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Inside the Black Box: (In)Tangible Assets, Intra-Industry Investment and Trade

Elias Dinopoulos

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Elias Dinopoulos

This paper contains preliminary findings from research work still in progress and should not be quoted without prior approval of the author.

DEPARTMENT OF ECONOMICS
THE UNIVERSITY OF WESTERN ONTARIO
LONDON, CANADA
N6A 5C2

8845

Comments are welcomed

INSIDE THE BLACK BOX: (IN)TANGIBLE ASSETS, INTRA-INDUSTRY INVESTMENT AND TRADE*

by

Elias Dinopoulos

Michigan State University

April 1985

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ABSTRACT

The present paper develops a new approach to the theory of the firm which produces a product differentiated by two characteristics. The product differentiation technology of the firm consists of two assets which are allocated between two activities to determine the amount of each characteristic per unit of output.

The above framework is then combined with the demand and market structure of Dinopoulos (1985b) to build a general equilibrium model of intra-industry trade and investment. Different assumptions on intra-firm resource mobility across activities result in a variety-quality trade-off which in turn provides the incentive for intra-industry investment.

The paper discusses conditions under which intra-industry investment occurs and the effects of the latter on prices and product specifications. It also provides a formal model which follows very closely the Bhagwati proposed "Biological" model of trade in similar products and the Mutual Penetration of Investment model scenarios.

To see a wo[illegible] and
And a heave[illegible]
Hold Infini[illegible] in hand
And eterni[illegible]

[illegible] Blake

Introduction

International capital flows have become increasingly [illegible] in empirical and theoretical international trade literature. [illegible]fects and types of direct foreign investment have been analyzed exte[illegible]e theorists under the so called interest rate theory of international [illegible]eats. The cornerstone of the above analysis has been the assumption [illegible] competitive factor and product markets. Thus, the above literature[1] fa[illegible]plain the existence of multinational corporations and recent phenomena [illegible]tra-industry investment.

The industrial organization approach to direct foreign investment initiated by Hymer (1960), focused explicitly on product differentiation, non-competitive market structures and incorporated the multinational corporation as the central element of analysis.[2] This approach resulted in informal hypotheses and a set of partial equilibrium models to explain the pattern of foreign direct investment. Vernon's (1971) Product Life Cycle, Caves' (1982) Intangible Assets and Bhagwati's (1972) Mutual Penetration of Investment models are few of the alternative scenarios developed within the above framework.

Recently, the new models on intra-industry trade have been extended to formalize certain hypotheses developed by the industrial organization literature, by developing general equilibrium models of direct foreign investment and imperfectly competitive markets. Krugman (1979) has provided an elegant model of the Product Life Cycle theory. Helpman (1984) and Markusen (1984) have modeled certain features

of the Intangible Assets hypothesis under different market structure assumptions. Ethier (1985) has provided helpful insights on the role of uncertainty and imperfect contractual arrangements as causes of direct foreign investment. The above literature stresses the public nature of an input of production and models the firm explicitly in order to examine the conditions under which is profitable for the firm to locate some of its operations abroad.

The main purpose of the present paper is to develop a new approach to the theory of the firm, which represents a novel extention of Lancaster's characteristics approach to demand theory, and generalizes the Helpman (1984), Markusen (1984) and Ethier (1985) models of the firm. The firm, which operates in a market for products differentiated by two characteristics, consists of two levels. Manufacturing uses labor and determines the scale of operations (the number of units the firm produces). The second level uses the unit bundle of resources, consisting of two inputs which are intangible vis-a-vis labor in manufacturing, but tangible when combined between them, to determine the amount of each characteristic embodied in each unit of the differentiated good. Each of the two characteristics is associated with an activity which is modeled by a neoclassical production function using both resources as inputs, and having as output the amount of the characteristic per unit of output. Intra-firm resource specificity results in a trade-off between variety and quality in the short-run, which is then sufficient to cause mutual exchange of activity specific resources across firms. When the proposed theory of the firm is combined with a differential national tastes framework developed by Dinopoulos (1985b), intra-industry trade and investment coexist based on weak assumptions on differential intra-firm resource mobility. Thus, the present paper uses a framework of sequential comparative statics equilibria to trace very closely the "Biological" model of trade in similar products and the Mutual Penetration of Investment model.

According to the "Biological" model of trade in similar products, as in biology a set of genetic traits (genotype) interacts with different environments and results in different "phenotypes," likewise, countries with identical know-how and technological capabilities, interacting with different tastes (interpreted broadly) would produce different similar products. Thus, these countries would engage in trade exchanging the different similar products developed in autarky. This taste-induced intra-industry specialization accounts for comparative advantage in similar products. Bhagwati (1972) has proposed the Mutual Penetration of Investment scenario according to which, intra-industry R&D induced specialization of MNC in different types of similar products, results in mutual exchange of investment by MNC in the same industry, in order to compete (or eliminate competition) in the product market.

The next section develops the new approach to the theory of the firm. Section II introduces differential national tastes and discusses the pattern and effects of intra-industry trade. Intra-industry investment is analyzed in section III and section IV contains a summary of results and possible extensions of the analysis.

I: Product Differentiation and Intra-Firm Resource Mobility

The present section generalizes Lancaster's (1979) characteristics framework by introducing additional analytical structure to the product differentiation technology of the firm which produces a differentiated product defined by two characteristics.[3] Suppose that there is a sharp dichotomy between the scale of operations of the firm defined by the total units of output produced, and the product differentiation technology. Thus, the operations of the firm can be classified into two levels (departments). The technical-managerial level is responsible for determining the quantity of each of the two characteristics embodied in each (and every) unit of the differentiated good. The second level consists of

the manufacturing department which determines the number of units of the group good produced. The production technology of the firm is represented with the following system of equations:

$$(1) \quad \mu = G(E_\mu, M_\mu)$$

$$(2) \quad \tau = G(E_\tau, M_\tau)$$

$$(3) \quad E_\tau + E_\mu = \bar{E}$$

$$(4) \quad M_\tau + M_\mu = \bar{M}$$

$$(5) \quad Q = F(\mu, \tau; L)$$

The first four equations describe the technical-managerial department. The firm is endowed with two inputs, $\bar{E}$ (for engineers) and $\bar{M}$ (for managers), called the unit resource bundle.[4] These two inputs are allocated between two activities each of which corresponds to one of the two characteristics embodied in each unit of the group good. Thus, equation (1) relates μ the amount of characteristic μ per unit of output, to E_μ and M_μ representing the engineers and managers working on this activity. Similarly equation (2) describes the activity which is related to characteristic τ, with τ denoting the amount of the characteristic embodied in every unit of output, and E_τ, M_τ referring to engineers and managers working on activity τ. The function G has all the usual neoclassical properties.[5] Equations (3) and (4) simply state that engineers and managers are fully employed.[6] Assume, now, that $\bar{E}$ and $\bar{M}$ are public inputs with respect to labor L which determines the scale of production. Equation (5) says that for a given μ and τ determined by equations (1) through (4), total output Q is a function of the total number of workers hired L. In the analysis which follows we will assume that F exhibits increasing returns to scale with respect to L, due to the public nature of $\bar{E}$ and $\bar{M}$.[7]

Few words on the interpretation of the production technology are useful at this point. Notice that the vector (μ, τ) provides complete information on the specification and the quality of group good. The product specification is simply defined by the ratio μ/τ. The absolute level of each characteristic per unit of output defines the quality of the product. For example product (μ_1, τ_1) is of higher quality than product (μ_2, τ_2) if $\mu_1 > \mu_2$ and $\tau_1 > \tau_2$ and at least one of the relationships holds as a strict inequality. Thus, equation (5) captures both the horizontal (variety) as well as vertical (quality) aspects of product differentiation.

Consider, now, Figures 1(a) and 1(b) which illustrate the case of a group defined by two characteristics and a one consumer one firm economy. The unit bundle of resources $\bar{M}$ and $\bar{E}$ defines the Edgeworth box in Figure 1(a), with $\bar{M}$ measured horizontally and $\bar{E}$ vertically.[8] Equations (2) and (3) can be represented by families of iso-characteristic curves, activity μ having its origin at O_μ and activity τ having its origin at O_τ. Thus, the firm can choose any point in the box, allocate its managers and engineers between the two activities and determine the characteristic content per unit of output from the iso-characteristic curves passing through that particular point.

Define the technical long-run as the situation characterized by perfect mobility of the unit bundle resources across activities. In this case, we can define the efficient locus $O_\mu O_\tau$, as the locus of tangencies of iso-characteristic curves which coincides with the diagonal of the box. The efficient locus $O_\mu O_\tau$ defines, in turn, the technical long-run product differentiation curve $aib\bar{b}\bar{d}$ in Figure 1(b) where the quantities of the two characteristics are measured along the axes. The technical long-run product differentiation line $aib\bar{b}\bar{d}$, shows the maximum quantity of characteristic τ that the firm can produce for a given quantity of characteristic μ, and a given bundle of resources $\bar{M}$ and $\bar{E}$, under the assumption of

FIGURE 1(a)

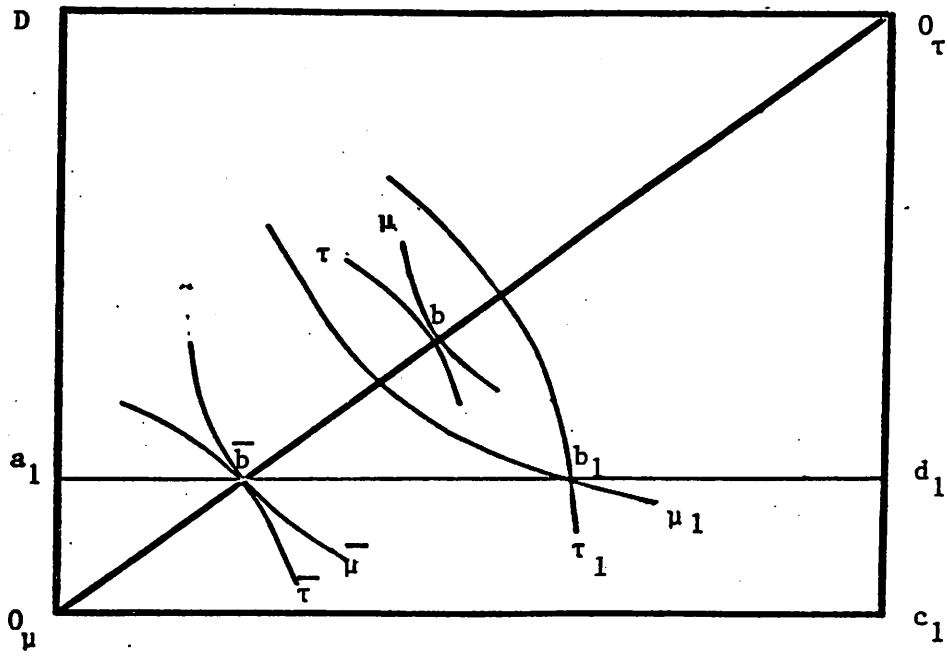
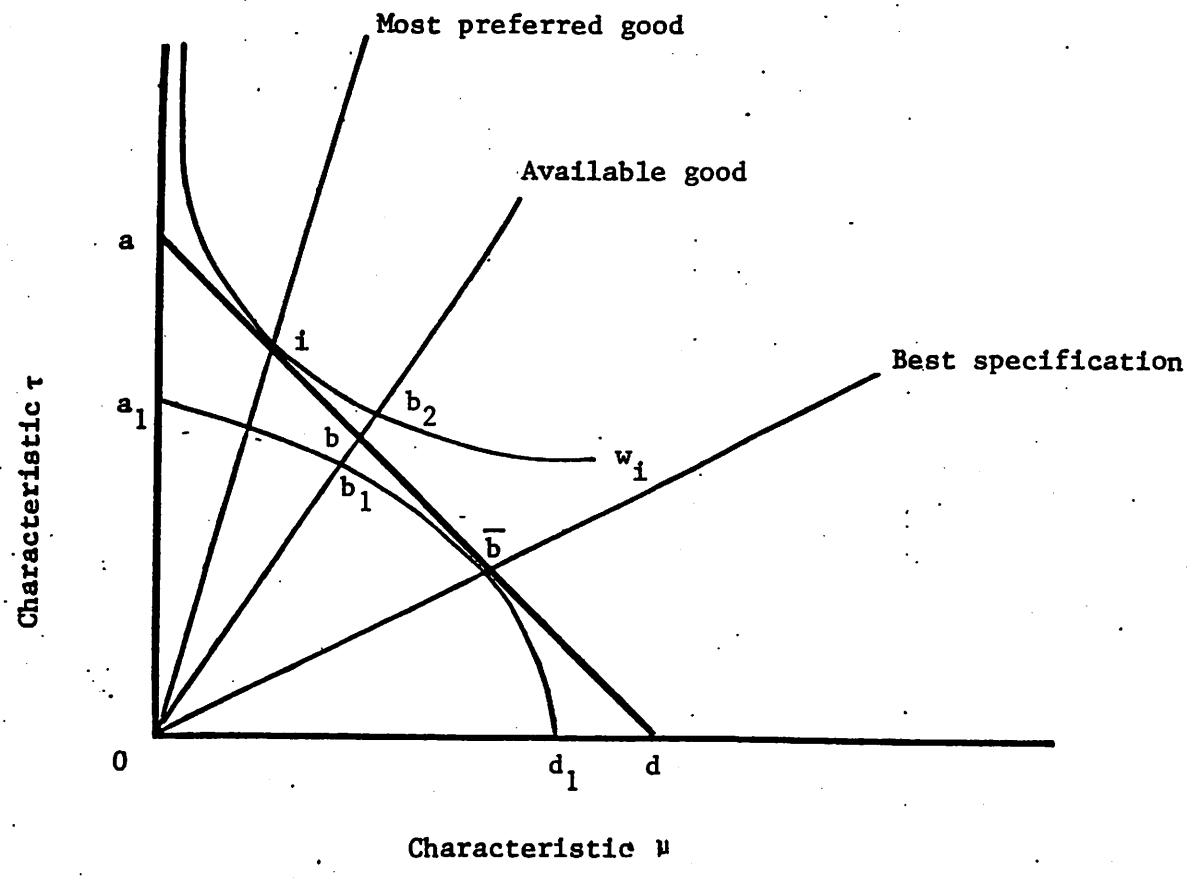


FIGURE 1(b)



perfect intra-firm resource mobility. Any point on line $ai\bar{b}\bar{b}d$ represents a potential product for the firm. For example, by measuring the slope of the line connecting point i and the origin O, we obtain the characteristics ratio and thus the specification of good i. From the point of view of the firm all points on $ai\bar{b}\bar{b}d$ are equivalent since they can be obtained with the unit bundle of resources.[9]

Define technical short-run the situation with engineers being activity specific, that is they cannot move across activities, but managers are perfectly mobile across activities.[10] Consider, now, a firm which starts at the technical long-run equilibrium point $\bar{b}$ in Figure 1(a) defined by the tangency of $\bar{\tau}$ and $\bar{\mu}$ iso-characteristic curves. Then the technical short-run efficient locus is $a_1\bar{b}b_1d_1$. Following Mayer (1974) and Neary (1978), one could define the technical short-run product differentiation curve of firm $\bar{b}$ as $a_1b_1\bar{b}d_1$ in Figure 1(b). Resource specificity implies that curve $a_1b_1\bar{b}d_1$ is concave to the origin, lies inside the technical long-run product differentiation line $ai\bar{b}\bar{b}d$ and that the two curves have one point in common, namely $\bar{b}$. This point is called the best specification of the firm in the sense that at $\bar{b}$ the unit bundle of resources has been used with maximum efficiency compared to other points on $a_1b_1\bar{b}d_1$.

It is obvious that differential resource mobility within the firm, creates a variety-quality trade-off in the technical short-run.[11] In Figure 1(b), assume the firm starts at the long-run position $\bar{b}$. In the technical short-run, if the firm decides to produce a product of different specification (say the one whose specification is given by the slope of line ob), then it will move along curve $a_1b_1\bar{b}d_1$ to point b_1 which contains less of both characteristics relative to point b. The latter can be called the long-run equivalent of b_1 since both points correspond to the same specification and require the same unit bundle of resources. Thus, in the short-run, the deterioration of quality increases, the further the new product is located vis-a-vis the best specification of the firm.[12]

The next step is to incorporate the geometric results in the conventional algebraic analysis used by the characteristics approach.[13] Consider, now, the consumer in Figure 1(b) whose preferences are defined over the two characteristics τ and μ.[14] In the technical long-run, if all potential products were available at equal prices, the consumer would maximize his utility by choosing good i, which is defined by the point of tangency of the product differentiation line $aib\bar{b}d$ and the indifference curve W_i. Following Lancaster (1979), good i can be called the most-preferred-good of consumer i.[15]

Assume now that the best specification of the firm in Figure 1(b) is $\bar{b}$, the most-preferred-good of our consumer is i and the firm chooses to produce a good with specification given by the slope of line ob_1, called the available good. In the technical short-run, the firm is located at point b_1 and provides a suboptimal transfer of characteristics to consumer i for two reasons. First, the consumer does not get the specification he would like to get (i.e. his most preferred good i). Second, the quality of good b_1 is lower to its technical long-run equivalent good b.

The ratio ob_2 to ob_1 measures the amount of the available good b_1 needed to bring the consumer to the welfare level he would attain if the unit bundle of resources were used with maximum efficiency to produce his most preferred good i.[16] Modifying slightly Lancaster's (1979) terminology, we can call the ratio ob_2 to ob_1 the technical short-run compensating ratio.

From Figure 1(b) it is easy to see that the ratio ob_2/ob_1 is the product of two other ratios:

$$(6) \quad \frac{ob_2}{ob_1} = \frac{ob_2}{ob} \frac{ob}{ob_1}$$

The ratio ob_2/ob is called the technical long-run compensating ratio and is identical to Lancaster's (1979) compensating ratio. The ratio ob/ob_1 is called the

quality-loss ratio, because it measures the relative deterioration of quality which characterizes the technical short-run product b_1 as compared to its technical long-run equivalent product b.

Consider, now, Figure 2 which is the transformation of Figure 1(b) in the product specification (spectrum), quantity/quality space.[17] The notation is identical in both figures and helps the reader understand how each point on Figure 1(b) is transformed into its counterpart on Figure 2. The horizontal line $aib\bar{b}d$ represents the technical long-run product differentiation curve, and it is the product differentiation spectrum. The distance ad is equal to unity, and each point in the spectrum represents a potential product whose specification can be measured by the distance from the origin of the spectrum. Curve W_i is the indifference curve of our consumer and curve $b_1\bar{b}di$ corresponds to the technical short-run product differentiation curve.

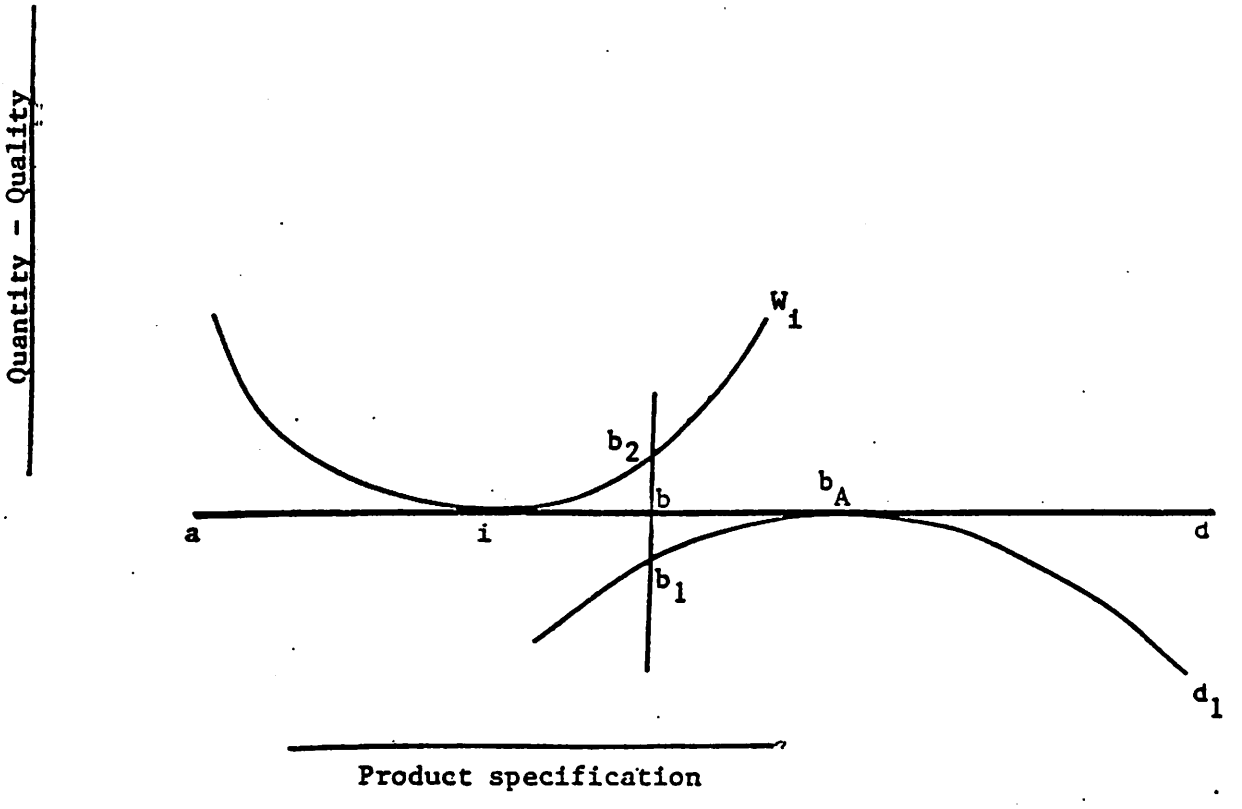
The technical short-run compensating function is defined as follows:

$$(7) \quad \frac{q}{\bar{q}} = h(u)\ f(z)$$

The left-hand side of equation (7) is the ratio of q the quantity (quality) of the available good b_1 to the quantity (quality) $\bar{q}$ of the most preferred good i corresponding to the same utility level W_i. The function h(u) is consumer i's technical long-run compensating function and corresponds to the ratio ob_2/ob. The function f(z) is the firm's quality-loss function and corresponds to ratio ob/ob_1. Finally, $u = ||b - i||$ is the spectral distance between consumer i's most-preferred-good i and the available good b, and $z = ||\bar{b} - b||$ is the spectral distance between the firm's best specification $\bar{b}$ and the available good b.

Both functions h(u), f(z) have the same properties, which are stated in terms of the quality-loss function.[18]

FIGURE 2



8(a) $f(0) = 1$

8(b) $\frac{\partial f(0)}{\partial z} = 0$

8(c) $\frac{\partial^2 f(0)}{\partial^2 z} > 0$

8(d) $f(z) > 1$ for $z > 0$

8(e) $\frac{\partial f(z)}{\partial z} > 0$ for $z > 0$

8(f) $\frac{\partial^2 f(z)}{\partial^2 z} > 0$ for $z > 0$

The technical short-run compensating function $h(u)\ f(z)$ is always greater than the technical long-run compensating function $h(u)$, except when the firm's available good b is identical to its best specification $\bar{b}$. The technical short-run compensating function is equal to one only when $b = \bar{b} = i$, and increases with the distance u between the most-preferred good and the available good and the distance z between the available good and the firm's best specification.

Thus, by incorporating the short-run compensating function into the analysis we can investigate the effects of intra-firm resource specificity on prices, profits, product specifications and entry using the well-known models of Lancaster (1980) and Helpman (1981). However, few words are needed at this point with respect to the returns of the factors of production used by the firm. The return to labor which is used in manufacturing is determined in the labor market, and in the present model in the competitive sector corresponding to the outside good. In general, the returns to $\bar{M}$ and $\bar{E}$ could be determined in economy-wide markets for these inputs.[19] In the

present paper we adopt a very simple rule, assuming that the firm is owned by managers and engineers and profits of the firm are distributed equally among them. Finally, the home country of each firm is the one where the majority of engineers and managers who own the firm are located.

II. Differential National Tastes and Intra-Industry Trade[20]

The present section combines the new approach to the theory of the firm with the differential national taste demand structure developed in Dinopoulos (1985b), under the assumption of no international factor mobility. Thus, it traces very closely the Bhagwati proposed "biological" model of trade in similar products.

The "biological" model can be formalized in the present context in two stages, in both of which each firm chooses its own price and product specification simultaneously to maximize profits, taking the other firm's decision variables as given. The first stage is the technical long-run, which corresponds to perfect intra-firm resource mobility and is identified with autarky. The product specification choice in this stage determines the best specification of each firm. The second stage is associated with trade and corresponds to the technical short-run. Given the autarky allocation of the unit resource bundle between the two activities, resource $\bar{E}$'s allocation is fixed whereas resource $\bar{M}$ is perfectly mobile across activities.

Consider now a two-sector economy, one sector producing a homogeneous good called the outside good, and the other sector being characterized by a differentiable group good, defined by two characteristics. The outside good Y uses only labor and is produced under perfect competition according to the production function.

$$(9) \quad Y = a_Y L_Y$$

where a_Y is a constant and L_Y is labor employed in sector Y. There is only one firm in the group sector. Suppose, also, that the group sector is small relative to the outside good sector, meaning that the monopolist does not have monopsony power in the labor market, profits are small and do not influence income per capita which is equal to the wage. The latter is determined in the competitive sector and is equal to a_Y when measured in units of the outside good which is used as the numeraire. The scale of firm's operations is described by the following cost function:

$$(10) \quad c(Q) = cQ + F$$

where Q is the total quantity of the group good, c is constant marginal costs and F is fixed costs. The full employment condition of labor is given by:

$$(11) \quad \bar{L} = L_Y + L_q$$

where $\bar{L}$ is the economy's labor endowment and L_q is the number of workers employed by the monopolist. The demand side of the economy follows a variation of Lancaster's (1979) approach. Consumer i's preferences are expressed as follows:

$$(12) \quad W_i = Y_i^{1-m} \left(1 + \frac{q_i}{\beta}\right)^m \qquad Y_i > 0,\ q_i = 0,\ 1.$$

where q_i and Y_i are the corresponding quantities of the available group and outside good, and $\beta = h(u_i)\ f(z)$ is the appropriate compensating function defined in equation (7). Notice that consumer i's most-preferred good is located at distance i from the origin of the spectrum and $(q_i/\beta) = \bar{q}$ is the most-preferred good equivalent of consumer i. Equation (10) implies that each consumer's preferences between the

outside good and the most preferred good equivalent are characterized by a Stone-Geary utility function. Notice that $f(z)$ is the quality loss function with $z = ||\bar{b} - b||$, and assume that $h(u_i) = 1 + ||b - i||$ to be the technical long-run compensating function. Thus, in the technical long-run we have that $\beta = h(u_i)$, and in the technical short-run $\beta = h(u_i)\, f(z)$ where $\bar{b}$ is the solution to the technical long-run problem.

Assume, now, that both the home and foreign economies are characterized by Equations (1) through (12). To close the model we need to specify the distribution of consumers along the spectrum, which allows the introduction of differential national tastes. Denote with stars variables referring to the foreign country, and define the national distributions of consumers as follows:

$$\xi = gi \tag{13}$$

$$0 < i < 1,\ g > 0$$

$$\xi^* = g(1-i) \tag{14}$$

where $\xi(\xi^*)$ is the number of home (foreign) consumers located at distance i from the origin of the spectrum and g is a constant. Notice that the world distribution of consumers is uniform, but as one moves along the spectrum from left to right the number of home (foreign) consumers increases (decreases).

In autarky, each monopolist chooses the price and specification of its product, under the assumption of perfect intra-firm resource mobility. The two first order conditions determine the optimum price P_A and product specification b_A.[21] Figures 3(a) and 3(b) summarize the relevant aspects of the group good equilibria in autarky for the home and foreign firm. The horizontal axis denotes the technical long-run spectrum, and distance OB = OB* is equal to unity. The line with slope g represents the density function of consumers. Figure 3(a) illustrates the home firm

FIGURE 3(a)

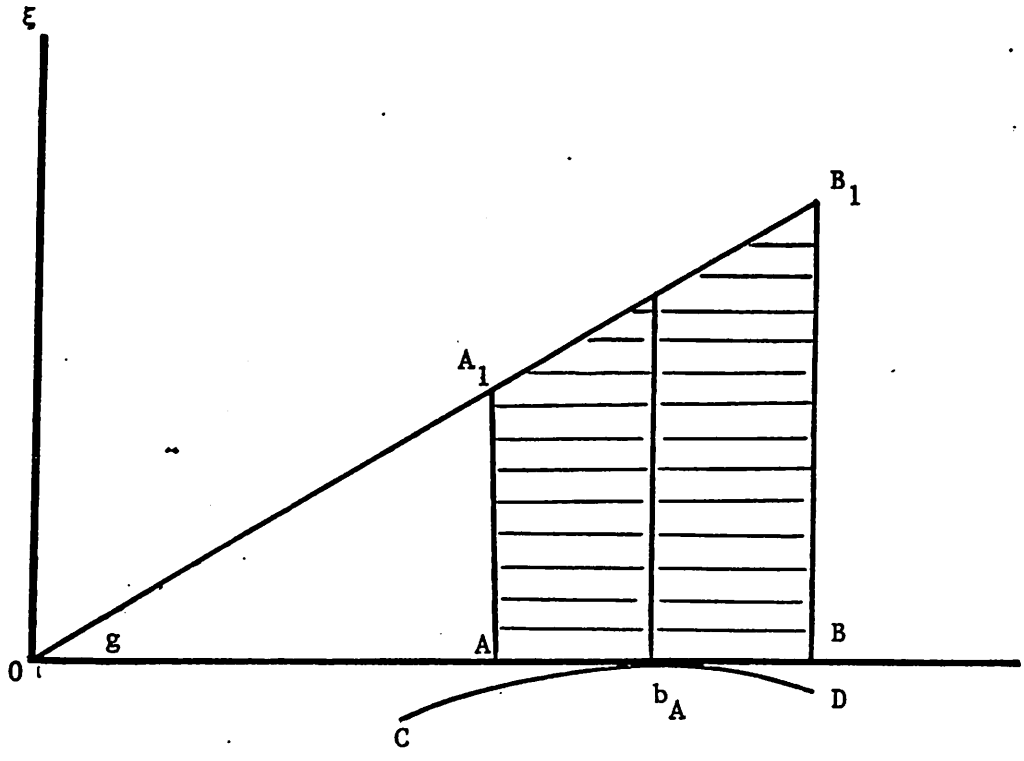
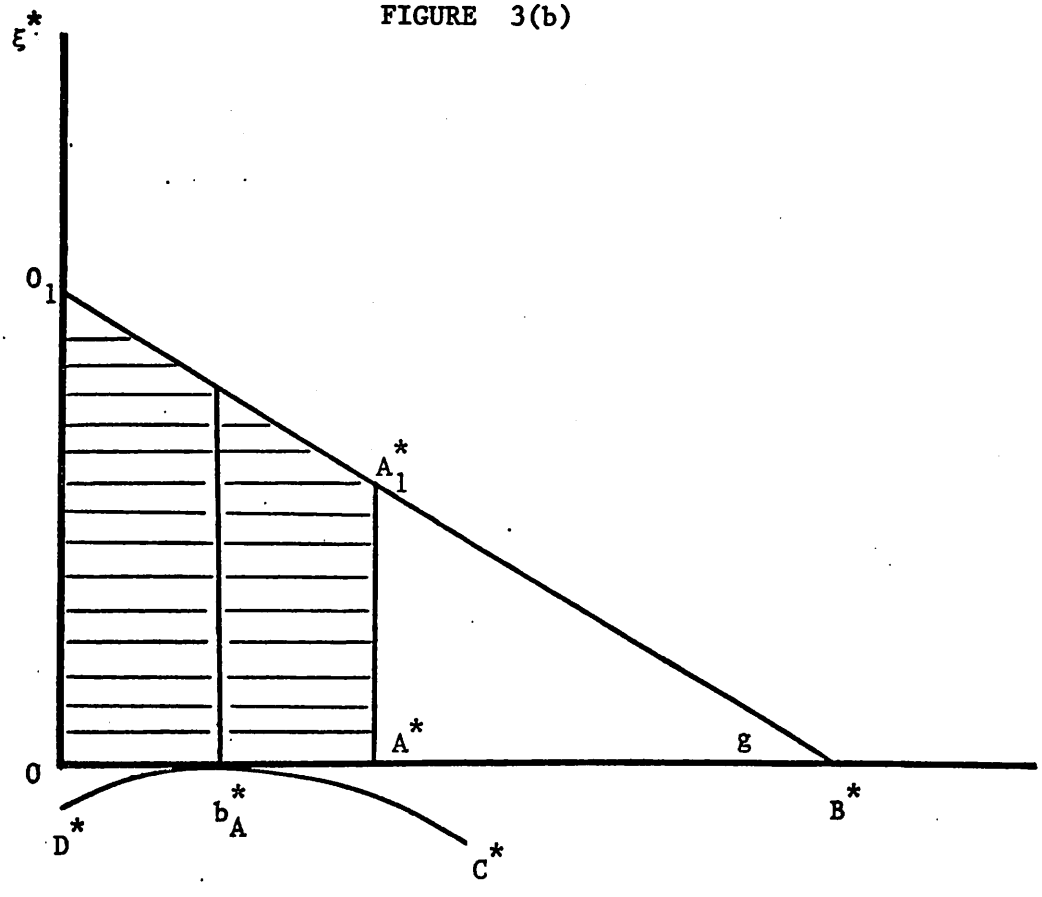


FIGURE 3(b)



equilibrium. The monopolist chooses b_A and P_A in such a way, that every consumer located to the right of b_A buys the group good b_A. Every consumer located on segment AB buys the group good and $Ab_A = b_AB$. If $b_A > \frac{1}{2}$, then all consumers located on the OA segment of the spectrum spend all income on the outside good Y. Curve Cb_AD denotes the technical short-run product differentiation spectrum, assuming that b_A determines the best specification of home firm. Figure 3(b) shows the group good equilibrium in the foreign country.

Differential national tastes give rise to the concept of intra-industry specialization. For example, if there are more Americans preferring large cars, then, a monopolist in the automobile industry will produce a large car. When the two economies engage in trade, there will be intra-industry trade in similar products produced in autarky. The absence of international factor mobility coupled with the assumption of intra-firm resource specificity of $\bar{E}$, implies that the pattern of intra-industry trade is determinate. The home (foreign) firm is the one whose best specificaton is b_A (b_A^*).[22]

Depending on the parameters of the model, the trade market structure of the group good can take two possible forms. The two firms might remain <u>local monopolists</u> when at least one consumer located between the post-trade positions of the two firms, <u>does not</u> buy any group good. Alternatively, the two firms might become <u>competing duopolists</u> when all consumers located between the two firms are served by either firm.

Denote with p_A, p_{ST} the equilibrium prices of the home group good in autarky and short-run trade, expressed in units of the outside good. Moreover, let b_A, b_{ST} be the equilibrium product specifications in the above two situations.[23] The following two propositions summarize the effects of intra-industry trade on price and product specification of home firm.

Proposition 1: When firms remain local monopolists intra-industry trade results in $p_A > p_{ST}$ and $b_A > b_{ST}$.

Proof: (See Dinopoulos (1985b), proposition 1)

Proposition 2: When firms become competing duopolists with trade if $\sigma \neq s\gamma$ then $p_A \neq p_{ST}$ and $b_A \neq b_{ST}$.

Proof: (See Dinopoulos (1985), proposition 3)

In proposition 2, σ and s are the corresponding price elasticities of left and right market widths which are the distances $(b_{ST} - b^*_{ST})/2$ and $(1 - b_{ST})$ respectively, and γ is a function of market widths and is always greater than one.

The economic intuition for the above results is straight forward. The exact location of each firm is determined by the interaction of two economic forces acting in opposite directions. The opening of trade results in a larger market for each firm and creates a tendency for products to converge, and prices to go down (as in the local monopolists case) because of scale economies. On the other hand, one side competition between the two firms creates a tendency for products to diverge and prices to rise. In the competing duopoly case both forces are present and the exact location of firms compared to autarky depends on the relative strength of these tendencies. For the present paper it is sufficient to establish that with the exception of a very special case ($\sigma = s\gamma$), product specifications change with intra-industry trade creating a quality loss for each firm which in turn serves as an incentive for intra-industry investment.

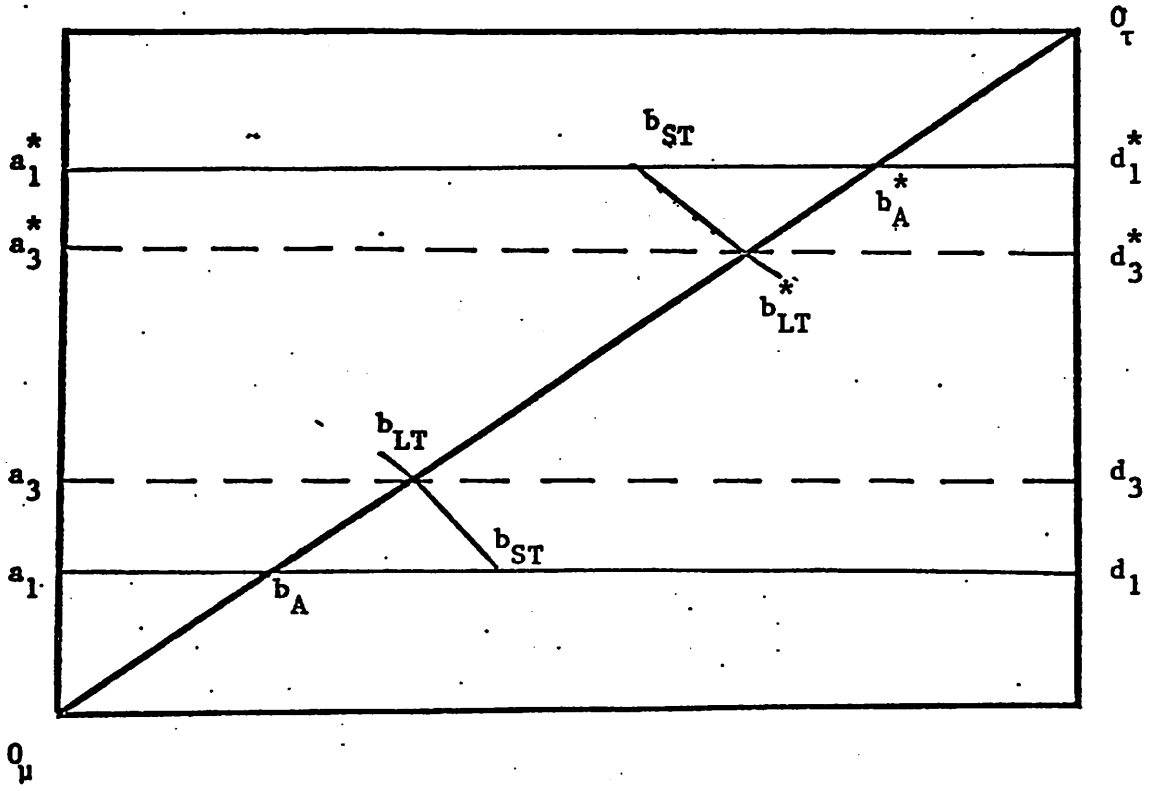
III: Intra-Industry Investment and Market Structure

This section analyzes the implications of international mobility of activity specific factors. In addition to intra-industry trade, the model generates intra-industry investment whose pattern is similar to the Bhagwati (1972) proposed Mutual Penetration of Investment (MPI) model scenario. The first part of this section shows how the quality loss associated with short-run changes in product specifications is eliminated by mutual exchange of activity specific factors between the two firms. The second part deals with the effects of intra-industry investment on the pattern of trade, prices and product specifications under alternative assumptions on product and factor market structures.

The economic intuition for the emergence of intra-industry investment is very simple. The assumption of a short-run activity specific resource imposes a quality loss to each firm associated with any change of product specification due to trade. A sufficient general condition for intra-industry investment to occur is that international mobility of a resource within the same activity is greater than its mobility across different activities within the firm. If this is the case, greater international mobility of resources allow each firm to overcome the inefficiency associated with activity specificity through mutual exchange of the activity specific resource between firms.[24]

Define the technical medium-run as the situation characterized by perfect mobility of resource M across both activities and firms, whereas resource E is perfectly mobile across firms within the same activity but immobile across activities. Consider Figure 4 which shows the product differentiation possibilities of each firm. It is identical to Figure 1(a) and both firms can be represented in the same diagram.[25] Suppose that b_A and b_A^* are the autarky product specifications of each firm. The, assumption of symmetric but differential national tastes implies that $0_\mu b_A = 0_\tau b_A^*$, and thus the allocation of engineers across the two activities is

FIGURE 4



symmetric across firms. The technical short-run efficient locus of home firm is $a_1 b_A b_{ST} d_1$, and the foreign firm's one is $a_1^* b_{ST}^* b_A^* d_1^*$ under the assumption of activity specific $\bar{E}$ ($\bar{E}^*$), and perfect mobility of $\bar{M}$ ($\bar{M}^*$).

Without loss of generality, suppose that intra-industry trade results in convergence of products to b_{ST} and b_{ST}^* in the short-run. The new product specifications are also symmetric with respect to the center of the efficient locus $0_\mu\ 0_\tau$. The short-run trade equilibrium is inefficient for both firms, since the iso-characteristic curves (not shown), passing through b_{ST} and b_{ST}^* on Figure 4 are not tangent to each other. Denote the long-run equivalent products of b_{ST} and b_{ST}^* as b_{LT} and b_{LT}^* respectively. It is very easy to see, then, that if the home firm increases E_μ by $a_1 a_3$ in exchange of $a_1 a_3$ units of E_τ it can shift its short-run efficient locus to $a_3 b_{LT} d_3$ and produce b_{LT}. Similarly the foreign firm has an incentive to shift its short-run efficiency locus from $a_1^* b_{ST}^* b_A^* d_1^*$ to $a_3^* b_{LT}^* d_3^*$ by giving $a_1^* a_3^*$ units of E_μ type of engineers and receiving $a_3^* a_1^*$ units of E_τ type of E. Thus, symmetry implies that $a_1^* a_3^* = a_1 a_3$ and both firms exchange different types of engineers to eliminate the short-run quality loss.[26] If instead of engineers resource E is specialized machinery, then the above mutual exchange of E between the two firms could be interpreted as intra-industry investment.

The next step of the analysis is to discuss the implications of intra-industry trade and investment on the pattern of intra-industry trade, prices and product specifications of the two firms. In principle the pattern of intra-industry trade becomes indeterminate in the medium-run. It is possible, for, example that the home firm shifts its short-run efficient locus to $a_3^* b_{LT}^* d_3^*$ instead of $a_3 b_{LT} d_3$ and the foreign firm ends up in b_{LT} instead of b_{LT}^*.[27] However, the present model can incorporate anyone of a number of assumptions which exclude this particular equilibrium. Infinitesimal transportation costs, any taxes on foreign products or factors, or the slightest degree of risk-aversion related to foreign markets,

induces both firms to choose the solution which corresponds to the minimum change of product specifications. If this is the case, the intra-industry pattern of trade is preserved even in the presence of intra-industry investment, in the sense that the home country exports the similar good which is home demand intensive.[28] For the rest of the analysis we concentrate on medium-run solutions which are symmetric and preserve the short-run pattern of intra-industry trade.

We now examine the effects of intra-industry investment on prices and product specifications under two assumptions regarding the duopolist's conjectures on the product market. If the activity specific resource consists of skilled labor, and mutual exchange of different types of labor is obtained through a market transaction, then firms remain competitive in the product market. On the other hand, if the activity specific resource consists of capital in the form of specialized machines then firms exchange capital in a form of a joint R&D venture. In this case competition in the product market will be eliminated. Notice also that analytically, the medium-run situation is equivalent to the long-run one which is characterized by perfect intra-firm resource mobility when it comes to the determination of prices and product specifications.

The case where the product market remains competitive has been analyzed by Dinopoulos (1985b) under the assumption of Cournot conjectures between the two firms. The main results are stated below for convenience. Denote with p_{MT} and b_{MT} the equilibrium price and product specification of the home firm in the medium-run, σ and s the corresponding price elasticities of left and right market widths and γ a function of market widths which is greater to one.

Proposition 3: When firms remain local monopolists intra-industry trade and investment result in $p_A > p_{ST} > p_{MT}$ and $b_A > b_{ST} > b_{MT}$.

Proof: (See Dinopoulos (1985b), proposition 1)

Proposition 4: When firms become competing duopolists with intra-industry trade and investment there are three possibilities:

(a) if $\sigma > sY$ then $p_A > p_{ST} > p_{MT}$ and $b_A > b_{ST} > b_{MT}$,

(b) if $\sigma = sY$ there is no intra-industry investment, $p_A = p_{ST} = p_{MT}$ and $b_A = b_{ST} = b_{MT}$.

(c) if $\sigma < sY$ then $p_{MT} > p_{ST} > p_A$ and $b_A < b_{ST}, b_{MT}$.

Proof: (See Dinopoulos (1985b), proposition 3).

Suppose now that because of mutual exchange of capital the two firms collude in the product market. In the local monopolists case proposition 3 still holds because by assumption the two firms are not competing against each other. Thus, prices will fall and products will converge. However, in the competing duopoly case the product market structure which emerges is the one of touching monopolists. All consumers whose most-preferred-good is located at the mid-point of the spectrum are indifferent between buying either group good and spending all their income on the outside good. The two firms cover the whole spectrum, with $b_{MT} = \frac{3}{4}$ and $b^*_{MT} = \frac{1}{4}$, and the common price is defined implicitly by $v(\bar{p}_{MT}) = \frac{1}{4}$ where v is the half market width of each firm. In this case prices and profits exceed those of the competing duopoly case in the medium-run, and products diverge relative to both autarky and short-run trade equilibria of the competing duopolists case. Thus, when intra-industry investment raises the possibility of product market cartelization through

joint ventures, it dominates the long-run perfect intra-firm resource mobility equilibrium. This asymmetry of market type (labor) versus non-market (capital) transactions related to international factor mobility in imperfect product markets is a phenomenon that has received limited formal attention in trade theory.

IV: Conclusions and Extensions

The present paper developed a new approach to the theory of the firm which produces a product differentiated by two characteristics. Differential intra-firm resource mobility results in a trade off between product specification changes and quality deterioration. Differential national tastes interact with intra-firm resource specificity to establish sufficient incentives for mutual exchange of different types of activity specific resources across firms.

Any change of product specification due to intra-industry trade results in intra-industry investment as a means of overcoming the short-run inefficiency caused by intra-firm resource specificity. The pattern of intra-industry investment depends on the direction of product specification changes. Moreover, intra-industry investment can act as a facilitating collusion device in the product market, if mutual penetration of investment is conducted in the form of a joint venture. Overall, by introducing sequential comparative statics equilibrium concepts the present model traces very closely the "Biological" as well as the Mutual Penetration of Investment models proposed by Bhagwati.

The specific and restrictive assumptions of the model make some of the results suggestive rather than conclusive. However, the proposed approach to the theory of the firm can be extended in several directions without altering substantially the basic conclusions. Thus, the assumption of the technical long-run efficient locus being identical to the diagonal of the Edgeworth box can be easily relaxed. The present analysis can be extended to any number of characteristics by assigning to

each one a characteristic production function with the appropriate number of inputs. Activity specificity of one input is sufficient to generate the short-run variety-quality trade-off needed for the emergence of intra-industry investment.

Following Helpman (1984) and Markusen (1984) one could assume that the public nature of the unit resource bundle with respect to manufacturing extends across national borders. Thus, one way flow of foreign direct investment can be generated when returns to manufacturing factors of production differ across countries. Another direction of research is to assume that one resource can be used in both the manufacturing as well as the product differentiation department of the firm. In this case, any changes in product specifications would result in changes of returns of manufacturing inputs, which will generate one way foreign investment. Yet, another extension of the present model is to incorporate the insights of Ethier's (1985) analysis, by assuming that the output of the characteristics production functions is random. This results in product quality uncertainty for a given product specification and R&D resources of the firm.

Perhaps the most fruitful direction of future research concerning the present model is to allow entry of firms and analyze the effects of short-run intra-firm resource specificity in oligopolistic and monopolistically competitive markets. The returns on the unit bundle resources will be market determined and one could formally endow the economy with an R&D sector. This, in turn, allows us to analyze important questions of commercial policy related to product differentiation, in a formal general equilibrium framework.

Footnotes

1. For a survey of the literature see Bhagwati and Srinivasan (1983) Chapters 28 and 29.

2. For a survey of the Industrial Organization literature on the subject, see Caves (1982).

3. A number of simplifying assumptions will be made for expositional convenience, which can be relaxed to generalize the approach to any number of dimensions in terms of both characteristics and factors of production.

4. The unit resource bundle is taken as given by the firm. Moreover, in the present paper $\bar{E}$ and $\bar{M}$ represent also the endowments of the economy since there is one firm in each country. However, in a more general framework $\bar{E}$ and $\bar{M}$ are market determined. For more details on this issue, see Helpman (1984).

5. Notice that both activities are characterized by the same function. This assumption is made for geometric simplicity and can be relaxed very easily.

6. The similarity of equations (1) through (4) with the supply side of the Heckscher-Ohlin-Samuelson model is not a coincidence but intentional. The reader is warned however that the interpretation of the results is different and the allocation of engineers and managers between the two activities is done in a non-market fashion, on purely efficiency grounds related to profit maximizing behavior of the firm, indirectly.

7. This property has been used in the literature to model the concept of intangible assets. See for example Helpman (1984) and Markusen (1984).

8. Notice that if $\bar{M}$ or $\bar{E}$ are used in the manufacturing level, then the size of the box will depend on the number of units produced by the firm.

9. The technical long-run product differentiation line corresponds to Lancaster's (1979) product differentiation curve.

10. This assumption can be justified if one considers engineers which are specialized (in terms of firm specific human capital) in one activity, but not in the other. If each activity corresponds to different parts of the final product and parts are produced in different plants then the present assumption is not unreasonable. One could introduce partial mobility of one resource following Grossman (1983) without altering the results of the present paper. However, differential resource mobility across activities is needed for the occurence of intra-industry investment.

11. The terms variety and quality are used to distinguish between horizontal and vertical product differentiation as discussed by Lancaster (1979).

12. This formulation is used by Dinopoulos (1985b) to formalize the concept of localized technical change. Helpman (1984) assumes implicitly this relationship but he does not attribute this property to intra-firm resource specificity.

13. Notice that Figure 1(b) suggests that the product differentiation technology interacts with consumers' preferences, and the effects of differential intra-firm mobility will manifest as part of the demand of the firm.

14. In the analysis which follows, each consumer's utility is a function of the two characteristics of the group good and the quantity of the outside good. The present simplification is necessary for expository purposes.

15. The choice of line $a_i\bar{b}\bar{b}d$ instead of $a_1 b_1 \bar{b}d_1$ for the definition of the most preferred good depends on the uniqueness of the former, and serves the purpose of consistency and comparison between the present paper and the rest of the literature on the subject.

16. In the case that each consumer consumes one unit of the available good, this ratio can be interpreted as an upgrade in quality of the available good.

17. For details on this transformation, see Lancaster (1979).

18. These properties depend on certain assumptions of symmetry and uniformity which characterize both functions. For details see Lancaster (1979), Chapter 2.

19. For the determination of returns of public inputs see Sandmo (1972), Helpman (1984) and Markusen (1984).

20. This section is a summary of Dinopoulos (1985b), sections II and III.

21. For the algebraic derivations of the results in this section see Dinopoulos (1985b).

22. In the technical short-run the pattern of trade is determinant, unlike Lancaster (1980) and Krugman (1979b). In the technical long-run infinitesimal transportation costs are needed to remove the pattern of trade indeterminacy.

23. Following the literature on the subject assume symmetry of solutions when necessary, which implies that $p = p^*$ and $b^* = 1 - b$, and allows us to concentrate only on the home firm.

24. In the present paper, differential national tastes interact with differential intra-firm resource mobility, to obtain intra-industry investment. Notice that the assumption of one firm per country plays a prominent role in the model. If the assumption of no entry is relaxed, then, firms within the same country would exchange the activity specific resource to eliminate the quality-loss and establish joint ventures. However, with differential national tastes we will still observe international intra-industry investment. Notice also that if the activity specific resource is capital, anti-trust laws might prevent joint ventures between firms in the same industry and the same country (horizontal mergers). In this case, international intra-industry investment would be the result.

25. In other words Figure 4 corresponds to two identical boxes since $\bar{E}^* = \bar{E}$ and $\bar{M}^* = \bar{M}$, one for home and the other one for the foreign firm.

26. The pattern of intra-industry investment is reversed if products diverge.

27. The implicit assumption here is that b_{LT} and b^*_{LT} are the medium-run equilibrium product specifications.

28. One way to define home demand intensity of a good is if there are more home than foreign consumers whose most preferred good is the product in question.

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