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Vertical Product Differentiation, Intra-industry Trade, and Infant Industry Protection

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Vertical Product Differentiation, Intra–industry Trade, and Infant Industry Protection

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Abstract

The higher the relative quality of the products of domestic firms, the greater their equilibrium outputs and prices, and the more are those prices affected by exchange rate fluctuations. If domestic firms produce relatively low quality varieties, their equilibrium output may be zero. This offers a rationale for "infant industry" protection while quality is improved.

1 Introduction

Drawing heavily on Cusumano (1985), one can list the following stylized facts from the history of the world automobile industry:

1. from the end of World War II through the early 1960s, Japanese cars were perceived by consumers as being of low quality;
2. during this period, Japanese cars were not especially successful on world markets;
3. however, they were protected against foreign competition in their home market by government measures that were rationalized, at least in part, on "infant industry" grounds, and during this period made substantial efforts to raise quality;
4. by the 1980s and 1990s, Japanese cars were perceived by consumers as being of high quality, and became immensely successful on world markets.

In the imperfectly competitive world automobile industry, it appears, consumers' perception of quality changes slowly and is a critical determinant of market performance. Yet while there have been important advances in our ability to model vertical product differentiation (Cremer and Thisse, 1991; Shaked and Sutton, 1982, 1983, 1987) and in the application of models of imperfect competition to the traditional questions of international economics (Greenaway, 1987; Gatsios, 1989; Krugman, 1989), it remains to explore the impact of vertical product differentiation on intra–industry trade. In this paper, I present a model of vertical product differentiation that generalizes a standard model of homogeneous–product oligopoly. This allows the analysis of intra–industry trade flows and the pass–through of exchange rate fluctuations to domestic prices in a way that is comparable to results in the literature (Brander, 1981; Markusen, 1981; Phlips and Martin, 1993). The model also yields a protect–quality rationale for infant industry protection.

2 Duopoly with Vertical Product Differentiation

2.1 Demand

Leaving aside questions of international trade for the moment, in this section I lay out the simplest possible version of a model of oligopoly with vertical product differentiation: quantity–setting duopoly. There are two firms, 1 and 2. Each firm produces a single variety, and associated with each variety is a quality index ξ. The impact of quality on market demand is straightforward: the greater a product's quality, the more consumers

will pay for it, and the less consumers will pay for other products, holding outputs constant. Linear inverse demand curves with these characteristics are[1]

$$p_1 = \xi_1 a - \xi_1 q_1 - \sqrt{\xi_1 \xi_2} q_2 \tag{1}$$

$$p_2 = \xi_2 a - \sqrt{\xi_1 \xi_2} q_1 - \xi_2 q_2 \tag{2}$$

An increase in ξ_1 increases the price–axis intercept of variety 1's demand curve, and makes it steeper (less elastic). An increase in ξ_1 also shifts variety 2's demand curve toward the origin. Equations (1) and (2) can be derived from a quadratic representative utility function:

$$u = m + a\left(\xi_1 q_1 + \xi_2 q_2\right) - \frac{1}{2}\left(\xi_1 q_1^2 + 2\sqrt{\xi_1 \xi_2} q_1 q_2 + \xi_2 q_2^2\right) \tag{3}$$

where m represents "all other goods". This is a common and sometimes a convenient procedure. Its weaknesses should be noted (Kirman, 1992). If this formulation is accepted, then ξ_1 is seen as an index of the marginal utility of variety i relative to the marginal utility of all other goods (which is normalized at one).

2.2 Equilibrium

The experience of the world automobile industry suggests that firms are able to change perceived product quality much less rapidly than price or output.[2] For this reason, I assume that firms treat product qualities as given when they maximize profit, and examine comparative static changes in market equilibrium as product qualities change parametrically. If each firm produces with constant marginal cost c per unit, quantity reaction curves are

$$2q_1 + \sqrt{\frac{\xi_2}{\xi_1}} q_2 = a - \frac{c}{\xi_1} \tag{4}$$

$$\sqrt{\frac{\xi_1}{\xi_2}} q_1 + 2q_2 = a - \frac{c}{\xi_2} \tag{5}$$

[1] Dividing equation (1) by ξ_1 and equation (2) by ξ_2, one obtains inverse demand curves written in terms of price per unit quality. As is usual in models of this kind, the assumption that the coefficient of own output in the equation of the inverse demand curve is made without loss of generality.

[2] The "Coca Cola Classic" episode suggests that firms may have difficulty changing perceived product quality, or at least that consumers may react in unpredictable ways to attempts to change product quality. Hotelling (1929) assumed that firms could costlessly change location, the spatial analoque of product type. This assumption is abandoned by Prescott and Visscher (1977) and the literature that builds on their work.

The implied Cournot equilibrium outputs and prices are[3]

$$q_1 = \frac{1}{3}\left[2\left(a - \frac{c}{\xi_1}\right) - \sqrt{\frac{\xi_2}{\xi_1}}\left(a - \frac{c}{\xi_2}\right)\right] \tag{6}$$

$$q_2 = \frac{1}{3}\left[2\left(a - \frac{c}{\xi_2}\right) - \sqrt{\frac{\xi_1}{\xi_2}}\left(a - \frac{c}{\xi_1}\right)\right] \tag{7}$$

$$p_1 = c + \xi_1 q_1 \tag{8}$$

$$p_2 = c + \xi_2 q_2 \tag{9}$$

(Equations (8) and (9) are implied directly by the reaction functions.)

It is apparent from (6) and (8) that the equilibrium values of q_1 and p_1 rise as ξ_1 rises and fall as ξ_2 rises. Since firm 1's equilibrium profit is $\pi_1 = \xi_1(q_1)^2$, π_1 is affected in the same way by changes in qualities. (7) and (9) yield corresponding comparative static relations for variety 2.

All of these results hold provided equilibrium outputs are nonnegative. The case in which this condition is violated is explored below.

3 Intra–industry Trade with Vertical Product Differentiation

3.1 Demand

I wish to examine intra–industry trade between two countries, A and B. The model is static. There are A firms in country A and B firms in country B. Inverse demand curves generalize those of the duopoly case outlined above. The price of each variety depends on the outputs and qualities of all varieties. In the most general case, each variety would have a distinct quality parameter. For simplicity and tractability, but also because it does not seem too far removed from the stylized facts of the automobile industry, I assume that in each country there is a common quality parameter for all varieties produced in the same country. Country A inverse demand curves are

$$p_{AA} = \xi_{AA}a - \xi_{AA}(q_{A1} + q_{A2} + ... + q_{AA}) - \sqrt{\xi_{AA}\xi_{BA}}(x_{B1} + ... + x_{BB}) \tag{10}$$

[3]Horizontal product differentiation can be introduced by adding a product differentiation parameter θ, which for substitute varieties would lie between 0 and 1, to the inverse demand curves. The inverse demand curve for variety 1 would then be

$$p_1 = \xi_1 a - \xi_1 q_1 - \theta\sqrt{\xi_1\xi_2}q_2.$$

This is equivalent to generalizing the Spence (1976) model of product differentiation to include quality differences. The resulting inverse demand curves can be inverted to obtain demand curves and investigate price–setting oligopoly with vertical product differentiation.

$$p_{BA} = \xi_{BA}a - \sqrt{\xi_{AA}\xi_{BA}}(q_{A1} + q_{A2} + ... + q_{AA}) - \xi_{BA}(x_{B1} + ... + x_{BB}) \quad (11)$$

ξ_{AA} is the quality index of country A varieties in country A and ξ_{BA} is the quality index of country B varieties in country A. q_{Ai} is the sales of country A firm i in country A; x_{Bj} is the export sales of country B firm j in country A.

In like manner, country B inverse demand curves are

$$p_{AB} = \xi_{AB}a - \xi_{AB}(x_{A1} + x_{A2} + ... + x_{AA}) - \sqrt{\xi_{AB}\xi_{BB}}(q_{B1} + ... + q_{BA}) \quad (12)$$

$$p_{AB} = \xi_{BB}a - \sqrt{\xi_{AB}\xi_{BB}}(x_{A1} + x_{A2} + ... + x_{AA}) - \xi_{BB}(q_{B1} + ... + q_{BA}) \quad (13)$$

In this formulation, there is no necessary connection between the quality valuation of a variety in different countries.[4]

3.2 Equilibrium

Firm A1's profit is

$$\pi_{A1} = (p_{AA} - c)q_{A1} + (ep_{AB} - c)x_{A1}, \quad (14)$$

where the exchange rate e converts country B currency into country A currency. By continuing to assume that firms operate with constant returns to scale, we separate sales decisions in the two countries. Firm A1's quantity reaction function for country A is

$$2q_{A1} + q_{A2} + ... + q_{AA} + \sqrt{\frac{\xi_{BA}}{\xi_{AA}}}(x_{B1} + ...x_{BB}) = a - \frac{c}{\xi_{AA}}. \quad (15)$$

There are similar reaction functions for every other firm for country A. Symmetry implies that in equilibrium every country A firm will sell the same amount in country A (q_A) and every country B firm will sell the same amount in country A (x_B). We can impose symmetry on the quantity reaction functions to obtain two condensed reaction functions that can be solved for country A equilibrium outputs:

$$(A+1)q_A + B\sqrt{\frac{\xi_{BA}}{\xi_{AA}}}x_B = a - \frac{c}{\xi_{AA}} \quad (16)$$

$$A\sqrt{\frac{\xi_{AA}}{\xi_{BA}}}q_A + (B+1)x_B = a - \frac{ec}{\xi_{BA}} \quad (17)$$

Thus in equilibrium, firm sales in country A are

$$q_A = \frac{(B+1)\left(a - \frac{c}{\xi_{AA}}\right) - B\sqrt{\frac{\xi_{BA}}{\xi_{AA}}}\left(a - \frac{ec}{\xi_{BA}}\right)}{A+B+1} \quad (18)$$

[4]Two polar cases may be distinguished. If $\xi_{AA} = \xi_{AB} = \xi_A$ and $\xi_{BA} = \xi_{BB} = \xi_B$, then varieties have the same quality image in both countries. (For example, consumers in both countries believe Japanese cars are of high quality.) On the other hand, if $\xi_{AA} = \xi_{BB} > \xi_{AB} = \xi_{BA}$, consumers in each country believe domestic varieties are of higher quality than imported varieties.

$$x_A = \frac{(A+1)\left(a - \frac{ec}{\xi_{BA}}\right) - A\sqrt{\frac{\xi_{AA}}{\xi_{BA}}}\left(a - \frac{c}{\xi_{AA}}\right)}{A+B+1} \tag{19}$$

It is apparent that in equilibrium an increase in ξ_{AA} increases q_A and reduces x_B. An increases in ξ_{BA} has opposite effects. Combining the equations of the inverse demand curves and the reaction functions, we find that in equilibrium

$$p_{AA} = c + \xi_{AA} q_A \tag{20}$$

$$p_{BA} = ec + \xi_{BA} q_A \tag{21}$$

This allows us to evaluate the impact of an increase in e — a devaluation of the country A currency — on country A prices:

$$\frac{\partial p_{AA}}{\partial e} = \frac{B}{A+B+1}\sqrt{\frac{\xi_{AA}}{\xi_{BA}}}c > 0 \tag{22}$$

$$\frac{\partial p_{BA}}{\partial e} = \frac{B}{A+B+1}c > 0 \tag{23}$$

(23) implies that the passthrough of exchange rate fluctuations to the country A price of country B varieties is invariant to product quality. But (22) shows that the price of domestic varieties is more sensitive to exchange rate fluctuations, the greater the quality of domestic varieties relative to the quality of foreign varieties. This reflects the fact that p_{AA} is greater, the greater is ξ_{AA}/ξ_{BA}.

4 Product Quality and Infant Industry Protection

Return to equation (18), which gives equilibrium domestic firm output in country A. q_A is nonnegative if and only if

$$\sqrt{\xi_{AA}}\left(a - \frac{c}{\xi_{AA}}\right) \geq \frac{B}{B+1}\sqrt{\xi_{BA}}\left(a - \frac{ec}{\xi_{BA}}\right) \tag{24}$$

The left–hand side of (24) rises as ξ_{AA} rises, and the right–hand side of (24) rises as ξ_{BA} rises. The right–hand side of (24) also rises as B rises. It follows that if ξ_{AA} is sufficiently small, and ξ_{BA} sufficiently large, inequality (24) will be violated and the Cournot equilibrium output of country A firms in the country A market will be zero. If domestic firms produce low–quality varieties in competition with many foreign firms that produce high quality varieties, they may be driven from their home market. For the many markets in which a relatively long time period is required to improve product quality, government protection of the home market may be called for if domestic firms are to make the transition from low–quality to high–quality production.

5 Conclusion

Vertical product differentiation is a critical determinant of market performance in oligopoly and of intra–industry trade flows in imperfectly competitive markets. The model examined here suggests that the higher the relative quality of the products of domestic firms, the greater their equilibrium outputs and prices, and the more are those prices affected by exchange rate fluctuations. If domestic firms produce relatively low quality varieties, their equilibrium output may be zero. This offers a rationale for "infant industry" protection while quality is improved.

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