Product Relocation and Resistance to Change

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September 2006

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ABSTRACT

This paper considers a duopoly market characterization where demand is horizontally differentiated by taste while firms vertically differentiate their products based on quality location. However, firms are able to relocate their product offerings based on changing consumer taste. In general, it is found that a "resistance to change" exists such that firms dislike quality relocation and prefer stable preferences in quality. Yet, a relative change in horizontal preferences may result in wider quality spreads in the market through vertical quality relocations, even though the resistance to change argument may still hold good.

I. INTRODUCTION

The analysis of endogenous quality choice under fixed and variable costs of quality by Motta (1993), as an extension of the works of Champsaur and Rochet (1989), and Vives (1985), set an interesting exposure into the area of differentiated quality choice under different cost assumptions of quality and output (capacity), given flexible preferences for consumer taste. However, such studies did not cast a full exposure of the impacts of flexible choice on brand relocation except in the form of discussion of such behavior using willingness to pay in demand. The interaction between flexible choice in demand to brand relocation in supply constitute the core of analysis in this research. Such is the motivation for this paper. In our current analysis, the notion of "flexible preferences for consumer taste" is examined more fully under the following general scenario: (1) consumers are uniformly differentiated by taste using unit transportation costs, (2) firms produce a single brand each, (3) there is an asymmetric cost structure in production (fixed and variable), (4) brands are differentiated based on quality location but can be relocated based on changing transportation costs, (5) the market is a duopoly, and finally, (6) competition is in prices.

The rationale behind such a scenario has multiple dimensions. *First*, in most industries, consumer choice is based on individual and independent preferences such that demand can be seen as rising from purchasing a brand least to the dislike of non-joint tastes (e.g. the choice of breakfast cereals). *Second*, those preferences may change (e.g. a consumer deciding to start a diet). Such a change in consumer taste is treated exogenous to the model setup (i.e. I did not solve for the endogenous change in tastes), but at the same time the impact of such a change is fairly examined on different fronts. *Third*, the duopoly market characterization is a simple treatment of segmented markets (e.g. local versus foreign brands) such that each firm can be seen as a representative firm for each market segment, although the model is then confined to two such segments. *Fourth*, due to different usage of technology and, consequently, different efficient scales of production for each market segment, the cost structure is asymmetric in both fixed (as in investment cost) and variable (as in raw materials, labor, etc.) costs of production. *Fifth*, firms when faced with changing tastes may decide to change their quality offerings, hence they react by relocating their brands accordingly and in a rational profit maximizing manner. Brand variety is not the context of analysis here but rather the relocation of brands along a quality scale (e.g. more hard disk space in new computers due to increased consumer taste for music and picture storage). *Sixth*, since consumer demand is derived from least disutility of purchase, prices play a key role in the purchasing decision and, accordingly, consumer payment has to be accounted for as part of the disutility of purchase.

Those assumptions, it is seen, produce qualitatively sound results to the proposed scenario just described.

II. CHOICE OF LOCATION

Let demand be uniformly distributed based on unit transportation costs τ such that disutility from purchasing a non-ideal brand is:

$$U(\tau, x) = \begin{cases} -P_a - \tau(x-a)^2 \\ -P_b - \tau(L-b-x)^2 \end{cases} \quad (1)$$

where L represents the spectrum of available brands offered in the market with $a, b \in [0, L]$, and $b \geq a$, such that the demand for the low quality brand (x) is:

$$D_a(P_a, P_b) = x^S = \frac{P_b - P_a}{2\tau(L-b-a)} + \frac{L-b+a}{2}. \quad (2)$$

The demand for the high quality brand (B) is derived to be:

$$D_b(P_a, P_b) = \frac{P_a - P_b}{2\tau(L-b-a)} + \frac{(2-L)+b-a}{2} \quad (3)$$

As consumer preferences become more biased against purchasing a non ideal brand, actual consumption tends to favor the higher quality brand, since $\frac{\partial D_a}{\partial \tau} < 0$ while $\frac{\partial D_b}{\partial \tau} > 0$.

In two stage (location-price) competition, a profit function with non symmetric fixed and variable costs is assumed to be[1]:

$$\begin{aligned} \pi_a[P_{a,} C_a, K(a)] &= \{P_a - C_a(a)\} x^S(\tau) - K(a) \\ \pi_b[P_b, C_b, K(b)] &= \{P_b - C_b(b)\}(1 - x^S(\tau)) - K(b) \end{aligned} \quad (4)$$

with $K'(a) > 0, K'(b) > 0, C_a'(a) > 0, C_b'(b) > 0, C''(\cdot) < 0, x^S(\tau) > 0.$

Solving for prices, we get:

$$\begin{aligned} P_a &= \frac{1}{3}\left[2C_a + C_b + \tau(L-b-a)(2+L-b+a)\right] \\ P_b &= \frac{1}{3}\left[2C_b + C_a + \tau(L-b-a)(4-L+b-a)\right] \end{aligned} \quad (5)$$

Equilibrium profits are therefore[2]:

$$\begin{aligned} \pi_a &= \frac{1}{3}\left[C_b - C_a + \tau(L-b-a)(2+L-b+a)\right] x^S(\tau) - K(a) \\ \pi_b &= \frac{1}{3}\left[C_a - C_b + \tau(L-b-a)(4-L+b-a)\right][1 - x^S(\tau)] - K(b) \end{aligned} \quad (6)$$

The realization of equilibrium profits, as given in (6), is contingent on realizing equilibrium location based on horizontal consumer preferences at the first stage of competition. For the case of the low quality firm (A), an implicit optimal location choice is found to be[3]:

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[1] Here, the finiteness property of oligopoly pricing is still assumed, following Vives (1985) and Motta (1993), and the market is also assumed to be fully covered by the two chosen quality levels.
[2] The second-order conditions are satisfied for maximum profits.
[3] Here, the quality spectrum is normalized to unity (L=1). Hence, consumer demand for each brand is equal to the market share of the respective firm producing that brand.

$$K'(a) = \frac{\partial x^S}{\partial(a)}(P_a - C_a) + \left(\frac{\partial P_a}{\partial(a)} - C_a'(a)\right)x^S \tag{7}$$

(7) above basically says that fixed capital investment "return" on quality improvements, $K'(a)$, has to equal, at equilibrium, the sum of its associated higher price markup due to a higher quality choice, $\frac{\partial x^S}{\partial(a)}(P_a - C_a)$, plus the marginal cost effect on net profits through indirect consumer demand as given by $\left(\frac{\partial P_a}{\partial(a)} - C_a'(a)\right)x^S$.

A positive investment outlay in horizontal quality choice at the first stage of competition, as given by $K'(a) > 0$, is evident only if the following condition holds true:

$$\left|\frac{\partial x^S(\tau)}{\partial(a)}(P_a - C_a)\right| > \left|\left(\frac{\partial P_a}{\partial(a)} - C_a'(a)\right)x^S\right| \tag{8}$$

The above inequality imply that a positive investment return on quality choice is only feasible if the absolute value of the quality markup (due to higher marginal pricing and higher indirect consumer demand captured by horizontal preferences in quality) exceeds the absolute value of the marginal cost effect.

The analysis can also be extended for the case of the high quality brand with similar results. It is also important to note that the second order condition for equilibrium location is found to be:

$$\frac{\partial^2 \pi_a}{\partial(a)^2} = \left(\frac{\partial^2 P_a}{\partial(a)^2} - C_a''\right)x^S(\tau) + \frac{\partial x^S(\tau)}{\partial(a)}\left(\frac{\partial P_a}{\partial(a)} - C_a'\right) + \frac{\partial^2 x^S(\tau)}{\partial(a)^2}(P_a - C_a) - K''(a) \tag{9}$$

With $\frac{\partial^2 P_a}{\partial(a)^2} = \frac{-2\tau}{3} < 0$, $\frac{\partial x^S}{\partial(a)} > 0$, and $\frac{\partial^2 x^S}{\partial(a)^2} < 0$, and with the retained assumptions of $\frac{\partial P_a}{\partial(a)} < 0$, $C_a' > 0$, the second-order condition of equilibrium location is negative (i.e. satisfied for maximal profits) if and only if the following two conditions hold:

(1) $K''(a) \geq 0$; or $K''(a) < 0$ but not too sufficiently negative (to offset the other three terms)

(2) $\left|\frac{\partial^2 P_a}{\partial(a)^2}\right| > \left|C_a''(a)\right|$.

The first condition basically states that fixed investments (fixed entry costs) should either be convex, linear, or not too concave for an optimal solution. The second condition, on the other hand, states that the marginal price effect to vertical quality location has to dominate the marginal cost effect in absolute value. Thus, if unit variable costs are linear in quality, the second condition always stands true.

III. EQUILIBRIUM SOLUTION WITH ASYMMETRIC COSTS

Assuming linear variable costs with quality location and quadratic fixed costs with quality choice[4], such that $C_a(a) = \mu a$, $C_b(b) = \mu b$, $K(a) = \frac{1}{2}a^2$, and $K(b) = \frac{1}{2}b^2$, the profit functions and equilibrium price locations for the low and high quality brands amount to be:

$$\pi_a = [P_a(a,b) - \mu a]x^S - \frac{1}{2}a^2$$
$$\pi_b = [P_b(a,b) - \mu b](1 - x^S) - \frac{1}{2}b^2 \tag{10}$$

$$P_a(a,b) = \frac{1}{3}[2C_a + C_b + \tau(L - b - a)(2 + L - b + a)]$$
$$P_b(a,b) = \frac{1}{3}[2C_b + C_a + \tau(L - b - a)(4 - L + b - a)] \tag{11}$$

To study the effect of horizontal differentiation (a change in consumer taste with respect to quality characteristics) on vertical location, marginal profits for a change in consumer preferences can be deduced, with profits of $\pi_a = (P_a - C_a(a))x^S(\tau) - K(a)$ for the low quality firm, and with the retained assumptions of $\frac{\partial D_a}{\partial \tau} < 0$ and $\frac{\partial P_a}{\partial \tau} > 0$, such that *marginal profits*[5] amount to:

$$\frac{d\pi_a}{d\tau} = \frac{\partial P_a}{\partial \tau} x^S(\tau) + \frac{\partial x^S(\tau)}{\partial \tau}(P_a - C_a(a)) \tag{12}$$

The first term, $\frac{\partial P_a}{\partial \tau} x^S(\tau)$, is the *price effect* (positive), whereas the second term, $\frac{\partial x^S(\tau)}{\partial \tau}(P_a - C_a)$, is the *demand effect* (negative). An increase in unit transportation costs (implying a higher consumer disutility from purchasing a non-ideal brand) increases the price of the low quality brand such that monopolistic gains are higher (per vertical location) and such that profits are ultimately higher, leading to a positive price effect on economic profits. On the other hand, higher unit transportation costs also imply lower indirect demand for the low quality brand, thus causing a negative demand effect on economic profit. Since marginal profit is an additive function of the price and demand effects, then $\frac{d\pi_a}{d\tau} > 0$ will only be true if $\left|\frac{\partial P_a}{\partial \tau} x^S(\tau)\right| > \left|\frac{\partial x^S(\tau)}{\partial \tau}(P_a - C_a)\right|$. In other words, marginal profits are positive for the case of the low quality brand only if the price effect strongly dominates the indirect demand effect on economic profits. Higher unit transportation costs therefore imply higher economic profits for the case of the low quality brand only if increases in monopolistic gains through higher prices dominate the decline in indirect consumer demand due to higher marginal disutilities from purchasing a non-ideal brand.

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[4] Following Motta (1993), yet in contrast to Shaked and Sutton (1982,1983).

[5] The term "marginal profit" has been borrowed from the corporate finance and management science literatures, and basically mean the change in net present value (or changes in investment returns given an opportunity cost of capital with a certain degree of risk aversion) for an additional unit of (inventory) demand or unit cost. For our economic purpose, marginal profits imply changes in equilibrium profits for a change in consumer demand through preferences in the form of unit transportation costs, given vertical quality location. A direct economic interpretation is marginal prices minus marginal costs for a change in consumer taste.

For the case of the high quality firm, with $\pi_b = (P_b - C_b(b))D_b(\tau) - K(b)$, and with the retained assumptions of $\frac{\partial D_b}{\partial \tau} > 0$ and $\frac{\partial P_b}{\partial \tau} > 0$, marginal profits amount to:

$$\frac{d\pi_b}{d\tau} = \frac{\partial P_b}{\partial \tau} D_b(\tau) + \frac{\partial D_b}{\partial \tau}(P_b - C_b(b)) \tag{13}$$

In that case, both the price and demand effects are positive, implying $\frac{d\pi_b}{d\tau} > 0$ is always true. Therefore, a higher disutility from purchasing a non-ideal brand always benefits the high quality firm in terms of yielding higher economic profits, since higher unit transportation costs cause high quality monopolistic gains and capture more indirect consumer demand[6].

Also note that competing price levels are inherently included in the marginal profit functions in (12) and (13). For the case of the low quality brand, we know that $\frac{\partial x^S}{\partial P_b} > 0$ such that the price of the high quality brand is implicit in the marginal profit formulation.

This gives rise to $\frac{d\pi_a}{d\tau(dP_b)} > 0$, implying that high quality price increases may actually increase marginal profits for the low quality firm. This could be due either to the positive price correlation between the low and high quality brands or due to larger monopolistic gains on the part of the low quality firm as a reaction to the high quality price increase. In addition, for the case of the high quality brand, given that $\frac{\partial D_b}{\partial P_a} > 0$, high quality marginal profits increase with low quality prices, i.e. $\frac{d\pi_b}{d\tau(dP_a)} > 0$.

IV. FIRM RELOCATION AND RESISTANCE TO CHANGE

Vertical quality *relocation*, in which firms adjust their quality locations based on changes in consumer preferences (which imply changes in marginal profits, and therefore profits), can now be examined based on the marginal profit functions in (12) and (13) and the vertical configuration of prices as given in (11). For the case of the low quality brand, the *marginal profit of relocation* is computed to be:

$$\frac{\partial \pi_a}{\partial(a)\partial\tau} = -\frac{2}{3}(1+a)x^S < 0 \tag{14}$$

Thus, an increase in unit transportation costs requiring higher marginal utilities to consume a non-ideal brand reduces the marginal profit of relocation for the case of the low quality brand. The reduction in marginal profits depend on the original level of vertical quality location and on the level of low quality demand. A higher original level of vertical quality location or a higher level of low quality demand imply a lower marginal profit of relocation, and therefore imply lower profits in low quality relocation.

For the case of the high quality brand, the marginal profit of relocation is:

$$\frac{\partial \pi_b}{\partial(b)\partial\tau} = \frac{2}{3}(L-2-b)(1-x^S) \tag{15}$$

[6] Higher disutility (higher unit transportation costs) always benefits the profits of the high quality firm, whereas this is not necessarily the case for the low quality firm (unless the price effect strongly dominates the demand effect). However, higher marginal disutility imply an increase in the price of both high and low quality brands.

For $L > (b+2)$, we have that $\frac{\partial \pi_b}{\partial (b) \partial \tau} > 0$, whereas for $L < (b+2)$ we have $\frac{\partial \pi_b}{\partial (b) \partial \tau} < 0$. Therefore, an increase in unit transportation costs increases the marginal profit of relocation for the case of the high quality brand *only if the range of available quality choices in the market is sufficiently high* (i.e. there is a large quality spectrum offered by the industry). If, however, quality choice is tight, then the marginal profit of relocation becomes negative. Intuitively, higher marginal disutilities will favor high quality relocation only if there is sufficient room for quality improvement, and if there is sufficient monopolistic space for additional profit gains from that relocation. If, however, quality choice is tight and the range of potential quality choices is relatively small, then vertical quality relocation due to increased transportation costs will reduce economic profits for the case of the high quality firm, due to insufficient monopolistic space or insufficient room for quality improvements.

The second-order marginal profit differentials for vertical relocation are:

$$\frac{\partial^2 \pi_a}{\partial (a)^2 \partial \tau} = -\frac{2}{3} x^S < 0 \qquad (16)$$

$$\frac{\partial^2 \pi_b}{\partial (b)^2 \partial \tau} = -\frac{2}{3} (1 - x^S) < 0 \qquad (17)$$

With both differentials for marginal relocation of profits always negative, this implies that the marginal profit of relocation for the low and high quality firms always declines with brand relocation, given an increase in unit transportation costs. Such an argument basically states that there is a *resistance to change* on the part of vertically located firms such that both firms dislike too much relocation with respect to changes in consumer taste. Both firms prefer stable vertical positioning of their brands in order to maximize their respective brand-space monopolistic gains, and therefore prefer stable preferences in quality characteristics (i.e. firms prefer stable demand). However, the higher quality firm may have a marginal profit incentive to change its vertical quality location (i.e. to re-locate) if unit transportation costs increase and if the range of quality choices is sufficiently high.

The effect of horizontal consumer taste on vertical quality relocation needs a final assessment. Given that a stable equilibrium solution entails $\frac{d\pi_a}{d\tau} > 0$ (if the price effect dominates the demand effect) and $\frac{d\pi_b}{d\tau} > 0$; and with $\frac{d\pi_a}{d(a)} < 0$ and $\frac{d\pi_b}{d(b)} > 0$, then we can indirectly deduce the direction of $\frac{da^*}{d\tau}$ and $\frac{db^*}{d\tau}$ from:

$$\frac{d\pi_a}{d\tau} = \frac{d\pi_a}{d(a)} \frac{da^*}{d\tau} \qquad (18)$$

$$\frac{d\pi_b}{d\tau} = \frac{d\pi_b}{d(b)} \frac{db^*}{d\tau} \qquad (19)$$

In other words, $\frac{da^*}{d\tau} < 0$ and $\frac{db^*}{d\tau} > 0$ are valid under a stable equilibrium outcome. A relative change in quality preferences, through more horizontal differentiation in consumer taste, may force more product differentiation by vertical quality relocation, with the low quality firm producing a lower quality brand and the high quality firm producing a higher quality brand, even though both firms prefer stable quality preferences and both firms dislike relocation. This also means that more product differentiation will arise by vertical quality choice only if quality preferences, as dictated by horizontal differentiation in consumer demand, force the relocation and vertical re-positioning of firms.

Thus, in location-price competition with flexible horizontal taste and vertical relocation, a duopoly market can become more differentiated on the basis of firms relocating their product (quality) characteristics along a wider quality range, even though firms exhibit resistance to change and prefer stable preferences in demand. In other words, more horizontal differentiation may induce more product differentiation by vertical quality relocation[7].

V. CONCLUSIVE REMARK

In summary, this paper addressed the issue of firm relocation to a change in consumer taste within a duopoly market setting characterized by an asymmetric cost structure. In the proposed analysis, consumers are horizontally differentiated by unit transportation costs while duopoly firms locate their product offerings based on vertical quality location. The analysis yields equilibrium capital investment returns composed of positive quality markups and negative marginal cost effects, with duopoly firms achieving positive profits through price-quality markups exceeding marginal costs. This is found contingent on the nature of investment, i.e. fixed capital investments should not be "too concave" with vertical quality location. On the other hand, when horizontal preferences are relatively flexible, there exists a "resistance to change" on the part of vertically located firms such that firms dislike quality relocation and prefer stable preferences in quality. However, a relative change in consumer taste may result in wider quality spreads in the market through vertical quality relocations even though the resistance to change conditions still hold good.

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[7] In other words, horizontal preferences may force more product differentiation. Such an outcome may be true for the cost-effective equilibrium solution with monopolistic brand-space gains. However, if the original vertical specification is such that both firms locate their quality choices at the extreme of the quality spectrum, meaning that the market is originally located on the premise of maximum product differentiation, then additional product differentiation may only occur if it is both technically and financially feasible for both firms to relax their differentiation characteristics based on changes in consumer taste. Investments in quality relocation, then, have to weighed against monopolistic gains and changes in indirect demand based on the new level of horizontal consumer taste.