

Appendix A: The Bergstrand and Egger (2007) Theoretical Model

A.1. Consumers

Consumers are assumed to have a Cobb-Douglas utility function between final differentiated goods (X) and homogeneous goods (Y). Consumers' tastes for final differentiated products (e.g., manufactures) are assumed to be of the Dixit-Stiglitz constant elasticity of substitution (CES) type, as typical in trade. We let V_i denote the utility of the representative consumer in country i . Let η be the Cobb-Douglas parameter reflecting the relative importance of manufactures in utility and ε be the parameter determining the constant elasticity of substitution, σ , among these manufactured products ($\sigma \equiv 1-\varepsilon$, $\varepsilon < 0$). Manufactures can be produced by three different firm types: national firms (n), horizontal multinational firms (h), and vertical multinational firms (v). In equilibrium, some of these firms may not exist (depending upon absolute and relative factor endowments and parameter values). These will be reflected in three sets of components in the first of two RHS bracketed terms in equation (1) below:

$$V_i = \left[\sum_{j=1}^3 n_j \left(\frac{x_{ji}^n}{t_{Xji}} \right)^{\frac{\varepsilon}{\varepsilon-1}} + \left(\sum_{j=1}^3 h_{3,j} (x_{ii}^{h_3})^{\frac{\varepsilon}{\varepsilon-1}} + \sum_{j \neq i} h_{2,ij} (x_{ii}^{h_2})^{\frac{\varepsilon}{\varepsilon-1}} + \sum_{j \neq i} h_{2,ji} (x_{ii}^{h_2})^{\frac{\varepsilon}{\varepsilon-1}} \right) \right]^{\frac{\varepsilon-1}{\varepsilon} \eta} \left[\sum_{j=1}^3 Y_{ji} \right]^{1-\eta} + \sum_{m \neq j} \sum_{j=1}^3 v_{mj} \left(\frac{x_{ji}^v}{t_{Xji}} \right)^{\frac{\varepsilon}{\varepsilon-1}} \quad (1)$$

The first component reflects *national* (non-MNE) firms that can produce final differentiated goods for the home market or export to foreign markets from a single plant in the country with its headquarters, where x_{ji}^n denotes the (endogenous) output of country j 's representative national firm in industry X sold to country i , n_j is the (endogenous) number of these national firms in j , and t_{Xji} is the gross trade cost of exporting X from j to i .

The second set of components reflects *horizontal* multinational firms that may have plants in either two or three countries to be “proximate” to markets to avoid trade costs; HMNEs cannot export goods. Every HMNE has a plant in its headquarters country. Let x_{ii} denote the output of a horizontal multinational firm producing in i and selling in i , $h_{3,j}$ denote the (endogenous) number of multinationals that produce in all three countries and are headquartered in j ($j = 1, 2, 3$), $h_{2,ij}$ denote the number of two-country multinationals headquartered in i with a plant also in j , and $h_{2,ji}$ denote the number of two-country multinationals headquartered in j with a plant also in i . Hence, $x_{ii}^{h_3}$ is output produced in country i (and consumed in i) of the representative three-country HMNE headquartered in country j and $x_{ii}^{h_2}$ is the output produced in country i (and consumed in i) of the representative two-country multinational firm either headquartered in i with a plant also in j or headquartered in j with a plant also in i . Note that h_2 plants arise when market size in one of the three countries is inadequate to warrant a local plant, and is more efficiently served (given trade and investment costs) by its own national firms and imports from foreign firms; this is one feature that extends the model in Bergstrand and Egger (2007), but is inconsequential in the calibration.

The third component reflects *vertical* multinational firms. VMNEs have headquarters in one country and a plant in one of the other countries, just not in the headquarters country. The primary motivation for a vertical MNE is “cost differences”; different relative factor intensities and relative factor abundances motivate separating headquarters from production into different countries. Let v_{mj} denote the number of vertical multinational firms with headquarters in m , a plant in j , and output can be sold to any country (including m). Let x_{ji}^v denote the output of the representative VMNE with production in j and consumption in i . In Bergstrand and Egger (2007), in equilibrium VMNEs did not surface; they will here

due to differences in relative factor endowments.

In the second bracketed RHS term, let Y_{ji} denote the output of the homogenous (e.g., agriculture) good produced in country j under constant returns to scale using unskilled labor and consumed in i .

We let t_{Xji} (t_{Yji}) denote the gross trade cost for shipping final differentiated (homogeneous) good X (Y) from j to i .¹ Let $t_{Xji} = 1$ for $i = j$, and analogously for t_{Yji} . It will be useful to define:

$$t_{Xji} = (1 + b_{Xji})(1 + \tau_{Xji})$$

$$t_{Yji} = (1 + b_{Yji})(1 + \tau_{Yji})$$

where τ denotes a “natural” trade cost of physical shipment (cif/fob - 1) of the “iceberg” type, while b represents a “policy” trade cost (i.e., tariff rate) which generates potential revenue. For instance, b_{Xji} denotes the tariff rate (e.g., 0.05=5 percent) on imports from j to i in differentiated final good X .

The budget constraint of the representative consumer in country i is assumed to be:

$$\begin{aligned} & \sum_{j=i}^3 n_j p_{Xj}^n x_{ji}^n + \sum_{j=i}^3 h_{3,j} p_{Xi}^{h_3} x_{ii}^{h_3} + \sum_{j \neq i} h_{2,ij} p_{Xi}^{h_2} x_{ii}^{h_2} + \sum_{j \neq i} h_{2,ji} p_{Xi}^{h_2} x_{ii}^{h_2} + \sum_{m \neq j} \sum_{j \neq i} v_{mj} p_{Xj}^v x_{ji}^v + \sum_{j=i}^3 p_{Yj} Y_{ji} \\ & = r_i K_i + w_{Si} S_i + w_{Ui} U_i + \sum_{j \neq i} n_j b_{Xji} p_{Xj}^n x_{ji}^n + \sum_{k \neq j} \sum_{j \neq i} v_{kj} b_{Xji} p_{Xj}^v x_{ji}^v + \sum_{j \neq i} b_{Yji} p_{Yj} Y_{ji} \end{aligned} \quad (2)$$

where $p_{Xi}^{h_3}$ ($p_{Xi}^{h_2}$) denotes the price charged by the representative 3-country (2-country) HMNE with a plant in i . Let p_{Xj}^n , p_{Xj}^v , and p_{Yj} denote the prices charged by producers in j for goods X (national firms and VMNEs, respectively) and Y , respectively. In the second line of equation (2), the first three RHS terms denote factor income; the last three RHS terms denote tariff revenue redistributed lump-sum by the government in i back to the representative consumer. Let r_i denote the rental rate for capital in i , K_i is the capital stock in i (which can be used at home or transferred abroad at a cost in units of capital of γ), w_{Si} (w_{Ui}) is the wage rate for skilled (unskilled) workers in i , and S_i (U_i) is the stock of internationally-immobile skilled (unskilled) workers in i .

Maximizing (1) subject to (2) yields the domestic demand functions:

$$x_{ii}^\ell \geq \left(p_{Xi}^\ell \right)^{\varepsilon-1} P_{Xi}^{-\varepsilon} \eta E_i; \quad \ell = \{n, h_3, h_2, v\} \quad (3)$$

where E_i is the income (and expenditure) of the representative consumer in country i from eq. (2), and

$$P_{Xi} = \left[\sum_{j=1}^3 n_j \left(t_{Xji} p_{Xj}^n \right)^\varepsilon + \sum_{j=1}^3 h_{3,j} \left(p_{Xi}^{h_3} \right)^\varepsilon + \sum_{j \neq i} h_{2,ij} \left(p_{Xi}^{h_2} \right)^\varepsilon + \sum_{j \neq i} h_{2,ji} \left(p_{Xi}^{h_2} \right)^\varepsilon + \sum_{m \neq j} \sum_{j=1}^3 v_{mj} \left(t_{Xji} p_{Xj}^v \right)^\varepsilon \right]^{\frac{1}{\varepsilon}} \quad (4)$$

is the corresponding CES price index. Following the literature, we assume that all firms producing in the same country face the same technology and marginal costs and we assume complementary-slackness conditions (cf., Markusen, 2002). Hence, the mill (or ex-manufacturer) prices of all varieties in a specific country are equal in equilibrium. Then, the relationship between differentiated final goods produced in j

¹For modeling convenience, we define Y_{ji} net of trade costs; trade costs t_{Yji} surface explicitly in the factor-endowment constraints.

and at home is:

$$\frac{x_{ji}}{x_{ii}} = \left(\frac{p_{Xj}}{p_{Xi}} \right)^{\varepsilon-1} t_{Xji}^{\varepsilon} (1 + b_{Xji})^{-1} \quad (5)$$

Hence, from now on we can omit superscripts for both prices and quantities of differentiated products for the ease of presentation. It follows that homogeneous goods demand is:

$$\sum_{j=1}^3 Y_{ji} \geq \frac{1-\eta}{p_{Yi}} E_i \quad (6)$$

where Y_{ji} denotes output of the agriculture good of county j demanded in country i .

A.2. Differentiated Goods Producers

We assume that manufactures can be produced in all three countries, using skilled labor, unskilled labor, and physical capital. Each country is assumed to be endowed with exogenous amounts of internationally immobile skilled labor and unskilled labor. Each country is assumed to be endowed with an exogenous amount of physical capital; however, the “services” of physical capital can be transferred endogenously (but with potential costs) across countries (in the form of financial claims) by MNEs to maximize their profits, thus making endogenous the determination of bilateral FDI flows. Differentiated goods producers operate in monopolistically competitive markets, similar to Markusen (2002, Ch. 6). Two assumptions used for our theoretical results that follow are the existence of a third factor – physical capital – *and* that any headquarters setup (fixed cost) requires the services of home skilled labor – to represent R&D – and any plant setup requires the services of home country’s physical capital – to represent the resources needed for a domestic or foreign direct investment.²

Assume the production of differentiated good X is given by a nested Cobb-Douglas-CES technology where F_{Xi} denotes production of these goods for both the domestic and foreign markets; we assume MNEs and NEs have access to the same technology. Let K_{Xi} , S_{Xi} , and U_{Xi} denote the quantities used of physical capital, skilled labor, and unskilled labor, respectively, in country i to produce X :

$$F_{Xi} = B(K_{Xi}^{\chi} + S_{Xi}^{\chi})^{\frac{\alpha}{\chi}} U_{Xi}^{1-\alpha} \quad (7)$$

The specific form of the production function is motivated by two literatures. First, the Cobb-Douglas function provides a standard, tractable, and empirically relevant method of combining capital and labor; α denotes the share of “capital” in production. Second, early work by Griliches (1969) indicates that physical capital and human capital tend to be complements, rather than substitutes, in production; recent evidence for this in the domestic (U.S.) literature is Goldin and Katz (1998) and in the MNE literature is found in Slaughter (2000). We nest a CES production function within the Cobb-Douglas function to allow for the potential complementarity of physical and human capital in production; χ determines the degree of complementarity or substitutability.

²Note it is not necessary that plants (firms) require only the services of physical (human) capital to setup plants (firms); what is necessary is that setups of plants (firms) are *relatively* more physical (human) capital intensive, which we conjecture is true empirically. Also, the model is robust to assuming instead that plants (firms) require the services of human (physical) capital for setups. The key is that the services of two factors are used in setups, and that the two setups have different relative factor intensities, cf., Bergstrand and Egger (2007).

NEs and MNEs differ in fixed costs. Each NE incurs only one firm (or headquarters) setup and one plant setup; each MNE incurs one firm setup (the cost of which is assumed larger than that of an NE, as in Markusen, 2002) and a plant setup for its home market and for each foreign market it enters endogenously. A horizontal MNE has headquarters at home and plants in two or three markets to serve them; it has no exports. A vertical MNE has headquarters at home and one plant abroad, which can export to any market. Maximizing profits subject to the above technology yields a set of conditional factor demands reported later.

A.3. Homogeneous Goods Producers

We assume homogeneous good (Y) is produced under constant returns to scale in perfectly competitive markets using only unskilled labor; assume the technology $Y_i = U_i$ ($i = 1,2,3$). In the presence of positive trade costs, we assume country 1 is the numeraire; hence, $p_{Y1} = w_{U1} = 1$.

A.4. Profit Functions, Pricing Equations, and the Definition of FDI

All firms are assumed to maximize profits given the technologies and the demand relationships suggested above. The profit functions are:

$$\begin{aligned}\pi_{ni} &= (p_{Xi} - c_{Xi}) \sum_{j=1}^3 x_{ij} - a_{Sni} w_{Si} - a_{Kni} r_i \\ \pi_{h3,i} &= \sum_{j=1}^3 (p_{Xj} - c_{Xj}) x_{jj} - a_{Sh3i} w_{Si} - a_{Kh3i} [3 + \sum_{j \neq i} (\gamma_{ij} + g_{ij})] r_i \\ \pi_{h2,ij} &= (p_{Xi} - c_{Xi}) x_{ii} + (p_{Xj} - c_{Xj}) x_{jj} - a_{Sh2i} w_{Si} - a_{Kh2i} [2 + \gamma_{ij} + g_{ij}] r_i \\ \pi_{v,ij} &= (p_{Xj} - c_{Xj}) \sum_{m=1}^3 x_{jm} - a_{Svi} w_{Si} - a_{Kvi} [1 + \gamma_{ij} + g_{ij}] r_i\end{aligned}\tag{8a-8d}$$

Eq. (8a) is the profit function for each national final goods enterprise (NE) in i . Let c_{Xi} denote marginal production costs of differentiated final good X in country i and the latter two RHS terms represent, respectively, fixed human and physical capital costs for the NE producer. Eq. (8b) is the profit function for each HMNE in country i with three operations. The last two terms in (8b) represent fixed costs of each 3-country HMNE. As with national firms, the HMNE incurs a single fixed cost of home skilled labor to setup a firm. However, each 3-country HMNE incurs a fixed cost of home physical capital for each plant. Moreover, each foreign investment incurs a potential “natural” investment cost γ (say, political instability) as well as an investment cost g , representing expropriation risk. Consequently, in the context of our model, the flow (and stock) of FDI of country i 's representative three-country HMNEs in j (if profitable) would be $a_{Kh3i} r_i (1 + \gamma_{ij} + g_{ij})$; in our model, international capital “mobility” is defined as the (exclusive) services of country i 's physical capital being used abroad (say, in j) in the form of a flow of financial claims, but the factor rewards are earned in i .³ Eq. (8c) is the profit function for each HMNE in country i with two operations (one at home and one abroad in j); FDI from i to j is defined analogously, $a_{Kh2i} r_i (1 + \gamma_{ij} + g_{ij})$. Finally, eq. (8d) is the profit function for a vertical MNE with a headquarters in i and a plant in j ; FDI from i to j is analogously $a_{Kvi} r_i (1 + \gamma_{ij} + g_{ij})$.

³Note that, while physical capital can be “utilized” in different countries, the “ownership” of any country's endowment of such capital is immobile, cf., Jones (1967) and footnote 12. In the typical 2x2x2 model, headquarters use home skilled labor exclusively for setups; home (foreign) plants use home (foreign) skilled labor for setups (cf., Markusen, 2002, p. 80). With only immobile skilled and unskilled labor, these models naturally preclude home physical capital being utilized to set up foreign plants.

A key element of our model is that – in each country – the numbers of NEs (type n), three-country HMNEs (type h_3), two-country HMNEs (type h_2), and vertical MNEs (type v) are *endogenous* to the model. Two conditions characterize models in this class. First, profit maximization ensures markup pricing equations:

$$p_{Xi} \leq \frac{c_{Xi}(\varepsilon - 1)}{\varepsilon} \quad (9)$$

Second, free entry and exit ensures:

$$\begin{aligned} a_{Sni} w_{Si} + a_{Kni} r_i &\geq \frac{c_{Xi}(-1)}{\varepsilon} \sum_{j=1}^3 x_{ij} \\ a_{Sh3i} w_{Si} + a_{Kh3i} [3 + \sum_{i \neq j} (\gamma_{ij} + g_{ij})] r_i &\geq \sum_{j=1}^3 \frac{c_{Xj}(-1)}{\varepsilon} x_{ij} \\ a_{Sh2i} w_{Si} + a_{Kh2i} [2 + \gamma_{ij} + g_{ij}] r_i &\geq \frac{c_{Xi}(-1)}{\varepsilon} x_{ii} + \frac{c_{Xj}(-1)}{\varepsilon} x_{ji} \\ a_{Svi} w_{Si} + a_{Kvi} [1 + \gamma_{ij} + g_{ij}] r_i &\geq \frac{c_{Xj}(-1)}{\varepsilon} \sum_{m=1}^3 x_{jm} \end{aligned} \quad (10a)-(10d)$$

A.5. Factor-Endowment and Current-Account-Balance Constraints

We assume that, in equilibrium, all factors are fully employed and that every country maintains multilateral (though not bilateral) current account balance; endogenous bilateral current account imbalances allow for endogenous bilateral FDI of financial claims (to physical capital). Following the established literature, this is a static model. The formal factor-endowment and multilateral current-account-balance constraints are provided below. The conditional factor demands for final goods production are given by:

$$\begin{aligned} K_{Xi}^* &= F_{Xi} \underbrace{\frac{1}{B} \left(\frac{w_{Ui}}{r_i} \frac{\alpha}{1-\alpha} \right)^{1-\alpha} \frac{\alpha(\chi-1)-\chi}{T_{1i}^\chi}}_{a_{KXi}} \\ S_{Xi}^* &= F_{Xi} \underbrace{\frac{1}{B} \left(\frac{w_{Ui}}{w_{Si}} \frac{\alpha}{1-\alpha} \right)^{1-\alpha} \frac{\alpha(\chi-1)-\chi}{T_{2i}^\chi}}_{a_{SXi}} \\ U_{Xi}^* &= F_{Xi} \underbrace{\frac{1}{B} \left(\frac{r_i}{w_{Ui}} \frac{1-\alpha}{\alpha} \right)^\alpha (T_{1i}^{-\chi} + T_{2i}^{-\chi})^{\frac{-\alpha}{\chi}}}_{a_{UXi}} \end{aligned} \quad (11)$$

where B is a constant and we introduce definitions:

$$T_{1i} = 1 + \left(\frac{r_i}{wS_i} \right)^{\frac{\chi}{1-\chi}} ; T_{2i} = 1 + \left(\frac{wS_i}{r_i} \right)^{\frac{\chi}{1-\chi}} \quad (12)$$

We assume that, in equilibrium, all factors are fully employed for each country i ($i=1,2,3$), so that:

$$\begin{aligned} K_i &\geq a_{KXi} \left[n_i \sum_{j=1}^3 x_{ij} + x_{ii} \left(\sum_{j=1}^3 h_{3,j} + \sum_{j \neq i} h_{2,ji} + \sum_{j \neq i} h_{2,ij} \right) + \sum_{j \neq i} v_{ji} \left(\sum_{j=1}^3 x_{ij} \right) \right] + \\ &a_{Kni} n_i + a_{Kmi} \left\{ \left[3 + \sum_{j \neq i} (\gamma_{ij} + g_{ij}) \right] h_{3,i} + [2 + \gamma_{ij} + g_{ij}] h_{2,ij} + [1 + \gamma_{ij} + g_{ij}] v_{ij} \right\} \\ S_i &\geq a_{SXi} \left[n_i \sum_{j=1}^3 x_{ij} + x_{ii} \left(\sum_{j=1}^3 h_{3,j} + \sum_{j \neq i} h_{2,ji} + \sum_{j \neq i} h_{2,ij} \right) + \sum_{j \neq i} v_{ji} \left(\sum_{j=1}^3 x_{ij} \right) \right] + \\ &a_{Sni} n_i + a_{Smi} (h_{3,i} + \sum_{j \neq i} (h_{2,ij} + v_{ij})) \\ U_i &\geq a_{UXi} \left[n_i \sum_{j=1}^3 x_{ij} + x_{ii} \left(\sum_{j=1}^3 h_{3,j} + \sum_{j \neq i} h_{2,ji} + \sum_{j \neq i} h_{2,ij} \right) + \sum_{j \neq i} v_{ji} \left(\sum_{j=1}^3 x_{ij} \right) \right] + a_{UYi} \sum_{j=1}^3 t_{Yij} Y_{ij} \end{aligned} \quad (13)$$

Multilateral current account balance for each country i ($i=1,2,3; i \neq j \neq m$) requires the following to hold:

$$\begin{aligned} &(n_i + v_{ji} + v_{mi}) p_{Xi} (x_{ij} + x_{ik}) + p_{Yj} Y_{ij} + p_{Ym} Y_{im} \\ &+ \frac{1}{1-\varepsilon} ([h_{2,ij} + h_{3,i}] p_{Xj} x_{jj} + [h_{2,im} + h_{3,i}] p_{Xm} x_{mm}) \\ &+ \frac{1}{1-\varepsilon} (v_{ij} p_{Xj} [x_{jj} + x_{ji} + x_{jm}] + v_{im} p_{Xm} [x_{mm} + x_{mi} + x_{mj}]) \\ &= \\ &(n_j + v_{ij} + v_{mj}) p_{Xj} x_{ji} + (n_m + v_{im} + v_{jm}) p_{Xm} x_{mi} + p_{Yi} (Y_{ji} + Y_{mi}) \\ &+ \frac{1}{1-\varepsilon} (h_{2,ji} + h_{3,j} + h_{2,mi} + h_{3,m}) p_{Xi} x_{ii} \\ &+ \frac{1}{1-\varepsilon} (v_{ji} + v_{mi}) p_{Xi} (x_{ii} + x_{ij} + x_{im}) \end{aligned} \quad (14)$$

The first line in equation (14) represents the exports of goods of country i . The second and third lines represent income earned on capital invested by country i in horizontal and vertical affiliates, respectively, in country's j and m (m denoting the *ROW* for country i). The fourth line represents country i 's imports of goods from j and m . The fifth and sixth lines represent i 's repatriation of income on capital of countries' j and m invested in country i in horizontal and vertical affiliates, respectively.

Appendix B: Calibration of Model

The complexity of the model (including the complementary-slackness conditions) introduces a high degree of nonlinearity, and it cannot be solved analytically. Consequently, as in Markusen (2002) we provide numerical solutions to the model. With three countries, we have several potential types of asymmetries, e.g., large vs. small GDPs, developed vs. developing economies. We focus initially on bilateral flows between three identical economies (in absolute and relative factor endowments). We then introduce absolute and relative factor endowment asymmetries. We use *GAMS* for our numerical analysis. The calibration of the model is very similar to that in Bergstrand and Egger (2007).

B.1. Values of (Exogenous) Factor Endowment, Trade Cost, and Investment Cost Variables

We assume a world endowment of capital (K) of 500 units, skilled labor (S) of 200 units, and unskilled labor (U) of 2000 units. Initially, countries i and j together have half of the world's endowments of each factor, and i 's and j 's factor endowments are identical. In the remaining summary of parameter choices, we note that we have tried to base selections upon empirical observations (as much as data availability allowed) or upon widely-known regression estimates of elasticities.

“Trade costs” include both the costs of shipping and distributing goods, as well as trade policies. Initially, we set the former costs for good X and good Y at (*ad valorem* equivalents of) 30 percent and 45 percent, respectively (for τ). This reflects recent estimates that homogeneous goods' transport costs are higher than those of differentiated goods, cf., Bergstrand and Egger (2006). Both values exceed estimated (c.i.f.-f.o.b.)/f.o.b. factors in that paper of 15 and 20 percent, respectively. However, values used are in the range of levels discussed in Anderson and van Wincoop (2004) on trade costs. For simplicity, we set tariff rates initially at *ad valorem* equivalents of 20 percent (for b).

In reality, of course, informational costs and policy barriers to FDI exist between countries. However, *ad valorem* empirical measures of such FDI cost are not available. We assumed initially a “tax-rate” equivalent (for γ) of 40 percent for FDI and a value for g of 10 percent.

B.2. Utility and Technology Parameter Values

Consider first the utility function (see Appendix A equation (1) for details). The only two parameters are the Cobb-Douglas share of income spent on differentiated products from various producers (η) and the CES parameter (ε) influencing the elasticity of substitution between differentiated products ($\sigma \equiv 1-\varepsilon$). Initially, we use 0.71 for the value of η , based upon an estimated share of manufactures trade in overall world trade averaged between 1990 and 2000 using 5-digit SITC data from the UNs' COMTRADE data set, which is a plausible estimate. The initial value of ε is set at -5, implying an elasticity of substitution of 6 among differentiated final goods, consistent with a wide range of recent empirical studies estimating the elasticity between 2 and 10, cf., Feenstra (1994).

Consider next the production function for differentiated goods (see Appendix A equation (7) for details). Labor's share of differentiated goods gross output is assumed to be 0.8; the Cobb-Douglas formulation implies the elasticity of substitution between capital and labor is unity. Griliches (1969) proposed – in a three-factor world with unskilled labor, skilled labor, and physical capital – that skills were more complementary with physical capital than with unskilled labor in production. Griliches found convincing econometric evidence that physical capital and skilled labor were relatively more complementary in production than physical capital and unskilled labor. Most evidence to date suggests that human and physical capital are relatively complementary in production, cf., Goldin and Katz (1998). In the only empirical study of MNE behavior considering this issue, Slaughter (2000) finds statistically significant evidence in favor of capital-skill complementarity. Initially, we assume $\chi = -0.25$, implying a technical rate (elasticity) of substitution of 0.8 [$=1/(1-\chi)$] and complementarity between physical and human capital.

As in the 2x2x2 KC model in CMM (2001), a firm (or headquarters) setup uses only skilled labor. For national final goods producers, we assume a headquarters setup requires one unit of skilled labor per

unit of output ($a_{S_{n,1}}=a_{S_{n,2}}=a_{S_{n,3}}=1$). As in the knowledge-capital model, we assume “jointness” for MNEs; that is, services of knowledge-based assets are joint inputs into multiple plants. Markusen suggests that the *ratio* of fixed headquarters setup requirements for a horizontal or vertical MNE relative to a domestic firm ranges from 1 to 2 (for a 2-country model). We assume initially a headquarters cost for MNEs of 1.01 ($a_{Sh,1}=a_{Sh,2}=a_{Sh,3}=a_{Sv,1}=a_{Sv,2}=a_{Sv,3}=1.01$); hence, we assume the additional firm setup cost of an MNE over a national firm is quite small. We assume that every plant (national or MNE) requires two units of home physical capital ($a_K=2$); however, MNEs setting up plants abroad face additional natural investment cost (γ), for which we assumed a value of 0.40 (40 percent), and an investment cost (g) of 0.1 (10 percent), representing expropriation risk.

Theoretical relationships are qualitatively similar for a wide range of alternative values of the parameters (results of which are available on request).

Appendix C

Figure C1

Change of VMNEs in $i+j$ through a bilateral BIT; $g=0.10$

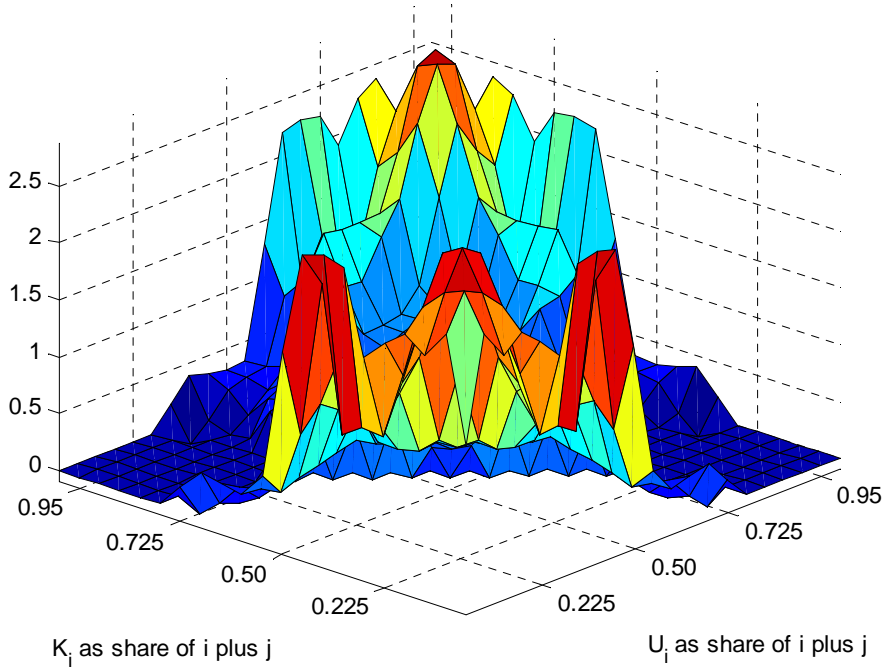


Figure C2

Change of HMNEs in $i+j$ through a bilateral BIT; $g=0.10$

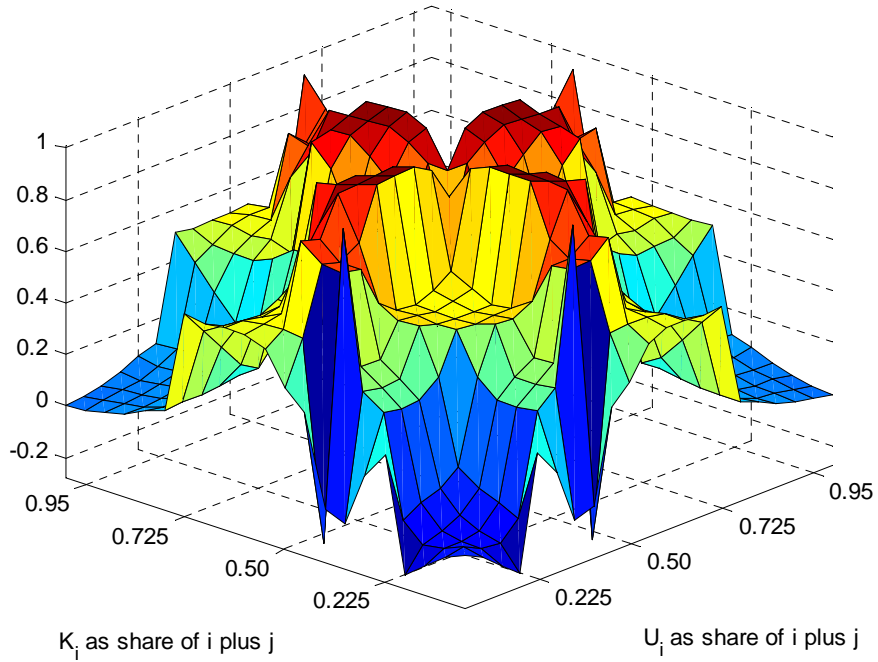


Figure C3

Utility change of RIA joining countries i plus j

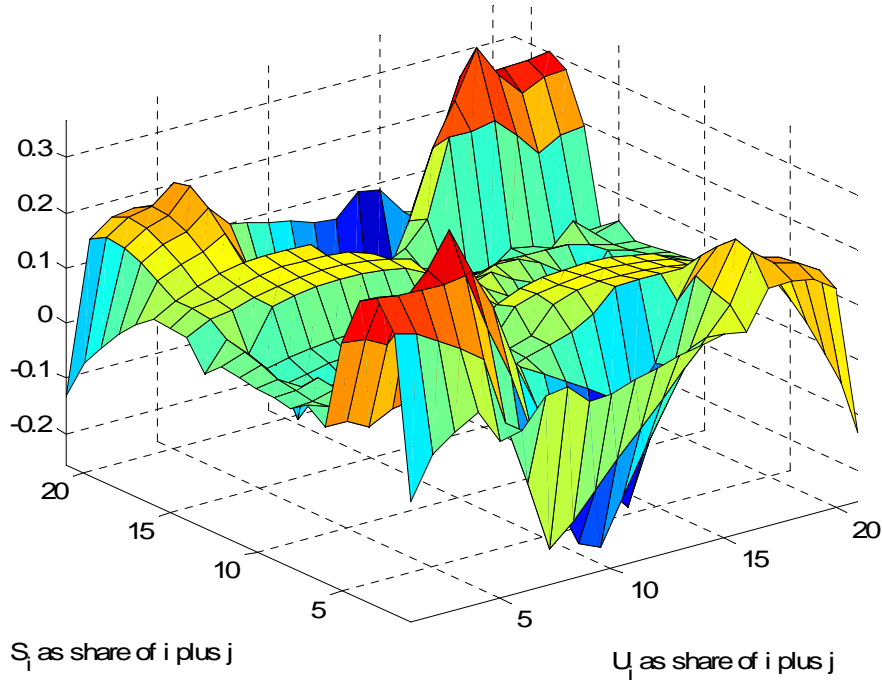


Figure C4

Utility change of RTA joining countries i plus j

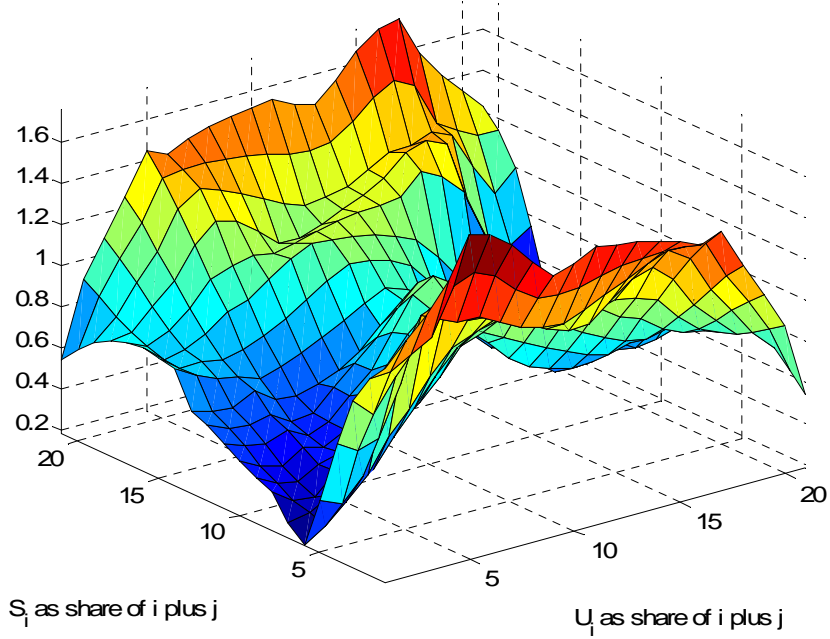


Figure C5

Utility change of RTA joining countries i plus j

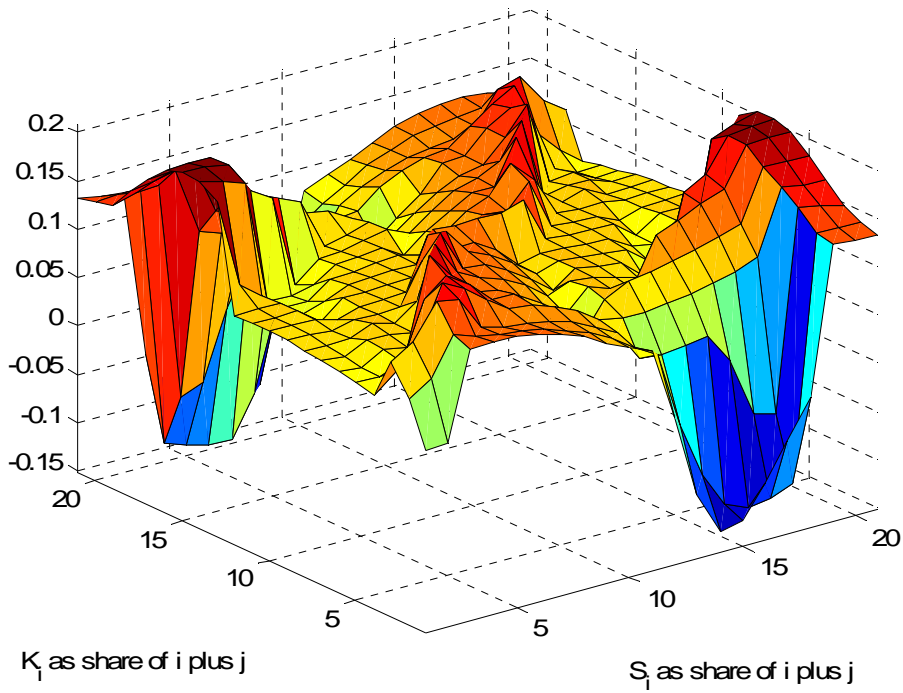


Figure C6

Utility change of RTA joining countries i plus j

