

# Investment Liberalization and the Geography of Firm Location

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## Abstract

Most of the so-called “new economic geography” concentrates on the location of firms with a single plant and headquarters in the same location, with firms serving foreign markets by exports. There is a good deal of focus on trade costs for goods, and resulting patterns of agglomeration and multiple equilibria. Here we ask related questions, but consider investment liberalization for an industry in which firms may have multiple plants or geographically separate their headquarters and single plant. Over a broad range of country characteristics (differences in size and/or relative endowments), the model predicts that investment liberalization can lead to an increased geographic concentration of firm headquarters, but to a dispersion of production plants. Investment

liberalization leads to factor-price equalization for similar countries and moves dissimilar countries toward factor-price equalization. A particularly important result confronts the widely-cited result of the standard national-firm core-periphery model, in which a symmetric equilibrium between similar countries is unstable in the presence of moderate trade costs. In the knowledge-capital model of the multinational, these are exactly the conditions that give rise to horizontal multinationals, which eliminate this instability.

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## 1. Introduction

The theory of international trade with increasing returns to scale and imperfect competition in production includes analyses of firm location and industry agglomeration that are sometimes referred to as “economic geography”. With increasing returns and interdependencies among firms, parameter changes in trade costs can have interesting and indeed non-monotonic effects on industry location patterns. The recent works by Fujita, Krugman, and Venables (1999), Brackman et. al. (2001), and Baldwin et. al. (2003) present a great deal of research in this interesting and important new sub-field.

One limitation of this location literature is that it almost exclusively deals with geographically integrated firms that conduct all activities from R&D to final production in a single location. But when we examine the industries which motivate this literature, we generally find them dominated by multinational firms. A parallel literature to the economic geography approach considers the endogenous formation of multinational firms. Much of it reflected in Markusen’s (1997, 2002) “knowledge-capital” model. Firms’ location strategies include not just where to located an integrated operation, but include horizontal expansion, producing roughly the same goods and services in multiple locations, and/or vertical strategies in which the production process is geographically fragmented into stages such as R&D, component production, and final assembly.

There are now a few relatively new papers which integrate some the new-

geography models with the multinational models. Important contributions include Barry (1996), Gao (1999), Raybaudi-Massilia (2000), and Ekholm and Forslid (2001), and Egger et. al. (2005). Much of this work concentrates on the question of how changes in trade costs affect location decision when multinational firms form endogenously versus when they are not allowed (the geography models), and/or the consequences of factor mobility with and without multinationals. They tend to have a particular focus on multiple and unstable equilibria in the geography tradition.<sup>1</sup>

This paper continues in the tradition of the research just discussed, trying to integrate results from the geography and multinationals models. We use the world Edgeworth box to consider a series of two-country cases in which the countries differ in size and/or in relative endowments. We use Markusen's knowledge-capital model in which firms may adopt national, horizontal, or vertical strategies. Second, instead of focusing on trade costs and/or factor mobility, we will focus on investment barriers and the effect of removal of investment barriers on the location of activities holding trade costs constant and factors immobile. The location of firm "headquarters" (R&D, management, marketing, finance and so forth) may change in ways quite different from the location and number of production plants.

The model is a two-good, two-factor, two-country general equilibrium model where the X sector has increasing returns and imperfect competition. An

X firm is associated with a country where its headquarters is located. If it has a single plant in that same country, it is referred to as a national firm (type-n). If it has plants in both countries, it is referred to as a horizontal multinational (type-m). If its single plant is in the non-headquarters country, then it is referred to as a vertical multinational (type-v). These three firm types can be headquartered in either country, giving a total of six firm types in all.

The experiment considered in the paper is to remove a prohibitive investment barrier holding the costs of trading X across borders constant. Initially only type-n firms can exist.<sup>2</sup> This experiment is repeated over a parameter space represented by points in the world Edgeworth box where each point is a division of the total world endowment of skilled and unskilled labor between the two countries. Thus the countries are allowed to differ in two dimensions, size and relative factor endowments. We assume that headquarters are more skilled-labor intensive than plants which are in turn more skilled-labor intensive than the other sector (Y) of the economy.<sup>3</sup>

We begin with the no-liberalization case, and show how firm location depends both on relative country sizes due to scale economies, and relative endowments. Investment liberalization tends to lead to headquarter location depending almost exclusively on relative endowments. Plant location depends on a combination of endowment and size differences, with the latter playing a major role. Averaged over all the two-country pairs in the world Edgeworth box, the

average Herfindahl index of concentration for plants falls and that for headquarters rises relative to the no-liberalization case. Thus production may become more dispersed but corporate headquarters and R&D labs may become more concentrated in a few locations. This result was identified earlier by Ekholm and Forslid (2001).

We consider the effects of investment liberalization on factor prices and the incentives for workers to migrate. We find that investment liberalization creates a substantial factor-price-equalization set in the world Edgeworth box, so migration cannot destabilize countries which are relatively similar.<sup>4</sup> More generally, investment liberalization moves countries toward factor-price equalization, but not completely so. Investment liberalization, while leading to convergence, can still leave a small country with lower real wages for both skilled and unskilled labor. Thus investment liberalization cannot substitute completely for free trade for a small country trying to build and maintain its skilled-labor workforce. Welfare changes are also considered. Both countries benefit if they are not too different, but the larger or skill-abundant country can lose when the difference is substantial. This result also tends to occur with trade liberalization, and is due to a loss of monopoly power in trade or alternatively an adverse terms-of-trade change for the large country.

We have not found suitable data for trying to estimate this model, but are able to present some suggestive statistics in our final section. We show that the

concentration across source countries of outward FDI in the world economy is substantially higher than the concentration of inward FDI across countries, and that this difference has been fairly stable and persistent over time. We also find that the concentration across countries of parent firms is more concentrated than foreign affiliates if China is excluded from the data, but not if China is included. The count of foreign affiliates in the world economy is more than ten times the number of parents. These results do not directly address or estimate our model, but they are at the very least consistent with the knowledge-capital model itself.

## 2. Model Structure

The model has two countries (h and f) producing two homogeneous goods,  $Y$  and  $X$ . There are two factors of production,  $L$  (unskilled labor), and  $S$  (skilled labor).  $L$  and  $S$  are mobile between industries but internationally immobile.  $Y$  will be used as numeraire throughout the paper.<sup>5</sup>

Subscripts ( $i, j$ ) will be used to denote the countries (f, h). The output of  $Y$  in country  $i$  is a CES function, identical in both countries. The production function for  $Y$  is

$$(1) \quad Y_i = (aL_{iy}^\epsilon + (1 - a)S_{iy}^\epsilon)^{1/\epsilon} \quad i = h, f.$$

where  $L_{iy}$  and  $S_{iy}$  are the unskilled and skilled labor used in the  $Y$  sector in country  $i$ . The elasticity of substitution ( $1/(1-\epsilon)$ ) is set at 3.0 in the simulation runs

reported later in the paper.

Good  $X$  is produced with increasing returns to scale by imperfectly-competitive, Cournot firms. There are both firm-level (arising from joint inputs such as R&D) and plant-level scale economies. There is free entry and exit of firms, and entering firms choose their "type". The term "regime" denotes the set of firm types active in equilibrium. There are six firm types, defined as follows.

- Type  $m_h$  - horizontal multinationals which maintain plants in both countries, headquarters is located in country  $h$ .
- Type  $m_f$  - horizontal multinationals which maintain plants in both countries, headquarters is located in country  $f$ .
- Type  $n_h$  - national firms that maintain a single plant and headquarters in country  $h$ . Type  $h$  firms may or may not export to country  $f$ .
- Type  $n_f$  - national firms that maintain a single plant and headquarters in country  $f$ . Type  $f$  firms may or may not export to country  $h$ .
- Type  $v_h$  - vertical multinationals that maintain a single plant in country  $f$ , headquarters in country  $h$ . Type  $v_h$  firms may or may not export to country  $h$ .
- Type  $v_f$  - vertical multinationals that maintain a single plant in country  $h$ , headquarters in country  $f$ . Type  $v_f$  firms may or may not export to country  $f$ .

Factor-intensity assumptions are crucial to the results that will be derived below. These are guided by evidence presented in Markusen (1997, 2002): (1) headquarters activities are more skilled-labor intensive than production plants (including both plant-specific fixed costs and marginal costs). This obviously implies that an "integrated" type- $n$  firm with a headquarters and plant in the same

location is more skilled-labor intensive than a plant alone. (2) We assume that a plant alone (no headquarters) is more skilled labor intensive than the composite  $Y$  sector. This is much less obvious, but some evidence suggests that this is probably true for developing countries: branch plants of foreign multinationals are more skilled-labor intensive than the economy as a whole.<sup>6</sup> Assumptions on the skilled-labor intensity of activities are therefore:

Activities

$$[\text{headquarters only}] > [\text{integrated X}] > [\text{plant only}] > [Y]$$

Superscripts (n,v,m) will be used to designate a variable as referring to national firms, vertical multinationals, and horizontal multinational firms respectively.  $(m_i, v_i, n_i)$  will also be used to indicate the number of active  $m$ ,  $v$ , and  $n$  firms based in country  $i$ . Hopefully, it will always be clear from the context what is being represented (e.g.,  $n_i$  as a variable in an equation always refers to the number of national firms in country  $i$ ). Important notation in the model is as follows.

$p_i$	-	price of $X$ (in terms of $Y$ ) in country $i$ ( $i = h, f$ )
$w_i$	-	wage of unskilled labor in country $i$
$z_i$	-	wage of skilled labor in country $i$
$c$	-	marginal cost of $X$ production in units of $L$ (both countries, all firm types)
$\tau$	-	transport cost for $X$ in units of $L$ (same in both directions)

- $M_i$  - Income of country i.
- $X_{ij}^k$  - Sales of: a type-k firm ( $k = n, v, m$ )  
based in country i  
sales in market j ( $i, j = h, f$ )
- $e_{ij}^k$  - Markup of: a type-k firm ( $k = n, v, m$ )  
based in country i  
sales in market j ( $i, j = h, f$ )
- $G^k$  - Fixed costs of a type-k firm in units of unskilled labor  
(where relevant: subscript 1 = headquarters' country  
subscript 2 = host country)
- $F^k$  - Fixed costs of a type-k firm in units of skilled labor  
(where relevant: subscript 1 = headquarters' country  
subscript 2 = host country)

A national firm undertakes all its production in its base country, so the cost function of one national firm in country i is given by

(2)

$$w_i L_i^n + z_i S_i^n = w_i [c X_{ii}^n + (c + \tau) X_{ij}^n + G^n] + z_i F^n, \quad i, j = h, f, \quad i \neq j.$$

$c$ ,  $\tau$ ,  $F^n$  and  $G^n$  are identical across countries.

A horizontal multinational based in country i has sales in country j,  $X_{ij}^m$ . It operates one plant in each country incurring fixed costs,  $(G_1^m, F_1^m)$  in its base country, and fixed costs  $(G_2^m, F_2^m)$  in country j. Sales are met entirely from local production not trade.  $L_{ij}^m$  ( $S_{ij}^m$ ) denotes a country i horizontal multinational firm's demand for unskilled (skilled) labor in country j. A firm type  $m_i$  thus has a cost function

(3)

$$w_i L_{ii}^m + w_j L_{ij}^m + z_i S_{ii}^m + z_j S_{ij}^m = w_i [cX_{ii}^m + G_1^m] + w_j [cX_{ij}^m + G_2^m] + z_i F_1^m + z_j F_2^m.$$

Similarly, a vertical multinational based in country i (plant in country j) has sales in country j,  $X_{ij}^v$ .  $L_{ij}^v$  ( $S_{ij}^v$ ) denotes a country i vertical multinational firm's demand for unskilled (skilled) labor in country j. A firm type  $v_i$  has a cost function

(4)

$$w_j L_{ij}^v + z_i S_{ii}^v + z_j S_{ij}^v = w_j [cX_{jj}^m + (c + \tau)X_{ji}^v + G^v] + z_i F_1^v + z_j F_2^v.$$

Let  $\bar{L}_i$  and  $\bar{S}_i$  denote the total labor endowments of country i. Adding labor demand from  $n_i$  national firms,  $v_i$  and  $v_j$  vertical multinationals, and  $m_i$  and  $m_j$  horizontal multinationals gives country i factor market clearing:

$$(5) \quad \begin{aligned} \bar{L}_i &= L_{iy} + n_i L_i^n + m_i L_{ii}^m + m_j L_{ji}^m + v_j L_{ji}^v \\ \bar{S}_i &= S_{iy} + n_i S_i^n + m_i S_{ii}^m + m_j S_{ji}^m + v_i S_{ii}^v + v_j S_{ji}^v \end{aligned}$$

In equilibrium, the X sector makes no profits so country i income, denoted  $M_i$ , is

$$(6) \quad M_i = w_i \bar{L}_i + v_i \bar{S}_i \quad i = h, f.$$

$p_i$  denotes the price of X in country i, and  $X_{ic}$  and  $Y_{ic}$  denote the consumption of X

and  $Y$ . Utility of the representative consumer in each country is Cobb-Douglas,

(7)

$$U_i = X_{ic}^\alpha Y_{ic}^{1-\alpha}, \quad X_{ic} \equiv n_i X_{ii}^n + n_j X_{ji}^n + m_i X_{ii}^m + m_j X_{ji}^m + v_i X_{ii}^v + v_j X_{ji}^v$$

giving demands

$$(8) \quad X_{ic} = \alpha M_i / p_i, \quad Y_{ic} = (1-\alpha) M_i.$$

Equilibrium in the  $X$  sector is the solution to a complementarity problem.

First, there are marginal revenue - marginal cost inequalities, associated with outputs per firm. These are:

$$(9) \quad p_i(1 - e_{ii}^n) \leq w_i c \quad (X_{ii}^n)$$

$$(10) \quad p_j(1 - e_{jj}^n) \leq w_j(c + \tau) \quad (X_{jj}^n)$$

$$(11) \quad p_i(1 - e_{ii}^m) \leq w_i c \quad (X_{ii}^m)$$

$$(12) \quad p_j(1 - e_{jj}^m) \leq w_j c \quad (X_{jj}^m)$$

$$(13) \quad p_i(1 - e_{ji}^v) \leq w_i c \quad (X_{ji}^v)$$

$$(14) \quad p_i(1 - e_{ii}^v) \leq w_j(c + \tau) \quad (X_{ii}^v)$$

In a Cournot model with homogeneous products, the optimal markup formula is given by the firm's market share divided by the Marshallian price elasticity of demand in that market. In our model, the price elasticity is one (see

equation (8)), reducing the firm's markup to its market share. This gives, (also using demand equations (8)),

$$(15) \quad e_{ij}^k = \frac{X_{ij}^k}{X_{jc}} = \frac{p_j X_{ij}^k}{\alpha M_j} \quad k = n, m, v \quad i, j = h, f.$$

There are six zero-profit conditions corresponding to the numbers of the four firm types. Given equations (9)-(14), zero profits can be written as the requirement that markup revenues equal fixed costs, with the number of firms as the associated complementary variable.

$$(16) \quad p_h e_{hh}^n X_{hh}^n + p_f e_{hf}^n X_{hf}^n \leq w_h G^n + z_h F^n \quad (n_h)$$

$$(17) \quad p_f e_{ff}^n X_{ff}^n + p_h e_{fh}^n X_{fh}^n \leq w_f G^n + z_f F^n \quad (n_f)$$

$$(18) \quad p_h e_{hh}^m X_{hh}^m + p_f e_{hf}^m X_{hf}^m \leq w_h G_1^m + z_h F_1^m + w_f G_2^m + z_f F_2^m \quad (m_h)$$

$$(19) \quad p_f e_{ff}^m X_{ff}^m + p_h e_{fh}^m X_{fh}^m \leq w_f G_1^m + z_f F_1^m + w_h G_2^m + z_h F_2^m \quad (m_f)$$

$$(20) \quad p_h e_{hh}^v X_{hh}^v + p_f e_{hf}^v X_{hf}^v \leq w_f G^v + z_h F_1^v + z_f F_2^v \quad (v_h)$$

$$(21) \quad p_f e_{ff}^v X_{ff}^v + p_h e_{fh}^v X_{fh}^v \leq w_h G^v + z_f F_1^v + z_h F_2^v \quad (v_f)$$

Substitute markups into MR=MC inequalities

$$(22) \quad X \geq \beta M_i \frac{p_i - w_i c}{p_i^2}, \quad \text{for } X_{ii}^n, X_{ii}^m, X_{ji}^v$$

$$(23) \quad X \geq \beta M_j \frac{p_j - w_i(c+\tau)}{p_j^2}, \quad \text{for } X_{ij}^n, X_{jj}^v.$$

Substitute these inequalities into the zero-profit conditions in order to derive some awful looking quadratic equations.

$$(24) \quad \beta \left[ M_h \left( \frac{p_h - w_h c}{p_h} \right)^2 + M_f \left( \frac{p_f - w_h(c+\tau)}{p_f} \right)^2 \right] \leq w_h G^n + z_h F^n, \quad (n_h)$$

$$(25) \quad \beta \left[ M_h \left( \frac{p_h - w_f(c+\tau)}{p_h} \right)^2 + M_f \left( \frac{p_f - w_f c}{p_f} \right)^2 \right] \leq w_f G^n + z_f F^n, \quad (n_f)$$

(26)

$$\beta \left[ M_h \left( \frac{p_h - w_h c}{p_h} \right)^2 + M_f \left( \frac{p_f - w_f c}{p_f} \right)^2 \right] \leq w_h G_1^m + z_h F_1^m + w_f G_2^m + z_f F_2^m, \quad (m_h)$$

(27)

$$\beta \left[ M_h \left( \frac{p_h - w_h c}{p_h} \right)^2 + M_f \left( \frac{p_f - w_f c}{p_f} \right)^2 \right] \leq w_f G_1^m + z_f F_1^m + w_h G_2^m + z_h F_2^m, \quad (m_f)$$

(28)

$$\beta \left[ M_h \left( \frac{p_h - w_f(c+\tau)}{p_h} \right)^2 + M_f \left( \frac{p_f - w_f c}{p_f} \right)^2 \right] \leq w_f G^v + z_h F_1^v + z_f F_2^v, \quad (v_h)$$

(29)

$$\beta \left[ M_h \left( \frac{p_h - w_h c}{p_h} \right)^2 + M_f \left( \frac{p_f - w_h(c+\tau)}{p_f} \right)^2 \right] \leq w_h G^v + z_f F_1^v + z_h F_2^v, \quad (v_f)$$

Assume that foreign ownership is initially banned, meaning that initially there are only type-n firms active in equilibrium. Consider first the effects of investment liberalization on the incentive for type-m firms to enter. Comparing (26)-(27) to (24)-(25), we see that type-m firms will have higher markup revenues but also higher fixed costs relative to type-n firms. The degree to which markup revenues will be higher will be greater the more similar are the sizes of the two countries. Thus type-m firms will enter following liberalization when the two countries are of relatively similar size.

Second, consider the incentives for type-v firms to enter. Comparing (28)-(29) to (24)-(25), we see no differences in markup revenues, but type-v firms can “arbitrage” factor price differences, locating their headquarters and incurring fixed costs where skilled labor is cheap.

### 3. Effects of Investment Liberalization

The regime shifts induced by investment liberalization are analyzed in Markusen (1997, 2002), and we will not repeat a detailed analysis here. Rather, the effects of liberalization on the location of plants and headquarters will be interpreted in terms of regime shifts as we go along.

Figures 1-7 show world Edgeworth boxes, with skilled labor on the vertical axis and unskilled labor on the horizontal axis. Country h’s endowment is measured from the southwest (SW) corner and country f’s endowment from the

northwest (NE) corner. Along the SW-NE diagonal, the countries differ in size but have identical relative endowments. The locus of points where the countries have roughly equal GDPs runs through the center of the box, but is steeper than the NW-SE diagonal.<sup>7</sup> The approximate equal-income locus is shown in several of the Figures. We limit the dimensions of the box to each country having at least 20% of the world endowment of each factor. Not much different happens for a wider range, and this allows more graphical clarity for the interesting part.<sup>8</sup>

The model itself is known as a non-linear complementarity problem, and we repeatedly solve a numerical version of the model over a grid of values of the world endowment of each factor using Rutherford's subsystem MPS/GE of GAMS. Each cell in Figures 1-7 is a solution to a particular two-country model with the countries differing in size and/or relative endowments. The shares are increased in steps of 0.0333 with 19 steps on each axis. Thus there  $19 \times 19 = 361$  cells or solutions to the model in each world Edgeworth box.

Figures 1a and 1b show the solutions under the assumptions that multinational firms are not permitted. The Figures show the share of firms (equals plants equals headquarters) that are located in country h. There are two sources of comparative advantage in the model: country size, due to scale economies, and relative endowments. Figure 1b presents two, two-dimension curves to help clarify this from the general three-dimension presentation in Figure 1a. The curve labeled "income locus" is the SW-NE diagonal of Figure 1a where

the countries differ in size but not in relative endowments. The curve labeled “rel endow locus” is the set of endowments where the countries have the same income, but differ in relative endowments, line E on the floor of Figure 1a.

Figure 1b has country h’s share of skilled labor on the horizontal axis, identical to its share of unskilled labor for the income locus, but not for the relative endowment locus (unskilled labor share moves in the opposite direction from the skilled labor share).

Both Figures 1a and 1b make clear the role of country size. Given relatively high trade costs of 20% ad valorem, a small country with an income share less than or equal to 30% of the world total is shut out of the X sector in equilibrium. Referring to Figure 1b, a country with a 40% income share has about 28% of the firms, and this of course reaches 50% when country h has a 50% income share. Figures 1a and 1b also show the role of relative endowment differences, the latter when the countries are of equal size. The relative endowment locus in Figure 1b seems relative flat, but remember that this is measuring the share of firms in each country, not the share of production. The skilled-labor-abundant country has more competition, more efficient firms, lower markups, and a share of production that exceeds its share of firms.

Finally, we present a Herfindahl index of concentration at the bottom of Figure 1a. This index squares each country’s share of the total number of firms, and then sums over the two countries in question. This ranges from 1.0 when all

firms are in one country, to 0.50 ( $0.50^2 + 0.50^2 = 0.50$ ) when the firms are equally distributed. The statistic 0.657 presented in Figure 1a averages this over all 361 country pairs in the simulation.

We then remove all barriers to multinational firms, allowing type-m and type-v firms to enter when profitable.<sup>9</sup> The shares of plants and headquarters located in country h are shown in Figures 2 and 3 respectively. The difference between the plant and headquarters location patterns is dramatic. Plants are much more divided between any two countries in a cell. The flat area of Figure 2 is a region dominated by horizontal multinationals, each with plants in both countries. When there are only horizontal firms in equilibrium, the Herfindahl index of plant concentration must be 0.50. When countries become quite different in size, national firms enter in the large country, and so the large country has a larger share of total plants. When a country is quite small but very skilled-labor-abundant, it becomes the headquarters of vertical firms with plants in the other country, and so its share of plants falls below 0.50. Average over all 361 country pairs, the Herfindahl index of concentration falls to 0.523. Similar results are found in Ekholm and Forslid (2001) and Raybaudi-Massilia (2000).

Figure 3 shows headquarters concentration across country pairs following investment liberalization. The pattern is clearly that investment liberalization increases the share of firms headquartered in the skilled-labor-abundant country. The reason for this is fairly clear from inequalities (24)-(29). When investment is

free, the choice for the location of firm headquarters depends only on factor prices, and not directly on either country size or trade costs. The latter directly influence whether a firm chooses to have one or two plants, and where to locate a single plant, but the choice of headquarters is influenced only indirectly by these variables insofar as they have general-equilibrium ramifications on factor prices. The Herfindahl index for headquarters averaged over all 361 country pairs is 0.903, much higher than the concentration index for plants.

Figure 4 explicitly turns to the changes induced by investment liberalization. Panel A maps the change in the share of plants located in country  $h$  and panel B maps the changes in country  $h$ 's share of headquarters. The equal-income locus is drawn in panel A to help make it clear that the change in plant location is driven a lot by country sizes as well as relative endowments. Small countries tend to gain plants through horizontal firms replacing national firms headquartered in the large country. But a small, very skilled-labor-abundant country can lose plants. This is because of entry of vertical firms headquartered in such a country, with plants in the large, unskilled-labor-abundant country.

Panel B of Figure 4 shows that the change in the share of firms headquartered in country  $h$  follows relative factor proportions almost exactly. As discussed above, this is because we are now essentially assuming that headquarters' services are freely traded, and thus they depend only on factor prices, which are only indirectly affected (and apparently not much) by country

size.

Figure 5 computes changes in the Herfindahl concentration index for firms and plants for each country going from no liberalization to investment liberalization. The dominate outcome, occurring in almost 75% of the cells, is that headquarters concentration *increases* between the two countries and plant concentration *decreases*. There are no cells where *both* of those outcomes are reversed. There are, however, several regions where *one* of the dominate outcomes is reverse. In the regions marked “A” in Figure 5, headquarters concentration decreases along with plant concentration. This is because the small country is gaining headquarters, but it had a smaller share to start with, so headquarters concentration is moving toward 0.50 rather than away from it. In the regions marked “B” in Figure 5, plant concentration increases while headquarters concentration also increases. This is because the smaller, skilled-labor-abundant country loses plants, concentrating on headquarters of vertical firms. But since that country had a smaller share of plants to begin with, concentration of plants increases.

Figure 6 turns to equilibrium factor real prices, nominal returns in terms of  $Y$  divided by the price index (cost of buying a unit of utility) in each country. Panel A gives the result for no liberalization. The model is calibrated so that the scale effect on the price index does not overwhelm factor proportions effects, and so countries that differ substantially in relative endowments show the usual

Heckscher-Ohlin pattern that factors are expensive where they are scarce. Because of trade costs, the factor-price-equalization (FPE) set is a singular point where the countries are identical. This symmetric equilibrium with identical countries is stable to the movement of one factor alone, in contrast to many of the new geography models that have a single factor used only in the X sector.

There are, however, regions where countries differ in size but not greatly in relative endowments, where both real factor prices are higher in the larger country. This is the scale-economies / imperfect-competition effect that leaves the price of X lower and real factor productivity higher in the larger country. These points can be thought of as unstable with respect to factor mobility, in that the mobility of either factor will necessarily increase the size differences of the countries, and if both factors can move as a bundle, the smaller country can disappear.

Panel B of Figure 6 shows real factor price differences under investment liberalization. The big change is in the appearance of a large FPE set. This is a region dominated by two-plant horizontal firms. Each country has the same number of plants, all of which have the same marginal cost, and so the prices and markups in each country are the same. This set contains countries which differ in relative endowments. This is sustained as an FPE equilibrium by allocating the headquarters between the two countries, more to the skilled-labor-abundant country, so as to achieve FPE.

It is also true that almost all cells in panel B show a smaller difference in the real price of each factor between the two countries (including obviously the expanded FPE set) relative to panel A. In other words, investment liberalization leads to partial convergence for virtually all pairs of countries, but full convergence for only those in the FPE set of panel B. The exception to this are the shaded cells in panel B of Figure 6, where the price of skilled labor diverges between the two members of the country pair. The intuition follows a couple of papers by Feenstra and Hanson (1996a,b, 1997). For these country pairs, investment liberalization shifts plants to the smaller country and headquarters to the larger country. The result is a relative increase in the demand for skilled labor in both countries as each country shifts to a relatively more skill-intensive activity. The real return to skilled labor rises for both countries in these cells, but tends to rise more in the unskilled-labor-abundant country. But it was higher there to start with, and so the return to skilled labor diverges.

Figure 7, which shows the welfare consequences of liberalization, concludes this section. It is not easy to describe the region where both countries gain in a single sentence. Basically and roughly, both countries gain when the size difference is moderate and when the smaller country is moderately skilled-labor abundant. Very similar countries, including two identical countries, both gain as horizontal firms replace costly exporting by national firms.

It seems a country can lose under two circumstances. First, if it is large

and has a relative endowment not much different from its trading partner. Or it can lose if it is of more middle sized, and is very skilled-labor abundant. In both cases, the country has an initially- strong comparative advantage in X, resulting in a concentration of X production at home and consequently a low price index (recall trade costs are 20%). Investment liberalization shifts plants to the other country and, while there are overall gains in scale and in lower markups, the price index increases in the large or very skilled-labor-abundant country which leads to an aggregate welfare loss for that country. The price index effect always works against the country losing plants, and note that the region where country h loses in Figure 7 is a sub-region of the region where country h has a decrease in its share of plants in Figure 4, panel A.

#### 4. Some Relevant Data

We have tried very hard to find data that would allow us to examine some of the ideas in this paper, however informally. We have not made much progress since, to the best of our knowledge, no comprehensive data set exists that would meet even basic requirements for formal econometric work. There has, however, been a good deal of recent work estimating and testing propositions from the knowledge-capital model and generally supporting evidence gives us some confidence for using this as serious theoretical model. Early papers particularly supported the horizontal motive for multinational production, beginning first with

Brainard (1997) and then later with Blonigen, Davies and Head (2003), and Markusen and Maskus (2002). Finding support for parts of the theory relating to vertical firms has been slower in emerging, but now includes Carr, Markusen, and Maskus (2001, 2003), Davies (2004), and Braconier and Norbäck (2004, 2005). Thus, despite limited data for formal econometric work on the present paper, there is an emerging body of evidence that the theory model is relevant.<sup>10</sup>

We can present some other data from the World Investment Report of UNCTAD which is at least consistent with the ideas expressed in this paper. Figure 8 presents Herfindahl indices of concentration for world inward and outward stocks for the 21 year period 1983-2003. Overall, the data on FDI and multinational firms indicates a higher concentration of headquarters than plants. The concentration was decreasing for both headquarters and plants during the 1980s. The concentration was stable during the 1990s, whereas the newest data suggests an increase in concentration of outward investment and a decrease in inward investment.

The inward investments have seen a rather stable decrease in concentration in the period. The decrease in concentration from the early 1980s to the early 1990s was partly due to an increase in the number of countries receiving FDI. The number of countries with a FDI stock of more than 10 million US\$ increased from around 140 in 1990 to around 180 in 1995<sup>11</sup>. The flattening of the curve from the mid-1990s is due to a very large increase in FDI in China.

The concentration of outward investment decreased a lot during the 1980s, when Japan and other large countries entered the scene as foreign investors. The US' share of total outward FDI (stock) decreased from 38% in 1980 to 24% in 1990. No new major players entered during the 1990s, which led to a stabled concentration with a slightly increasing trend.

If we make the assumption that outward investment is roughly related to the number of parent firms in a country and further assume that inward investment is a crude proxy for foreign affiliates, then these data are at least consistent with our model and with the outcomes shown in Figures 2 and 3. The data are consistent with the idea that headquarters are concentrated in skilled-labor-abundant countries (this has been verified in much other empirical work) but that affiliates (plants in our model) tend to be much more widely dispersed. The latter in turn is consistent with horizontal models and motives in particular, a phenomenon that has also received strong empirical support.

The UNCTAD (2004) report also gives count data on parent firms and foreign affiliates operating in each country. We have also calculated Herfindahl concentration indices on parent and affiliate shares across countries. These are shown in Table 1. The data on parent corporations and foreign affiliates does not confirm the higher concentration of headquarters than plants if taken at face value. Calculations show that plants are about three times more concentrated than headquarters. However, these data are highly biased by China. China had about

45% of the world's foreign affiliates in 2002. However, it had only about 6.1% of the world's inward FDI stock in 2002. There is thus a dramatic difference between the count data and the value data with respect to China. If both numbers are accurate, it suggests that China is host to a great many very small foreign affiliates. In any case, the second row of Table 1 also presents the concentration statistics with China deleted from the data set.

China's FDI should also be seen in relation to its size. China accounts for almost 30 percent of the developing world's population. Thus many OECD parent countries are going to have plants, perhaps many firms having multiple plants, in China. Thus the fact that China is so large in a multi-country world is going to give a big upward push to affiliate concentration, but not to parent concentration.

China figures are also inflated by the round-tripping of FDI through Hong Kong (China), which some estimates suggest may account for as much as 30 percent of total FDI to China (World Bank, 2004). It is possible to break the Chinese data up in the 31 Chinese provinces, which makes the data much more comparable with other countries. The average population in a province is about 44 million people. Including the provinces reduces the concentration of the world plants significantly but has very little effect on the concentration of headquarters. Results are shown in the third row of Table 1. Using this approach of treating Chinese provinces as additional countries in the full world data set, headquarters

(parents) are now significantly more concentrated than plants (affiliates).

Interestingly, the concentration index for outward FDI in Figure 8 was 54% higher than the concentration index for inward investment in 1992 (0.108/0.070), while the concentration index for parents in Table 1 using the Chinese provinces as additional countries was 48% higher than the concentration index for affiliates in 1992 (0.071/0.048).

As noted above, these results are at least consistent with our model and with the importance of horizontal firms in particular (again, there is much existing evidence to that effect already). This is an important finding for the geography literature, which often emphasizes the instability of a symmetric equilibrium with similar countries. The introduction of horizontal multinationals in particular eliminates this instability property, as shown in Ekholm and Forslid (2001), Baybaudi-Massilia (2000), in the present paper (Figure 6) and for vertical multinationals by Gao (1999).

## 5. Summary and Conclusions

Much of the recent literature on location decision with increasing returns to scale and imperfect competition has concentrated on integrated single-plant national firms and the effects of trade-cost changes. Here we shift the focus to multinational firms and the effects of reductions in investment barriers. A firm is composed of two activities, a headquarters and a plant. In addition to the option

of being a single-plant firm with headquarters and plant in the same location, referred to as a national firm, we allow two additional options. The firm may choose to have plants in both countries, referred to as a horizontal multinational, or have a single plant but locate the headquarters and plant in different countries, referred to as a vertical multinational. We model investment liberalization in a very simple way.

Initially, either type of multinational is simply banned, meaning that a plant in one country cannot be controlled by a headquarters in another country. Thus only national firms headquartered in either country are permitted initially. As suggested by the geography literature, both relative size and relative endowments are determinants of “revealed” comparative advantage. An equilibrium in which countries differ in size but have similar relative endowments is unstable with respect to factor migration, meaning that such migration would cause the size difference to grow.

Investment liberalization leads to a concentration of headquarters in the skilled-labor-abundant country. With investment permitted, the optimal location of headquarters depends only on equilibrium factor prices. The location of plants is more complicated, depending on both factor prices and market size, with the latter of particular importance.

We define a Herfindahl concentration index for plants and headquarters, which is the sum of the squared market shares over the two countries. Over a

broad area of parameter space, we find that investment liberalization leads to an increased concentration of headquarters but to a decreased concentration of plants. This is especially robust when the countries are of similar size. When size is similar and investment is banned, national firms exist in both countries but are concentrated in the skilled-labor-abundant and/or larger country (the latter is referred to as a “home market effect”). Liberalization moves headquarters toward the skilled-labor-abundant or large country, thus moving the shares further away from 0.5 and increasing concentration. But the entering firms are generally two-plant horizontal firms, so liberalization moves the shares of plants closer to 0.5, decreasing concentration.

A section on the factor-market consequences of investment liberalization follows. Our results indicate that investment liberalization moves countries toward factor-price equalization, but incompletely so. A factor-price-equalization set exists, so migration incentives are removed by investment liberalization for countries similar in size and in relative endowments. In a generally more complex model, we thus obtain similar findings on migration incentives and the concentration of headquarters versus plants to those found in Gao (1999), Ekholm and Forslid (2001), and Raybaudi-Massilia (2000). Simply put, the introduction of endogenous multinationals, *in general*, decrease the agglomeration of production and the tendency for symmetric equilibria to be unstable with respect to migration (exception: headquarters become more concentrated).

The paper concludes by considering some data on inward versus outward investment, and the concentration of parent firms versus foreign affiliates. While not very suitable for formal econometric work, the data are at least consistent with the general thrust of Markusen's knowledge-capital model and the results of this paper. We should also emphasize again that a great deal of empirical work over the last five years has affirmed the importance of horizontal multinationals, and that the consequences of this observation for the new geography models are profound: horizontal firms arising between similar countries under moderate trade costs destroy the instability of symmetric equilibria that occurs under the same circumstance in the standard national-firm core-periphery model.

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## Endnotes

1. As we will note at several points throughout the paper, a number of our results are not new, but have been previously identified in Barry (1996), Gao (1999), Raybaudi-Massilia (2000), and Ekholm and Forslid (2001). We feel that one contribution of the present paper is a more general approach to the problem which nests these earlier contributions as special cases.

2. In order to avoid confusion later, we should note here that there is no “capital” in the model in the usual macroeconomic sense. Multinational firms supply the services of “knowledge-based” or “intangible” assets to plants abroad and repatriate markup revenues. This is what is meant by “investment” in this paper. Banning investment means that no firm headquartered in country  $i$  can own a plant in country  $j$ .

3. Egger et. al. (2005) use a very similar model to ours, drawn from Markusen (1997, 2002), but focus on the role of trade costs and factor mobility given the existence of multinationals. In other words, they assume liberalized investment and concentrate on trade cost changes, while we assume fixed trade costs and consider investment liberalization.

4. Various versions of these results were identified by Barry (1996), Gao (1999), Raybaudi-Massilia (2000) and Ekholm and Forslid (2001).

5. “Real wages” will however be properly defined as nominal values divided by the consumer price index (the unit expenditure function).
  
6. Evidence supporting the assumption that multinational branch plants are more skilled-labor intensive than the overall economy (at least for developing economies) is inferred from Feenstra and Hanson (1996a,b, 1997), and Aiken, Harrison, and Lipsey (1996). Slaughter (2000) , gives data on the labor-force composition of US multinationals' home operations versus their affiliates abroad, but no comparable data is available for the overall economy. See also Braconier, Norbäck and Urban (2005a,b).
  
7. The model is calibrated such that unskilled labor has a much larger share of GDP than unskilled labor, so the locus of equal incomes is much steeper than the NW-SE diagonal.
  
8. At this point, following an important observation of one referee, we should pause and emphasize that the world Edgeworth box is really a series of two-country models, not a true multi-country world. In reality, a firm faces may host countries and may choose one country in the EU, for example, on the basis of cost (as in a vertical investment) to serve the whole EU (essentially a horizontal investment). There is thus a major gap between the theory and empirical estimation in this regard. It is a poor defense to say that we are following the tradition of almost all trade and geography modeling, but at least our approach does permit a very precise comparison of our results to the new economic

geography. Ekholm, Forslid and Markusen (2007) makes some progress in constructing a multi-region model and taking it to the data.

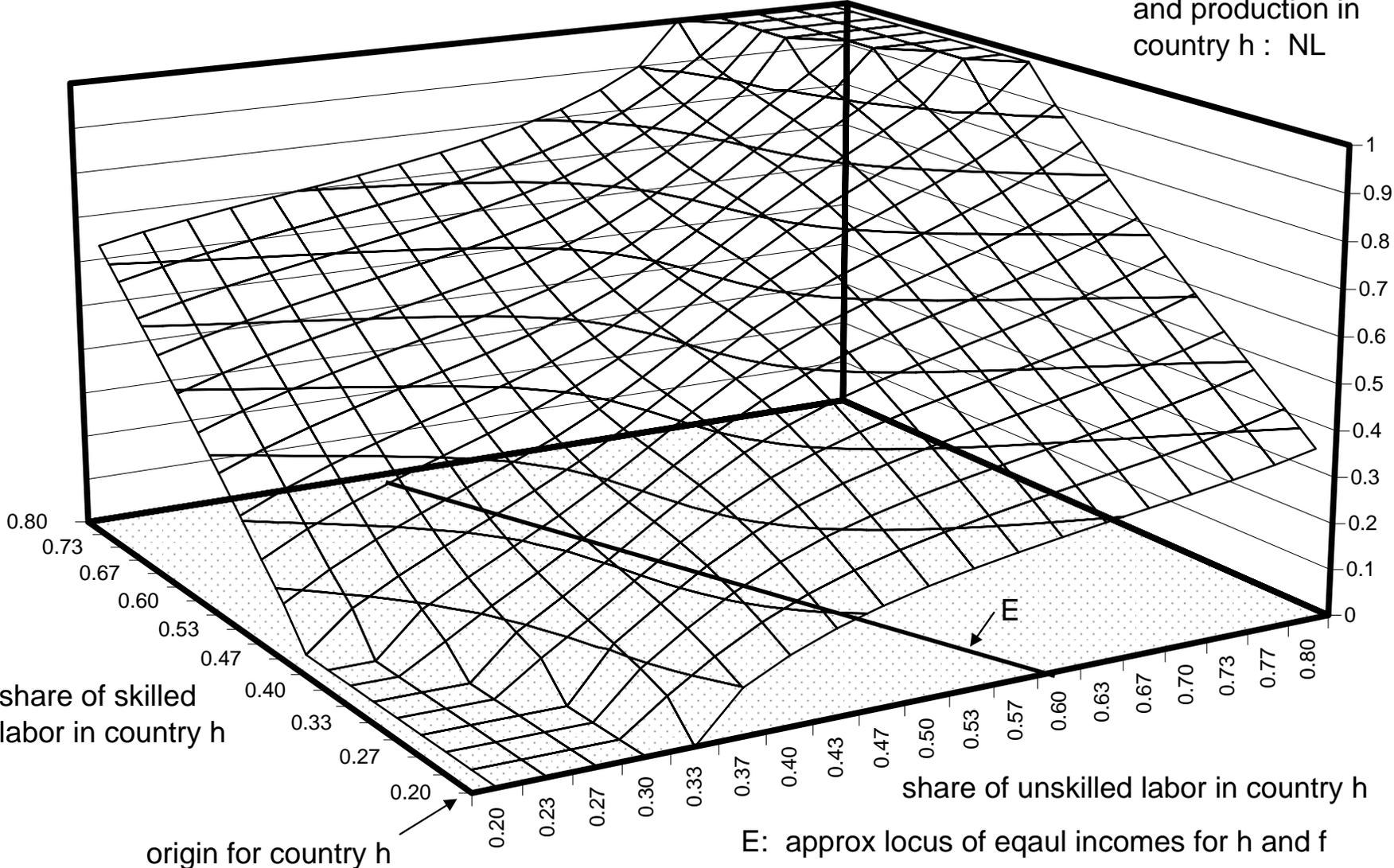
9. This could be thought of as technical or institutional advances (e.g., legal changes that allow foreign investment, enforce property rights and contracts, etc.) that permit fragmentation, or alternatively the technical and managerial costs of fragmentation going from a prohibitive value to zero.

10. Once again, we would like to repeat an important caveat mentioned by one of our referees, which is that there remains an important disconnect between the existing body of theory, which is overwhelmingly two-country models, and the multi-country data. The latter reflects export platform production for sale in third countries (other than home and host) which of course cannot occur in two-country models. Ekholm, Forslid and Markusen (2007) is one attempt to deal with this issue.

11. A change of the threshold to 100 million \$US would imply a rather stable number of firms through the period.

Figure 1a: Share of plants and headquarters in country h: no liberalization (NL)

share of plants and production in country h : NL



Average Herfindahl index of concentration: 0.657

Figure 1b: Share of plants and headquarters in country h: NL

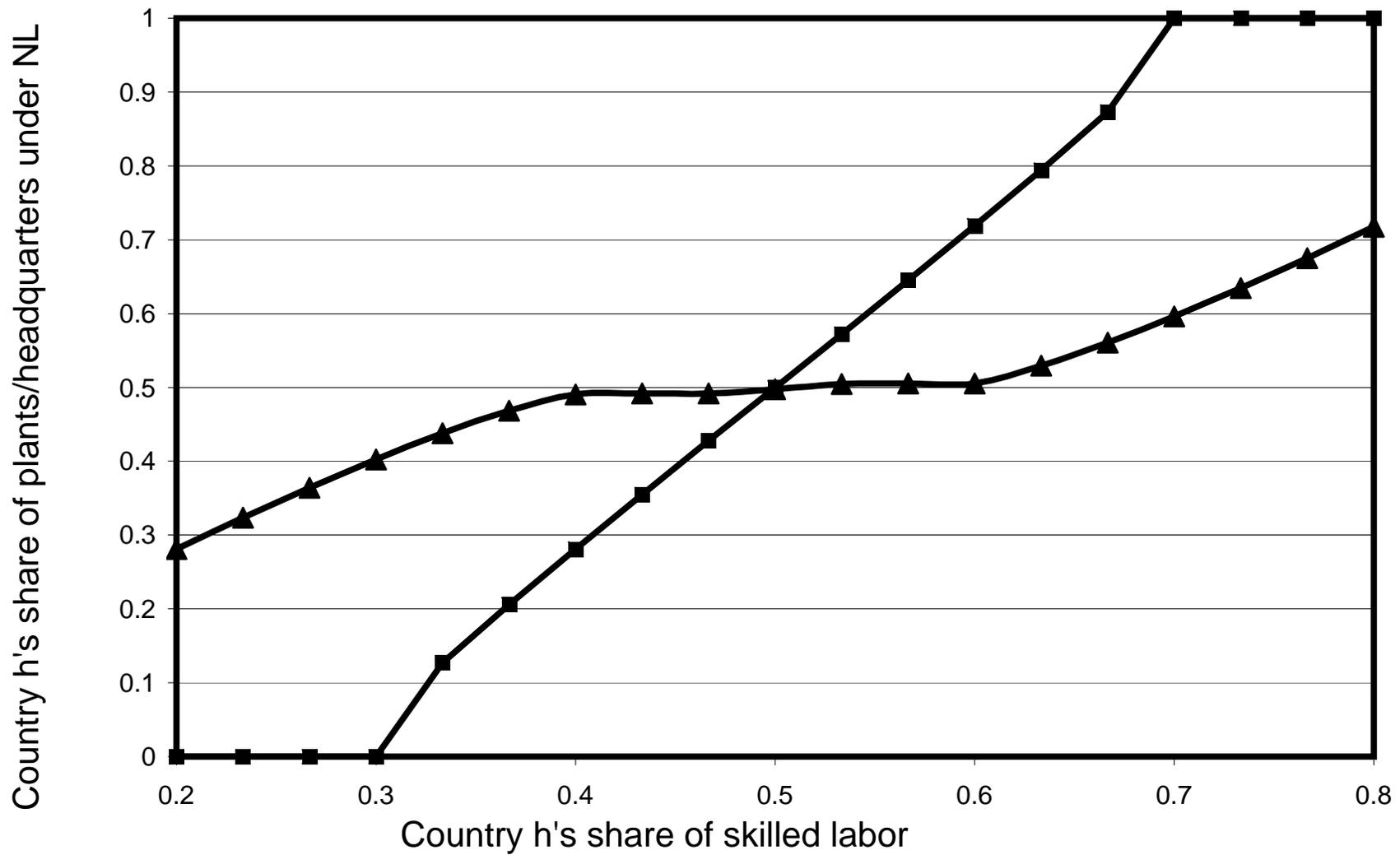


Figure 2: Share of plants in country h: with liberalization (IL)



Figure 3: Share of headquarters in country h: with liberalization (IL)

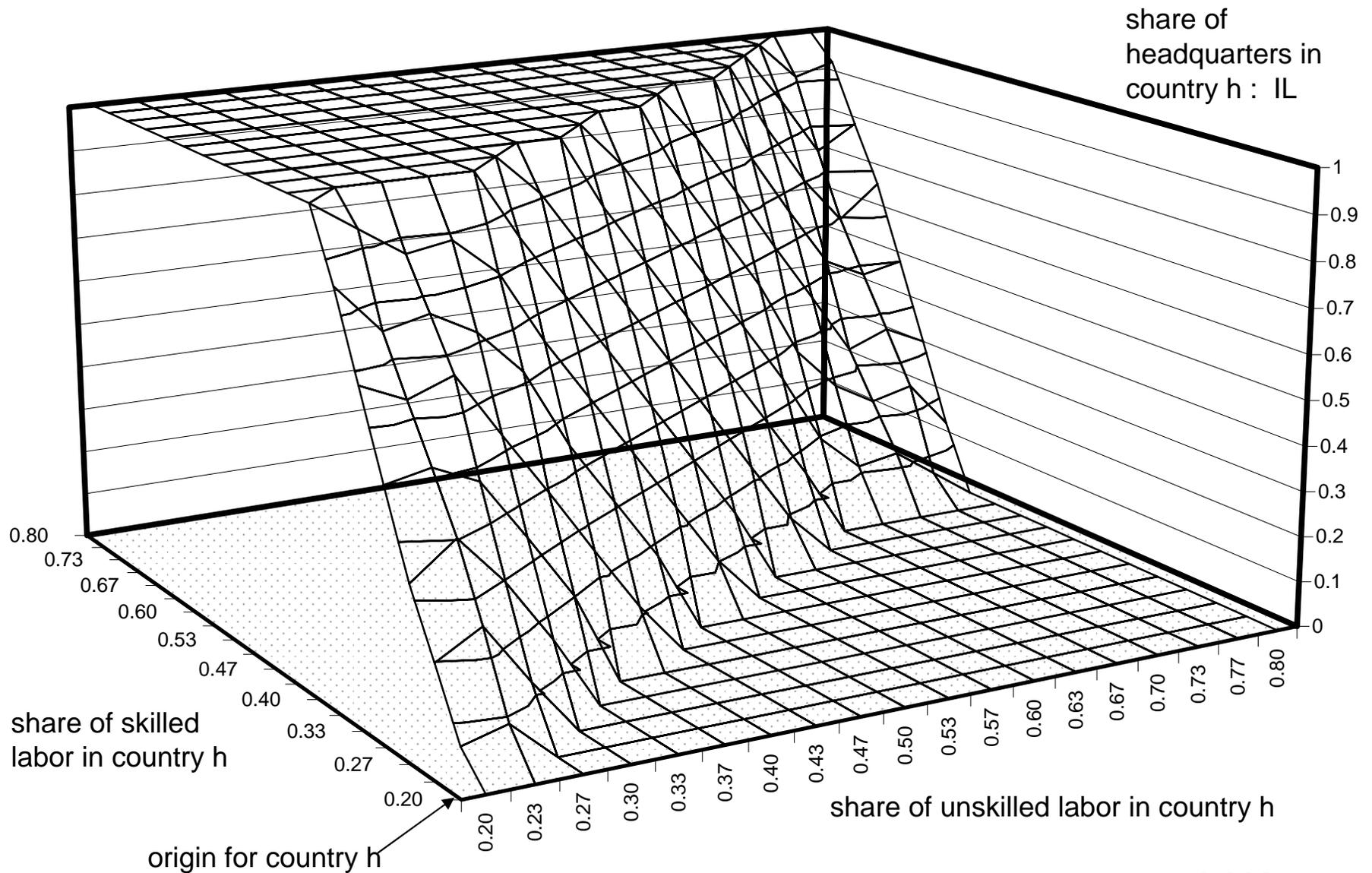
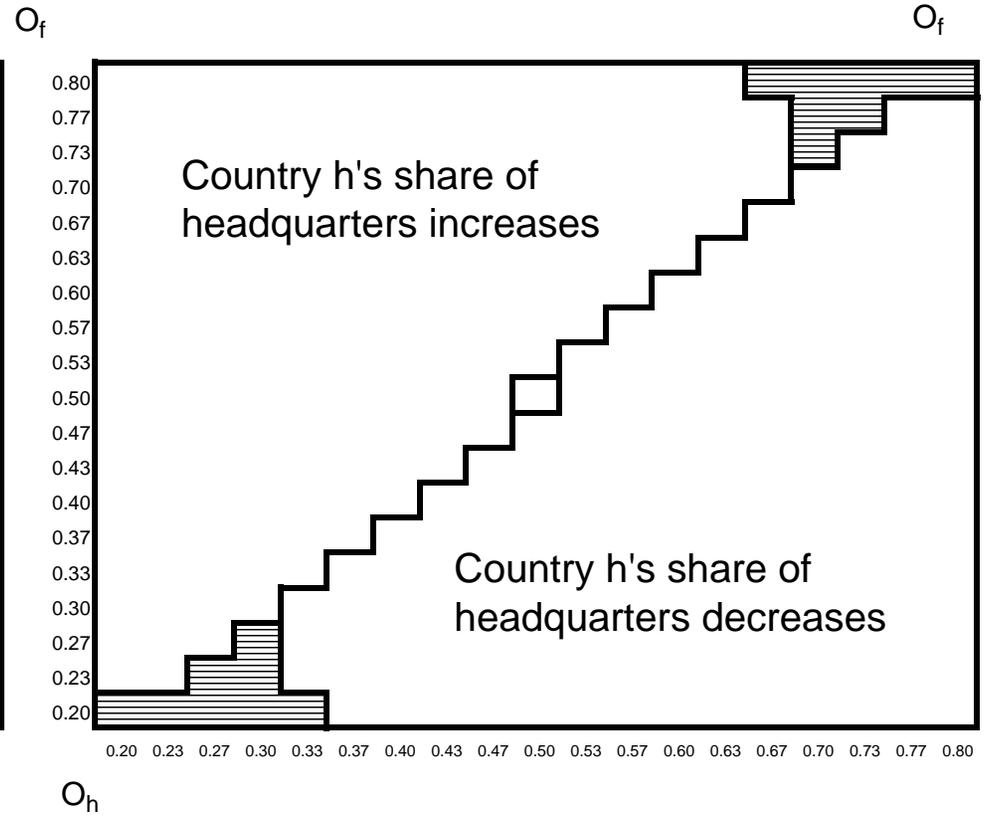
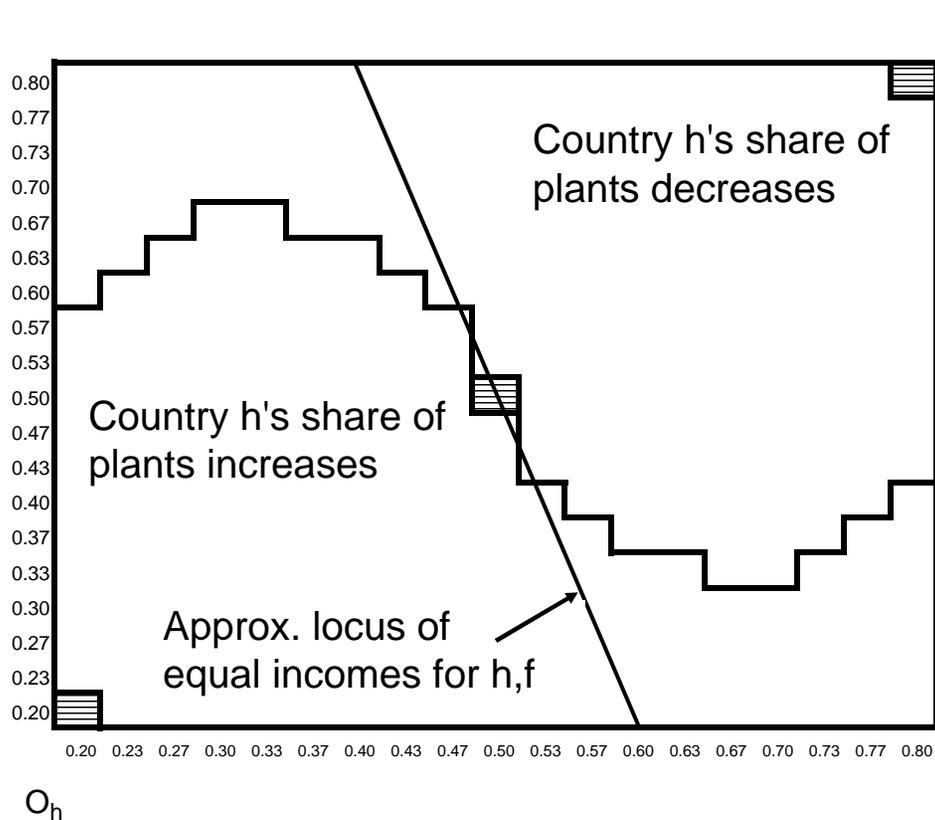


Figure 4: Change in the location of plants following investment liberalization

A: change in the share of plants located in h

B: change in the share of headquarters located in h

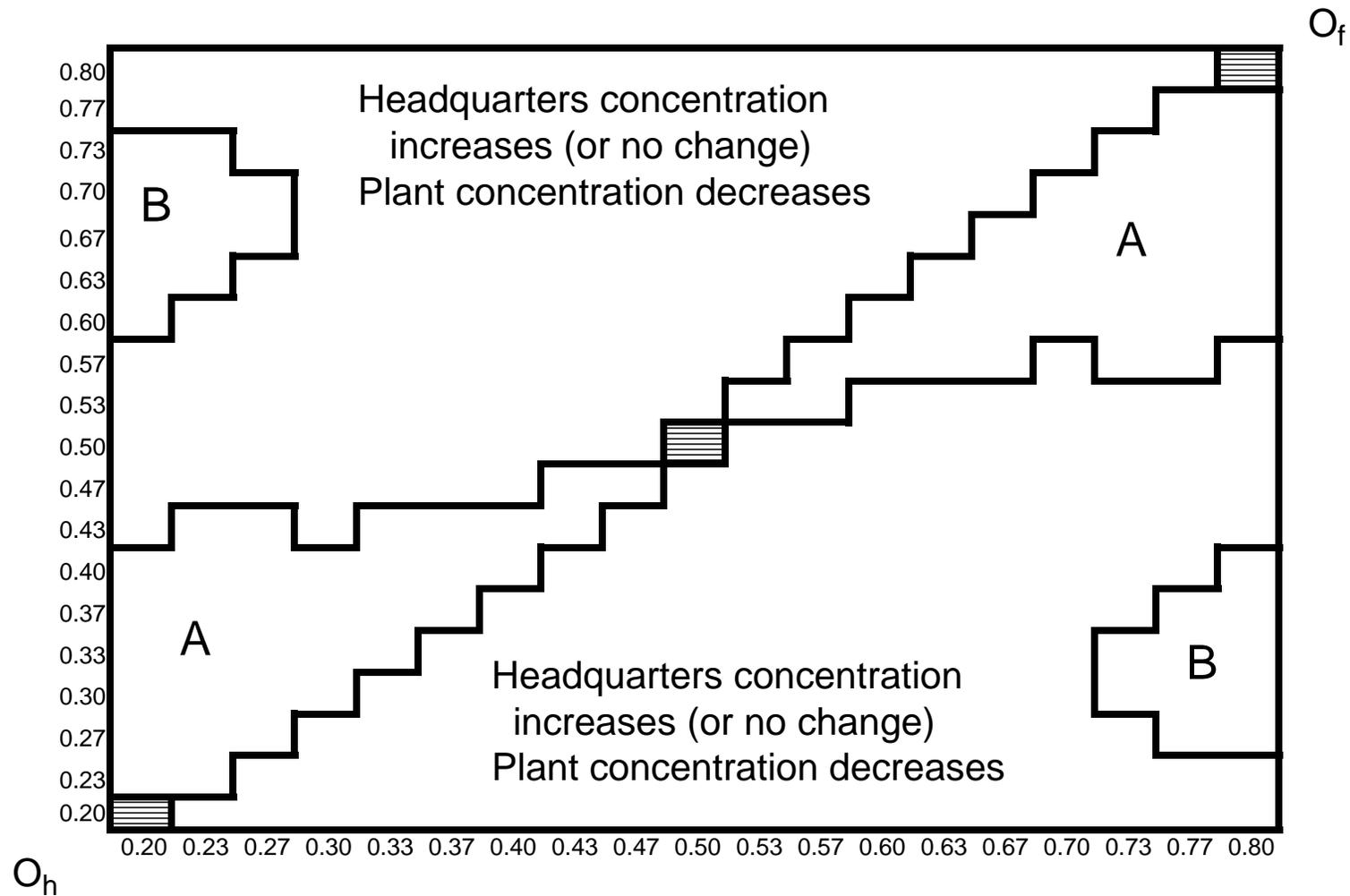


Vertical axes: country h's share of skilled labor

Horizontal axes: country h's share of unskilled labor

 No change

Figure 5: Change in the concentration of plant and headquarters following liberalization



Exceptions to:

headqtr conc increases  
plants conc decreases

A: headquarters concentration decreases

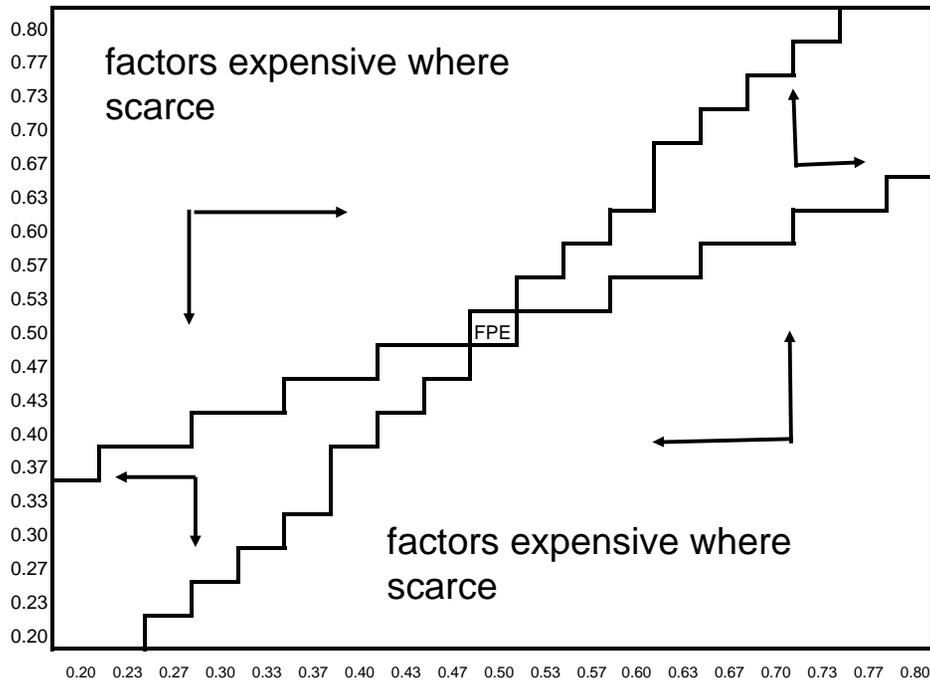
small country gains headquarters, had smaller share to start with

B: plant concentration increases

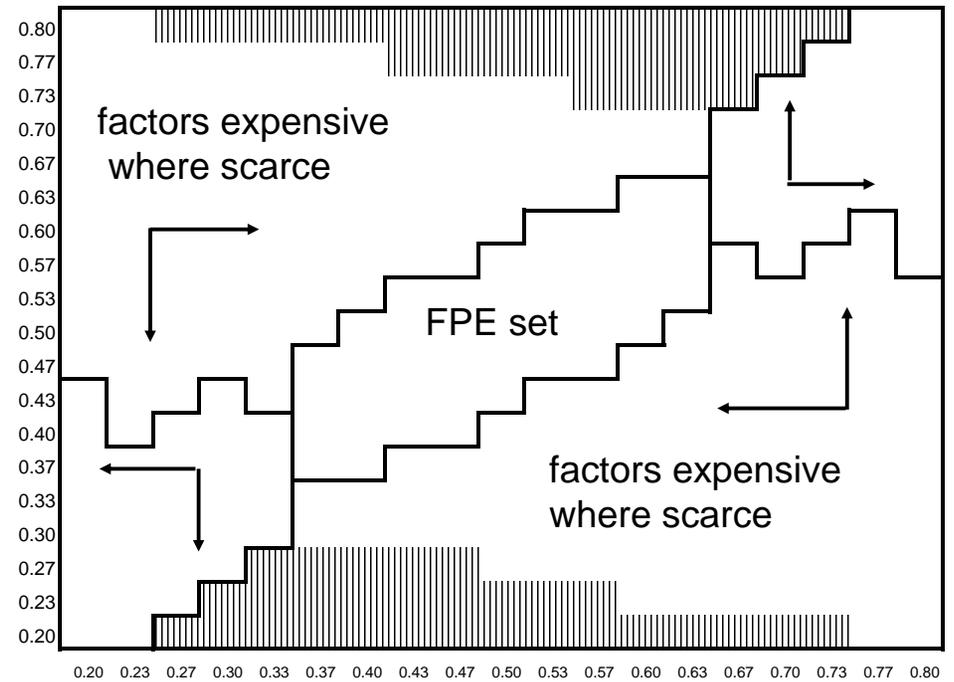
small loses plants, had smaller share to start with

Figure 6: Factor-price differences before and after liberalization

A: Factor-price difference under NL



B: Factor-price differences under IL



Vertical axes: country h's share of skilled labor

Horizontal axes: country h's share of unskilled labor



Pairs where the price of skilled labor diverges between countries  
all other points, convergence

Figure 7: Change in welfare following investment liberalization

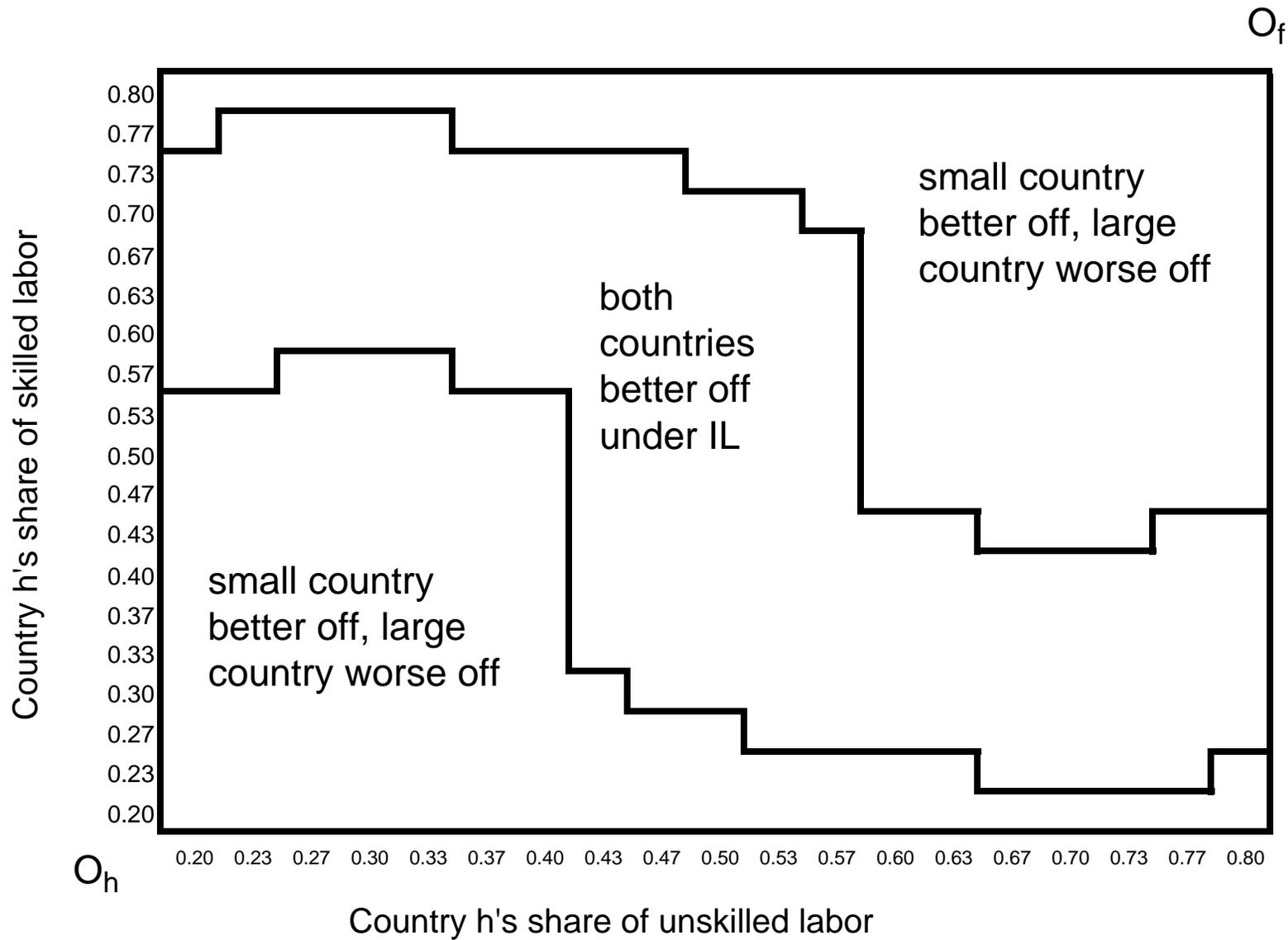


Figure 8: Herfindahl concentration indices for world inward and outward FDI

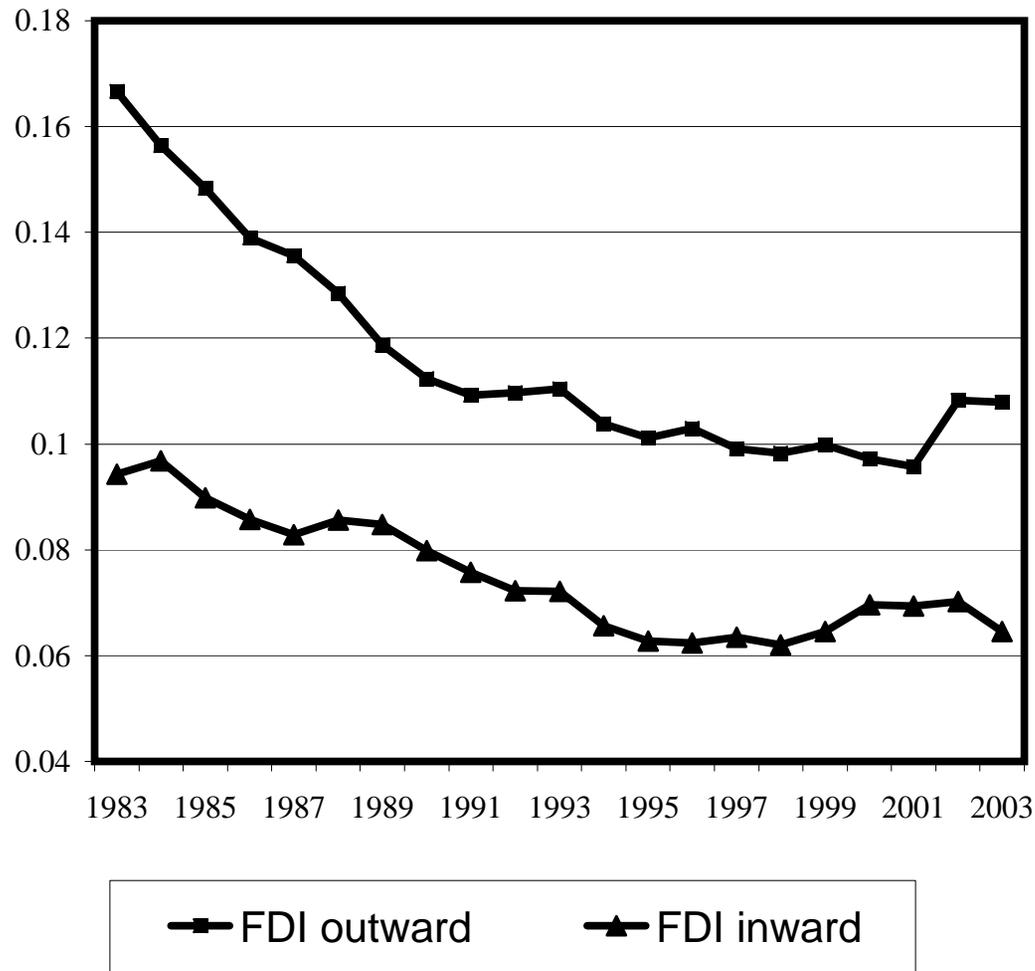


Table 1: Herfindahl concentration of parents and affiliates (count data)

	Parents	Affiliates
All Countries	0.072	0.229
All Countries minus China	0.072	0.067
All Countries - 31 Chinese Provinces	0.071	0.048