

Eaton, Jonathan; Kierzkowski, Henryk

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Oligopolistic Competition, Product Variety and Entry Deterrence

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ECONOMIC GROWTH CENTER

YALE UNIVERSITY

Box 1987, Yale Station
New Haven, Connecticut

CENTER DISCUSSION PAPER NO. 423

Oligopolistic Competition, Product Variety
and Entry Deterrence

Jonathan Eaton
Yale University

and

Henryk Kierzkowski

Graduate Institute of International Studies, Geneva

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ABSTRACT

This paper develops a model of industrial structure and product variety when technology is characterized by increasing returns to scale. Unlike theories of increasing returns in markets that are contestable, we assume here that an entrant must incur a fixed cost prior to entering the market. Pricing and output decisions occur subsequently. When entry and pricing decisions are sequential in this way the nature of the resulting market equilibrium is quite different from that which arises when they are simultaneous. Product variety is likely to be lower and there is room for excess profits. When there is more than a single producer consumers benefit from having majority tastes. Entry deterrence behavior on the part of an initial entrant can reduce social welfare. Growth and convergence of tastes can benefit or harm consumers. An incentive may arise for an efficient firm to sell its technology to relatively inefficient producers.

1. Introduction

This paper develops a model of product variety to examine how competition among actual and potential producers determines the characteristics of products produced. The model is used to consider the effects of market size, barriers to entry, and differences in tastes between different groups of consumers on the configuration of models produced, welfare, and distribution of income. The incentive for a firm with a superior technology to sell that technology to other actual and potential producers is also analyzed.

We model an industry that produces a differentiated commodity that embodies a characteristic that may be represented by a real number. Each consumer has an ideal model of that commodity, and will buy other models only when the price is sufficiently lower. Diversity in tastes is represented by differences among consumers in their ideal models. In this respect our formulation follows from the location models developed by Hotelling (1929), Lancaster (1971), Eaton and Lipsey (1975), Prescott and Visscher (1977), Salop (1979), and Lane (1980), among other. We depart from these authors, however, in representing the distribution of consumer tastes by discrete points rather than a continuum along a line or circle. This representation allows us to examine the effects of differences in the relative number of consumers with different tastes very easily. In contrast, models that represent the distribution of consumer tastes as a continuum have difficulty characterizing the distribution of tastes as anything but uniform (See Eaton and Lipsey, 1975). Our approach, in particular, allows us to distinguish minority and majority groups of consumers.

We follow Prescott and Visscher (1977), Eaton and Lipsey (1978), and Lane (1981) in describing equilibrium as the outcome of a two-stage process. In the first stage firms commit themselves to producing a particular model of a commodity; they do so sequentially. In the second stage firms that have entered determine prices and outputs given the set of firms that entered initially and the models they established. We assume perfection in the sense that actual and potential producers make their entry and model choice decisions calculating correctly the effects of their actions on the second stage outcome.

By treating entry and model choice as decisions that are made prior to price and output decisions, the choice of model becomes a component of a firm's behavior to deter entry. By committing itself to produce a particular model a firm can deter entry by other firms. Furthermore, because firms enter and establish models before price and output decisions are made, free entry does not enforce average cost pricing. Lancaster, (1971), Spence, (1976), Salop (1979), Baumol, Panzar and Willig (1982), on the other hand, assume that firms may enter and exit in response to the price and output decisions of existing firms. As a consequence the threat of entry leads to average cost pricing by existing firms. Treating entry and pricing decisions as sequential rather than as simultaneous actions leads to very different conclusions to a number of questions.

For example, because a firm may bias its choice of model to deter further entry, the threat of entry or expansion in the size of a market can reduce welfare. A firm, by appropriate choice of a model, may be able to establish an artificial monopoly. In the consequent equilibrium welfare is lower than if the first entrant had been granted a franchise monopoly, i.e., if further entry were prohibited. It is also

the case that when model choice is a component of entry deterrence strategy, the opening of international trade can yield an outcome that is Pareto inferior to autarky. We develop this point at greater length elsewhere. (Eaton and Kierzkowski, 1982).

Turning to the second stage of the determination of equilibrium, the price and output decisions of firms that have previously entered and committed themselves to particular models, we show that there are a continuum of Nash-Cournot equilibria when there are two entrants. The Nash-Bertrand equilibrium concept, on the other hand, does not yield any solution in pure strategies if firms have established non-identical models, unless the models they produce are very different and tastes are very disparate. This nonexistence problem is similar to that pointed out by d'Aspremont, Gabszewicz and Thisse (1979) for the Hotelling model in which two firms compete for a continuum of consumers along a line segment. These authors show that existence reemerges when disutility or transport cost is quadratic rather than linear in distance. Introducing quadratic costs does not yield existence when consumers are located at discrete intervals, however. To obtain a unique, well-defined equilibrium in prices and outputs we therefore introduce an alternative equilibrium concept that assumes more sophisticated beliefs on the part of each firm about the reactions of its competitors to its decisions. This alternative equilibrium concept, which we call a semi-reactive Bertrand equilibrium, does yield a unique solution in pure strategies for the problem we consider here. The conjectures on the part of each firm about its rival's behavior assumed in our equilibrium definition have the property of being locally correct, unlike the Nash-Cournot and Nash-Bertrand conjectures (See Bresnahan, 1981).

The outline of the paper is as follows. Section 2 sets forth our assumptions about technology and preferences. Section 3 characterizes the market equilibrium that obtains, section 3.1 treating the price and output competition that arises among a given number of entrants and section 3.2 the sequential entry of firms in the previous stage. Section 4 considers the effects of the threat of entry on welfare and the distribution of income. Here we show that the threat of entry can reduce welfare. The effect of an increase in the number of consumers is discussed in section 5. One result is that an increase in the number of minority consumers can have a Pareto worsening effect. Another is that when two firms have established production, consumers typically benefit from an increase in the number of similar consumers but are adversely affected by an increase in the number of consumers with different tastes. Section 6 considers the effect of the disparity of tastes between groups of consumers on their welfare. Up to a point consumers benefit from buying in an economy in which other consumers' tastes are not too different from their own. The proximity creates more rivalry among producers. At some point this rivalry inhibits entry, however, thereby leading to monopoly and leaving consumers worse off. Section 7 examines the issue of the transfer of technology between firms. It is shown that a firm with unique access to a superior technology may be able and willing to sell that technology to a subsequent entrant if (i) no other entrant would otherwise have entered, (ii) tastes among consumers are sufficiently different, and (iii) the number of total consumers is sufficiently large. A transfer of technology among two successful entrants is sustainable, however, only when the entrant with the superior technology is restricted to the smaller market. Finally, some concluding remarks appear in section 8.

2. Technology and Preferences

We follow Lancaster (1971) in considering a differentiated commodity that embodies some characteristic Z that may be represented by a real number. Product differentiation is thus isomorphic to location on a line of infinite length. A particular model of the commodity embodies some characteristic Z .

We also assume that production occurs at increasing returns to scale. There is a fixed cost K that must be incurred to produce a particular model and there is a constant marginal cost of production c . The total cost of producing an amount x of a particular model is therefore $K + xc$. This specification of technology is found, for example, in Salop (1977) and Dixit and Stiglitz (1977). We assume in addition, however, that a firm must incur the fixed cost K and commit itself to a particular model before the level of output and price are determined. Thus at the time the firm establishes output and price the cost K is sunk and the model of the product it produces is determined.

We assume, in keeping with other literature on differentiated products, that a single firm can produce no more than a single model of the product. There are extreme diminishing returns to scope in this sense.

The preferences of each individual i are characterized by a parameter θ_i that denotes the individual's ideal model of the commodity. His utility declines as the model he consumes becomes more distant from his ideal. For concreteness we adopt the form of the utility function used by Salop (1977):

$$(1) \quad V(Y, p, \theta_i, Z_i) = \max [Y - p_i - |\theta_i - Z_i|, Y - \bar{p}]$$

where Z_i is the model consumed by individual i , p_i the price paid for it, and Y his income. This functional form implies that the individual demands one unit of the commodity if it is available at a price $p \leq \bar{p} - |\theta_i - Z_i|$ and zero units

otherwise. If more than one variety is available the individual consumes the model for which $p_i + |\theta_i - Z_i|$ is at a minimum, if this amount is less than or equal to \bar{p} .

3. Market Equilibrium

Consider a market that consists of two types of individuals, each characterized by a different taste parameter θ_i , $i = 1, 2$ and numbering n_i , $i = 1, 2$.

Let $\theta_2 \geq \theta_1$.

Equilibrium in the market for the commodity is established in a two-step process. First, firms incur the fixed cost K and select models. Second, firms determine output levels and prices given the models that were established in the first stage. The objective of a potential entrant is to maximize expected profits.¹

3.1 Price and Output Equilibrium

We analyse the second stage of the process, output and price determination given established models, first. We then turn to the issue of firm entry.

Pricing equilibrium is discussed according to the number of entrants.

3.1.1 A Single Firm

Consider first the case in which a single entrant has established a model Z_1 . It may choose to sell only to the market closer to Z_1 (i.e., the one for which $|Z_1 - \theta_i|$ is lower), and earn a maximum of $[\bar{p} - |Z_1 - \theta_i| - c] n_i - K$ or else to sell to both markets, in which case he must set $p \leq \bar{p} = \bar{p} - \max\{|Z_1 - \theta_1|, |Z_1 - \theta_2|\}$ to earn at most $(\bar{p} - c)(n_1 + n_2) - K$. If $|Z_1 - \theta_1| < |Z_1 - \theta_2|$, the second or first option is more attractive as

$$(\bar{p} - c)(1 - \lambda) \gtrless |Z_1 - \theta_2| - \lambda |Z_1 - \theta_2|$$

where $\lambda \equiv n_1 / (n_1 + n_2)$, the proportion of type 1 consumers. Assuming that any production is profitable, selling to the broader set of consumers is more attractive when (i) the reservation price \bar{p} is high relative to marginal cost; (ii) the size of the closer market is small relative to the entire market; and (iii) the closer market is not substantially closer.

3.1.2 Two firms

Consider now the situation in which two firms have established models

Z_1 and Z_2 . Assume, for the moment, that $\theta_1 \leq Z_1 \leq Z_2 \leq \theta_2$. We constrain the two firms to have the same overhead cost K but allow them to have different marginal costs, c_1 and c_2 respectively. We assume that the firms must charge both types of buyers the same prices, i.e. price discrimination between markets is infeasible.

The output and pricing decisions of the two firms, given Z_1 and Z_2 , thus constitute a standard duopoly problem modified to incorporate different product characteristics. The standard equilibrium notions applied to such problems are the Nash-Cournot and Nash-Bertrand concepts. As is well known, they can yield very different outcomes. It is also the case that each raises several difficulties for the problem we consider here.

Consider first Nash-Cournot equilibrium. Denoting the outputs of the two firms as q_1 and q_2 respectively, any outcome $q_1^*, q_2^*, p_1^*, p_2^*$, such that

$$(2) \quad q_1^* + q_2^* = n_1 + n_2,$$

$$p_1^* = \bar{p} - |Z_1 - \theta_1|$$

$$p_2^* = \bar{p} - \max \{ |Z_2 - \theta_1|, |Z_2 - \theta_2| \}$$

$$(p_2^* - c_2) (n_1 + n_2 - q_1^*)$$

$$> [\bar{p} - |Z_2 - \theta_2| - c_2] n_2$$

if $q_1^* < n_1$

$$p_1^* = \bar{p} - \max \{ |Z_2 - \theta_1|, |Z_2 - \theta_2| \}$$

$$p_2^* = \bar{p} - |Z_2 - \theta_2|$$

if $q_1^* > n_1$

$$(p_1^* - c_2) (n_1 + n_2 - q_2^*) >$$

$$[\bar{p} - |Z_1 - \theta_1| - c_2]$$

$$p_1^* \geq c \quad \text{if } q_1^* > 0$$

$$p_2^* \geq c \quad \text{if } q_2^* > 0$$

where p_1^* and p_2^* constitute the two firms' respective output prices, is an equilibrium. An attempt by firm i to increase q_i above q_i^* given q_j^* , $j \neq i$, will drive the price to zero in whichever market the increment is sold, thereby lowering firm i 's profits. Reducing q_i from q_i^* , given q_j^* , $j \neq i$, will reduce profits by $p_i^* - c_i$. The Nash-Cournot equilibrium concept thus fails to identify a single or even a countable number of outcomes.

Consider the Nash-Bertrand equilibrium, however. Define $\delta \equiv Z_2 - Z_1$, the distance between the two models. Taking firm 1's price as given at p_1 , firm 2 will choose p slightly below

$$(3a) \quad p_2 = p_1 - \delta$$

or at

$$(3b) \quad p_2 = \max(p_1 + \delta, \bar{p} - |\theta_2 - Z_2|)$$

as

$$(3c) \quad (p_1 - \delta - c_2)(n_1 + n_2) \geq [\max(p_1 + \delta, \bar{p} - |\theta_2 - Z_2|) - c_2] n_2$$

If the resulting $p_2 < c_2$, firm 2 will not produce. To break ties we assume that, if (3c) obtains with equality, firm 2 chooses (3b).

In other words, the second firm may sell at the maximum price at which its product is attractive to both types of consumers (3a) or else may sell at a price attractive only to consumers with tastes relatively closer to the product firm 2 produces (3b). Condition (3c) determines which will yield higher profits.

Similarly, firm 1 will choose p slightly below

$$(4a) \quad p_1 = p_2 - \delta$$

or at

$$(4b) \quad p_1 = \max(p_2 + \delta, \bar{p} - |Z_1 - \theta_1|)$$

as

$$(4c) \quad (p_2 - \delta - c_1)(n_1 + n_2) \geq [\max(p_2 + \delta, \bar{p} - |Z_1 - \theta_1|) - c_1] n_1$$

Let \hat{p}_1 and \hat{p}_2 denote the values of p_1 and p_2 at which (4b) and (4c) both hold with

equality.

Equation (3) constitute firm 2's reaction function to firm 1's price while (4) is firm 1's reaction function to firm 2's price. They are illustrated in Figure 1 for the case in which $\hat{p}_1 + \delta \leq \bar{p} + |\theta_2 - z_2|$ and $\hat{p}_2 + \delta < \bar{p} + |z_1 - \theta_1|$. The curve ABCD constitutes the second firm's reaction function to p_1 while A'B'C'D' is firm 1's response to p_2 . Along the segment B'C the second firm tries to sell to both types of consumer; p_1 and p_2 both fall to point C. The price \hat{p}_1 is the price at which (3c) holds with equality. At this point firm 2 raises its price from C to B, making sales to both types of consumers attractive to firm 1. Firm 1 now lowers its price to compete with firm 2 for type 2 consumers. Prices are driven down along BC' to C', at which point type 2 consumers are no longer attractive to firm 1, since \hat{p}_2 is the price at which (4c) holds with equality. Firm 1 raises its price from C' to B'. The cycle repeats. The discontinuity of firm 2's reaction function between B' and C' and firm 1's between B and C eliminates the possibility of a Nash-Bertrand equilibrium in pure strategies.

This discontinuity persists when either $\hat{p}_1 \leq \bar{p} - |z_1 - \theta_1|$ or $\hat{p}_2 < \bar{p} - |\theta_2 - z_2|$, as the reader may verify on figure 1. Only when $\hat{p}_1 \geq \bar{p} - |z_1 - \theta_1|$ and $\hat{p}_2 \geq \bar{p} - |\theta_2 - z_2|$ does an equilibrium obtain. At this equilibrium $p_1 = \bar{p} - |z_1 - \theta_1|$ and $p_2 = \bar{p} - |\theta_2 - z_2|$: each firm sells to its closer market at the monopoly price in that market. Since \hat{p}_1 and \hat{p}_2 both rise with δ , equilibrium is more likely to obtain the greater the distance between the two firms.²

Modifying the definition of Nash-Bertrand equilibrium by allowing each firm to incorporate the other firm's response to its own price leads to a well-defined equilibrium in pure strategies, however, that is independent of the firms' distance apart.³ We adopt the following, modified definition of Bertrand equilibrium.

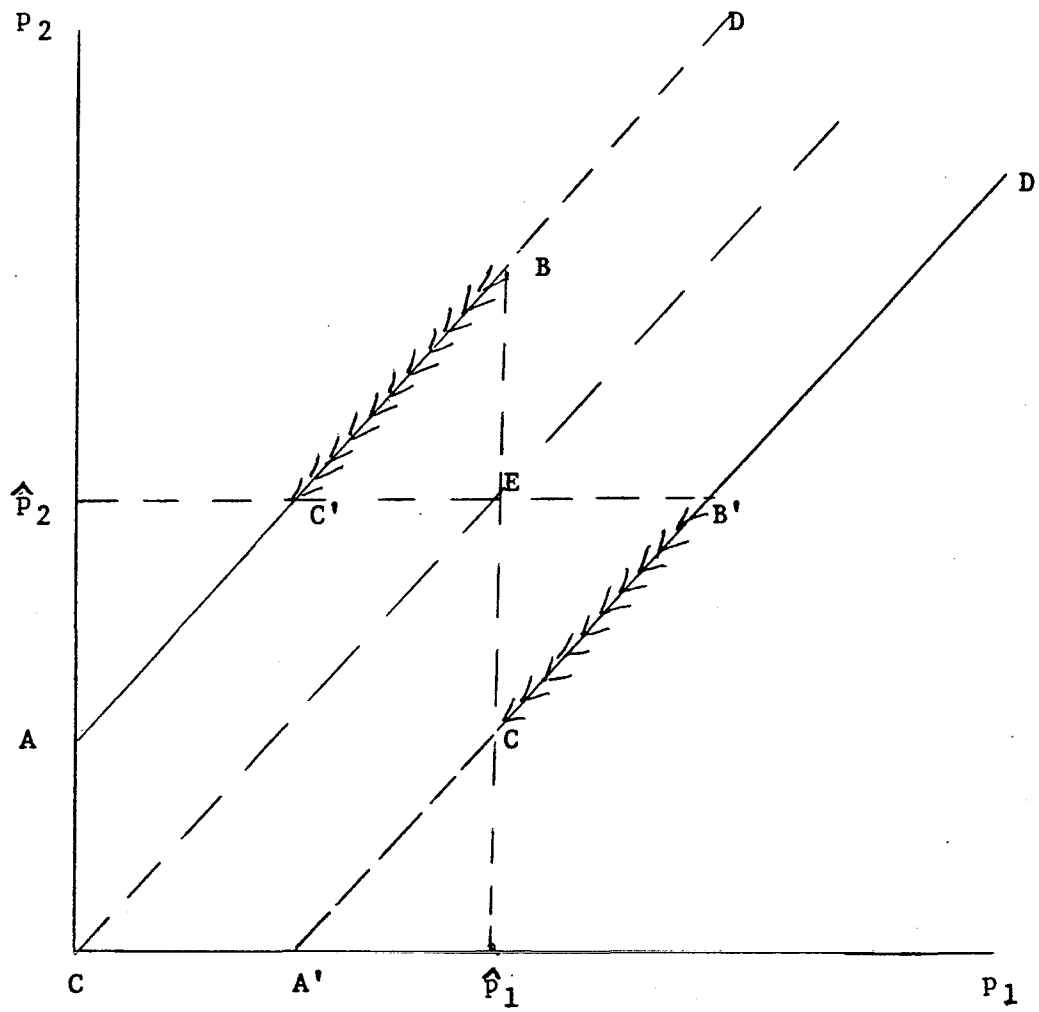


Figure 1.

Definition: If n firms have established models Z_1, \dots, Z_n , the prices $\{p_i^*, i = 1, \dots, n\}$ constitute a semi-reactive Bertrand equilibrium if and only if for each firm j : (i) given the prices $\{p_i^*, i \neq j\}$ firm j cannot earn a higher profit at any price below p_j^* and (ii) at any price above p_j^* at least one firm $i \neq j$ can earn a higher profit at a price below p_i^* or else p_j^* is the monopoly price in at least one market.

The semi-reactive Bertrand equilibrium price vector and the corresponding profit level of each firm are functions of the established models Z_1, \dots, Z_n and are denoted $\{p_i^*(Z), i = 1, \dots, n\}$ and $\{\Pi_i^*(Z), i = 1, \dots, n\}$ respectively.

In this equilibrium each firm takes other firms' prices as given when contemplating price reductions. In considering price increases, however, each firm takes into account the incentive it may create for any other firm to lower its price. At the point of equilibrium this conjecture constitutes the locally correct conjectural variation (see, e.g., Bresnahan (1981)). Any firm not located very close to another firm can reduce its price slightly without creating an incentive for any other firm to reduce its price. It cannot raise its price without creating an incentive for a competing firm to lower its price unless it is charging the monopoly price in one market.

Returning to the two firm case consider firm 2's decision to set p_2 , given p_1 . Selling to both markets requires setting p_2 below

$$(5a) \quad p_2 = p_1 - \delta$$

If firm 2 sells only to its own market at some price p_2' , it provides an incentive to firm 1 to charge just below $p_2' - \delta$, selling to both markets, iff

$$(5b) \quad (p_2' - \delta - c_1) (n_1 + n_2) > (p_1 - c_1) n_1$$

The highest price that firm 2 can charge without inducing firm 1 to lower its price from p_1 is thus given, from (5b), by

$$(5b') \quad \tilde{p}_2 = \lambda p_1 + (1 - \lambda) c_1 + \delta$$

Firm 2 will thus set

$$p_2 = p_1 - \delta \text{ or } p_2 = \tilde{p}_2 \text{ as}$$

$$(5c) \quad (p_1 - \delta - c_2) (n_1 + n_2) \geq (\tilde{p}_2 - c_2) n_2$$

Given p_2 , firm 1 may choose p just below

$$(6a) \quad p_1 = p_2 - \delta$$

and sell to both markets. Selling to type 1 consumers only it can charge as much as

$$(6b) \quad \tilde{p}_1 = (1 - \lambda) p_2 + \lambda c_2 + \delta$$

without attracting entry by firm 2. Selling to both markets rather than just to type 1 consumers yields higher on lower profits as

$$(6c) \quad (p_2 - \delta - c_1) (n_1 + n_2) \geq (\tilde{p}_1 - c_1) n_1$$

Figure 2 illustrates the two reaction functions implied by (5) and (6).

If firm 1 charges a price above

$$(7) \quad p_1^* = \frac{(1 - \lambda)^2 c_1 + \lambda c_2 + (2 - \lambda) \delta}{1 - \lambda + \lambda^2}$$

then firm 2 will charge $p_1 - \delta$ and attempt to sell to both markets. Both prices will then be bid down along DC. Similarly, if firm 2 sells at a price above p_2^* , prices will fall along D'C'. If firm 1 sets p_1 below p_1^* , firm 2 will respond by selling p_2 on the segment AB. Firm 1 can raise its profits by raising its price until p_1^* is reached. Beyond this price firm 2 will respond by lowering rather than by raising its price.

The threshold price for firm 2 is

$$(8) \quad p_2^* = \frac{\lambda^2 c_2 + (1 - \lambda) c_1 + (1 + \lambda) \delta}{1 - \lambda + \lambda^2}$$

The price combination p_1^* , p_2^* , point B in figure 2, thus constitutes a semi-reactive Bertrand equilibrium:⁴ if firm 1 raises its price above p_1^* firm 2, will lower p_2 in order to sell to both markets. Anticipating this reaction, firm 1 will thus not raise p_1 . Lowering p_1 , on the other hand, given p_2 , cannot raise firm 1's profits. Similarly for p_2 .

Several conclusions follow from (7) and (8):

- (1) If the two firms have the same marginal cost (i.e., if $c_1 = c_2 = c$), then

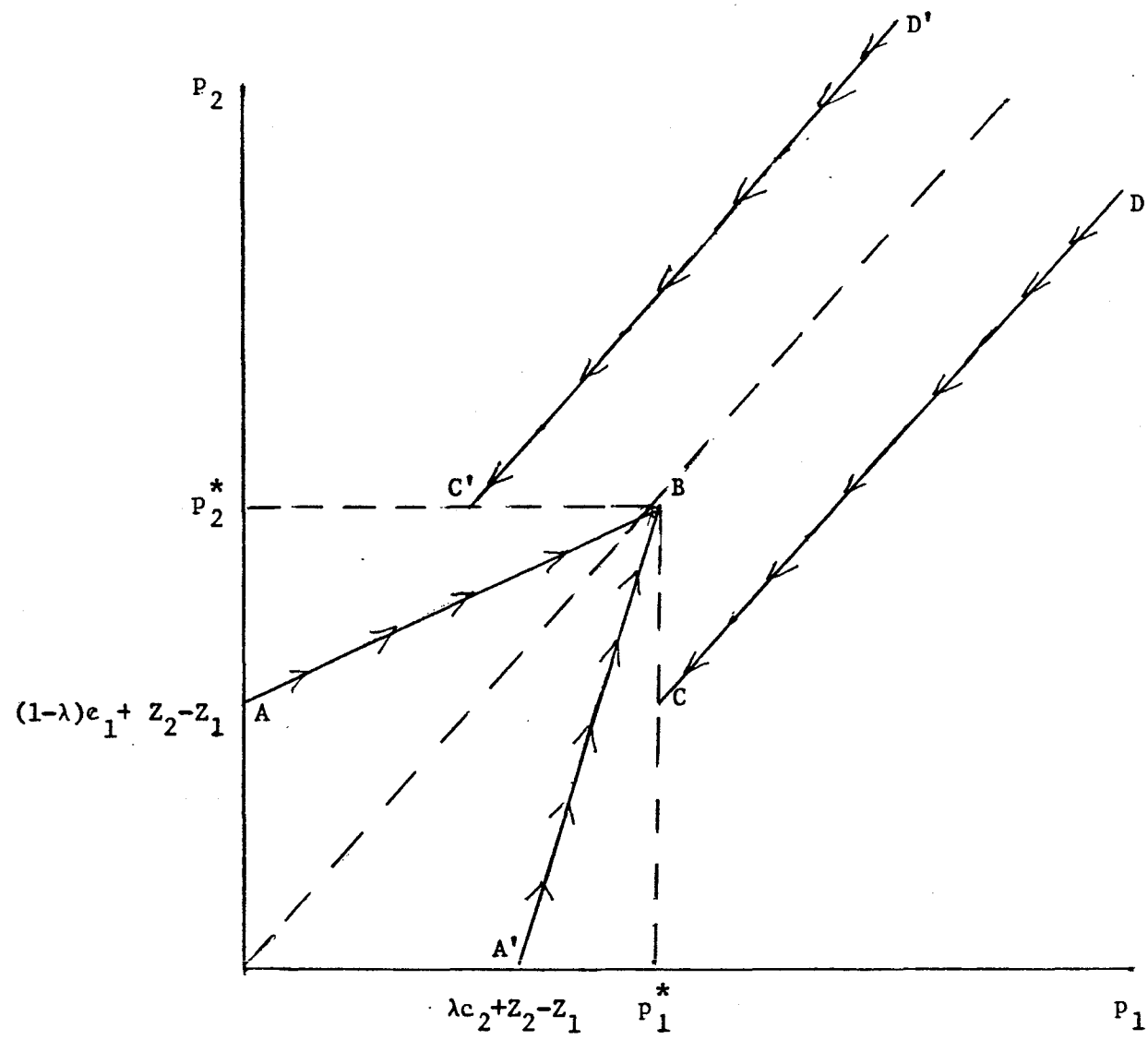


Figure 2

$$(7') \quad p_1^* = c + \frac{(2 - \lambda) \delta}{1 - \lambda + \lambda^2}$$

$$(8') \quad p_2^* = c + \frac{(1 + \lambda) \delta}{1 - \lambda + \lambda^2}$$

The firm selling to the smaller number of consumers will charge the higher price. This firm's market is the less attractive one, and it can charge a higher price without providing an incentive for the other firm to enter.

(ii) If, in addition to $c_1 = c_2$, the two firms produce the same models, (i.e., if $\delta = 0$) then $p_1^* = p_2^* = c$; i.e., the reactive Bertrand equilibrium price equals the marginal cost of production. This price also corresponds to the Nash-Bertrand equilibrium for this case.⁵ If $\delta = 0$ while $c_1 > c_2$, the condition $p_1^* > c_1$ would be violated. Firm 1 would not produce while firm 2 would set p_2 just below c_1 .

(iii) If the two firms have the same market sizes ($\lambda = 1/2$) then

$$(7'') \quad p_1^* = (1/3) c_1 + (2/3) c_2 + 2 \delta$$

$$(8'') \quad p_2^* = (2/3) c_1 + (1/3) c_2 + 2 \delta$$

Both firms' marginal costs affect each firm's price; but the firm with the lower marginal cost charges the higher price.

(iv) The greater the difference between the two models the higher the price each will charge.

In equilibrium firm 1 earns a profit

$$(9) \quad \Pi_1 = \left[\frac{\lambda (c_2 - c_1) + (2 - \lambda) \delta}{1 - \lambda + \lambda^2} \right] n_1 - K$$

while firm 2 earns

$$(10) \quad \Pi_2 = \left[\frac{(1 - \lambda) (c_1 - c_2) + (1 + \lambda) \delta}{1 - \lambda + \lambda^2} \right] n_2 - K$$

Not surprisingly, Π_1 rises (and Π_2 falls) as firm 2's cost of production rises relative to firm 1's (i.e., as $c_2 - c_1$ rises). The absolute levels do not matter. In addition, both firms' profits rise as their products become more different (i.e., as δ rises). Finally, substituting $n_1 = \lambda (n_1 + n_2)$ into (9) and $n_2 = (1 - \lambda) (n_1 + n_2)$ into (10), it can be shown that both firms' profits rise when the total market size increases (i.e., as $n_1 + n_2$ rises) holding λ constant, and that each firm's profits rise as its share of the market (λ for firm 1 and $1 - \lambda$ for firm 2) rises, given the total market size, $n_1 + n_2$. Thus, even though the firm with the larger market must charge the lower price to preclude entry by the other firm, its larger sales volume more than compensates it.

3.1.3 Three or More Firms

Consider the case in which three firms have established models Z_1, Z_2, Z_3 where $\theta_1 < Z_1 < Z_2 < Z_3 < \theta_2$. It is straightforward but tedious to establish that in a reactive Bertrand equilibrium at most only two firms will sell in positive amounts or else at least two firms will sell at their marginal cost. If

$$(11a) \quad c_2 + (Z_2 - Z_1) > c_1$$

$$(11b) \quad c_2 + (Z_3 - Z_2) > c_3$$

then only firms 1 and 3 will produce, selling $p_1 = c_2 + (Z_2 - Z_1)$ and $p_3 = c_2 + (Z_3 - Z_2)$ respectively. If only (11a) is reversed, firm 2 will displace firm 1, selling to type 1 consumers at $p_3 = c_1 - (Z_2 - Z_1)$, while if only (11b) is reversed firm 2 will displace firm 3, selling to type 2 consumers at $p_3 = c_2 - (Z_3 - Z_1)$. If both are reversed firm 3 will displace one or both firms as

$$\min [c_1 - (Z_2 - Z_1), c_3 - (Z_3 - Z_2)] (n_1 + n_2) \geq$$

$$\max \{ [c_1 - (Z_2 - Z_1)] n_1, [c_3 - (Z_3 - Z_2)] n_2 \}$$

In the event that (11a) is replaced by an equality while (11b) continues to hold both firms 1 and 2 will sell at marginal cost to type 1 consumers. Similarly if (11b) is replaced by an equality while (11a) continues to hold both firms 2 and 3 will sell at marginal cost to type 3 consumers. Given that all firms have incurred the fixed, sunk cost K at least one firm will earn negative profits.

3.2 Model Equilibrium

In Section 3.1 we discussed how in equilibrium outputs, prices and profits are determined among a group of established producers. We now consider the entry decision itself. We follow Prescott and Visscher (1977) and Lane (1980) (i) in treating entry and model choice as determined prior to price and output decisions and (ii) in treating the entry decision as sequential rather than simultaneous. This second assumption means that each entrant decides whether or not to enter taking as given the model choice of previous entrants and assuming that subsequent potential entrants will behave similarly, choosing to establish a model or not taking its own entry and model as given. All potential entrants are assumed to maximize profits and to be perfectly informed about the distribution of tastes and about each other's technologies.

The equilibrium number of entrants and their models can be determined via the backward induction method of dynamic programming. Consider the case in which n firms have entered and established models Z_1, \dots, Z_n . For this set of models to constitute an equilibrium no additional firm can establish a model and earn nonnegative profits in the resulting equilibrium; i.e.,

$$(12) \quad V(Z_1, \dots, Z_n) \equiv$$

$$\max_{Z_{n+1}} \Pi(Z_1, \dots, Z_n; Z_{n+1}) < 0$$

Let $Z_{n+1}^*(Z_1, \dots, Z_n)$ denote the value of Z_{n+1} that attains $V(Z_1, \dots, Z_n)$

The n th firm to enter will choose Z_n , taking Z_1, \dots, Z_{n-1} and the function $Z_{n+1}^*(Z_1, \dots, Z_n)$ as given, to attain

$$(13) \quad V(Z_1, \dots, Z_{n-1}) \equiv \\ \max_{Z_n} \{ \Pi(Z_1, \dots, Z_n, Z_{n+1}^*(Z_1, \dots, Z_n)) \}$$

Here

$$(14) \quad \Pi(Z_1, \dots, Z_n, Z_{n+1}^*(Z_1, \dots, Z_n)) \equiv \\ \Pi(Z_1, \dots, Z_n)$$

as long as $V(Z_1, \dots, Z_n) < 0$. Let $Z_n^*(Z_1, \dots, Z_{n-1})$

denote the value of Z_n that attains $V(Z_1, \dots, Z_{n-1})$. In general, the i 'th entrant chooses its model Z_i to attain

$$(13') \quad V(Z_1, \dots, Z_{i-1}) \equiv \\ \max_{Z_i} \{ \Pi(Z_1, \dots, Z_{i-1}; Z_i; Z_{i+1}^*(Z_1, \dots, Z_i), \dots, Z_{n+1}^*(Z_1, \dots, Z_n)) \}$$

where, as before,

$$(14') \quad \Pi(Z_1, \dots, Z_i, Z_{i+1}^*(\quad), \dots, Z_{n+1}^*(\quad)) = \\ \Pi(Z_1, \dots, Z_i, Z_{i+1}^*(\quad), \dots, Z_n^*(\quad))$$

as long as $V(Z_1, \dots, Z_i, Z_{i+1}^*(Z_1, \dots, Z_i), \dots, Z_n^*(Z_1, \dots, Z_{n-1})) < 0$

We may now establish some propositions about the models that will be established in a market with two classes of consumers.

First, these will be at most two producers. Section 3.1.3 establishes that in a market with three producers at most two will sell positive amounts or else two firms will sell at marginal cost. In either case at least one firm will sustain negative profits.⁶ This firm would not choose to enter.

Consider now the second entrant's decision. It takes the first firm's entry and its model, Z_a , as given, and chooses its model, Z_b , to maximize its profits. It need not concern itself with further entry. If it sets $Z_b > Z_a$ it will realize profits of

$$\Pi_2(Z_a, Z_b) = \left[\frac{\lambda(c_a - c_b) + (2 - \lambda)(Z_b - Z_a)}{1 - \lambda + \lambda^2} \right] n_2 - K$$

while, if it set $Z_b < Z_a$ its profits are

$$\Pi_2^*(Z_a, Z_b) = \left[\frac{(1 - \lambda)(c_a - c_b) + (1 + \lambda)(Z_a - Z_b)}{1 - \lambda + \lambda^2} \right] n_1 - K$$

The first expression is maximized at $Z_b = \theta_2$ while the second is maximized at $Z_b = \theta_1$.⁷ Thus, given Z_a , firm 2 sets $Z_b = \theta_1$ or $Z_b = \theta_2$

as $\Pi_2^*(Z_a, \theta_1) \geq \Pi_2(Z_a, \theta_1)$, assuming that the larger is nonnegative. Otherwise it does not enter at all. In either case there will be no further entry.

Consider now the first firm's entry decision, which is considerably more complicated. It must consider (i) whether it can preclude further entry; (ii) if so, if it is profitable to preclude further entry; and (iii) if it does preclude further entry, whether it should sell to one or to both types of consumers.

The first entrant can preclude further entry if for some value of Z_a , $V(Z_a) \equiv \max[\Pi(Z_a, \theta_2), \Pi^*(Z_a, \theta_1)] < 0$

or, equivalently, if there exists a $Z_a \in (\underline{Z}_a, \bar{Z}_a)$ where

$$(15a) \quad \underline{Z}_a = \theta_2 - \left[(1 - \lambda)(c_b - c_a) + (1 - \lambda + \lambda^2) K/n_2 \right] / (1 + \lambda)$$

and

$$(15b) \quad \bar{Z}_a = \theta_1 + \left[\lambda(c_b - c_a) + (1 - \lambda + \lambda^2) K/n_1 \right] / (2 - \lambda)$$

That such a Z_a exists is more likely (i) the more similar are tastes (i.e., the smaller $\theta_2 - \theta_1$), (ii) the stronger the first entrant's cost advantage ($c_b - c_a$), and (iii) the larger the fixed cost K .

If the first entrant does not block further entry, then the second entrant will choose either $Z_b = \theta_1$ or $Z_b = \theta_2$. If the second entrant chooses $Z_b = \theta_1$ the first entrant's profit are maximized when $Z_a = \theta_2$. Conversely, when $Z_b = \theta_2$ the first entrant's profits are at a maximum when $Z_a = \theta_1$. If the first firm sets $Z_a = \theta_1$ the best the second firm can do is to set $Z_b = \theta_2$. Thus if the first firm does not deter entry it will set $Z_a = \theta_1$ or $Z_a = \theta_2$ as $n_1 \gtrless n_2$. We assume that $n_1 \geq n_2$. Therefore, in an equilibrium in which both entrants are present $Z_a = \theta_1$ and $Z_b = \theta_2$.⁸

We now enumerate the types of outcomes that can occur. We do not attempt to provide conditions that lead to each one. Instead we discuss some examples.

(i) No entry. If both $(\bar{p} - c) n_1 - K$ and $[\bar{p} - (\theta_2 - \bar{\theta}) - c] (n_1 + n_2) - K$ are negative there will be no entry. Here $\bar{\theta} \equiv |\theta_2 - \theta_1| / 2$, the model halfway between tastes in the two markets.

(ii) One entrant selling to a single market.

There may be only one firm selling to only type one consumers. With no further entry, to maximize profits it will establish $Z_a = \theta_1$ or, if it is necessary to deter entry, set $Z_a > \theta_1$. For the case in which $\lambda = 2/3$ and $c_a = c_b$, the firm can set $Z_a = \theta_1$ and not deter entry iff $\theta_2 - \theta_1 \leq \frac{7K}{15n_2}$. If this condition does not obtain it must set $Z_a \geq \theta_2 - \frac{7K}{15n_2}$ to deter an entrant from establishing $Z_b = \theta_2$. The single entrant's profits are given by

$$(16) \quad \Pi_a = [\bar{p} - (Z_a - \theta_1) - c] n_1 - K$$

(iii) One entrant selling to both markets. A single firm may sell to both types of consumers. With no further entry, to maximize profits it will establish $Z_a = \bar{\theta}$ but may find it necessary to set $Z_a < \bar{\theta}$ to deter

entry. For the case in which $\lambda = 2/3$ and $c_a = c_b$ the firm can set $Z_a = \bar{\theta}$ and not deter entry iff $\theta_2 - \theta_1 \leq \frac{7K}{6n_1}$. If this condition does not obtain it must set $Z_a \leq \theta_1 + \frac{7K}{12n_1}$ to prevent an entrant from establishing $Z_b = \theta_1$. The single entrants profits are given by

$$(17) \quad \Pi_a = [\bar{p} - (\theta_2 - Z_a) - c](n_1 + n_2) - K$$

Assuming that $\theta_2 - \theta_1 \leq \frac{7K}{15n_2}$, so that entry deterrence is possible at any location between θ_1 and $\bar{\theta}$, the single entrant will prefer to set $Z_a = \theta_1$ and sell only to type one consumers or to set $Z_a = \bar{\theta}$ and sell to both types of consumers as $(\theta_2 - \theta_1) \geq 2/3 (\bar{p} - c)$.

(iv) Two entrants, each selling to a single market. The first entrant may not be able to deter further entry (as would be the case if, for instance, $\lambda = 2/3$ and $\theta_2 - \theta_1 > \frac{7K}{12n_2}$) or else not find it profitable to deter further entry. In this case the first entrant will establish $Z_a = \theta_1$ and the second $Z_b = \theta_2$.

Thus, like d'Aspremont, Gabszewicz and Thisse (1979) we find that when two firms do enter there is no tendency for them to locate adjacent to one another, contrary to Hotelling's (1929) "principle of minimum differentiation."

4. Threat of Entry, Welfare and Distribution

According to the contestable markets theory of increasing returns to scale industries, the threat of entry serves the desirable role of enforcing efficiency (see, e.g., Baumol, 1982). If increasing returns take the form of sunk fixed costs, however, the threat of entry can lead to socially wasteful location decisions. Welfare may be raised by the elimination of all potential entrants, i.e., by establishing a franchise monopoly.

Consider the case in which there is only a single entrant selling to a single market. Social welfare is at a maximum when $Z_a = \theta_1$, i.e., when the model produced by the single entrant corresponds to the ideal model of the consumers it sells to. The threat of additional entry may cause a single entrant to modify its product in the direction of the tastes of consumers in another market to preclude entry by a firm servicing that market. In the resulting equilibrium the single entrant will not sell to this second market, yet its presence will have modified the model produced. The firm's profits are consequently lower while no consumer's welfare is higher. The threat of entry thus leads to socially wasteful strategic behavior on the part of a single entrant. Social welfare would be higher if further entry were prohibited.

The first entrant's decision to modify its model constitutes the establishment of a artificial monopoly. (Dixit 1980). Another example of such behavior by an initial entrant, which has received some attention, is the first entrant's decision to invest in capacity beyond the level that is efficient to produce the optimal monopoly output, thereby lowering short run marginal cost and enhancing the first entrant's competitive position vis-a-vis potential entrants. (See, e.g., Spence, 1977; Dixit, 1980; Eaton and Lipsey 1980, 1981; Brander and Spencer, 1982.) In this case, however, under an artificial monopoly, price and output may be closer to their socially optimal levels than under a franchise monopoly (i.e., with restricted entry). The

threat of entry in this case can engender strategic behavior that is welfare improving. When this artificial monopoly is achieved by biasing model choice, however, it is not the case that entry deterrence lowers effective price and raises output. It is purely wasteful.

We discuss the effects of international trade on welfare at length elsewhere (Eaton and Kierzkowski, 1982). It is worth mentioning here that in the case just considered a social gain results from prohibiting trade between markets. With trade prohibited two firms rather than one can establish production, each servicing one market. The first entrant will earn a higher profit, establishing $Z_1 = \theta_1$ and charging \bar{p} , while a second entrant with $Z_2 = \theta_2$, also charging \bar{p} , will earn positive profits as well. Prohibiting trade thus constitutes a superior policy to precluding further entry while both policies dominate laissez-faire.

Entry deterrence can also lead to a redistribution of income from a firm to consumers in the larger market. This occurs when a single firm sells to both markets but biases his product toward the taste of consumers in the larger market to preclude further entry. Consumers in the larger market consequently pay a price below their reservation price $\bar{p} - |\theta_1 - z_1|$ while the firm's profits are below maximum profits if further entry were precluded.

5. Growth and Welfare

The literature on increasing returns to scale provides many examples in which growth in the form of an increase in the number of consumers raises welfare.⁹ In the model developed in sections 2 and 3 the effect of market growth on welfare is ambiguous, and an increase in the number of consumers can result in a Pareto inferior outcome.

Consider the case in which there is a single entrant selling only to the larger market. An increase in the number of consumers in the smaller market may, given the model produced by the single entrant, allow a second entrant to establish production and sell to the smaller market. To deter entry the first entrant may modify its product to correspond more closely to the taste of consumers in the smaller market, even though in the resulting equilibrium no sales are made to those consumers. The single entrant must sell to the larger market at a lower price. Its profits are consequently lower while no consumer's utility is higher. Thus growth in the size of the smaller market yields a Pareto inferior outcome.

Welfare does not fall monotonically as the number of consumers in the smaller market increases, however. Eventually, entry deterrence becomes unprofitable or infeasible so that two firms enter, each producing the ideal model for one market. At this point further increases in the number of type 2 consumers benefit both firms and type 2 consumers while harming type 1 consumers.

6. Taste Differences and Welfare

The disparity of tastes in an economy can be represented by the distance between the ideal models of type 2 and type 1 consumers. It is interesting to compare consumer utility and firm profits in an economy where tastes are disparate ($\theta_2 - \theta_1$ is large) with utility and profits in an economy of equal size where tastes are similar ($\theta_2 - \theta_1$ is small). Alternatively, if the model characteristic Z corresponds literally to its location on a line and if transportation costs are linear in distance a decrease in $\theta_2 - \theta_1$ may be interpreted as a reduction in transportation costs.

Consider first the case in which markets are sufficiently large and tastes everywhere sufficiently disparate to allow entry by two firms. Prices will be lower in the economy in which tastes are similar. Consumers will thus be better off and firms worse off than in the economy in which tastes are disparate.

In the case in which tastes are everywhere sufficiently similar to allow only one entrant, the producer will never earn less where tastes are more similar while in most configurations consumers are unaffected by the difference in taste disparity. An exception arises when the single firm sells to both markets but biases its model toward the taste of the larger market to deter entry. The bias will be less where tastes are similar and consumers in the larger market are consequently worse off.

Finally, if the economy in which tastes are disparate can sustain two producers while the one in which they are similar can sustain only one, consumers benefit from taste disparity. The successful entrant in the economy where tastes are similar will earn more than either firm in the economy where tastes are disparate. In summary, neither firms nor consumers necessarily benefit or lose from a reduction in the disparity of tastes.

7. Technology Transfer

We have assumed that each entrant has access to a potentially different technology. In this section we consider conditions under which a sale of technology from an efficient to an inefficient producer is sustainable in a market equilibrium.

Consider a situation in which there are many potential producers. Only one, firm a, however, has access to a technology that allows it to produce at marginal cost c_a . The rest only have the ability to produce at marginal cost $c_b > c_a$. We assume that firm a is always the initial entrant, possibly because it can sell at a price below c_b and sustain non-negative profits, thus under-bidding any previous entrant.

7.1 Technology Transfer that Leads to Entry

We first consider a situation in which, at the initial levels of c_a and c_b , the market is sufficiently small to allow firm a to preclude entry by establishing any model between θ_1 and $\bar{\theta}$. Firm a's profits are

$$(18) \quad \Pi_a = \left\{ \max \{ (\bar{p} - c_a) n_1, [\bar{p} - (\theta_2 - \bar{\theta}) - c_a] (n_1 + n_2) \} \right\} - K$$

Consider the case of a potential entrant purchasing for an amount T the ability to produce at marginal cost c_a . We assume that its entry to the market would lead to a new, long-run equilibrium in which $Z_a = \theta_1$ and $Z_b = \theta_2$; i.e., we assume that the initial entrant maintains the ability to choose the more popular model. We also assume that in the new equilibrium price competition occurs so that $p_a < \bar{p}$ and $p_b < \bar{p}$.¹⁰ Profits are then

$$(19) \quad \Pi_a = \left[\frac{(2 - \lambda) (\theta_2 - \theta_1)}{1 - \lambda + \lambda^2} \right] n_1 - K + T$$

$$(20) \quad \Pi_b = \left[\frac{(1 + \lambda) (\theta_2 - \theta_1)}{1 - \lambda + \lambda^2} \right] n_2 - K - T$$

For a sale of technology to be sustainable it must be the case that there exists

a. T such that $\Pi'_a \geq \Pi_a$ and $\Pi'_b \geq 0$. Since there are many potential entrants but only one producer with access to the efficient technology, T is determined by the zero profit condition for a potential entrant; i.e. $\Pi^{b'} = 0$ or

$$(21) \quad T = -K + n_2 \left[\frac{(1 + \lambda) (\theta_2 - \theta_1)}{(1 - \lambda + \lambda^2)} \right]$$

Substitution (24) into (22) indicates that sustainability requires

$$(22) \quad \left(\frac{1 + 2\lambda - 2\lambda^2}{1 - \lambda + \lambda^2} \right) (\theta_2 - \theta_1) (n_1 + n_2) - 2K > \Pi_a$$

Inspection of this condition reveals that a transfer is more likely to be sustainable the larger taste differences $(\theta_2 - \theta_1)$ and the overall market size $(n_1 + n_2)$, and the smaller the entry cost K and the monopoly markup $(\bar{p} - c_a)$. The last relationship indicates that, ceteris paribus, a technology transfer is less likely to occur when the technology is highly efficient.

7.2 Technology Transfer Between Successful Entrants.

Consider now the case in which c_b is sufficiently low relative to c_a to allow a second entrant in the absence of a transfer of technology. In this case, prior to any transfer, profits of the two firms are

$$(23) \quad \Pi_a = \left[\frac{\lambda(c_b - c_a) + (2 - \lambda) (\theta_2 - \theta_1)}{1 - \lambda + \lambda^2} \right] n_1 - K$$

$$(24) \quad \Pi_b = \left[\frac{(1 - \lambda) (c_a - c_b) + (1 + \lambda) (\theta_2 - \theta_1)}{1 - \lambda + \lambda^2} \right] n_2 - K$$

For a transfer to occur the price T of the technology must satisfy $\Pi'_a > \Pi_a$ and $\Pi'_b > \Pi_b$, where Π'_a and Π'_b continue to be defined by (19) and (20), respectively. Continuing to assume that the number of potential entrants with technology c_b is large, and assuming now that any purchaser of the technology necessarily becomes the second entrant (perhaps because it could sell below c_b and still realize a profit) we define T by the condition $\Pi'_b = \Pi_b$ so that:

$$(24) \quad T = \frac{(1 - \lambda) (c_b - c_a)}{1 - \lambda + \lambda^2} n_2$$

The first producer will find a technology sale profitable iff $\Pi_a^* \geq \Pi_a$ or iff $\lambda < 1/2$. Since we assumed initially that $n_1 \geq n_2$ the efficient producer will transfer technology only if the two markets are of equal size, and then be indifferent between selling and not selling. More generally, an efficient producer can profit from selling a more efficient technology to a firm in a larger market, even if the two firms affect each other's price. It will not sell to a competing firm in a smaller market, however.

8. Conclusion

This paper has developed a model of market structure which combines elements of the theory of imperfect competition and oligopoly. As in models of imperfect competition there are, ex ante, a large number of potential producers that are, in principle, free to enter. Ex post, however, the number is fixed. The nature of competition is thus different from that in models in which markets are contestable in that there is a fixed cost that must be assumed before prices are determined. This distinction implies that there is scope both for positive profits and strategic entry-deterrence behavior.

In order to characterize equilibrium fully in closed form we have made some very special assumptions about tastes and technology. Nevertheless, a number of our results are likely to remain under a more general specification. First, oligopolistic competition among firms is likely to benefit consumers whose tastes are in the majority. To avoid penetration by other firms a firm selling to consumers in a large market will have to charge a relatively lower price. Conversely, a firm selling to a small number of consumers can charge a higher price without providing an incentive for another firm to lower its price in order to sell to both markets. Second, entry deterrence behavior may affect the characteristics of products produced. One possible modification is toward the taste of consumers in a small market to preclude the emergence of a second entrant catering to that market, even though no sales are consequently made to the smaller market. In this case the threat of entry lowers welfare. A second possible modification is toward the taste of consumers in larger market by a firm selling to two markets. Here the threat of entry redistributes income from the firm toward consumers

in the larger market. A third result is that market growth can exacerbate the distortions imposed by entry deterrence behavior. Fourth, consumers benefit from the greater intensity of competition in an economy where other consumers are not too different from them as long as the number of producers remains the same. When similarity of tastes among consumers breeds such intense price competition among firms that entry is discouraged, however, consumers lose. Finally, when consumers differ sufficiently in their tastes and when the number of consumers is sufficiently large an incentive arises for an efficient firm to sell its superior technology to other firms.

1. In treating the model choice and pricing decisions as sequential rather than simultaneous our treatment is isomorphic to Prescott and Visscher's (1977) model of location choice. See also Lane (1980).
2. The non-existence of Nash-Bertrand equilibrium for the case in which the two firms are located less than some critical distance apart resembles the result of d'Aspremont, Gabszewicz and Thisse (1979) on the non-existence of a solution to the Hotelling model. They show that existence reemerges when transport costs are made quadratic rather than linear. This is not the case when individuals are located at distinct points rather than along a continuum.
3. In his analysis of insurance markets, Wilson (1977) provides an example in which, when firms have more sophisticated beliefs about other firms' reactions, equilibrium in pure strategies exists when it fails to obtain under a Nash specification.
4. We assume throughout that \bar{p} is sufficiently high to insure that $\bar{p} > p_1^*$ and $\bar{p} > p_2^*$. If the first inequality is violated $p_1 = \bar{p}$ and if the second is violated $p_2 = \bar{p}$. We also assume that $p_1^* \geq c_1$ and $p_2^* \geq c_2$. Otherwise, firm 1 or firm 2 will not produce in equilibrium as the first or second inequality fails to obtain.
5. See Bresnahan (1981) and Grossman (1981).
6. Only models in the interval $[\theta_1, \theta_2]$ are of interest. Consider an equilibrium in which there is a firm producing a model a distance d above θ_2 (below θ_1). There is a corresponding equilibrium in which that firm locates at θ_2 (θ_1), charges a price greater by an amount d , and maintains its previous level of sales. Its profits are consequently higher. The firm would have chosen this location over the location outside the interval.

7. It is the case the c_b cannot be so low relative to c_a that $p_a^* < c_a$ in the resulting equilibrium. Otherwise, the second entrant would sell to both markets in equilibrium. The first entrant would experience a loss and consequently would not have chosen to enter. Again, we are assuming that in this equilibrium the level \bar{p} is not binding.
8. Again, this result assumes that c_a is not much higher than c_b . If the first entrant has a strong cost disadvantage (i.e., if $c_a \gg c_b$): then the second entrant may nevertheless choose $Z_b = \theta_1$ and sell at $p = c_a$ even though $Z_a = \theta_1$. In this case the first entrant would have chosen $Z_a = \theta_2$.
- Given that $Z_a = \theta_1$ and $Z_b = \theta_2$, a third entrant cannot establish production and earn a positive profit unless it has a strong cost advantage. There is consequently no incentive for a firm to delay entry. See Shaked and Sutton (1982) for a model in which firms do have an incentive to delay establishing a model.
9. Hart (1979) and Novschek (1980) show that with free entry Cournot equilibrium among firms converges to competitive equilibrium and a Pareto optimum. In these models entry and pricing decisions are simultaneous so that free entry enforces average cost pricing.
10. If after the transfer, the two producers could charge \bar{p} in their markets, a technology transfer would necessarily be sustainable.

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