bar{\theta}$. If we now normalize $\bar{\theta} = 1$ (and $\underline{\theta} = 0$), then we can conclude that about 79% of consumers enter the market and buy one of the two quality variants. Because the high quality firm charges a higher price and faces a larger demand, it has higher profits and greater market share than the low quality firm. This can also be seen from the profit solutions for high and low quality firms, $\pi_H = \frac{0.0244386\bar{\theta}^4}{b}$ and $\pi_L = \frac{0.00152741\bar{\theta}^4}{b}$. As we shall see, this result must be modified for the case of variable costs of production.

2.2 Price and Quality Games: Variable costs

Next we assume the costs of providing quality are variable in terms of output. Under this assumption, and given the demands q_k and the cost function in (2), the profit functions for each firm are written,

$$\pi_k = [p_k - c_k(s_k)]q_k, \text{ for } k = H, L. \quad (8)$$

As before, in the second stage firms choose prices given the costs of quality production. From the first-order conditions, $\partial\pi^H/\partial p_H = 0$ and $\partial\pi^L/\partial p_L = 0$, we can solve for optimal prices,

$$p_H^* = \frac{[2\bar{\theta}s_H(s_H - s_L) + bs_H(s_H^2 + (1/2)s_L^2)]}{4s_H - s_L} \quad (9a)$$

$$p_L^* = \frac{[\bar{\theta}s_L(s_H - s_L) + bs_H((1/2)s_H^2 + s_L^2)]}{4s_H - s_L}. \quad (9b)$$

$$p_H^* - p_L^* = \frac{\bar{\theta}(2s_H - s_L)(s_H - s_L) + (1/2)bs_H(s_H^2 - s_L^2)}{4s_H - s_L} \quad (9c)$$

Again, duopoly prices and their difference depend on quality differences and on the upper bound of the consumer taste distribution.

Substituting these optimal prices into the profit functions, we can express indirect profits in terms of quality as,

$$\pi_H^* = \frac{s_H^2 (s_H - s_L) [-4\bar{\theta} + b(2s_H^2 + s_L^2)]}{4(-4s_H^2 + s_L^2)^2} \quad (10a)$$

$$\pi_L^* = \frac{s_L s_H (s_H - s_L) [2\bar{\theta} + b(s_H - s_L)^2]}{4(-4s_H^2 + s_L^2)^2}. \quad (10b)$$

Optimal second stage qualities then follow from the first-order conditions,

$$\frac{\partial \pi_H^*}{\partial s_H} = 0 \Leftrightarrow \frac{\Omega [-4\bar{\theta}^2 (4s_H^2 - 3s_H s_L + 2s_L^2) - b(24s_H^3 - 22s_H^2 s_L + 5s_H s_L^2 - 2s_L^3)]}{4(4s_H - s_L)^3} = 0 \quad (11a)$$

$$\frac{\partial \pi_L^*}{\partial s_L} = 0 \Leftrightarrow \frac{\Lambda [2\bar{\theta}^2 s_H (4s_H - 7s_L) + b(s_H - s_L)(4s_H^2 - 15s_H s_L + 2s_L^2)]}{4(4s_H - s_L)^3} = 0, \quad (11b)$$

where $\Omega = s_H [-4\bar{\theta} + b(2s_H + s_L)]$ and $\Lambda = s_H [2\bar{\theta}^2 + b(s_H + s_L)]$.

Given the complexity of the first-order conditions, solving for the actual equilibrium qualities is a bit laborious. Without loss of generality we define $s_H = ds_L$ for some $d > 1$, where d indicates the degree of product differentiation between firms expressed in terms of the quality spread between high and low quality firms. Note that this assumption does not predetermine the results presented later concerning differences between socially optimal and duopoly outcomes. It simply implies that the high quality firm produces higher quality than the low quality firm, which is always the case in these models.

Using $s_H = ds_L$ and solving (11a) - (11b) with *Mathematica*, we obtain the following equilibrium qualities and their difference,

$$s_H^* = \frac{0.8195\bar{\theta}^2}{b}; \quad s_L^* = \frac{0.3987\bar{\theta}^2}{b}, \quad s_H^* - s_L^* = \frac{0.4208\bar{\theta}^2}{b}. \quad (12)$$

Equilibrium duopoly qualities and the degree of quality differentiation are positive functions of the upper bound of the square of the taste distribution, $\bar{\theta}^2$, and a negative function of the marginal cost parameter of quality provision, b . This result is qualitatively similar to those found in full market coverage models. Note also that the quality difference is higher with variable costs compared to the fixed cost case.

This last finding can be interpreted as follows. Under fixed costs, the costs of producing both quality variants of the good in the second stage are zero (even though the costs of providing quality differ), but they are strictly positive under variable costs. Thus under variable costs of production, quality competition between the firms is tighter because the firms obtain greater rents from differentiating compared to the fixed cost case.

Finally, using the optimal qualities above, we can solve the previous first-order conditions for equilibrium prices and demands: $p_H^* = \frac{0.453313\bar{\theta}^2}{b}$; $p_L^* = \frac{0.15002\bar{\theta}^2}{b}$; $q_H^* = 0.279245\bar{\theta}$; $q_L^* = 0.344503\bar{\theta}$. Interestingly, for our case of variable costs of production, we find that the high quality firm has higher profits but lower market share than the low quality firm. The overall demand (i.e., coverage) in the market is given by $q_H^* + q_L^* = 0.623748\bar{\theta}$. Thus, under variable costs, overall market coverage is *smaller* than in the case of fixed costs. This is a natural result since production costs are now positive and the quality spread is wider, which serves to relax price competition between firms and allows the firms to charge higher prices. The firms' indirect profit functions can now be solved to obtain $\tilde{\pi}^H = \frac{0.0328129\bar{\theta}^3}{b}$; $\tilde{\pi}^L = \frac{0.024298\bar{\theta}^3}{b}$.

3 Socially Optimal versus Profit-Maximizing Quality Decisions

Now we turn to the main part of our paper, i.e., the determination of the socially optimal qualities and their relationship with the equilibrium duopoly qualities under both assumptions of fixed and variable cost of production. The socially optimal levels of quality are those that maximize a social welfare function, which is the sum of surplus to consumers net of costs to produce high and low quality goods,

$$SW = \int_{\hat{\theta}}^{\bar{\theta}} (\theta s_H - \frac{1}{2} b s_H^2) d\theta + \int_{\theta^c}^{\hat{\theta}} (\theta s_L - \frac{1}{2} b s_L^2) d\theta. \quad (13)$$

3.1 Fixed Costs and the Socially Optimal Qualities

We start by analyzing the properties of the first-best solution under fixed costs. The social planner simultaneously chooses prices and qualities to maximize (13). The planner accounts for the critical taste parameter separating consumers of high and low quality variants, while keeping it open whether it is socially optimal to serve the whole market or not. Thus, the planner uses the following critical values of the taste parameter

$$\hat{\theta} = \frac{p_H - p_L}{s_H - s_L}; \quad \theta^c = \underline{\theta}. \quad (14)$$

Differentiating first the social welfare function (13) with respect to high and low quality prices gives $p_H = p_L$.⁵ Using this in the social welfare function and differentiating it with respect to high and low qualities yields,

$$SW_{s_H} = \frac{1}{2} (\bar{\theta}^2 - 2b s_H) = 0, \quad SW_{s_L} = \frac{1}{2} (-\underline{\theta}^2 - 2b s_L) = 0. \quad (15)$$

⁵ The first-order conditions for the prices of the high and low variants are

$$SW_{p_H} = -\frac{p_H}{s_H - s_L} + \frac{p_L}{s_H - s_L} = 0, \quad SW_{p_L} = \frac{p_H}{s_H - s_L} - \frac{p_L}{s_H - s_L} = 0.$$

Solving for optimal high quality yields $s_H^w = \frac{\bar{\theta}^2}{2b}$. Note however that $SW_{s_L} < 0$, implying that production of low quality variant is zero. Thus, it is socially optimal to provide just one quality variant (high quality), $s^w = \frac{\bar{\theta}^2}{2b}$, as pointed out by Ecchia et al. (2002).

Consider now the relationships between socially optimal qualities and duopoly qualities (which has been characterized in equation 7),

$$s_H^* - s_H^w = -\frac{0.246689\bar{\theta}^2}{b} < 0 \quad (16a)$$

$$s_L^* - s_L^w = \frac{0.048238\bar{\theta}^2}{b} > 0 \quad (16b)$$

$$s_a^* - s_a^w = -\frac{0.24669\bar{\theta}^2}{b} < 0, \quad (16c)$$

where the subscript ‘a’ refers to average quality. Clearly, a duopoly provides too little high quality and too much low quality goods. This implies that profit maximization results in a quality dispersion that is socially sub-optimal. Moreover, the average quality provided by the market is too low from the social planner’s perspective. We summarize these findings in:

Proposition 1: Under fixed costs of production, the socially optimal outcome involves production of only the high quality variant. Compared to the socially optimal outcome, the profit maximizing duopoly provides too little high quality and too much low quality.

Using the socially optimal quality, we can also solve for the socially optimal price. Inserting optimal qualities into the first-order conditions for prices would imply that the optimal price is zero, because, when quality is given, the cost of commodity production is zero. There are several possible ways to solve for the optimal prices. First, the social planner could offer the high quality commodity to consumers at a zero price, given that investment in quality is independent of the commodity’s price level, and investment as such represents a sunk cost. The second way is to assume that society charges a positive price such that either some subset or all of consumers purchase the commodity. The latter price

can be determined from the indifference relation between buying and not buying for the consumer having the lowest preference for quality. By inserting the socially optimal quality into this indifference relationship, we have $\underline{\theta}s^{sw} - p = 0$. Recall that we solved for the socially optimal quality such that $s^w = \frac{\bar{\theta}^2}{2b}$. Using this yields the following socially optimal price, $p^w = \frac{\theta\bar{\theta}^2}{2b}$. Under this price, demand for the commodity is simply given by $q^{swf} = \bar{\theta} - \underline{\theta}$, so that relative to the duopoly equilibrium, the socially optimal solution with this pricing strategy yields 21% higher demand for the good (see our earlier analysis of duopoly in Section 2.1).

3.2 Variable Costs and the Socially Optimal Qualities

Next we compare the equilibrium duopoly solution with the socially optimal one in the case of variable costs of production. Unlike with fixed costs of production, the assumption of variable production costs allows the social welfare maximizer to offer products at a nonzero marginal cost. Therefore, replacing duopoly prices by the marginal costs of quality provision in the critical taste parameters $\hat{\theta}$ and θ^c , we can define new threshold critical taste parameters for the upper and lower bounds of the taste distribution,

$$\hat{\theta} = \frac{1}{2}b(s_H + s_L); \quad \theta^c = \frac{1}{2}bs_L. \quad (20)$$

Using equation (20) and differentiating the social welfare function (13) with respect to the qualities s_H and s_L then gives the following first-order conditions,

$$SW_{s_H} = 0 \Leftrightarrow \left[\frac{\bar{\theta}^2}{2} - \bar{\theta}bs_H \right] = \left[\frac{\hat{\theta}^2}{2} - \hat{\theta}bs_H \right], \quad (21a)$$

$$SW_{s_L} = 0 \Leftrightarrow \left[\frac{\hat{\theta}^2}{2} - \hat{\theta}bs_L \right] = \left[\frac{\theta^{c^2}}{2} - \theta^cbs_L \right]. \quad (21b)$$

The socially optimal qualities can then be solved from (21a) and (21b) to obtain,

$$s_H^w = \frac{4\bar{\theta}^2}{5b}, \quad s_L^w = \frac{2\bar{\theta}^2}{5b} \quad \text{and} \quad s_H^w - s_L^w = \frac{2\bar{\theta}^2}{5b}. \quad (22)$$

Like the quality difference in the profit maximizing duopoly case, the socially optimal quality difference depends positively on the square upper bound of the taste distribution, $\bar{\theta}$ and negatively on the marginal cost parameter of quality provision b .

As for the relationship between socially optimal qualities in the duopoly and social welfare maximization cases, we obtain (using equation 12),

$$s_H^* - s_H^w = \frac{0.0195\bar{\theta}^2}{b} > 0, \quad (23a)$$

$$s_L^* - s_L^w = -\frac{0.087\bar{\theta}^2}{b} < 0. \quad (23b)$$

The magnitude of these expressions depends on the size of the squared upper bound of the taste distribution, which indicates how many consumers can potentially be captured by differentiating product qualities. Unlike in the case of fixed costs, the profit-maximizing duopoly produces too much high quality and too little low quality than would the social planner. Further, if we compare quality differences across the outcomes, we see that profit maximization gives a quality dispersion that is too wide, i.e.,

$$(s_H^w - s_L^w) - (s_H^* - s_L^*) = -\frac{0.140\bar{\theta}^2}{5b} < 0. \quad (23c)$$

This implies that, in order to relax price competition, firms will behave in a manner that increases the spread of quality dispersion too much by maximizing profits. Such behavior decreases social welfare. We can summarize these findings in:

Proposition 2: Under variable costs of production, the socially optimal outcome involves provision of both high and low quality variants. Compared to the socially optimal outcome, the profit maximizing duopoly provides too much high quality and too little low quality.

Next, we solve the demands for qualities in the socially optimal outcome. Using (12) in (9a) and (9b) and accounting for the definition of demands yields $q_H^w = q_L^w = 0.4\bar{\theta}$. Hence, the high and low quality firms will have demand of equal size at the social welfare optimum. The difference between total demand in the socially optimal and duopoly outcomes are given by: $(q_H^w + q_L^w) - (q_H^* + q_L^*) = 0.176252\bar{\theta} > 0$, implying that production of each variety and market coverage are both too small under the duopoly. Intuitively, the duopoly restricts production in order to charge prices higher than marginal production costs. This is strikingly different from the well-known result derived in fully covered markets, which states that the size of the economy's production of quality is equal under duopoly and socially optimal outcomes. Our new finding may have important policy implications for achieving efficient levels of quality in markets.

Finally, it is interesting to compare the features of socially optimal quality provision under fixed and variable costs. The major difference between these two cases is as follows: under fixed costs we showed that only one quality variant of the good is provided. Both variants are optimal under variable costs, and we can show that provision of the high quality variant is greater than in the case of fixed production costs. In the duopoly equilibrium, we also showed that the quality spread is too wide under variable costs, but it is too narrow under fixed costs of production. In both the fixed and variable cost cases, average quality is too low from the perspective of the social welfare maximizer.

4 Conclusion

We have used a vertical product differentiation model under the assumption of partial market coverage to characterize the social welfare and profit maximizing duopoly outcomes, in terms of quality provision and quantities produced. We consider these under both variable and fixed convex costs of production.

Under an assumption of fixed costs, the high quality firm has higher profits and greater market share than the low quality firm. Unlike in the duopoly equilibrium, however, we demonstrated, as has been pointed out in Ecchia et al. (2002), that it is socially optimal to provide the high quality commodity and set low quality production to zero at the social optimum. We also demonstrated that production of high quality at the social optimum is higher than that provided by the market, and therefore the average quality provided by the market is lower than at the social optimum. As production is costless and investment in quality is lump sum, the planner may be free to set a zero or positive price, and to serve either all or part of the market.

Under an assumption of variable costs, we also find a new result that the spread of product quality in the profit maximization duopoly outcome is too high relative to the social welfare maximizing outcome. At the social welfare optimum, overall output is greater than the output produced under the duopoly.

At the social optimum there are two major differences between fixed cost and variable cost assumptions. First, under fixed costs only one variant of quality is provided, while both variants are optimal under variable costs. Second, provision of high quality is greater under variable costs of production. Comparing social welfare maximizing and duopoly outcomes, we also show that the product differentiation spread is too wide under a variable cost assumption, but it is too narrow under fixed costs. Average quality in both variable and fixed cost duopoly cases is too low from a social planner's perspective.

References

- Crampes C. and A. Hollander 1995. Duopoly and Quality Standards. *European Economic Review* 39, 71-82.
- Cremer, H. and J. Thisse. 1999. On the Taxation of Polluting Products in a Differentiated Industry. *European Economic Review*, 43, 575-594,95-106.
- Ecchia, G., L. Lambertini and C. Scarpa 2002. On the Regulation of Vertically Differentiated Markets through Minimum Quality Standards. *Rivista di Politica Economica* 912, 163-202.
- Kuhn, M. 2000. Low Quality Leadership in Vertically Differentiated Duopoly. *University of York, Department of Economics, Working Paper Series*.
- Lambertini, L. 1996. Choosing Roles in a Duopoly for Endogenously Differentiated Products. *Australian Economics Papers*, 205-223.
- Lehmann-Grube, U. 1997. Strategic Choice of Quality When Quality is Costly: the Persistence of the High-Quality Advantage, *Rand Journal of Economics*, 28, 372-384.
- Motta, M. 1993. Endogenous Quality Choice: Price vs. Quantity Competition. *Journal of Industrial Economics*, 41:113-32
- Ronnen, U. 1991. Minimum Quality Standards, Fixed Costs and Competition. *Rand Journal of Economics*, 22, 490-504.
- Tirole, J. 1988. *The Theory of Industrial Organization*. MIT Press, Cambridge, Mass.

ELINKEINOELÄMÄN TUTKIMUSLAITOS (ETLA)

THE RESEARCH INSTITUTE OF THE FINNISH ECONOMY

LÖNNROTINKATU 4 B, FIN-00120 HELSINKI

Puh./Tel. (09) 609 900

Telefax (09) 601753

Int. 358-9-609 900

Int. 358-9-601 753

<http://www.etla.fi>

KESKUSTELUAIHEITA - DISCUSSION PAPERS ISSN 0781-6847

Julkaisut ovat saatavissa elektronisessa muodossa internet-osoitteessa:

<http://www.etla.fi/finnish/research/publications/searchengine>

- No 818 ISMO LINNOSMAA – RAINE HERMANS – TARU KARHUNEN, Price-Cost Margin in the Pharmaceutical Industry: Empirical Evidence from Finland. 03.09.2002. 20 p.
- No 819 RAINE HERMANS – TERTTU LUUKKONEN, Findings of the ETLA Survey on Finnish Biotechnology Firms. 10.09.2002. 30 p.
- No 820 ARI HYYTINEN – OTTO TOIVANEN, Do Financial Constraints Hold Back Innovation and Growth? Evidence on the Role of Public Policy. 17.09.2002. 31 p.
- No 821 KARI E.O. ALHO, Stabilization Inside and Outside EMU. 27.09.2002. 20 p.
- No 822 HANNU PIEKKOLA, From Creative Destruction to Human Capital Growth: Wage Dispersion Effects in Finland. 27.09.2002. 20 p.
- No 823 ARI HYYTINEN – OTTO TOIVANEN, Misuse and Non-use of Information Acquisition Technologies in Banking. 11.10.2002. 14 p.
- No 824 HELI KOSKI – TOBIAS KRETSCHMER, Entry, Standards and Competition: Firm Strategies and The Diffusion of Mobile Telephony. 14.10.2002. 36 p.
- No 825 PEKKA SULAMAA – MIKA WIDGRÉN, EU-Enlargement and the Opening of Russia: Lessons from the GTAP Reference Model. 15.10.2002. 24 p.
- No 826 JUHA M. ALHO, The Population of Finland in 2050 and Beyond. 11.11.2002. 28 p.
- No 827 JUKKA JALAVA, The Production and Use of ICT in Finland, 1975-2001. 21.10.2002. 23 p.
- No 828 ARI HYYTINEN – TUOMAS TAKALO, Enhancing Bank Transparency: A Re-assessment. 23.10.2002. 23 p.
- No 829 REIJO MANKINEN – PETRI ROUVINEN – PEKKA YLÄ-ANTTILA, Palveluiden tuottavuus – kilpailu ja teknologia muuttavat rakenteita. 31.10.2002. 49 s.
- No 830 PEKKA MANNONEN, The Strategic Response of Banks to an Exogenous Positive Information Shock in the Credit Markets. 31.10.2002. 16 p.
- No 831 JYRKI ALI-YRKKÖ – PEKKA YLÄ-ANTTILA, Pääkonttorien sijainti, kansainvälistyminen ja verotus. 05.11.2002. 38 s.
- No 832 ARI HYYTINEN – LOTTA VÄÄNÄNEN, Government Funding of Small and Medium-sized Enterprises in Finland. 06.11.2002. 50 p.
- No 833 TUOMAS MÖTTÖNEN, Idänkaupan ennusteet 1987-1991. 11.11.2002. 88 s.

- No 834 MARKKU STENBORG, Economics of Joint Dominance. 21.11.2002. 24 p.
- No 835 RAINE HERMANS – ANTTI-JUSSI TAHVANAINEN, Ownership and Financial Structure of Biotechnology SMEs: Evidence from Finland. 12.12.2002. 41 p.
- No 836 MARIANNE PAASI, Economics of Collective Benchmarking – Learning in Research and Innovation Policy. 12.12.2002. 18 p.
- No 837 KARI E.O. ALHO, Kannattaako tulopolitiikkaa jatkaa? 30.12.2002. 22 s.
- No 838 HANNU PIEKKOLA, Palkkaneuvottelut ja työmarkkinat Pohjoismaissa ja Euroopassa. 30.12.2002. 26 s.
- No 839 KARI E.O. ALHO, The Equilibrium Rate of Unemployment and Policies to Lower it: The Case of Finland. 31.12.2002. 26 p.
- No 840 LUIS H.R. ALVAREZ – ERKKI KOSKELA, On Forest Rotation Under Interest Rate Variability. 15.01.2003. 14 p.
- No 841 LUIS H.R. ALVAREZ – ERKKI KOSKELA, Irreversible Investment under Interest Rate Variability: some Generalizations. 22.01.2003. 27 p.
- No 842 OLAVI RANTALA, Tuotekehitys, toimialojen panos-tuotosrakenteen muutokset ja talouden kasvu. 29.01.2003. 64 s.
- No 843 KARI E.O. ALHO, The Impact of Regionalism on Trade in Europe. 05.02.2003. 14 p.
- No 844 LAURA PAIJA, Distribution of Intellectual Property Rights and the Development of Technology Suppliers. 05.02.2003. 20 p.
- No 845 ESA VIITAMO, Knowledge-intensive Services and Competitiveness of the Forest Cluster – Case Finland. 06.02.2003. 44 p.
- No 846 JYRKI ALI-YRKKÖ – MIKA PAJARINEN, Julkinen T&K-rahoitus ja sen vaikutus yrityksiin – Analyysi metalli- ja elektroniikkateollisuudesta. 21.02.2003. 37 s.
- No 847 HELI KOSKI – CAROLINA SIERIMO, Entry and Exit in the ICT Sector – New Markets, New Industrial Dynamics? 25.02.2003. 21 p.
- No 848 GREGORY S. AMACHER – ERKKI KOSKELA – MARKKU OLLIKAINEN, Environmental Quality Competition and Eco-Labeling. 10.03.2003. 28 p.
- No 849 TOMI HUSSU, Reconfiguring Knowledge Management. Combining Intellectual Capital, Intangible Assets and Knowledge Creation. 19.03.2003. 25 p.
- No 850 LOTTA VÄÄNÄNEN, Public Provision of Business Support Services in Finland. 22.04.2003. 59 p.
- No 851 GREGORY S. AMACHER – ERKKI KOSKELA – MARKKU OLLIKAINEN, Quality Competition and Social Welfare in Markets with Partial Coverage: New Results. 23.04.2003. 15 p.

Elinkeinoelämän Tutkimuslaitoksen julkaisemat "Keskusteluaiheet" ovat raportteja alustavista tutkimustuloksista ja väliraportteja tekeillä olevista tutkimuksista. Tässä sarjassa julkaistuja monisteita on mahdollista ostaa Taloustieto Oy:stä kopiointi- ja toimituskuluja vastaavaan hintaan.

Papers in this series are reports on preliminary research results and on studies in progress. They are sold by Taloustieto Oy for a nominal fee covering copying and postage costs.