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FIRST MOVER ADVANTAGES, BLOCKADED ENTRY, AND THE ECONOMICS OF UNEVEN DEVELOPMENT

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ABSTRACT

A two-sector, two-period trade model is developed in which one sector has increasing returns based on the creation of specialized intermediate inputs. One of the two (otherwise identical) countries is not able to enter the increasing returns sector in the first period through some "accident of history". A theoretical and numerical analysis solves for parameter regimes under which firms in the disadvantaged country are or are not able to enter the increasing returns sector in the second period. The welfare consequences of the two alternative second period outcomes are compared to one another and to an equilibrium with both countries entering in the first period. The disadvantaged country may fall further behind in the second period even when its firms are able to enter.

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1. Introduction

It is probably reasonable to suggest that increasing returns to scale are now believed to be an important cause of international trade along with, if not as important as, more traditional determinants of trade such as differences in factor endowments. More recently, economists have incorporated elements of increasing returns into models designed to explain long–run, sustained growth in per capita incomes without having to appeal to ad hoc factors such as exogenous technical change. Little work has been done, however, on investigating the possibility of divergent growth between two economies due to dynamic increasing returns.

The setting of the present paper is two countries which are initially identical in all respects, so that there is no comparative–advantage basis for trade. One of the two sectors has an increasing–returns to scale technology. The approach follows Ethier (1982) and later Romer (1987), Grossman and Helpman (1988), and Markusen (1988, 1989, 1990) in that the final good is produced from specialized intermediate inputs. There are increasing returns to the number of inputs, incorporating the Smithian notion of increased division of labor. But the specialized inputs themselves require a fixed cost plus a constant marginal cost, indicating that the division of labor is limited by the extent of the market. The fixed cost is once–and–for–all, paid by a firm only in the period of entry, and thus conforms to the notion of non–depreciating knowledge capital that has been introduced in a number of recent papers. The specialized inputs are non–traded, and are produced by a monopolistically competitive industry with free entry. The inputs can be thought of as knowledge–based consulting services that are costly to trade internationally or, as is often the case, face high trade barriers.

The issues I wish to address with this model are suggested by the title to the paper. I am interested in whether "accidents of history", in which one country is able to enter the increasing returns sector one period earlier than the other country, translate into permanent advantages for the first entrant. This question is, perhaps, of considerable importance to our understanding of the dynamics of uneven development. The paper thus relates to issues addressed by Krugman (1981, 1989), Grossman and Helpman (1988, 1989), and Murphy, Shleifer, and Vishny (1988) but has a somewhat different focus.

The first entrant, referred to as the home country, builds knowledge capital in the first period and, because specialized inputs are complementary in final production, the incentives for the entry of additional firms in the second period are strengthened by the first period entry. This effect is the key to understanding why the present model behaves quite differently from a traditional model with diminishing returns to factor accumulation.

Because of this "complementarity effect", the disadvantaged country (referred to as the foreign country) may fall further behind in the second period for either of two reasons, despite being allowed to enter the increasing–returns sector. First, its firms may be unable to enter at all due to the inherited productivity advantage in the home country. This is referred to as "blockaded entry". Second, some firms may be able to enter, but the level of entry may be well below the level of additional entry in the home country such that the foreign country falls further behind.

Section 2 examines the role of various parameters in determining whether firms from country f can or cannot enter in the second period. Suppose that parameters are chosen so that the solution to the model is that country f is "marginally" blockaded in the second period. Any of the following changes will switch the model solution to one in which country f enters in the second period: (1) the length of the second period increases, (2) the consumer's rate of time preference increases, (3) the complementarity of specialized inputs (degree of scale economies) increases, (4) the elasticity of the wage rate with respect to labor demand in the increasing returns sector increases, (5) the fixed costs of producing a new specialized input decreases. A theoretical analysis of whether or not f catches up when it does enter is not presented. It turns out that the qualitative rolēs of key parameters depend on the numerical values of other parameters and on the convexity of the wage function in particular. This will be confirmed in numerical analysis.

Section 4 employs numerical analysis to (A) solve for parameter regimes in which entry by the foreign country is and is not blocked, (B) examine the welfare consequences of these two alternative outcomes, and (C) examine whether or not the foreign country "catches up" in the second period when it is able to enter. Results concerning the roles of the various parameters confirm those derived analytically.

Several results emerge with respect to welfare issues. First, the foreign country suffers a "large" welfare loss and the home country a smaller welfare gain when the foreign firms are blockaded from entering relative to a situation where firms from both countries can enter in the first period. Second, arbitrarily small parameter changes which shift the equilibrium from one in which foreign firms are blockaded in the second period to one in which they may enter result in large changes in world production and trade flows, and, in some cases, a significant discrete jump in welfare. This discrete jump resulting from an infinitesimal parameter change is due to the non–convex technology (when firms enter they enter in large numbers) and to the fact that the social marginal product of an additional input exceeds the private marginal product. With respect to the issue of catching up in the second period when foreign firms do enter, simulation results produce both outcomes in which the foreign country does catch up and in which it falls further behind.

2. Production

In this section we examine the production side of the general equilibrium model. There are two countries, home (h) and foreign (f), and two time periods ($T=0,1$). There are two traded final goods, X and Y, which have identical production functions in the two countries. Y is produced by a competitive industry with constant returns to scale from labor (L) and sector specific capital (K).

(1) $$Y = G(L_y, K); \qquad G_L > 0, G_{LL} < 0.$$

Countries h and f have identical endowments of L and K in each time period, but their (common) second–period endowment of capital and labor may be larger than the first–period endowment by some multiple, indicating that the second period is perhaps "longer". Further discussion of this point is postponed until section 3. The assumption of identical endowments and technologies is quite deliberately made in order to ensure that there is no ex ante comparative advantage basis for trade.

Good X is assembled from produced intermediate inputs (S) as in Ethier (1982) followed by Markusen (1989, 1990). The S_i are non–traded, and could be thought of as, perhaps, the services of specialized consulting firms that do not deal internationally. A simple CES function is used as in those papers in order to exploit symmetry to solve the model.

(2) $$X = \left[\sum_{i=1}^{n} S_i^{\beta}\right]^{1/\beta}; \qquad 0 < \beta < 1.$$

The number (n) and level of the S_i are endogenous. It is assumed that production of an S_i requires only labor, and that units are chosen such that the marginal cost of S in terms of labor is one. There is a fixed cost in terms of labor F. Let Y be numeraire and let w denote the wage rate in terms of Y ($w = G_L$). The cost of producing an S_i in terms of Y are then given by

(3) $$C_i = wS_i + wF.$$

The fixed cost need only be incurred once, in the initial period of entry. F could be thought of as the learning costs of acquiring knowledge capital which does not depreciate. p will denote the price of X in terms of Y, and r will denote the price of an S in terms of Y. Because of the symmetry in (2) and identical cost functions in (3), any S_i that is produced will be produced in the same amount as any other S_j and sell for the same price r. p is equalized across countries by free trade while r is not. The demand for the S_i is a derived demand and the demand price r is the value of the marginal produce of S_i in X. Multiplying (2) by p and differentiating, this VMP is given by

$$(4) \qquad r = (p/\beta)\left[\Sigma S_j^{\beta}\right]^{\alpha} \beta\, S_i^{\beta-1} = \left[p\left[\Sigma S_j^{\beta}\right]^{\alpha}\right] S_i^{\beta-1}$$
$$\alpha \equiv 1/\beta - 1;$$

There is a simple assumption about S producers' conjectures that gives a mark–up pricing rule familiar from the final–goods literature. Assume that each S_i producer views n and the total input demand in the X sector as fixed, $d(\Sigma S_j)/dS_i = 0$: an increase by producer i of dS_i leads each other S_j producer to decrease his output by $dS_j = -dS_i/(n-1)$. A conjecture that (ΣS_j) is constant also implies that $(\Sigma S_j^{\beta})^{1/\beta}$ and $(\Sigma S_j^{\beta})^{\alpha}$ are locally constant due to the initial symmetry of the S_i. This conjecture in turn implies that p is constant and that the term in brackets in (4) is constant. Note from (4) that r is nevertheless not constant and is decreasing in producer i's own output (there is a diminishing marginal product to substituting one's own output for the output of other firms). Multiplying r in (4) by S_i to get producer i's revenue (rS_i), we then see that marginal revenue is given by

$$(5) \qquad MR_i = d(rS_i)/dS_i = \beta\left[p\left[\Sigma S_j^{\beta}\right]^{\alpha}\right] S_i^{\beta-1} = \beta r.$$

Since the marginal cost of an S_i is just w, the marginal–revenue–equals–marginal–cost conditions thus have the simple mark–up form $\beta r = w$.

Let subscripts 0 and 1 denote the first and second periods respectively (subscripts denoting individual S producers are henceforth dropped so S_j denotes the output level of a representative S at $T = j$). Let i denote the interest rate at which producers are allowed to borrow and lend in terms of Y_0, the numeraire. Superscripts h and f will denote the home and foreign countries. For firms entering in the first period in h, three equations determine the equilibrium values of S_0, S_1, and n_0. These are the two $MR = MC$ conditions for each period and the zero–profit, free–entry constraint that the present value of profits is zero. These are given by

$$\beta r_0^h - w_0^h = 0 \tag{6}$$

$$\beta r_1^h - w_1^h = 0 \tag{7}$$

$$(r_0^h - w_0^h)S_0^h + (1 + i)^{-1}(r_1^h - w_1^h)S_1^h - w_0^h F = 0. \tag{8}$$

Now consider firms entering in the second period (if any) in the home country. The intuition as to why additional firms might enter despite the shorter time horizon to recover F can be seen by considering the possibility that they do not enter. If the output of S was the same across periods (it generally is not), then the labor previously devoted to financing F returns to the Y sector, the world production and consumption ratio Y/X must rise and p rises. $r_1 = p_1 n_0^{\alpha}$ (from (4)) therefore exceeds $r_0 = p_0 n_0^{\alpha}$. Similarly, $w_1 < w_0$ as labor returns to Y production. With a higher r and lower w, second–period entry may be possible. The first–order condition ($MR = MC$) and the free–entry condition are given by

$$\beta r_1^h - w_1^h \leq 0 \tag{9}$$

$$(r_1^h - w_1^h)S_1^h - w_1^h F \leq 0. \tag{10}$$

The first of these inequalities is identical to (7), implying that it holds with equality. The zero–profit condition in (10) need not hold with equality, in which case there is no entry at $T = 1$. Substituting for w_1^h from (7), this zero profit condition becomes

(11) $$(1-\beta)r_1^h S_1^h - \beta r_1^h F \le 0.$$

Equation (11) gives a result that will be heavily exploited in what follows. If there is entry at $T = 1$, then the equilibrium level of S_1 is necessarily given by

(12) $$S_1 = \beta F/(1-\beta) \qquad \text{(if entry at } T=1\text{)}$$

which is independent of the values of all other endogenous variables. This applies, of course, to firms which entered at $T=0$ as well, since all firms have the same marginal cost and marginal revenue functions at $T=1$.

Foreign firms, which can only enter at $T=1$ by assumption, have the same first–order condition and free–entry condition as firms entering in h at $T=1$.

(13) $$\beta r_1^f - w_1^f \le 0$$

(14) $$r_1^f S_1^f - w_1^f S_1^f - w_1^f F \le 0.$$

If entry occurs, then both equations hold with equality and we again have the equilibrium level of S_1 given by $S_1 = \beta F/(1-\beta)$ as in (12).

The production side of the model is summarized by six equations and inequalities (6, 7, 8, 10, 13, 14) in six unknowns (n_0^h, n_1^h, S_0^h, S_1^h, n_1^f, S_1^f). We noted that $S_1^h = S_1^f = \beta F/(1-\beta)$ if there is a second–period entry in both countries. Two questions are of interest. The first is whether or not entry into X by f at $T=1$ is blockaded ((13) and (14) are slack). The second is whether or not f catches up in the second period when it does enter. The first question will occupy the remainder of this section while the second will be addressed numerically.

The question of whether or not f can enter at $T=1$ is a difficult question due to the non–convex technology. In particular, we note below that we cannot simply check whether or not a single firm can enter in f. Because of the complementarity of the S_i, a large number may be able to enter while a single firm cannot. But the entry of a large number of firms disturbs the initial prices at which we are evaluating the possibility of entry. Nevertheless, a good deal of progress can be made.

For the remainder of this section, all variables will be taken to refer to country f in period $T=1$, so unless otherwise noted, the superscript f and the subscript 1 will be dropped to avoid clutter. We will also assume a Cobb–Douglas technology in Y in order to obtain explicit results and to be consistent with the later numerical analysis. Y and w are given by

(15) $$Y = L_y^{\gamma} K^{1-\gamma}, \qquad w = \gamma L_y^{\gamma-1} K^{1-\gamma}.$$

The wage function can be rearranged to give us a labor demand function for L_y.

(16) $$L_y = (w/\gamma)^{1/(\gamma-1)} K = (w/\gamma)^{\varepsilon} K; \qquad \varepsilon \equiv 1/(\gamma-1) < -1.$$

From (4), we have that $r = pn^{\alpha}$ and from (13) that $w = \beta r$. We can thus replace w in (16) with $p\beta n^{\alpha}$.

(17) $$L_y = (p\beta n^{\alpha}/\gamma)^{\varepsilon} K = (p\beta/\gamma)^{\varepsilon} n^{\sigma} K; \qquad \sigma \equiv \alpha\varepsilon < 0.$$

We noted in (12) that S has a constant value if firms do enter. Since the labor demand in X is $n(S + F)$, we then have

(18) $$L_x = n(\beta F/(1-\beta) + F) = nF/(1-\beta).$$

The sum of (17) and (18) gives us the total demand for labor as a function of p and n.

(19) $$L_d = L_y + L_x = (p\beta/\gamma)^{\varepsilon} n^{\sigma} K + nF/(1-\beta)$$

The derivative of labor demand with respect to n at constant p is given by

(20) $$d(L_d)/dn = \sigma(p\beta/\gamma)^{\varepsilon} n^{\sigma-1} K + F/(1-\beta).$$

The first term is negative ($\sigma < 0$) while the second term is positive. Since the exponent of n is negative, the first term obviously dominates for small n and (20) is negative, while the second term must dominate for a sufficiently large n. Labor demand as a function of n at constant p is thus given by the U–shaped curves shown in Figure 1.

The minimum point on this L_d curve is at the level of n that sets (20) to zero. For firms in f to be able to enter the X industry, the L_d curve must touch or pass below the labor supply curve L_s in Figure 1. Strictly speaking, the L_d curve evaluated at the (lower) post–entry p must have this property, but the post–entry price is itself a function of the level of entry. In what follows, we shall ignore this interdependency and focus on factors that shift L_d relative to L_s at no–entry prices. But we should keep in mind that it is not in general sufficient to just touch L_s as is the case with L_d^2 in Figure 1.

Figure 1 emphasizes two important points. The first is that a small number of firms may not be able to enter, but that a "large" number may. Second, there may be three equilibria as illustrated with demand curve L_d^1 in Figure 1. One is at A (no entry into X) and the other two are at B and C. Equilibrium B is presumably unstable under some reasonable adjustment mechanism and can be thrown out. The subsequent analysis will not focus on getting stuck at A, although that is an interesting and important research topic. Rather, we will be concerned with whether or not an equilibrium like C (or D) in Figure 1 exists, and assume that country f reaches that equilibrium when it does exist.

FIGURE 1

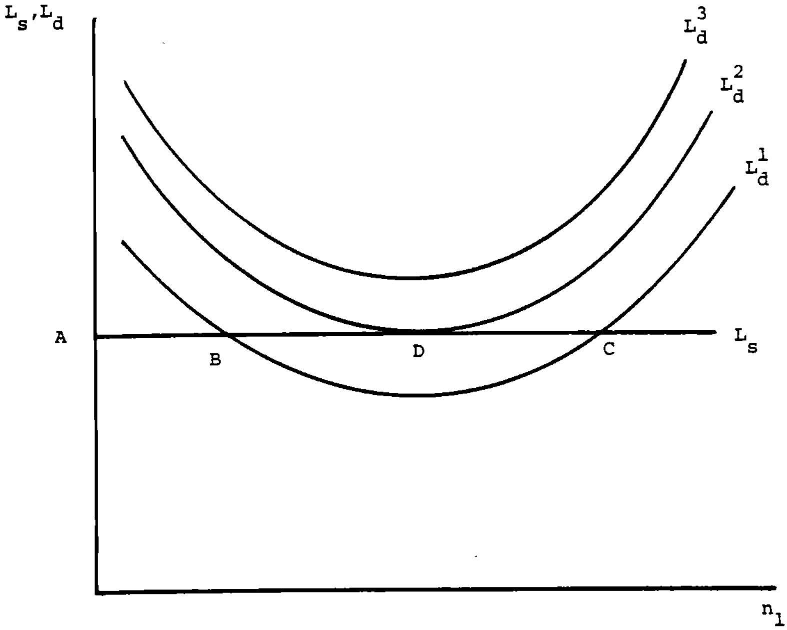
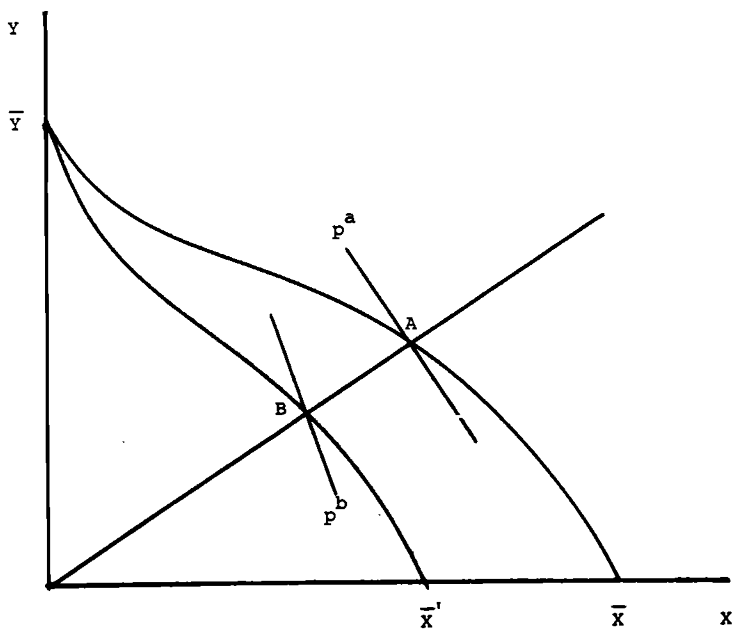


FIGURE 2



The U–shaped labor demand curve in Figure 1 is closely related to the shape of the production frontier shown in Figure 2. I have derived the properties of the production frontier elsewhere (Markusen 1988, 1989, 1990) so I will simply repeat the results here. Given the constant output of any S that is produced at $T=1$, the marginal rate of transformation along the production frontier is given by the ratio of the marginal product of labor in Y (MP_{ly}) to the (social) marginal product of labor in X (MP_{lx}).

(21) $$MRT = w/n^{\alpha} = MP_{ly} / MP_{lx}.$$

The production frontier is locally concave if and only if

(22) $$\theta > \alpha; \qquad \theta \equiv (dw/w)/(dn/n) = (1-\gamma)(S+F)n/L_y$$

where θ is the elasticity of w (or of MP_{ly}) with respect to n, given in the Cobb–Douglas case by the right–hand equation of (22). The production frontier is locally concave if and only if the elasticity of MP_{ly} with respect to n exceeds the elasticity of MP_{lx} with respect to n, the latter simply being α. The right–hand equation of (22) shows that in the Cobb–Douglas case, θ runs from zero to infinity as we move down the production frontier, thus the frontier must be convex in the neighborhood of $X = 0$ and concave in the neighborhood of $Y = 0$ with a single inflection point as shown in Figure 2.

My earlier papers also show that the relationship between p and the MRT is given by $p\beta = MRT < p$ (the private $MP_{lx} = \beta n^{\alpha}$), so the price ratio cuts the production frontier as shown in Figure 2.

The supply price ratio MRT/β at first falls and then rises due to the non–convexity and the analysis of Figure 1 is equivalent to asking in Figure 2 if the (U–shaped) supply price ever falls below the prevailing world (home country) price. Country h inherits a productivity advantage at the beginning of $T=1$ in the form of n_0^h, so we could think of the inner and outer frontiers of Figure 2 as representing countries f and h respectively at $T=1$. It seems intuitive that there may or may not exist an equilibrium with f producing X depending on the gap between $\bar{X}'$ and $\bar{X}$.

To analyze the possibility of entry by f, consider a change in L_d in response to a change in p, the second period price (recall that all variables are second period values unless otherwise indicated). Assume that f cannot enter at the initial p, so we can focus only on whether or not the minimum point on L_d moves up or down. Differentiating (19) and evaluating it at the minimum value of n ((20) equal to zero) we get

$$(23) \qquad dL_d/dp = \varepsilon(\beta/\gamma)^{\varepsilon}p^{\varepsilon-1}n^{\sigma}K + (0)dn/dp < 0$$

since $\varepsilon < 0$ (the second term emphasizes that (23) is evaluated at the minimum value of L_d). (23) states that an increase in p shifts L_d down and thus a sufficient increase makes entry by f feasible.

But p is of course endogenous, and the question is, what can change p independently of second–period parameters? A principal determinant of p is n_0^h, which is in turn influenced by certain independent first–period parameters. Suppose that n_0^h falls due to a change in a first–period parameter. The second–period effect is described in Figure 2. The decrease in n_0^h reduces the output of X_1^h from any given L_{x1}^h and shifts country h's second–period production frontier from $\bar{Y}\bar{X}$ to $\bar{Y}\bar{X}'$. Compare points A and B which have the same production ratio (Y/X) in Figure 2. The MRT along the production frontier is as noted above

$$(24) \qquad MRT_1^h = w_1^h/(n_1^h)^{\alpha}; \qquad n_1^h = n_0^h + (n_1^h - n_0^h)$$

where n_1 denotes total n at $T=1$, not new entry (the latter given by $(n_1^h - n_0^h)$).

In moving from A to B in Figure 2, labor is withdrawn from Y (the decrease in n_0^h will be partly offset by additional second–period entry), so the (K/L_y) ratio rises and w rises. Since

S_1^h is constant and X_1^h decreases, n_1^h must decrease implying in turn that $(n_1^h)^\alpha$ falls. The *MRT* at *B* is unambiguously higher than at *A*, and $p^b > p^a$.

Considering *A* and *B* in Figure 2 further, world supply of *X* has decreased more than *Y* (country *f* remains specialized in *Y*), so the demand price–ratio rises (preferences are assumed to be homothetic). The latter may rise more or less than the supply price rise $(p^b - p^a)$ shown in Figure 2, but we can show that the new equilibrium price ratio must be higher than the initial price ratio p^a using a simple proof by contradiction.

Suppose that the new equilibrium price ratio did fall back to p^a. Beginning at *B* in Figure 1, this would require an increase in X_1^h and a decrease in Y_1^h relative to *B* in order to restore the world output ratio to its original level. But this raises the supply price ratio further (assuming production on the concave portion of the production frontier) in *h* above p^b. Thus clearly the decrease in n_0^h cannot leave the equilibrium price ratio at or below its initial level p^a.

What factors can reduce n_0^h and therefore increase p_1 for given values of second–period parameters? Two factors are obvious and their effects are presented without formal proof. The first is to lower both countries' first–period factor endowments (K_0, L_0) (remember that we wish to keep the countries identical). With reference to equations (7) and (8), this raises the wage rate for a given L_{x0}^h and n_0^h and lowers the demand price for that given level of *X* (the output of *Y* is falling). Thus fewer firms can be supported at *T=0*. The second factor is to raise the consumer's discount rate ρ, which leads to a higher *i*, ceteris paribus. The heavier discounting of future profits leaves the present value negative and forces some firms to exit at *T=0*.

Changes in other parameters of the model have complicated effects due to changing first–period entry and second–period prices. An obvious example is that an increase in *F* might make it harder for *f* to enter at *T=1* at constant p_1. But such a change in *F* might raise p_1 for two reasons. First, the increase in *F* will reduce initial entry (n_0^h) at *T=0* and second, reduce additional entry by firms in h at $T=1$. Although there is no reason to expect the intuitive effect to be reversed by the effect on p_1, unambiguous results are difficult to obtain from the algebra because of the large number of equations and unknowns.

In order to obtain some results and intuition, let us therefore introduce the notion of compensated changes. By a compensated change in parameter z, I will mean a change in z accompanied by a change in the first–period endowment (thereby changing n_0^h) such that p_1 is left unchanged ($dp_1/dz = 0$). Thus if an increase in z raises p_1, other things equal, the first–period endowment is increased to return p_1 to its initial level. Referring back to equation (19), p_1 but not (K_0, L_0) appears in this equation. Thus in performing comparative statics with (19), it is assumed that "background" changes are affected for (K_0, L_0) to hold p_1 constant.

Consider an increase in γ, which is a reduction in the elasticity of w with respect to n as shown in (22). An increase in γ does not necessarily increase w for a given labor demand in X, and therefore does not necessarily have the intuitive effect of shifting the labor demand curve up at constant p. w can be written as

$$(25) \qquad w = \gamma(K/L_y)^{1-\gamma}; \qquad \ln w = \ln \gamma + (1-\gamma)\ln(K/L_y)$$

$$(26) \qquad d \ln w/d\gamma = 1/\gamma - \ln(K/L_y) \gtrless 0.$$

In our simulations of section 4, capital and labor endowments are assumed equal, so (26) is positive for small sizes of the X sector ($K/L_y < e$) and negative for large sizes of the X sector. When firms in f do enter, Figure 2 emphasizes that they enter in large numbers and thus we cannot be sure of the sign of (26) at the minimum of L_d.

Despite this ambiguity, it is easy to show that an increase in γ shifts up the minimum point of L_d at constant p by reducing L_y. The first term of (19), the demand for labor in Y, written in full becomes

(27) $$(p\beta/\gamma)^{\varepsilon}\, n^{\sigma}K = (p\beta n^{\alpha}/\gamma)^{\varepsilon}K = K[\gamma/(p\beta n^{\alpha})]^{1/(1-\gamma)}$$

γ appears in the bracketed term and in the exponent, and (27) is increasing in γ with both cases. Thus the derivative of (19) with respect to γ at minimum L_d ($dL_d/dn = 0$) must be positive. $d\gamma > 0$ shifts up the minimum point of the labor demand curve. Conversely, a sufficiently large $d\gamma < 0$ (increasing the elasticity of w with respect to n) makes entry by f possible by reducing L_y.

Now consider the effects of an increase in F which, at constant p_1, has the intuitive effect of shifting L_d up. The first term of (19) is independent of F while the second term is positive and increasing in F. Holding p constant, the effect of an increase in F on the minimum point of L_d is

(28) $$dL_d/dF = n/(1-\beta) + (0)dn/dF > 0.$$

A (compensated) decrease in F thus permits f to enter.

Finally, consider the effects of an increase β (decrease in the complementarity of the S_i, decrease in returns to scale to n). Differentiating (19) at the minimum value of L_d, we have

(29) $$dL_d = [\varepsilon K(p\beta/\gamma)^{\varepsilon-1}n^{\sigma}(p/\gamma) + K(p\beta/\gamma)^{\varepsilon}n^{\sigma}(\varepsilon \ln n)d\alpha/d\beta + nF(1-\beta)^{2}]d\beta + (0)dn_1.$$

The first term of (29) is negative ($\varepsilon < 0$) while the third term is positive. The second term, which derives from the fact that α (or β) appears in the exponent σ, is positive ($\varepsilon < 0$, $d\alpha/d\beta < 0$).

A sufficient condition for (29) to be positive is that the first term is less in absolute value than the third term. Multiplying (29) through by $\alpha\beta/n$, the first and third terms are

(30) $$\{\sigma K(p\beta/\gamma)^{\varepsilon}n^{\sigma-1} + F/(1-\beta)[\alpha\beta/(1-\beta)]\}n/(\alpha\beta).$$

But $\alpha\beta/(1-\beta) = 1$ since $\alpha = (1-\beta)/\beta$. Thus (30) is the same as (20) set equal to zero: the minimum value of L_d. At this value, the first and third terms of (29) cancel and we are left with

$$dL_d = K(p\beta/\gamma)^{\varepsilon} n^{\sigma}(\varepsilon \ln n)d\alpha/d\beta > 0. \tag{32}$$

At constant p, an increase in β shifts the labor demand curve up. Conversely, a decrease in β can permit f to enter. This may seem paradoxical insofar as a decrease in β is in a sense an increase in the returns to scale to n ($X = n^{1/\beta}S$). I think that the intuition lies in the fact that a decrease in β supports a smaller firm size ($S = F\beta/(1-\beta)$). Thus for a given w (given amount of labor drawn into the X sector), a smaller β permits a greater measure of differentiation n and an unambiguously greater value of marginal product in X, pn^{α} (α increases with a decrease in β). Thus at a constant p, entry by f becomes more likely as β decreases.

Results: Assume that entry by f is marginally blockaded in the second period. The equilibrium shifts toward permitting entry if any of the following changes occur:

(A) The first-period endowment shrinks (the second period becomes relatively "longer").

(B) Time preferences increase (ρ increases).

(C) There is a (compensated) fall in F.

(D) There is a (compensated) fall in β.

(E) There is a (compensated) fall in γ.

Before turning to the simulations, we now specify a demand side to the model, which is assumed identical in the two countries.

3. Demand

Consumers have a two-period Cobb-Doublas utility function given by

$$(33) \qquad U(Y_0,X_0,Y_1,X_1) = (Y_0^{\delta_0} X_0^{\delta_0})(Y_1^{\delta_1} X_1^{\delta_1})$$

Consumer's may borrow and lend at interest rate i (endogenous in general equilibrium) in terms of Y_o. p_o continues to denote the price of X_o in terms of Y_o and p_1 and the price of X_1 in terms of Y_1. $p_1(1+i)^{-1}$ is thus the price of X_1 in terms of Y_o. Let I_o and I_1 denote first and second-period factor income respectively. The intertemporal budget constraint is given by

$$(34) \qquad I_0 + (1+i)^{-1} I_1 - Y_0 - (1+i)^{-1} Y_1 - p_0 X_0 - p_1(1+i)^{-1} X_1 = 0$$

Maximizing (33) subject to (34) gives us marginal-rate-of-substitution conditions familiar for Cobb-Douglas functions

$$(35) \qquad p_0 = (Y_0/X_0), \quad p_1 = (Y_1/X_1)$$

$$(36) \qquad (1+i) = (\delta_0/\delta_1)(Y_1/Y_0)$$

In order to interpret (36), suppose that Y was the only good in the economy and that consumer's had an indentical endowment of it in each period: $Y_1 = Y_0$. From (36), the rate of interest that would induce consumer's to just hold their endowment is given by

$$(37) \qquad i = (M/D) - 1 \; ; \qquad M \equiv Y_1/Y_0, \;\; D \equiv \delta_1/\delta_0$$

The term $(M/D) - 1$ is a natural measure of time preference, and we shall denote it by $\rho \equiv (M/D) - 1$. The reason for this is that numerical analysis shows that entry by f is always blockaded when the second-period endowment is the same as the first, even at $D \to 0$ (ρ approaching infinity). Rather than add additional periods which greatly increases the dimensionality, I will assume that the second period can be "longer" than the first. M will now be defined as the ratio of the second period's factor endowment to that of the first, factor proportions being the same.

(38) $$M \equiv L_1/L_0 = K_1/K_0 ; \qquad \rho \equiv (M/D) - 1$$

A value of $M = 2$ suggests a situation of no growth with a second period twice as long. Equation (37) gives the value of i necessary to induce consumers to consume twice as much in the second period as the first. The definition of ρ in (38) implies that the utility-weighting of second-period consumption must increase in proportion to the length of that period if the rate of time preference is to be constant. Thus in the simulations, an adjustment of M at constant ρ means that D is adjusted in proportion to M.

4. Numerical Analysis

In order to quantify the theory, I created a seven-equation model in the seven unknowns. n_0^h, n_1^h, n_1^f, S_0, L_{y0}^h, L_{y1}^h, L_{y1}^f to solve for equilibria under the assumption that those equilibria do involve second-period entry by firms in country f (we do not need the additional equation for S_1, since it equals $\beta F/(1-\beta)$ if entry occurs in either country). The model is solved by a Newton method of successive approximation. A solution is found for a certain set of parameters, and then one parameter is adjusted in the direction which the theory suggests will lead to blockaded entry (i.e., the non-existence of a solution to the seven equation model). I chose values of M and B *ex ante*, and then successively decreased ρ until no solution to the model existed.

Two values of β were chosen, 0.5 and 0.6. In the former case, scale economies are very strong with X homogeneous of degree 2 in n, while X is homogeneous of degree 1.67 in n in the latter case. I then solved for the integer value of M below which entry could not occur at any rate of time preference and the integer value of M above which entry would occur even at a zero rate of time preference (for the two values of β indicated). These values are, respectively, $M = 2$ and $M = 4$.

Tables 1 through 4 present results for four sets of critical values of M, β, and ρ, where the latter is solved for from the other two. In each Table, three sets of results are presented. The first (solution A) results are for entry by f at time $T=1$. The second (solution B) results assume that country f does not enter in either period. Rather than adjust parameters slightly so that the latter are the only equilibria in each case (leaving confusion about what is the effect of the parameter change and what is the effect of blocking) solution B is computed at the same set of parameter values as solution A so that the effect of blocking *per se* is presented. Solution C in each case presents the equilibrium with both countries entering at $T=0$. I_0 and I_1 give the value of production in periods 0 and 1 respectively (at current period prices in terms of Y) and E_0^f is country f's excess demand (current account deficit) at $T=0$.

Several results are apparent from Tables 1–4. Note first the results for the number of foreign firms entering at $T=1$ in solution A (n_1^f). This is clearly a discrete number of firms not close to zero. Remembering that these are equilibria which are arbitrarily close to no entry by f, we see the problem that I noted in Figure 1. We have entry possible only with a single, large number of foreign firms. Slight decreases in M or ρ. or slight increases in β. F, or γ, drop this number of firms to zero (solution B).

Second, note that entry in country f is always less than the additional entry in country h at $T=1$. In three of the four cases, the number of firms entering in f is less than the number that entered in h in the first period. If we were to define "catching up" in terms of the number of specialized inputs in the X sector, and hence the marginal productivity of labor in the X sector, the foreign country always falls further behind in the sense that $n_1^f < (n_1^h - n_0^h)$.

TABLE 1: Case 1

Parameter Values: $M = 2$, $\beta = 0.5$, $\rho = 2.704$

	SOLUTION A f enters at T=1	SOLUTION B f does not enter	SOLUTION C f enters at T=0
n_0^h	201.4	204.3	175.7
n_1^h	435.8	455.1	375.3
n_0^f	0	0	175.7
n_1^f	194.3	0	375.3
s_0	8.27	8.05	7.98
s_1	10.0	10.0	10.0
i	2.528	2.856	3.042
p_0	0.437	0.437	0.254
p_1	0.123	0.147	0.097
E_0^f	3622.0	-1388.0	0
I_0^f/I_0^h	0.516	0.518	1.0
I_1^f/I_1^h	0.602	0.487	1.0
U^f/U^h	0.545	0.507	1.0
U^f	122,793	116,751	193,351
U^h	225,019	230,345	193,351

Income ratios in terms of X	$(I^f_{1a}/I^f_{1b})_x = 1.260$	$(I^h_{1a}/I^h_{1b})_x = 1.020$
	$(I^f_{1a}/I^f_{1c})_x = .690$	$(I^h_{1a}/I^h_{1c})_x = 1.008$
Income ratios in terms ot Y	$(I^f_{1a}/I^f_{1b})_y = 1.051$	$(I^h_{1a}/I^h_{1b})_y = .851$
	$(I^f_{1a}/I^f_{1c})_y = .769$	$(I^h_{1a}/I^h_{1c})_y = 1.227$

NOTES TO TABLES 1–4:

1. Parameters are: $L_o = K_o = 4000$, $F = 10$, $\gamma = 0.3$, $c = 25$ (c is a scaling parameter on $Y = cL_y^{\gamma} K^{1-\gamma}$).
2. I_k^j is the value of production in country j in period k.
3. E_o^f (equal to $-E_o^h$) is country f's current account deficit at $T=0$.

TABLE 2: Case 2

Parameter Values: $M = 4$, $\beta = 0.5$, $\rho = 0.023$

	SOLUTION A f enters at T=1	SOLUTION B f does not enter	SOLUTION C f enters at T=0
n_0^h	256.7	261.1	236.2
n_1^h	825.7	844.8	706.2
n_0^f	0	0	236.2
n_1^f	257.9	0	706.2
S_0	4.74	4.53	4.33
S_1	10.0	10.0	10.0
i	0.033	0.096	0.204
p_0	0.453	0.457	0.236
p_1	0.076	0.085	0.054
E_0^f	543.0	-5304.0	0
I_0^f/I_0^h	0.546	0.549	1.0
I_1^f/I_1^h	0.552	0.494	1.0
U^f/U^h	0.551	0.501	1.0
U^f	461,175	436,518	726,161
U^h	837,642	864,445	726,161

Income ratios in terms of X	$(I^f_{1d}/I^f_{1b})_x = 1.137$	$(I^h_{1d}/I^h_{1b})_x = 1.012$
	$(I^f_{1d}/I^f_{1c})_x = .537$	$(I^h_{1d}/I^h_{1c})_x = .970$
Income ratios in terms of Y	$(I^f_{1d}/I^f_{1b})_y = 1.017$	$(I^h_{1d}/I^h_{1b})_y = .912$
	$(I^f_{1d}/I^f_{1c})_y = .757$	$(I^h_{1d}/I^h_{1c})_y = 1.373$

TABLE 3: **Case 3**

Parameter Values: $M = 2$, $\beta = 0.6$, $\rho = 5.667$

	SOLUTION A *f* enters at T=1	SOLUTION B *f* does not enter	SOLUTION C *f* enters at T=0
n_0^h	157.6	157.9	134.5
n_1^h	345.2	347.6	287.6
n_0^f	0	0	134.5
n_1^f	42.7	0	287.6
s_0	13.2	13.2	13.2
s_1	15.0	15.0	15.0
i	5.709	5.855	6.704
p_0	2.423	2.423	1.369
p_1	1.131	1.177	0.718
E_0^f	-96.0	-633.0	0
I_0^f/I_0^h	0.512	0.512	1.0
I_1^f/I_1^h	0.509	0.492	1.0
U^f/U^h	0.512	0.508	1.0
U^f	41,176	40,972	69,665
U^h	80,478	80,719	69,665

Income ratios in terms of X	$(I^f_{1a}/I^f_{1b})_x = 1.043$	$(I^h_{1a}/I^h_{1b})_x = 1.007$
	$(I^f_{1a}/I^f_{1c})_x = .471$	$(I^h_{1a}/I^h_{1c})_x = .926$
Income ratios in terms of Y	$(I^f_{1a}/I^f_{1b})_y = 1.002$	$(I^h_{1a}/I^h_{1b})_y = .967$
	$(I^f_{1a}/I^f_{1c})_y = .743$	$(I^h_{1a}/I^h_{1c})_y = 1.458$

TABLE 4: Case 4

Parameter Values: $M = 4$, $\beta = 0.6$, $\rho = 0.081$

	SOLUTION A f enters at T=1	SOLUTION B f does not enter	SOLUTION C f enters at T=0
n_0^h	225.9	227.3	205.0
n_1^h	659.5	663.8	555.4
n_0^f	0	0	205.0
n_1^f	74.4	0	555.4
S_0	6.71	6.16	6.34
S_1	15.0	15.0	15.0
i	0.125	0.148	0.245
p_0	2.528	2.535	1.283
p_1	0.770	0.796	0.475
E_0^f	–3002.0	–4595.0	0
I_0^f/I_0^h	0.543	0.543	1.0
I_1^f/I_1^h	0.511	0.496	1.0
U^f/U^h	0.518	0.506	1.0
U^f	149,766	147,579	252,038
U^h	289,240	291,840	252,038

Income ratios in terms of X	$(I^f_{1d}/I^f_{1b})_x = 1.035$	$(I^h_{1d}/I^h_{1b})_x = 1.050$
	$(I^f_{1d}/I^f_{1c})_x = .462$	$(I^h_{1d}/I^h_{1c})_x = .905$
Income ratios in terms of Y	$(I^f_{1d}/I^f_{1b})_y = 1.002$	$(I^h_{1d}/I^h_{1b})_y = .971$
	$(I^f_{1d}/I^f_{1c})_y = .750$	$(I^h_{1d}/I^h_{1c})_y = 1.467$

Note that solution A has substantially more total firms in the market at $T = 1$ than solution B but fewer than solution C. This is due to the increased costs in a single country of drawing labor from the Y sector and is reflected in the differences in the equilibrium relative price of X at $T=1$.

The current account statistic E_0^f in Tables 1–4 is of some interest. In solution B, this value is always negative, indicating that the foreign country is making consumption loans to the home country in the first period in order to help the latter finance "capital formation" or, alternatively, to allow the latter to smooth its consumption stream. There is naturally no intertemporal or temporal trade in solution C when the countries are in the same situation. The interesting results occur in solution A, where we see that country f is the first-period borrower in Cases 1 and 2 but a first-period lender in Cases 3 and 4. The reason for this, as we shall see shortly, is that country f "catches up" a bit in terms of production income in Cases 1 and 2, and thus it borrows in the first period to smooth consumption.

Now turn to overall welfare measures (utility). Here the results in all four cases suggest that whether country f is just able to enter or is just blockaded in period 2 is of much less welfare significance than the fact that it is not allowed to enter at $T=0$ in the first place. Nevertheless, there clearly is a discrete jump in welfare moving from the blockaded solution B to the entry solution A. The biggest difference is in Table 2 (Case 2), where utility at solution A is 5.6% higher than at solution B. In the same Table, the ratio of U^f/U^h is .551 in solution A versus .501 in solution B, about 10% higher.

One limitation of the welfare measure is that it smooths the second period effect over two periods. We also wish to focus on the second-period situation, particularly with respect to the catching-up issue. Tables 1–4 thus present levels and ratios of the value of production (I) at $T=0,1$ for the two countries and three equilibria. In Cases 1 and 2, the ratio of f's to h's second period income is higher at $T=1$ than at $T=0$. This seems to be a sensible measure of "catching up". By this measure, country f falls further behind in Cases 3 and 4 and falls further behind in solution B for all cases. These very limited results thus suggest catching up is more likely to occur at strong scale economies (low values of β).

One interesting aspect of the catching up question in that an important component of it is a strong terms-of-trade effect in which the price of X falls significantly in the second period, as we can see by comparing p_0 and p_1 in Tables 1–4. It is not of course possible to separate the terms-of-trade effect from the dynamic scale economies effect, because the former is simply the general-equilibrium consequence of the great productivity increase afforded by the latter. Nevertheless, the terms-of-trade effect is of conceptual importance, especially in understanding (A) why f may catch up measured in income while falling behind measured in specialized inputs, and (B) why the degree to which f falls further behind in solution B is not much worse than it is. Country f catches up or falls less further behind due to the strong appreciation in its terms of trade at $T=1$.

There is an important limitation to using production income measures, which relates to comparing the income of a single country across the different equilibria. We are interested in such comparisons in order to assess the discrete difference to f and h of reaching solution A versus B. p_1 is significantly different in solutions A, B, and C as is clear from Tables 1–4. With p_1 at solution A less than p_1 at B, country f will gain more at A over B when income is measured in X than in Y. Conversely, country h will lose less at A versus B when income is measured in terms of X than in Y. At bottom of Tables 1–4, I have therefore presented income ratios both in terms of X and Y. $(I^f_{1a}/I^f_{1b})_x$ is, for example, the ratio of f 's second-period income in solution A to solution B measured in terms of X.

Case 1 involves the largest difference between solution A and solution B for country f, with the former increasing output by 26% in terms of X (5% in terms of Y) over its value in the blockaded case. The smallest such difference for country f is in Case 4, where solution A increases the value of production by only 3.5% in terms of X (0.2% in terms of Y) over solution B. These discrete changes resulting from an infinitesimal parameter change are due to the non-convex technology (if firms in f enter, they enter in large numbers) and to the fact that the social marginal cost of an additional input is less than the private marginal cost, the ratio of the two being given by β (Markusen, 1988, 1989, 1990).

Recall also in this context that country f can get stuck at the $n_1 = 0$ solution, due to the lack of coordination among firms. Case 1 then gives a situation where the gains from a policy which kicks the economy over to the other equilibrium results in a significant welfare gain. I should emphasize again in this connection that these welfare gains for country f in solution A over solution B are in a sense minimum, in that they are calculated for cases in which the A equilibrium "marginally" exists.

As a final point, the results for the home country presented in Tables 1–4 are also worth examining. They indicate that the home country makes significant welfare gains from being able to prevent entry by the foreign country in the first period, with additional gains from being able to prevent second-period entry as well. In Cases 3 and 4 (the low scale economies cases), the additional gains from preventing second-period entry are very small relative to the gains from preventing first-period entry.

5. Summary and Conclusions

The purpose of this paper is to consider the consequences of first-mover advantage in a trade model with dynamic scale economies. The model follows Ethier (1982) in that one (traded) final good is assembled from specialized intermediate inputs. There are increasing returns to the number of specialized inputs (the division of labor) but fixed costs limit the number of such inputs. The fixed costs need only be incurred in the initial period of entry, corresponding to the notion of non-depreciating knowledge capital. The fact that the specialized inputs are complementary in production means that the country which enters in the first period inherits a productivity advantage at the beginning of the second period. The disadvantaged country may either not be able to enter the increasing returns sector at the beginning of the second period, or may enter but fall further behind.

The paper focused on situations in which the late entrant (the foreign country) is "marginally" able to enter or not enter in the sense that small parameter changes flip the solution from one equilibrium to the other. Parameter regimes that support one equilibrium or the other were analyzed theoretically and numerically. Numerical analysis permits us to quantify the effects of blockaded entry on both countries. For the parameters chosen, the welfare costs of being blockaded in the first period are large, with the costs of being blockaded in the second period being smaller. Of course, the latter result is partly due to the focus on cases where second-period entry is only "marginally" possible. Even so, one case was found (Case 1) in which the ability to enter in the second period increases the value of second-period production by 26% to 5% (depending on choice of numeraire) over its value when no entry occurred. This discrete difference due to a small parameter change is due to the non-convex technology (if entry occurs, it occurs with a large number of firms) and to the fact that the social marginal productivity of an additional input is greater than its private marginal productivity.

The first entrant (the home country) clearly benefits from the fact that the foreign country is blockaded in the first period and receives a much smaller additional benefit if the latter is blockaded in the second period as well. There are two effects at work. First, if both countries enter at $T=0$, there is no trade and no gains from trade. Second, the first entrant produces more of the increasing returns good when the foreign country is blockaded, and this is a good in which the (social) marginal cost of an additional unit is less than its price, so that expansion in its production generates an additional welfare gain of price minus marginal cost times the change in output. We also noted that the gains to country h and the losses to country f from blockaded entry are in large part offset by a large deterioration in the home country's terms of trade in the second period.

The model can serve as a simple model of uneven development. Using this simple framework, we are not forced into the constraints of steady states and constant growth rates and, indeed a principal contribution of the paper is to show how growth rates may diverge due to some arbitrary accident of history. In addition, the results suggest further normative and policy work that is beyond the scope of this paper. Almost all of the trade/industrial organization literature has focused on marginal price/output effects in discussing strategic trade policy (Horstmann and Markusen (1989) is an exception). The present paper focuses attention on the discrete question of entry versus no entry. In our "marginal" Cases 1–4, for example, the foreign country can possibly get a large benefit from a very small subsidy that shifts the equilibrium from solution B (no entry) to solution A (second-period entry). Conversely, the home country can potentially get a very large welfare benefit from a very small subsidy that blockades the foreign country from entering in one or both periods.

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