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**MULTINATIONAL PRODUCTION,
SKILLED LABOR, AND REAL WAGES**

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MULTINATIONAL PRODUCTION,
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ABSTRACT

Adapting our earlier model of multinationals, we address policy issues involving wages and labor skills. Multinational firms may arise endogenously, exporting their firm-specific knowledge capital to foreign production facilities, and geographically fragmenting production into skilled and unskilled-labor-intensive activities. Multinationals thus alter the nature of trade, from trade in goods (produced with both skilled and unskilled labor) to trade in skilled-labor-intensive producer services. Results shed light on several policy questions. First, multinationals increase the skilled/unskilled wage gap in the high income country and, under some circumstances, in the low income country as well. Second, there is a sense in which multinationals export low skilled jobs to the lower income country. Third, trade barriers do not protect unskilled labor in the high income countries. By inducing a regime shift to multinationals, trade barriers protect the abundant factor, at least in the high income country and possibly in both countries. Fourth, a convergence in country characteristics induces the entry of multinationals and raises the skilled-unskilled wage gap in the initially large and skilled-labor-abundant country, and possibly in the small skilled-labor-scarce country as well.

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1. Introduction

International trade has a long tradition of explaining trade flows and international differences in sectoral production levels by differences in relative factor endowments among countries. Dual results relate real factor rewards to international prices and trade barriers. But factor-proportions trade theory, at least in its traditional competitive formulation, is not well suited to discussions about the role of trade in technologies and knowledge capital in determining real wages and national standards of living. Because of problems relating to the public-goods nature of knowledge or to the firm-specific character of knowledge and skills, the services of these assets are often exploited internally within multinational firms in serving foreign markets.

Many theoretical and empirical developments have improved our understanding of what firm-level characteristics lead to industries dominated by multinationals. More recently, we have begun to incorporate these firm-based models into the general-equilibrium theory of international trade so that we understand, for example, what country characteristics lead to international activity dominated by direct investment rather than trade.¹

The purpose of this paper is to exploit these recent developments in order to improve our understanding of how multinationals in turn influence certain variables in equilibrium, outputs and factor prices in particular. While previous work has given us a basis for understanding how country characteristics such as size, relative endowments, and trade costs lead to multinational firms, we now turn to the question of how the introduction of multinational production alters the inter-country

¹ Some examples are Brainard (1993a,b,c), Ekholm (1995), and Markusen and Venables (1995a,b,c). Brainard and Markusen and Venables do not address human capital issues. Ekholm addresses them empirically, but theory of exporting versus direct investment in relation to human capital endowments is not developed. Theoretical results in this paper are consistent with Ekholm's empirical findings that outward direct investment is closely associated with a country's human capital endowment. Helpman and Krugman (1985) model a separation of headquarters and production activities. However, there is no endogenous choice of single versus multi-plant production and their factor-price-equalization framework makes their approach unsatisfactory for the policy issues addressed here.

distribution of production and the intra-country distribution of income.²

We adapt our two-country, two-sector, two-factor static model developed in Markusen and Venables (1995a,b). Here factors are skilled and unskilled labor. One sector of the economy (X) is composed of three distinct activities: (1) creating firm-specific capital, (2) creating plant-specific capital, and (3) final production. Skilled labor is required in the production of firm-specific knowledge capital ("blueprints", etc.) and is also combined with unskilled labor in the creation of plant-specific fixed costs (producing capital equipment). Production of final output of X requires only unskilled labor. Our other work focusses almost entirely on the determinants of what types of firms are active in equilibrium and trade-volume issues, assuming that all three of these activities use factors in the same proportion, or indeed use only one composite factor.

There are two countries, and the nationality of a firm corresponds to the location of its firm-specific capital. There are four firm types. There are two types (nationalities) of single-plant firms, corresponding to locations in the two countries. Each single-plant firm may or may not export to the other country. There are similarly two types (nationalities) of multinationals, each maintaining plants in both countries. The term regime denotes the set of firm types active in equilibrium. We review, with appropriate modifications, our earlier results as to how differences between countries in relative endowments of skilled labor and in country size (absolute endowments), along with trade barriers, determine the equilibrium regime.

Multinationals fragment production geographically, locating skilled-labor-intensive activities and one production plant in their home country and an additional production plant in the host country. To put it differently, these firms change the nature of what is traded, from commodity

²Technologies and skill levels will be taken as exogenous in this paper. In a later paper, we hope to examine how multinational firms in turn endogenously determine international differences in skills by transferring technologies and other forms of knowledge capital. See Blomstrom and Kokko (1995) for an excellent review of existing work in this area.

exports to skilled-labor-intensive producer services. Assessing the consequences of multinationals, however, requires a well-defined counterfactual. An equilibrium with multinationals can be compared to (a) one in which parameters (e.g., countries sizes, trade barriers) are altered such that national firms displace multinationals, or (b) those parameters are held constant, but direct investment is simply banned. We will concentrate mostly on the latter situation, so that "the effects of multinationals" compares a case in which multinationals exist in equilibrium to one in which there is a prohibitive investment barrier, all other parameters being equal.

When the two countries have asymmetric relative endowments but are of similar size, the entry of multinationals due to the removal of a prohibitive investment barrier has several effects. For the skilled-labor-abundant country (also referred to as the "advantaged" or "high-income" country), two results are of interest. First, final production of X decreases in the advantaged country, so in a relevant sense multinationals do export less-skilled jobs. Second, the entry of multinationals raises the real wage of skilled labor and the skilled-unskilled wage gap in the advantaged country.

The unskilled-labor-abundant ("disadvantaged" or "low-income") country gains production from the entry of multinationals. But effects on the real wage of skilled labor and the skilled-unskilled wage gap are ambiguous. On the one hand, MNEs export skilled-labor-intensive producer services (knowledge capital) that indirectly substitute for host-country skilled labor, thereby lowering the latter's relative return. On the other hand, national firms in the disadvantaged country may be severely handicapped by the scarcity of skilled labor so that few or possibly zero of them can enter when investment is banned. In such cases, the entry of MNEs headquartered in the advantaged country increases the demand for skilled labor in the disadvantaged country and raises the skilled-labor wage. The latter possibility is likely when the difference in the relative endowments of the two countries is large. The entry of multinationals then raises the real wage of skilled labor in both countries; intuitively, branch plants requiring significant skilled-labor inputs replace transport costs

which use only unskilled labor.³

The effects of multinational entry when the countries differ in absolute size is somewhat different. Again, multinationals transfer production from the advantaged to the disadvantaged country (in this case "advantaged" and "disadvantaged" referring to large and small). But the effects on the wage of skilled labor can be reversed, with the disadvantaged country's wage rising and the advantaged country's wage falling. Both results can be understood in terms of effects identified in the trade-industrial-organization literature. In the absence of multinationals, national firms headquartered in the advantaged country have a significant home-market advantage that allows them to dominate in equilibrium out of proportion to country-size differences. The entry of multinationals shifts ownership and therefore the demand for skilled labor more towards the smaller country.

Two final sections generate additional results. Section 6 notes that a convergence in country sizes can raise the skilled-unskilled wage gap in both countries as multinationals displace national firms. A country which is both large and skilled-labor abundant initially will experience an increasing wage gap as the countries converge in both size and in relative endowments.

Section 7 considers trade costs. By inducing the entry of multinationals, we show a case in which trade costs protect the abundant factor in each country. This is a result opposite to traditional theory in which trade barriers protect the country's scarce factor. If skilled labor requirements in branch-plant fixed costs are high however (our central case), then the regime shift to multinationals raises the wage of skilled labor in both countries.

³Rising skilled-unskilled wage gaps in both north and south have been discussed, modelled, and hypotheses tested in a number of recent papers, including Feenstra and Hanson (1995a,b), Cragg and Epelbaum (1995), and Berman, Machlin, and Bound (1995). Feenstra and Hanson model a continuum of intermediate inputs for an industry, ranked in terms of skilled-unskilled labor intensity. Investment liberalization moves capital to the south, and shifts the dividing line in the continuum in favor of more inputs produced in the south. The shifted inputs are skilled-labor intensive in the south, but unskilled labor intensive from the north's point of view, hence the relative demand for skilled labor rises in both countries. Cragg and Epelbaum focus on capital mobility and skill-biased technical change while Berman, Machlin, and Bound also find evidence of skill-biased technical change.

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. Skilled labor is used for the firm-specific fixed cost of producing X, and plant-specific fixed costs use a combination of the two labor types. Unskilled labor is used in variable costs, and in addition there are transport costs between countries, specified as units of unskilled labor per unit of X exported.

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 5.0 in the simulation runs reported later in the paper.

Superscripts (n,m) will be used to designate a variable as referring to national firms and multinational firms respectively. (m_i, n_i) will also be used to indicate the number of active m firms 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).

In order to enter X production with one plant, a firm must incur a fixed cost in units of skilled labor, denoted F, and a fixed cost in units of unskilled labor G: national-firm fixed costs are thus $L_i = G, S_i = F$.

A two-plant multinational headquartered in country i incurs additional fixed costs in both countries. These include both skilled and unskilled labor costs in the branch-plant in country j, and possibly additional skilled-labor costs in the source country i. Total fixed costs for a two-plant

multinational headquartered in country i are:

$$L_i = G, \quad L_j = \beta G, \quad S_i = F + \gamma F, \quad S_j = \delta F, \quad 1 \geq \beta > (\gamma + \delta)$$

The inequality on the right expresses the assumptions that the second plant is more unskilled-labor intensive than the first, and that there are multi-plant economies of scale arising from the joint-input nature of knowledge capital. γ can be thought of as a technology-transfer cost. Later in the paper our central-case uses $\beta = 0.75$, $\gamma = 0.1$, $\delta = 0.4$.⁴

Marginal factor requirements are constant in units of unskilled labor.⁵ X_{ij}^n denotes the sales in country j of a national firm based in country i . Let w_i , and v_i , denote the prices of unskilled labor and skilled labor respectively in country i . 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

$$(2) \quad w_i L_i^n + v_i S_i^n = w_i [c X_{ii}^n + (c + \tau) X_{ij}^n + G] + v_i F, \quad i, j = h, f, \quad i \neq j.$$

where c is the constant marginal production cost. c , F , and G are identical across countries. τ is the amount of unskilled labor needed to transport one unit of X from country i to country j , which we assume to be the same in both directions. In our calibration, national firms in the X sector are moderately more skilled-labor intensive than Y -sector firms. However, this is not particularly

⁴Reiterating what we noted above, our earlier papers either assume that all X -sector activities use factors in the same proportion (Markusen and Venables, 1995c) or use just a single factor (Markusen and Venables, 1995a,b). Labor-market effects are only of second-order importance in those papers and not addressed. The technology-transfer cost ($\gamma > 0$) is motivated by empirical results, especially those of Teece (1977, 1986), that direct investments require significant further investments in skilled-labor-intensive activities for multinational firms.

⁵Skilled workers could be used in X production (and in G) but they enjoy no productively advantage over unskilled labor: engineers are no better on the assembly line than unskilled workers. Since skilled workers are differentiated from unskilled workers in the composite Y sector, all "excess" skilled workers not needed in fixed costs will be allocated to the Y sector in equilibrium.

important in our model since we are focussing on the switch between national and multinational X-sector firms.

A multinational based in country i has sales in country j , X_{ij}^m . It operates one plant in each country incurring fixed costs, $(G_i, (1 + \gamma)F_i)$ in its base country, and fixed costs $(\beta G_j, \delta F_j)$ in country j . Sales are met entirely from local production not trade. $L_{ij}^m(S_{ij}^m)$ denotes a country i multinational firm's demand for unskilled (skilled) labor in country j . A firm type m_i thus has a cost function

$$(3) \quad w_i L_u^m + w_j L_y^m + v_i S_u^m + v_j S_y^m = w_i [c X_u^m + G] + w_j [c X_y^m + \beta G] + v_i (1 + \gamma) F + v_j \delta F.$$

In our calibration, multinational firms are generally more skilled-labor intensive than national firms, using more skilled labor for branch-plant fixed costs versus the additional unskilled labor for transport costs used by national firms. This depends, however, on firm scale.⁶

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

$$(4) \quad \begin{aligned} \bar{L}_i &= L_{iy} + n_i L_i^n + m_i L_u^m + m_j L_y^m \\ \bar{S}_i &= S_{iy} + n_i S_i^n + m_i S_u^m + m_j S_y^m \end{aligned}$$

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

⁶An exception can occur when the two countries are very similar. The removal of an investment barrier leads, in equilibrium, to multinational firms with significantly higher output per firm than the national firms they displace, a type of pro-competitive effect. Since final output is unskilled-labor intensive, the difference in equilibrium firm scale contributes toward making the multinational firms less skilled-labor intensive. In the simulation results we report, this firm-scale effect approximately cancels out the fixed-cost effect (making multinationals more skilled-labor intensive at common scale) so that the equilibrium skilled-labor wage and the skilled-unskilled wage gap are essentially unaffected by the removal of an investment ban when the countries are identical.

$$(5) \quad M_i = w_i \bar{L}_i + v_i \bar{S}_i \quad i = h, f.$$

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,

$$(6) \quad U_i = X_{ic}^\alpha Y_{ic}^{1-\alpha}, \quad X_{ic} = n_i X_{ii}^n + n_j X_{ji}^n + m_i X_{ii}^m + m_j X_{ji}^m$$

giving demands

$$(7) \quad X_{ic} = \alpha M_i / p_i, \quad Y_{ic} = (1-\alpha) M_i.$$

Equilibrium in the X sector is determined by pricing equations (marginal revenue equals marginal cost) and free-entry conditions. We denote proportional markups of price over marginal cost by e_{ij}^k , ($k = n, m$), so, for example, e_{ji}^m is the markup of a country j multinational in market i. Pricing equations of national and multinational firms in each market are (written in complementary-slackness form with associated variables in brackets):

$$(8) \quad p_i(1 - e_{ii}^n) \leq w_i c \quad (X_{ii}^n)$$

$$(9) \quad p_j(1 - e_{ji}^n) \leq w_i(c + \tau) \quad (X_{ji}^n)$$

$$(10) \quad p_i(1 - e_{ii}^m) \leq w_i c \quad (X_{ii}^m)$$

$$(11) \quad p_j(1 - e_{ji}^m) \leq w_j c \quad (X_{ji}^m)$$

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 (7)), reducing the firm's markup to its market share.

This gives, (also using demand equations (7)),

$$(12) \quad e_{ij}^k = \frac{X_{ij}^k}{X_{jc}} = \frac{p_j X_{ij}^k}{\alpha M_j} \quad k = n, m, \quad i, j = h, f.$$

There are four zero-profit conditions corresponding to the numbers of the four firm types. Given equations (8)-(11), zero profits can be written as the requirement that markup revenues equal fixed costs.

$$(13) \quad p_h e_{hh}^n X_{hh}^n + p_f e_{hf}^n X_{hf}^n \leq w_h G + v_h F \quad (n_h)$$

$$(14) \quad p_f e_{ff}^n X_{ff}^n + p_h e_{fh}^n X_{fh}^n \leq w_f G + v_f F \quad (n_f)$$

$$(15) \quad p_h e_{hh}^m X_{hh}^m + p_f e_{hf}^m X_{hf}^m \leq w_h G + v_h (1 + \gamma) F + w_f \beta G + v_f \delta F \quad (m_h)$$

$$(16) \quad p_f e_{ff}^m X_{ff}^m + p_h e_{fh}^m X_{fh}^m \leq w_f G + v_f (1 + \gamma) F + w_h \beta G + v_h \delta F \quad (m_f)$$

To summarize the X sector in the model, the eight inequalities (8)-(11) are associated with the eight output levels (two each for four firm types), the eight equations in (12) are associated with the eight markups, and the four inequalities in (13)-(16) are associated with the number of firms of each type. Additionally goods prices are given by (7), income levels from (5) and factor prices from factor market clearing equation (4) together with labor demand from the Y sector.

The model is quite complex and inherently involves inequalities making traditional analytical, comparative-statics methods of limited value. The problems introduced by inequalities are compounded by the factor that we have four different production activities (Y, X-sector output, national-firm fixed costs, multinational-firm fixed costs), all using factors in different proportions. In the next section, we will try to gain some intuition by reviewing analytical results from our earlier

papers, and later in the paper simulate the full model which involves 51 non-linear inequalities.⁷

3. Forces at Work

In our related papers (Markusen and Venables, 1995a,b) we were able to make considerable analytical progress, although partly at the expense of assuming the same factor intensity in all of the X-sector activities. Rather than re-derive some of the previous results here, we will simply explain the intuition behind them, and conjecture on some extensions to the case of differing factor intensities considered in this paper. The focus of the section will be on the equilibrium regime as a function of relative and absolute factor endowments, and trade costs.

Suppose that the two countries are absolutely identical. Suppose also that we calibrate fixed costs and trade costs so that all four firm types could exist together in equilibrium. The higher total fixed costs of national firms are exactly balance by the higher trade costs of the national firms. Our previous work then establishes the following results.

- (a) An increase in both countries' size ($\Delta M_h = \Delta M_f > 0$) will imply that only multinational firms exist in equilibrium. Large markets favor high fixed-cost multinational firms over high variable-cost national firms.
- (b) An increase $v\Delta F = -w\Delta G > 0$ will imply that only multinational firms exist in equilibrium. This shift leaves national firms unaffected, but benefits multinationals (the second plant is more unskilled-labor intensive: $\beta > (\gamma + \delta)$).
- (c) An increase in trade costs will imply that only multinational firms will exist in equilibrium. High trade costs favor two-plant firms which pay no trade costs.

We thus have the result that multinationals are more likely to exist in equilibrium when incomes are high, skilled-labor requirements in fixed costs are more important relative to unskilled-labor requirements, and trade costs are relatively high.

Now consider the two countries differing in relative endowments, and assume that the

⁷Reviewing points made separately earlier, multinational firms are moderately more skilled-labor intensive than national firms which are moderately more skilled-labor-intensive than Y production in our calibrations. But many of the interesting factor-market effects that we identify are driven by geographical rearrangement of activities when multinationals are allowed to enter rather than by the skilled-labor intensities of type-n firms versus type-m firms versus Y production per se.

countries are large, F is large relative to G , and trade costs sufficiently high that multinationals dominate in equilibrium when the two countries are initially identical. As the countries begin to diverge somewhat in relative endowments, with h becoming more skilled-labor abundant, the regime should stay fixed at (m_h, m_f) . Firm numbers should adjust with more firms headquartered in country h , but there is no reason to expect the regime to shift for relatively small differences. But eventually relative factor prices in the two countries will begin to diverge along with the divergence in relative endowments. Holding the regime fixed, skilled labor will become more expensive in the skilled-labor-scarce country. This in turn disadvantages multinational firms, which must purchase skilled labor in both countries, relative to (potential) national firms headquartered in the skilled-labor-abundant country. At some point, type- n_h firms will enter and type- m_f firms will exit (not necessarily at the same parameter values) leaving a regime of type- m_h and/or type- n_h firms in equilibrium. While production in country f may continue, we would expect all firms to be headquartered in country h for sufficiently large differences in relative endowments.

Next, consider the effects of country size, making country h larger and country f smaller. Assume again that initially multinational firm only exist in equilibrium. As the country sizes begin to diverge, there is no inherent disadvantage created for type- m_f multinationals, although they should be fewer in number. If factor prices are the same in the two countries (consistent with $0 < m_f < m_h$), then type- m_f and type- m_h firms are in fact in a perfectly symmetric position. Each incurs the same total fixed costs, and produces the same amount in a given country's plant, with simply a larger output in the country- h plant than in the country- f plant.

As the country sizes diverge further, type n_h firms gain a potential advantage. Their (potential) sales are concentrate in their low-cost (zero transport cost) market, whereas multinationals must incur fixed costs in country f to serve an ever shrinking market there. Eventually, some type- n_h firms should be able to enter in competition with the multinationals.

Eventually, there will come a point where only type- n_h firms can exist in equilibrium. As country f 's size and therefore demand becomes very small, it is simply not profitable for a firm to build a plant in f . Markup revenue cannot cover fixed costs.

Taken as a whole, these arguments suggest that country h firms will dominate when the countries are very different in size or in relative factor endowments, there will be a mixed regime (both in types and nationalities) as the countries converge, and eventually only multinationals of both countries will exist provided transport costs and/or income levels are sufficiently high.

It seems rather obvious that skilled-labor-intensive activities, which translate here into firm ownership, should be concentrated in the skilled-labor-abundant country, although the role of country size is perhaps less obvious. But the concentration of firm ownership in the large and/or skilled-labor-abundant country does not lead to any simple predictions about the effects of multinational entry due to the removal of an investment ban. For example, the entry of multinationals may decrease the X-sector demand for skilled labor in the large or skilled-labor abundant country h as branch plants are built in country f and/or type- m_f firms are able to enter. Or alternatively country h X-sector skilled-labor demand could increase as type- m_h firms replace type- n_f firms. Similarly, intuition suggests contradictory effects of multinational entry on skilled-labor demand (and hence wages) in host countries as we noted earlier. Exports of skilled-labor-intensive producer services by multinationals to branch plants may substitute for host-country skilled-labor demanded by local firms. But if there are few or zero local firms in the absence of multinationals, then multinational entry is likely to correspond to an increased demand for local skilled labor. With strong analytical results unavailable, we thus turn to simulation analysis in the next two sections.

4. Entry of Multinationals due to Investment Liberalization: Countries differ in Relative Endowments

In this section, we assume that countries differ in relative endowments, but that they are of the same size, meaning that their GDP levels are about the same. A numerical model using Rutherford's (1989) non-linear complementarity algorithm solves a model of 51 non-linear equations and inequalities. Our central case uses the values $\beta = 0.75$, $\gamma = 0.1$, $\delta = 0.4$. A second plant requires 75% as much unskilled labor as the first plant, all drawn from the host country. The second plant also requires 50% as much skilled labor as the first plant, 10% drawn from the country of headquarters and 40% in the country in which the branch plant is located. If the S/L ratio in Y is normalized to 1.0, the calibration implies an overall S/L ratio in the X sector between about 2.1 and 2.6 in case 1 depending on what firm types are active in equilibrium.⁸

In almost all experiments conducted, we found the results qualitatively robust with respect to significant variations in these values. One exception occurred with respect to increased trade costs which induce multinational entry, so in section 7 presents an interesting result using alternative values: $\beta = 1.0$, $\gamma = \delta = 0.1$. In this case the branch plant uses more unskilled labor and less skilled labor relative to the central case.

Figure 1 presents qualitative results on the equilibrium regime for the relative endowment experiment (all results are "central case" unless otherwise noted). The countries are identical in the top row and their difference is maximized in the bottom row. The units of measure on the vertical axis is country f's endowment of skilled labor as a proportion of its initial endowment. Moving down a column, S is transferred from country f to country h, and L is transferred in the opposite direction

⁸If multinationals are banned, this can result in inefficiently many firms in protected markets producing at small scale, resulting in a significantly higher S/L ratio in the X sector as we shall note later.

in amounts needed to maintain approximate parity in the two countries GDP levels.⁹ The horizontal axis measures the transport cost variable τ as a proportion of marginal production costs (both use unskilled labor only). Results would be similar using a tariff variable except for a relatively small income effect. When the two countries are relatively similar and trade costs are low, the equilibrium regime involves intra-industry trade competition between national firm types n_h and n_f (region b). When trade costs are higher, the regime involves intra-industry investment competition between type- m_h and m_f multinational firms (region i).

Consider moving down the column for $\tau = .15$ in Figure 1. As country f becomes relatively more scarce in skilled labor, we expect that v_f/v_h eventually, rises, making country h more suitable and country f less suitable as the location for corporate headquarters. This is what we see in Figure 1 moving down column $\tau = .15$ with a regime shift to type- m_h firms only at row 0.60. Continuing the spread in relative endowments by moving further down this column should further raise v_f/v_h making country f less suitable even for branch plants of type- m_h firms. Alternatively, potential type- n_h firms become more profitable (they use no S_f), serving country f by exports. This occurs in Figure 1 with a second regime shift to type (m_h, n_h) firms at row 0.40. Moving down a column for moderate transport costs, such as $\tau = .15$, we see a sequence about the same as that suggested in the previous section.

$$(m_h, m_f) \rightarrow (m_h) \rightarrow (m_h, n_h)$$

In order to understand exactly how multinationals affect variables of interest, we re-ran the model suppressing multinational firms (e.g., a prohibitive investment barrier), comparing the resulting values with those in which multinationals are endogenous. Figure 2 plots ratios of variables with and without multinationals, where the subscript n indicates "no multinationals". v_i now denotes the real

⁹Note that the vertical axis of Figure 1 gives S_f as a proportion of its initial value. Skilled labor is transferred to country h holding the world endowment constant. Thus the row 0.4 in Figure 1 has a ratio of $S_f/S_h = 0.4/1.6$, or .25. The vertical axis in the later regime diagram (Figure 3) is similarly defined.

wage of skilled labor in country i , the wage divided by the consumer price index (the unit expenditure function). r_i denotes the skilled-unskilled wage ratio v_i/w_i in country i . The values run down the column for $\tau = .15$ in Figure 1, so countries are identical on the left-hand side of each panel, and their relative endowment differences maximized on the right-hand side.¹⁰

Looking at the left-hand side of each panel (countries identical) of Figure 2, we see that the removal of an investment barrier has virtually no effect on outputs in the two countries, or on the real wages of skilled labor. Actually, these "zero" changes mask two counter-acting changes. The type- m firms are skilled-labor intensive relative to type- n firms, so the removal of the investment barrier generates an increased demand for skilled labor as constant firm scale. But the removal of the investment barrier (and given the moderate transport costs) has a pro-competitive effect in which the multinational firms have a significantly higher output per firm than the national firms that they displace. Since output is unskilled-labor intensive, this tends to reduce the overall skilled-labor intensity of the X sector. The two effects approximately cancel.

Now consider relative endowments values in the range .95 to .50 in Figure 2. Entry of multinationals due to the removal of a trade barrier raises X production in country f and lowers it in country h (the top panel). Exports of knowledge capital by type- m_h firms compensate for the shortage of skilled labor in country f , and production (which is unskilled-labor intensive) is transferred from country h to country f . In some sense, the entry of multinationals does result in the "export" of unskilled jobs from the high-income country.

The middle and bottom panels of Figure 2 consider the real wage of skilled labor and the skilled-unskilled wage ratio respectively. Over the range .95 to .50 we see that the entry of

¹⁰Apologies for the different scales for the two ratios in each of the panels of Figure 2. The fact that one of the ratios generally changes much more than the other makes the change in the smaller one difficult to evaluate if the two ratios are plotted on the same scale. We calibrated the two scales such that the ratios have the same position when the countries are initially identical and the ratios are equal.

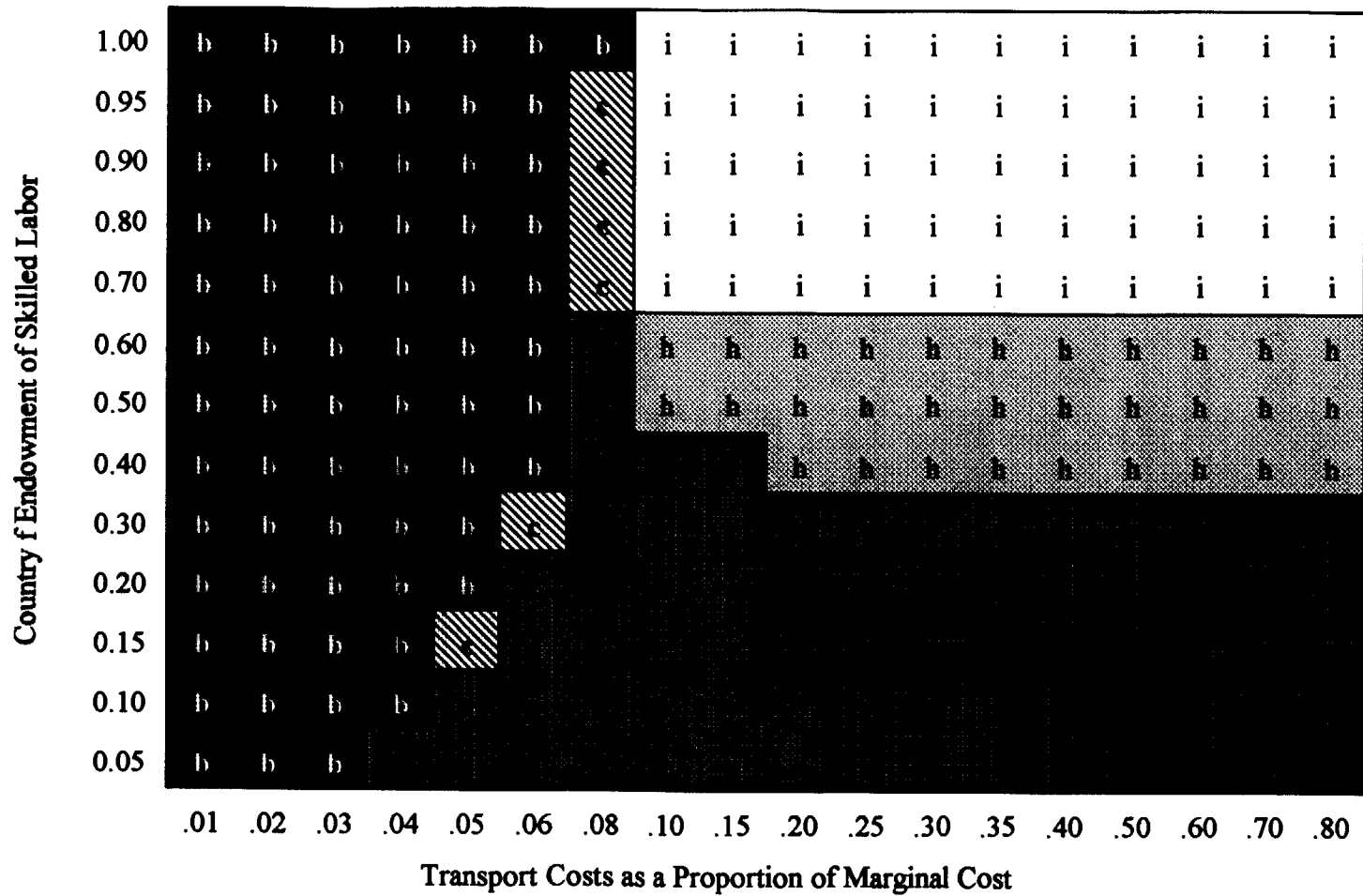
multinationals due to the removal of an investment barrier raises the real wage of skilled labor and the skilled-unskilled wage ratio in country h, and lowers these same ratios in country f. The removal of the investment barrier permits the export of skilled-labor-intensive producer services (knowledge capital) from the skilled-labor-abundant to the skilled-labor-scarce country. Thus the result is fairly intuitive but of considerable importance for public policy. For example, multinationals do contribute to raising the skilled-unskilled wage gap in the high-income country, something that has been of great concern in these countries.

These results are reversed for country f (but not for country h) when the difference in relative endowments becomes larger, values .40 to .05 in Figure 2. In such a situation, country f is so short of skilled labor that its national firms are uncompetitive in the absence of multinationals and production in country f is close to zero. The removal of the investment barrier removes this constraint on production, and the number of plants (type- m_h multinationals) is 3.5 as large as the number of type- n_f firms displaced. Hence the aggregate demand for S_f increases substantially even though each plant of a type- m_h firm demands less S_f than did a type- n_f firm in the absence of direct investment. In this region, the removal of an investment barrier increases the real wage of skilled labor and the wage ratio in both countries, and home-country exports of skilled-labor-intensive producer services become a complement rather than a substitute for foreign-country skilled labor.

To summarize this section in which countries are of roughly equal GDP but differ significantly in relative factor endowments, we see several results. The entry of multinationals due to the removal of a prohibitive investment barrier transfers production from the high-income to the low-income country, and raises the real wage of skilled labor and the skilled-unskilled wage ratio in the high income country. The one ambiguous result relates to the real wage of skilled labor and the skilled-unskilled wage ratio in the low income country. If the difference in the relative endowments between the countries is not too large, then the entry of multinationals harms skilled labor in the low-income,

skilled-labor-scarce country. The result is reversed if the relative endowment differences are large. In the latter case, exports of skilled-labor-intensive producer services by the high income country are complementary to skilled labor in the low-income country.

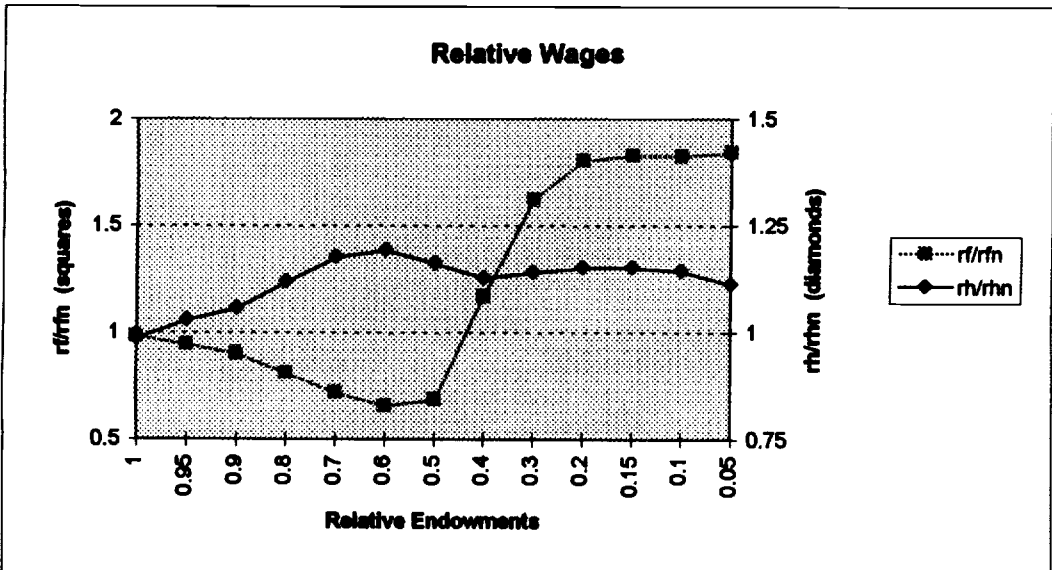
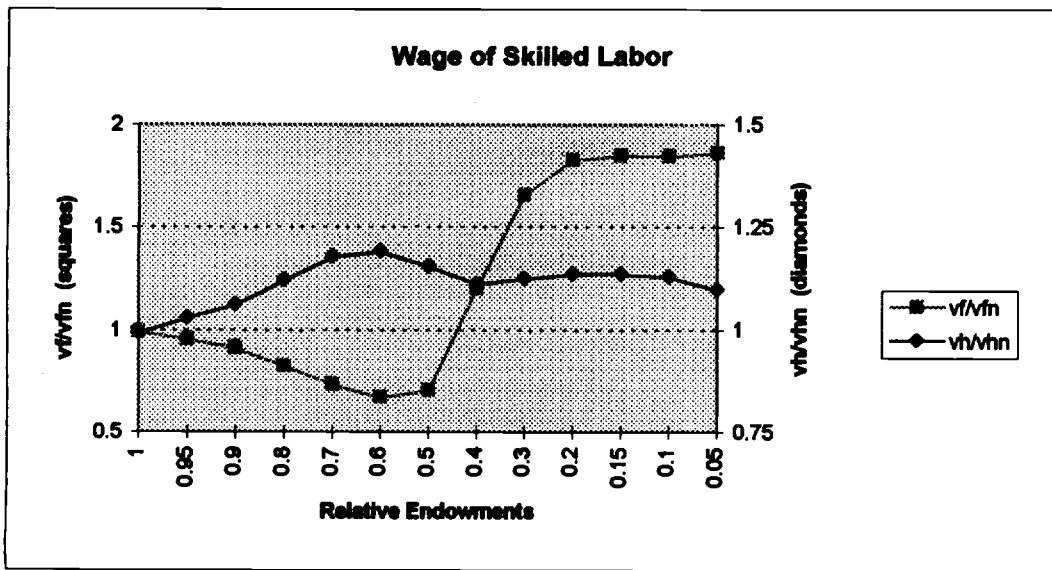
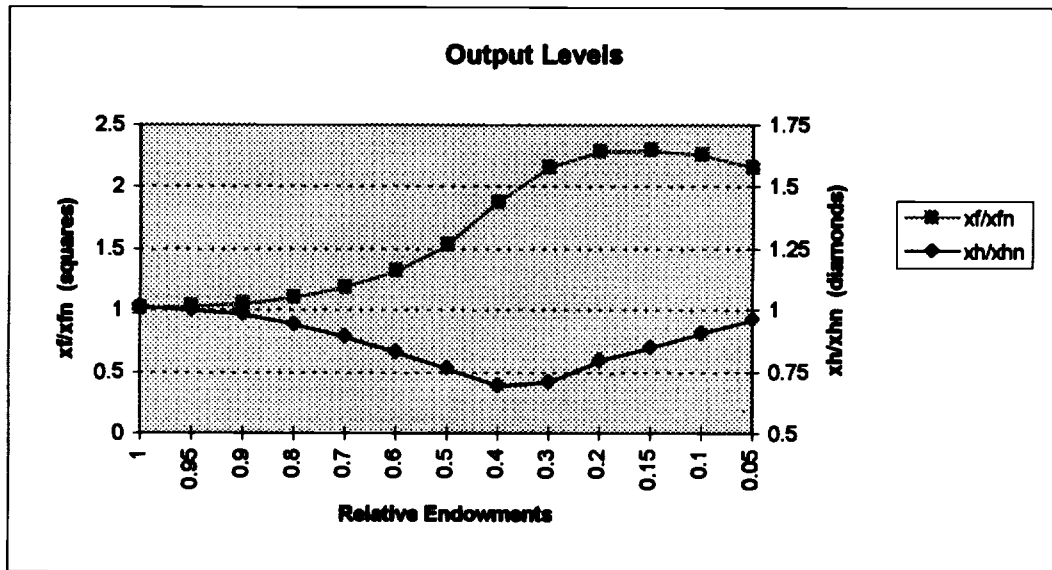
Figure 1—Relative Endowment Experiment



- b** n_b, n_f firms
- b** n_b, n_f, m_h firms
- b** n_b, m_h firms
- h** m_h firms
- i** m_h, m_f firms

Note: Countries are identical in the top row.

Figure 2: Effect of Removing an Investment Barrier
Differences in Relative Endowments, $\tau = .15$



5. **Entry of Multinationals due to Investment Liberalization: Countries differ in Size (Absolute Endowments)**

Now consider pure country size effects, in which we hold the total world endowment constant but transfer factors in equal proportion from country f to country h , beginning with the two countries identical. The equilibrium regime is shown in Figure 3. As in the case of Figure 1, the two countries are identical in the top row and their size difference is maximized in the bottom row. The scaling on the vertical axis is country f 's factor endowment as a proportion of its initial endowment. The horizontal axes of the Figures 1, 3 are the same. Results in the top halves of Figures 1 and 3 are similar. When the countries are not too different, intra-industry trade competition between national firm types occurs when trade costs are small, and intra-industry investment competition between multinational firm types occurs when trade costs are higher.

Figures 1 and 3 differ substantially in their middle and bottom sections, when relative endowment and size differences are moderate to large. Consider low trade costs, and compare points in row-column (0.50 0.05) in the two diagrams. When the difference between countries h and f is in relative endowments (Figure 1), some country f -owned firms (type n_f) firms can exist. A small endowment of S_f will restrict the number of firms, but they are not hampered by a small domestic market. When the difference between countries h and f is in relative size (Figure 3), no country f -owned firms can exist. The small domestic market size in country f disadvantages country f firms sufficiently that they cannot be supported in equilibrium.

Now consider high trade costs and compare points in row-column (0.50, 0.15) in Figures 1 and 3. Here it is in the case of relative endowment differences (Figure 1) that no country f -owned firms can exist in equilibrium. Once endowment differences become sufficiently large that factor-price equalization cannot hold, type m_f and m_h firms cannot coexist with $v_f > v_h$. But when countries differ only in size (Figure 3), the two multinational firm types are in a symmetric position and the real

wage of skilled labor can remain equalized across the countries despite the large difference in country size. Moving down a column of Figure 3 such as $\tau = .15$, we see a sequence of regime shifts similar to that suggested by the partial equilibrium analysis of section 3.

$$(m_h, m_f) \rightarrow (m_h, m_f, n_h) \rightarrow (n_h).$$

Figure 4 plots the same ratios as Figures 2, but this time for the column $\tau = .15$ of Figure 3. The two countries are identical at the left-hand edge of each panel of Figure 4 as before with their size differences being maximized at the right-hand edge. The top panel give production ratios with and without multinationals banned as in earlier figures. The ratio X_f/X_{fn} quickly goes off to infinity as the denominator goes to zero with a moderate difference in country size: with multinationals banned, the smaller country specializes in good Y. As in the case of the countries differing in relative endowments, the removal of an investment barrier shifts production from country h to country f, in this case from the larger to the smaller country.¹¹

The country-size experiment, however, yields rather different results from the relative-endowment experiment in Figure 2 with respect to the real wage of skilled labor and the skilled-unskilled wage ratio. In the present case, the removal of an investment ban raises v_f and r_f and lowers v_h and r_h .¹² The reason for this is familiar from the industrial-organization approach to trade. With the countries different in size and multinationals banned, type- n_h firms have a significant advantage over type- n_f firms in that the former have their sales concentrated in their low-cost (no transport costs) domestic market, whereas type- n_f firms have a small domestic market. Thus in equilibrium, country f generally has fewer firms than its relative size would predict. Even after accounting for size, X-sector demand for skilled labor is greater in country h than in country f, and

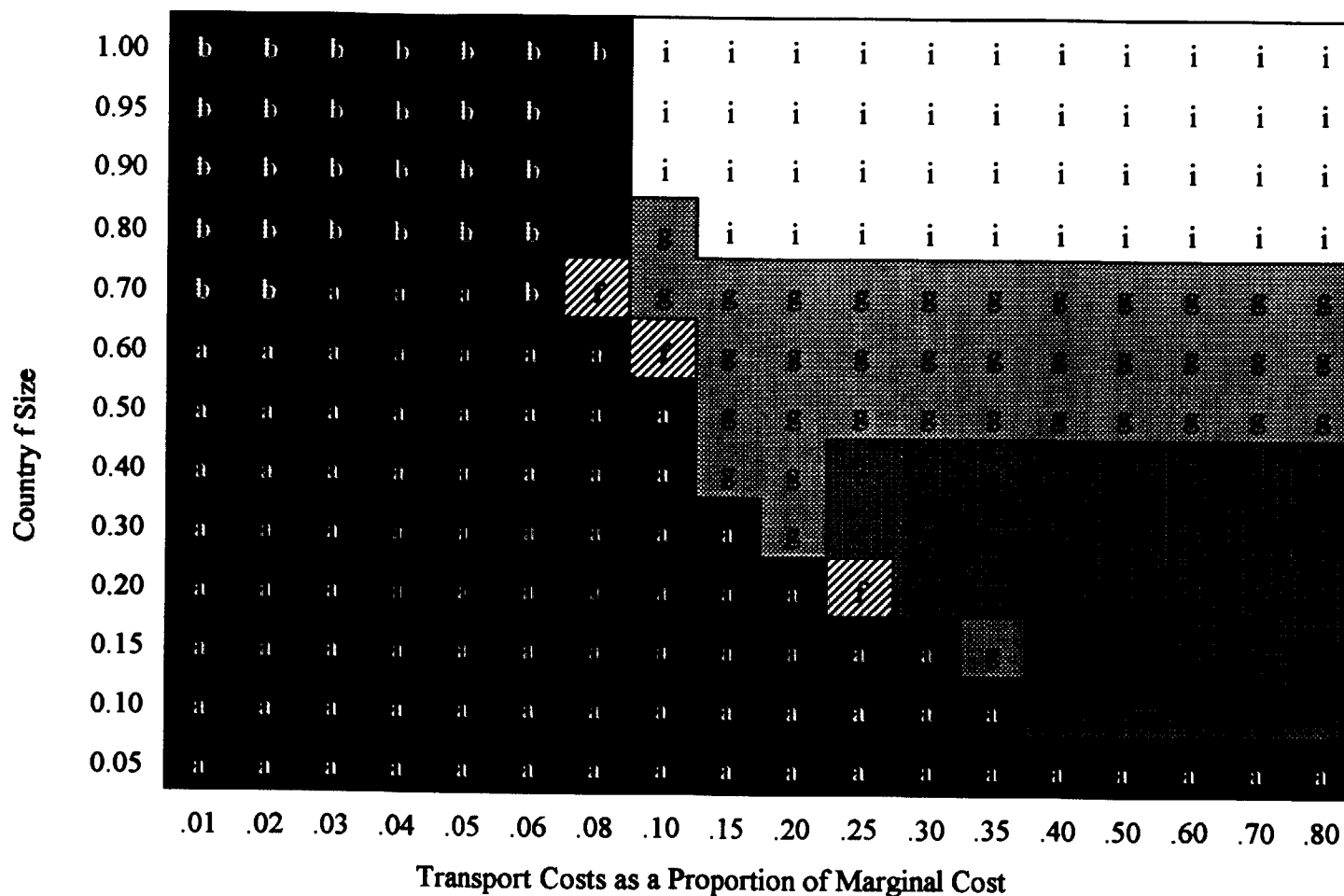
¹¹Of course, we see from Figure 3 that, when size differences are very large, multinationals do not enter even in the absence of an investment barrier.

¹²As we shall see shortly, this does not imply that $v_f > v_h$! We are only referring here to the change in these prices when an investment barrier is removed.

the real wage of skilled labor is higher in the former. The introduction of multinationals removes country size as a "determinant of comparative advantage", shifts production and firm ownership to country f, and thus increases v_f and decreases v_h .¹³ Conversely, one could say that the removal of the investment barriers causes country h to "lose competitiveness", not only as the favored site for production (also true in Figure 1), but as the favored site for firm headquarters.

¹³When the different in size becomes very large, we see from Figure 3 that multinationals do not produce in country f even though they could. Thus all of the ratios in Figure 4 become equal to one when the absolute endowment number is less than or equal to .30.

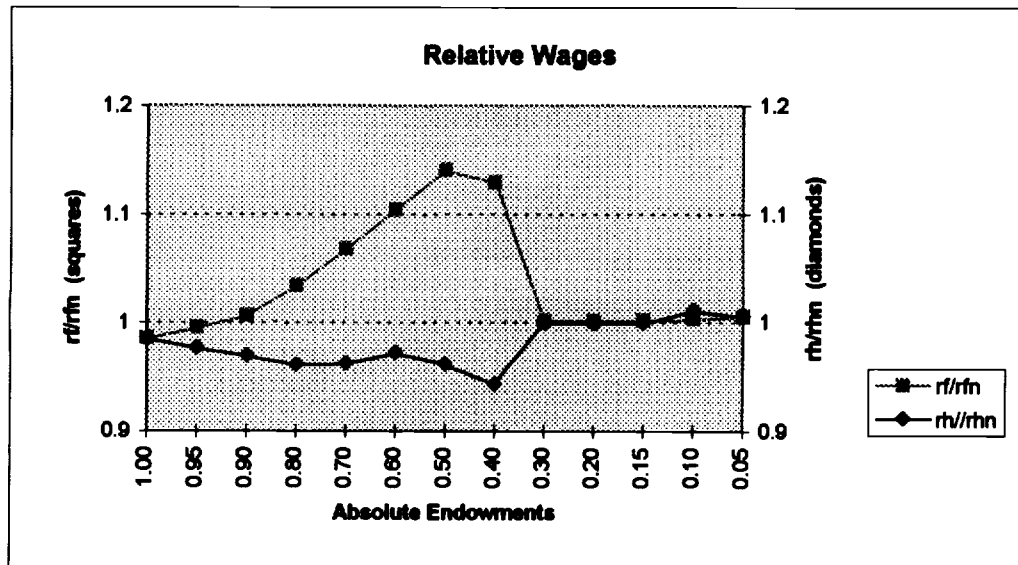
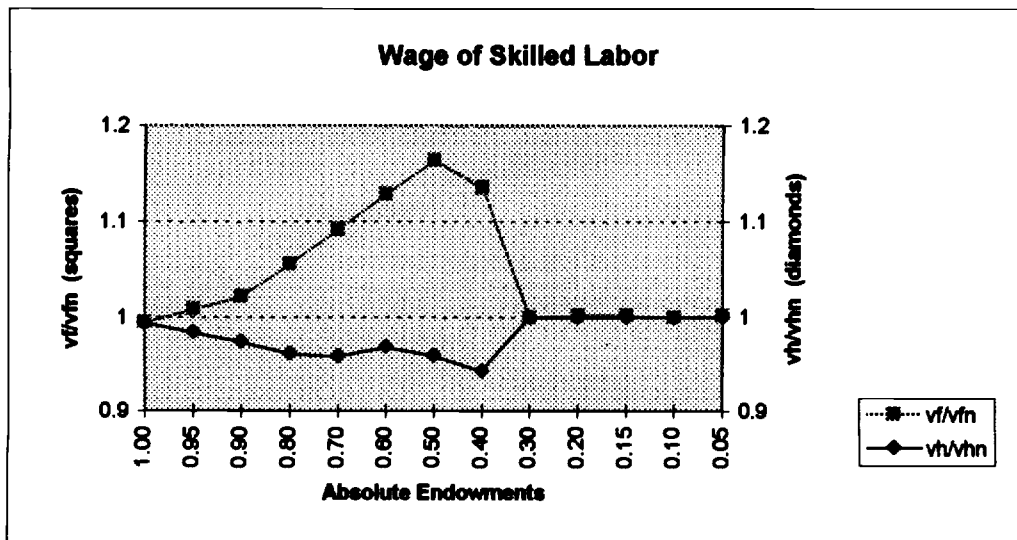
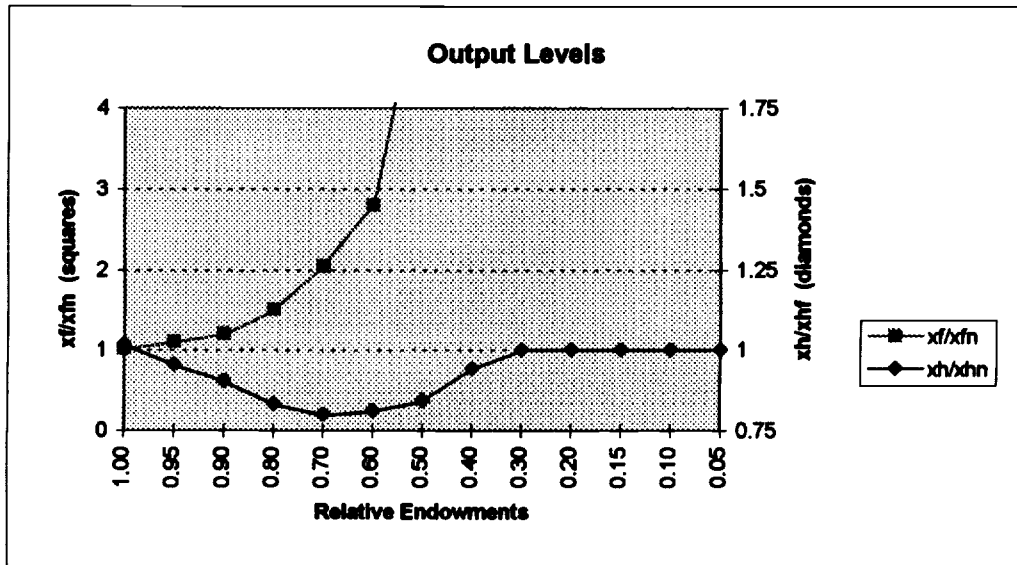
Figure 3—Absolute Endowment Experiment



- a** n_h firms
- b** n_h, n_f firms
- n_h, n_f, m_f firms
- n_h, m_h firms
- f** n_h, m_f firms
- g** n_h, m_h, m_f firms
- i** m_h, m_f firms

Note: Countries are identical in the top row.

Figure 4: Effect of Removing an Investment Barrier
 Differences in Absolute Endowments: $\tau = .15$



6. The Real Wage of Skilled Labor

The analysis of the preceding two sections focussed on the effects of multinationals by comparing a situation in which they are present to one in which they are excluded by a direct investment ban. But the fact that the removal of such a ban, for example, raises v_h and lowers v_f does not imply that $v_h > v_f$ post liberalization. In this section, we directly examine v_f and v_h when multinationals enter endogenously.

Figure 5 has two panels corresponding to the two experiments shown in Figures 1, and 3. These panels move down the column for $\tau = .15$ as in the case of Figures 2, and 4. In both panels of Figure 5, we see that there is a region of factor-price equalization when the two countries are similar. We see the intuitive result in the top panel that, as country f becomes increasing scarce in skilled labor, the return to skilled labor in country f rises and that in country h falls. Combining these results with those of Figures 2 suggests that multinationals reduce the difference in v_h and v_f except possibly when the countries are very different in relative endowments (in which case direct investment increases both v_h and v_f).

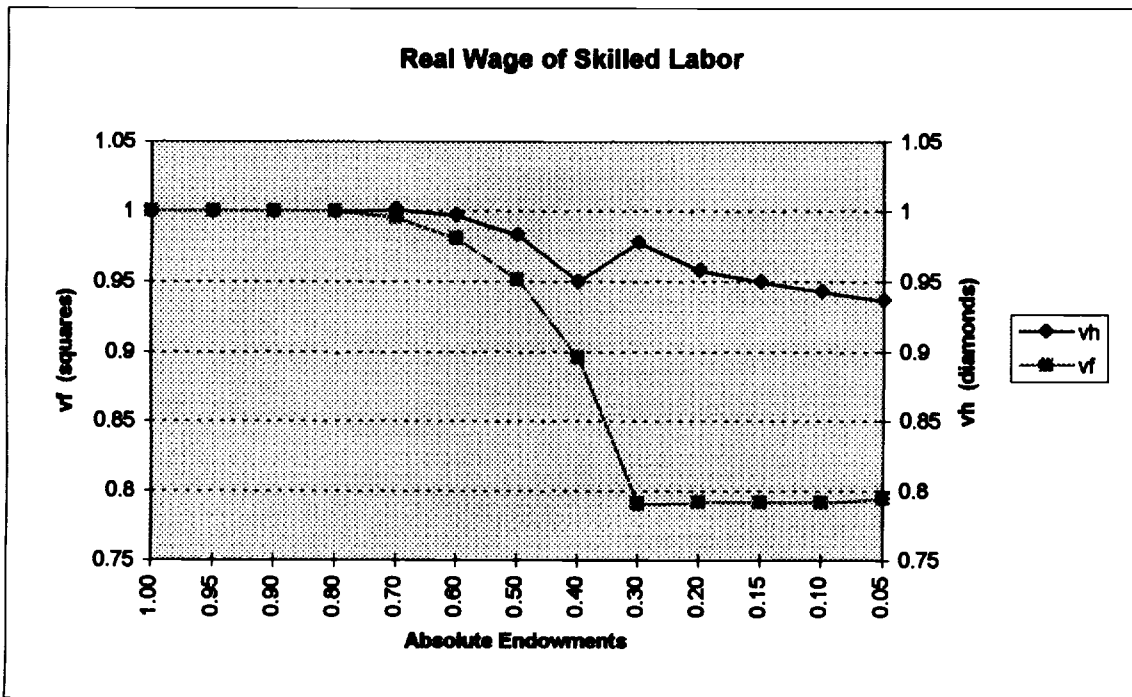
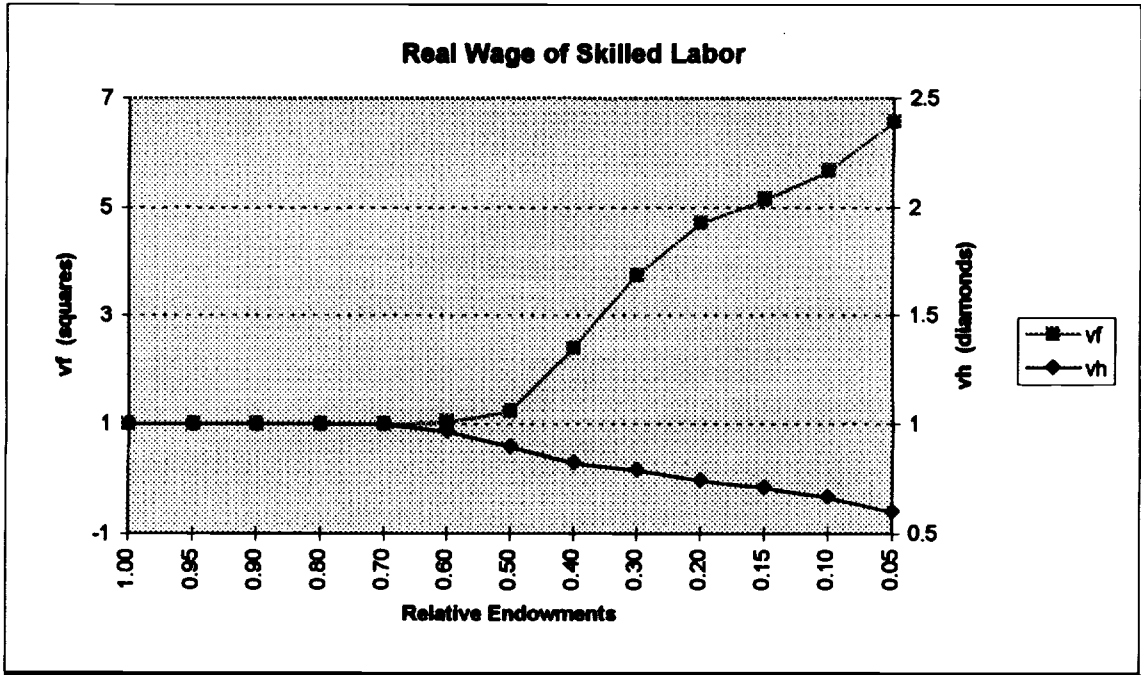
In the bottom panel, we see that the large country has a high real wage for skilled labor and the small country a low real wage even though their relative endowments are the same. This is an effect that is familiar from the new trade theory as noted in the previous section. In this model, country size is itself a source of comparative advantage and the small country will have firm numbers less than in proportion to its size when multinationals are not present. Referring back to Figure 3, multinationals disappear in the column $\tau = .15$ at absolute endowment ratio 0.4-0.3, and it is here we see the large divergence in v_h and v_f in the bottom panel of Figure 5. This is a rather startling finding with implications for a dynamic analysis or even a static one with factor migration. If countries are identical in relative endowments but differ so significantly in size that multinationals do not enter, factor trade or accumulation may produce a divergence in relative endowments, with the

small country becoming skilled-labor scarce: a brain-drain phenomenon.

Finally, note in the bottom panel of Figure 5 that the real wage of skilled labor is lower in both countries when they are of very different size, even though total world endowments are constant. This is a reflection of the fact that multinational firms are more skilled-labor intensive than national firms. Moving from right to left (convergence in country size), the wage of skilled labor rises in both countries as multinational firms displace national firms. Considering both panels of Figure 5 together, we see that a convergence in both relative and absolute endowments tends to raise the wage of skilled labor in the initially large and skilled-labor abundant country.

Combining these results with those of the previous two sections, the general conclusion is that multinationals create a tendency toward factor-price equalization relative to a situation where they are exogenously excluded. The possible exception occurs when the countries are very different in relative endowments but similar in size, in which case the removal of an investment ban might increase the (positive) difference between v_f and v_h .

Figure 5: Effect of Endowments on the Real Wage of Skilled Labor;
 $\tau = .15$ (Multinationals Permitted)



7. Trade Costs

Some of the same questions we have addressed above can also be asked with respect to trade costs, insofar as multinationals are associated with moderate to high trade costs relative to the size of the market. Thus multinationals can also be induced to enter by raising trade costs from an initial low level. Figure 6 show the effects of trade costs on the real wage of skilled labor for row 0.40 of Figure 1, the relative endowment experiment. The effects are pretty much as expected, trade barriers reduce the degree of specialization in production, moving the output levels together. But the "togetherness" is much more dramatic here in that the production levels are in fact equalized, whereas in the Heckscher-Ohlin model they would remain well apart given the differences in relative endowments. The key to understanding the result here is that, although production levels converge, the firm numbers do not converge, m_h being the only firm type in equilibrium (see Figure 1). Exports of skilled-labor-intensive producer services by country h compensate for the low endowment of S in country f.

The lower panel of Figure 6 plots the real wages of skilled labor. Here we see something that is rather different from the Heckscher-Ohlin model. In the HO model, trade costs drive the prices of a factor apart across countries. Here the effect of trade costs is to raise the price of skilled labor in both countries. The intuition lies in the regime shift induced by the higher trade costs. The entry of multinationals actually increases the demand for skilled labor in country f. The larger number of branch plants that are established by type- m_h firms generates more demand for country f skilled labor than was generated by its smaller number of type- n_f firms when trade barriers were very low. Although we do not show it here, a similar effect of trade barriers on v_f occurs when the countries differ in size: trade barriers raise v_f when multinationals enter or, in other words, the "brain drain" problem referred to above is worse when trade barriers are low than when they are high.

The analysis of trade barriers is one case where a somewhat different parameterization yielded

qualitatively different results, and since they are interesting, we report them in Figure 7. In Figure 7 the parameterization is $\beta = 1.0$, $\gamma = \delta = 0.1$, so that a branch plant is much more unskilled-labor intensive than in our central case. The upper panels of Figures 6 and 7 are not much different. The interesting result is in the lower panel of Figure 7 where we see something that is completely opposite from the Heckscher-Ohlin model. In the latter, free trade tends to equalize factor prices, trade barriers drive factor prices apart as just noted. Here we see the opposite with trade barriers nearly equalizing the return to skilled labor in the two countries. The left-hand region in this lower panel can be thought of as a competitive effect familiar in the trade-IO literature. Despite (almost) free trade, the difference in the endowments of the two countries leads to significantly fewer firms in country f, and hence to differences between countries in markups and in the price of X. With multinationals induced to enter at higher trade costs, the markups and prices are the same in the two countries and the real returns to skilled labor are almost the same.

Finally, results shed light on a question raised in the abstract of the paper: do trade barriers protect unskilled labor in the skilled-labor abundant country? Although we do not plot the price of w_f it moves in the opposite fashion to v_f . Trade barriers do not protect unskilled labor in country h, another result that seems opposite to that of traditional factor-proportions trade theory in which trade barriers protect the scarce factor. The reason is that trade barriers encourage the entry of multinationals, which are skilled-labor intensive and which tend to headquarter in the skilled-labor abundant country. Thus trade barriers actually raise the return to the abundant factor by altering the trade regime.

Figure 6: Effects of Trade Costs, Relative Endowment Experiment, Central Case
 Multinationals Permitted, Relative Endowment = .40

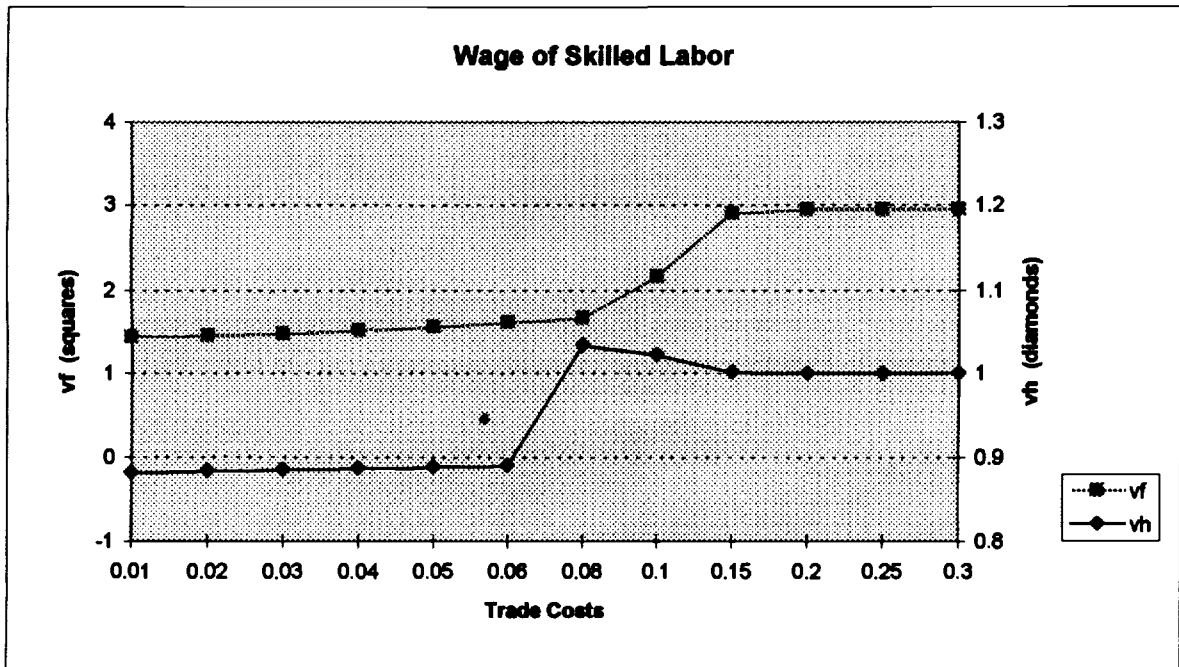
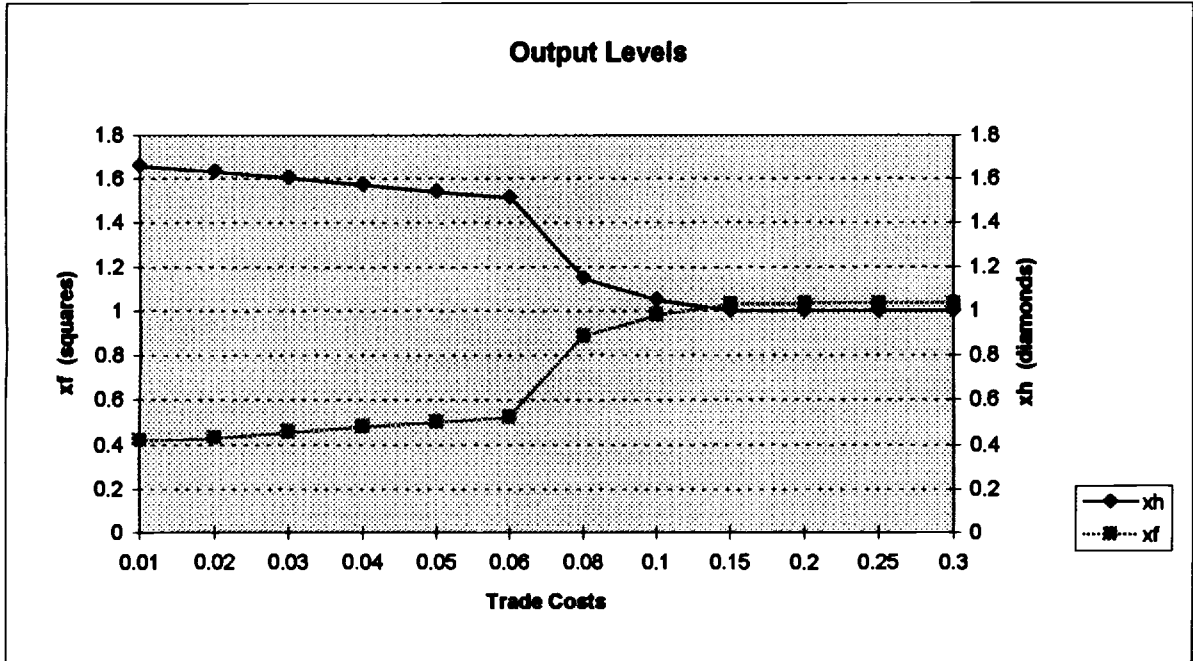
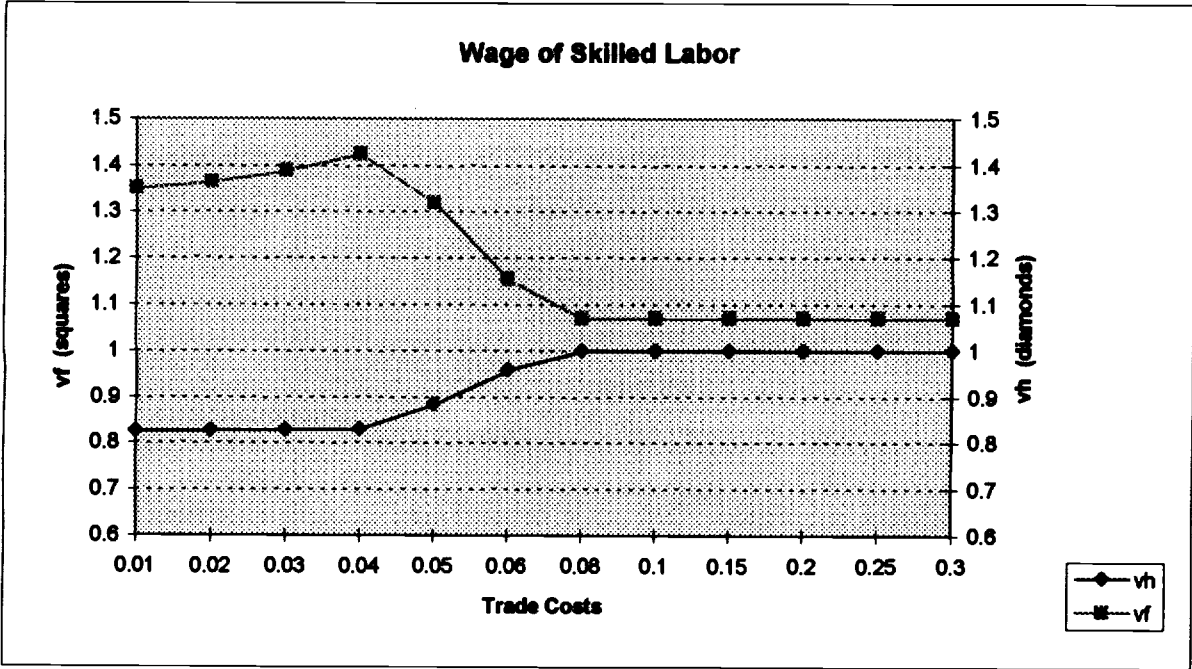
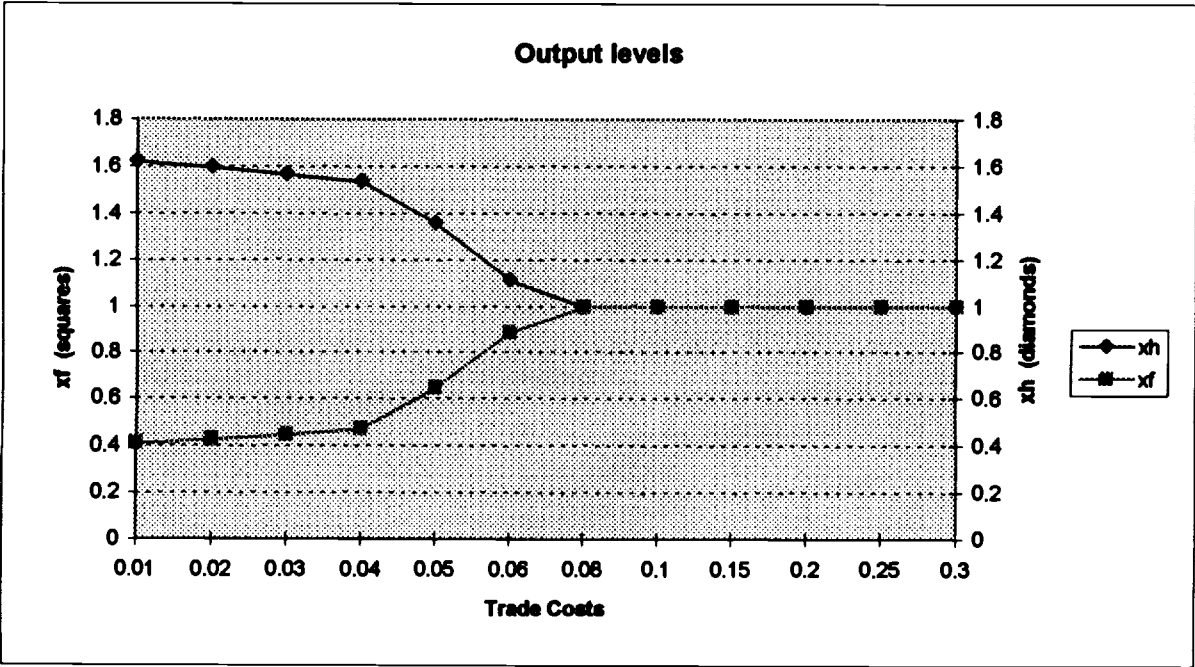


Figure 7: Effects of Trade Costs, Relative Endowment Experiment, $\beta = 1.0$, $\gamma = \delta = 0.1$
 Multinationals Permitted, Relative Endowment = .40



8. Conclusions

The general findings and implications of the paper can be summarized as follows.

(1) The industry of interest in this paper is characterized by both firm-level and plant-level scale economies. The value-added of this paper is to explicitly introduce human capital, and to model human capital as necessary for the creation of firm-specific knowledge capital and, to a lesser extent, for plant fixed costs as well. Final production is assumed to use unskilled labor.

(2) The entry of multinationals corresponds to a change in the nature of what it traded between countries. National firms engage in the export of goods, which are bundles of skilled and unskilled-labor services. Multinationals are exporters of skilled-labor-intensive producer services (or services of knowledge capital). Accordingly, multinationals should have important implications for factor returns in addition to their implications for the volume and composition of trade.

(3) When countries differ in relative endowments of factors, we found that the entry of multinationals due to the removal of a barrier to direct investment shifts production from the skilled-labor-abundant (advantaged) to the unskilled-labor abundant (disadvantaged) country. By being able to geographically segment activities, multinationals lead to more concentration of knowledge-capital production in the advantaged country and more concentration of unskilled-labor-intensive production in the disadvantaged country.

(4) The entry of multinationals when countries differ in relative endowments raises the return to skilled labor in the advantaged country as more firms are "headquartered" in this country and raises the skilled-unskilled wage gap, an issue of considerable interest to public policy.¹⁴ The effect of

¹⁴The role of trade in explaining the growing gap in skilled-unskilled wages has been an important policy issue. An excellent discussion of the evidence and conceptual arguments is present in articles by Freeman, Richardson, and Wood in a recent issue of the *Journal of Economic Perspectives* (summer 1995). No role for multinationals is identified by these authors. The paper suggests that such a role should be considered, especially due to the empirical fact that direct investment has grown much more rapidly than trade over the last two decades.

multinational entry on the disadvantaged country is however ambiguous. We found that entry was more likely to raise the return to skilled labor in the disadvantaged country when the relative endowment difference between the countries is moderate to large. In these circumstances, multinationals raise the return to skilled labor in both countries.¹⁵ Intuitively, the regime shift replaces less skilled-labor intensive national firms with more skilled-labor intensive multinational firms.

(5) When countries differ in size, multinational entry shifts production from the large to the small country. But now the return to skilled labor falls in the large country and rises in the small country. The intuition here is a home-market effect familiar from the trade-industrial-organization literature. In the absence of multinationals, most national firms are headquartered in the large country where most of their sales are in their low-cost domestic market. The entry of multinationals eliminates this locational advantage, and firm ownership (headquarters) and/or plants become geographically dispersed in proportion to country size.

(6) A comparison of the real wage of skilled labor between countries reveals that the entry of multinationals creates a tendency toward factor-price equalization. Although multinational entry might lower the wage of skilled labor in the skilled-labor-scarce country f , entry does not lower it below the wage in country h . In other cases (particularly size differences) multinational entry eliminates a "brain drain" possibility in which the skilled-labor wage in the disadvantaged country is significantly below that in the advantaged country. The one exception to the tendency of multinationals to create factor-price equalization occurs when the countries are very different in relative endowments.

¹⁵As we noted earlier, the puzzle of the rising wage gap in both north and south has been documented and modelled by Feenstra and Hanson (1995a,b), with the rising gap in the south a particular focus of Cragg and Epelbaum (1995), and Berman, Machlin, and Bound (1995). Capital mobility from north to south has been a focus of the first two papers in particular. Physical capital acts in a complicated way as a general-equilibrium complement to southern skilled labor, just as northern exports of skilled-labor-intensive producer services can be a general-equilibrium complement for southern skilled labor in the present paper.

(7) Figure 5 also suggested that a convergence in country characteristics has interesting implications for the wage of skilled labor and the skilled-unskilled wage gap. Beginning with one country both large and skilled-labor abundant, convergence in characteristics should lead to a rising skilled-unskilled wage gap in that country as the other country "catches up".

(8) A final section looks at the effects of trade costs when the countries differ in relative endowments. Trade costs generally raise X production in the disadvantaged country and raise the return to skilled labor in the advantaged country (its multinationals are the dominant firm type when trade costs are high). By inducing a regime shift, trade barriers thus protect the abundant factor in the skilled-labor-abundant country. Trade protection lowers the return to skilled labor in the small country (i.e., also protecting the abundant factor) if host-country skilled labor is relatively unimportant in plant fixed costs but raises its real wage if skilled labor is important (our central case).

(8) Results suggest some important dynamic extensions. Much recent literature has stressed favorable effects of multinationals on host countries via the transfer of technology, knowledge, and skills. Some of these effects are present here (the transfer of firm-specific knowledge capital raises X output and welfare), but there may also be adverse factor-price effects on skilled labor, resulting in a slower rate of skill and knowledge accumulation. Such adverse effects are unlikely (a rise in v_f due to multinational entry is likely) when the host country is small, poorly endowed with S, and host-country S is important in branch-plant operation.

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