Title
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Publication Date
2001-12-01

2001-18

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DEPARTMENT OF ECONOMICS

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DISCUSSION PAPER 2001-18
NOVEMBER 2001

OVERCOMING INFORMATIONAL BARRIERS TO INTERNATIONAL RESOURCE ALLOCATION: PRICES AND TIES

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December 2001

Incomplete information in the international market creates difficulty in matching agents with productive opportunities and interferes with the ability of prices to allocate scarce resources across countries. Ties through international information-sharing networks or parent-subsidiary relationships overcome this matching friction. When the difference between country factor-endowment ratios is small relative to the share of agents that is tied, efficient arbitrage and the standard properties of neoclassical trade models prevail. When the difference between factor-endowment ratios is sufficiently large, this equilibrium breaks down and countries become partially insulated from each other in the sense that the price (wage) of each country's immobile resource is more sensitive to changes in domestic than foreign supply and trade liberalization causes less convergence in relative resource prices. The model is applied to the debate over the impact of international trade on domestic wages, and extended to address whether ties can reduce world welfare through trade diversion and to compare the effect of ties on trade in differentiated versus homogeneous products.

JEL classification: F10

*Both authors are also affiliated with the NBER (and Casella with GREQAM, Marseilles, France and the CEPR). Financial support was provided by NSF grant #SBR-9709237. We thank Vitor Trindade and Max Auffhammer for outstanding research assistance, and Jonathan Eaton, two anonymous referees, and seminar participants at Russell Sage Foundation, NYU, Columbia, the Federal Reserve Bank of New York, the NBER, UCLA, Northwestern, Boston College, Harvard, Humboldt and UT-Austin for helpful comments. The first draft of this paper was written while Casella was a Visiting Scholar at the Russell Sage Foundation, whose support and hospitality are acknowledged with gratitude. Initial work on the project was made possible by UCSD through its Distinguished Visitor program.

I. Introduction

Countries appear to trade too much with themselves (e.g., McCallum 1995) and invest too much in themselves (e.g., Feldstein and Horioka 1980). Cross-border price differentials seem too large (e.g., Engel and Rogers 1996). Trade costs are seen as the root cause of these and other international macroeconomic puzzles (Obstfeld and Rogoff 2000).

As tariffs and transportation costs have come down, research has increasingly focused on informal barriers to international trade as an explanation for high trade costs. One informal barrier is lack of information about international trade and investment opportunities (Portes and Rey 1999). Empirically identifiable information-sharing networks have been found to increase the volume of international trade. Such evidence has been found for business groups[1] operating across national borders (e.g., Belderbos and Sleuwaegen 1998), immigrants (e.g., Gould 1994), and long-settled ethnic minorities that maintain coethnic business societies, such as the Overseas Chinese (Rauch and Trindade forthcoming).[2] Gould (1994) and Rauch and Trindade (forthcoming) find that these groups have less effect on trade in more homogeneous products, for which prices can effectively convey the relevant information, than on trade in more differentiated products, for which matching of multifarious characteristics of buyers and sellers is more important.

Closer study of how coethnic business societies and transnational business groups

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[1]Business groups are "sets of firms that are integrated neither completely nor barely at all" (Granovetter 1995, pp. 96-97), and where the lineages of the members can often be traced back to a founding family or small number of allied families. Typical mechanisms serving to integrate the firms include mutual stockholdings and frequent meetings of top executives. Business groups are common throughout Asia, continental Europe, and Latin America, but are rare to non-existent in Great Britain and the United States.

[2]For a full survey of this literature see Rauch (forthcoming).

overcome informational barriers to trade and investment suggests formulating these barriers as a problem of matching entrepreneurs or firms: it is more difficult in the international than in the domestic market for producers to find the right distributors for their consumer goods, for assemblers to find the right suppliers for their components, for investing firms to find the right partners for their joint ventures, and so on. Weidenbaum and Hughes (1996, p. 55) write of the Overseas Chinese:

> the members of the bamboo network operate in the interstices of the trading world. They make components, manufacture for others, and perform subassembly work. They are also heavily involved in wholesaling, financing, sourcing, and transporting....The leading businessmen know each other personally and do deals together, with information spreading through an informal network rather than through more conventional channels.

We can thus view "ties" that exist across borders as helping agents solve their matching problems and find suitable trade or investment partners in other countries. These international ties need not be of a "group" nature; the same purpose can be served by pairwise ties, probably the most important of which (at least of those that are empirically identifiable) are ties between parent firms and their subsidiaries.[3]

Our major concern in this paper is with the impact of incomplete information and ties on the ability of prices to allocate scarce resources internationally. With this goal in mind, we introduce a matching problem between entrepreneur-firms ("producers") into the standard one-

[3]It has been estimated that intrafirm trade accounts for 25 percent of world trade (Sauvant et al. 1992, p. 53). Rangan and Lawrence (1999, Table 1.1) compute that the total intrafirm share of U.S. manufacturing exports, excluding petroleum and coal products, was 37.6 percent in 1994. A parent-subsidiary tie does not always guarantee a perfect match: a parent might introduce a new product its overseas distribution subsidiary is not suited to handle, or might make a "greenfield" investment rather than expand an existing plant.

good, two-factor, two-country model of trade in factor services.[4] Price signals (wage differentials) guide all producers in the labor-scarce country to seek matches in the labor-abundant country, such as joint venture partners who know how to adapt the industry technology to local conditions or land developers of sites with access to the appropriate mixes of nontraded inputs. However, only tied producers know the locations of their best foreign partners, thereby extending to foreign partners the knowledge that all producers are assumed to have about domestic partners.

We find that, when the difference between the factor-endowment ratios of the two countries is small relative to the share of producers that is tied, our model is equivalent to the standard model with complete information, despite the fact that only a subset of producers know the locations of their best foreign matches. In this equilibrium relative country wages are determined solely by a conventional trade barrier or wedge and the production technology that links costs or profits to wages. When the difference between factor-endowment ratios is sufficiently large, this equilibrium breaks down and relative country wages become a function of relative country labor supplies. In the new equilibrium, the two countries are partially insulated from each other in the sense that each country's wage is more sensitive to changes in domestic than foreign labor supply and trade liberalization causes less convergence in country wage rates. This partial insulation ultimately stems from the imperfection created by the matching friction in the process by which international trade arbitrages country wage differentials. Tied producers

[4]Since we have no reason to expect informational barriers to trade to affect the pattern of trade in commodities any differently than conventional barriers (Deardorff 2001), we can avail ourselves of the simplicity of this model relative to the two-good (Heckscher-Ohlin-Samuelson) model. The use of the one-good model to analyze the impact of trade barriers dates back at least to Becker (1957) and MacDougall (1960). We will see in section III that the one- and two-good models have the same qualitative properties relevant for our results, which are therefore not driven by use of the simpler model.

eliminate this matching friction and thus eliminate the imperfection in the arbitrage process, so if enough producers are tied they restore the independence of relative country wages from relative country labor supplies. The greater ability of tied producers to efficiently arbitrage international cost differentials is consistent with the evidence presented in Rangan and Lawrence (1999, Chapter 4). They find that manufactured imports of U.S. multinationals from countries in which they have subsidiaries, most of which are intrafirm, are much more elastic with respect to real exchange rates than are overall U.S. manufactured imports from the same countries.

The next section of this paper presents our model and the following section derives the results just discussed plus some others. In section IV we discuss application of the model to the debate over the impact of international trade on domestic wages, and extend the model to address whether ties can reduce world welfare through trade diversion and to compare the effect of ties on trade in differentiated versus homogeneous products. Our conclusions are in section V.

II. The model

A. Endowments and technology

The world is composed of two countries, home and foreign. In each country, there is a continuum of types of *producers* distributed over a circle of unit length. For each type, there is a continuum of producers of unit mass. The producers can therefore be said to lie on a "unit cylinder." Each country is also endowed with a homogeneous, inelastically supplied mass of internationally immobile labor. Since there is an equal mass, one, of producers in both countries, the ratio of labor-producer endowment ratios across countries can be summarized by the ratio L/L^*, where L is the home labor endowment and L^* is the foreign labor endowment. In all that

follows, asterisks will be used to indicate foreign variables. We assume that the foreign country is the labor-abundant country, so that $L/L^* < 1$.

Output is generated through a joint venture of two producers, and the distance between their types on the circle is an index of their complementarity or the gains from trade that result from their matching. To actively engage in production, a partnership needs to hire labor; thus output is a function of the quality of the producers' match and the labor employed:

$$y_{ij} = F(x, z_{ij}) \quad \textbf{(1)}$$

where z_{ij} is the shortest arc distance between the two producers of types i and j, and x is labor. Note that the maximum value of match quality z_{ij} is $1/2$. The function F is characterized by constant returns to scale.

Producers want to maximize profits. They take the wage rate w as given. With a constant returns to scale production function, total profits from the match of types i and j can be written as:

$$\Pi_{ij} = z_{ij}\pi(w) \quad \textbf{(2)}$$

where the function $\pi(w)$ is decreasing and convex in w. For ease of later proofs, let us also assume that $\pi(w)$ is a constant elasticity function (as would be the case, for example, if the technology were Cobb-Douglas). The labor demand generated by a partnership is then given by:

$$L^d_{ij} = -z_{ij}\pi'(w), \quad \textbf{(3)}$$

where the prime sign indicates the first derivative. The closeness of our model to the standard one-good, two-factor model of trade becomes more apparent once we recognize that the integral of match qualities z_{ij} over all producer partnerships plays the role of the aggregate capital stock in

the standard model.[5]

B. Domestic and international matching

The timing of the model is the following. First, home country producers travel to the foreign country, where foreign producers await them. Each home producer meets with one and only one potential foreign partner. Next, the type of one's partner is revealed,[6] successful matches are confirmed and unsuccessful ones are broken. Finally, home and foreign producers who have rejected their international matches establish domestic partnerships with other home and foreign producers, respectively, whose international matches were also unsuccessful. The home and foreign labor markets clear when all demands for labor, from domestic and international ventures, are received.

Given the model timing, we must find the outcome of domestic matching before we can solve for the results of international matching. Domestic matching proceeds as follows. Each producer selects a partner. If his choice does not select him, he gets zero. If his choice does select him, the two producers form a match and bargain over the surplus. If the bargaining breaks down, both producers get zero. Hence the surplus equals the total value of the match. We use the Nash bargaining solution, so any pair of producers that forms a match will divide the total match value equally between them. We assume that every producer knows at least the domestic location of his best match type. In this case it seems natural to focus on the efficient equilibrium

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[5]We should note that a profit function of the form $h(z_{ij})\pi(w)$, $h(z_{ij})$ strictly monotonically increasing, would leave the results of this paper qualitatively unchanged. Since this could be derived from a production function that is linear homogeneous in $h(z_{ij})$ and x, we could allow match quality to be any strictly monotonically increasing function of distance z_{ij}. We use the specification $h(z_{ij}) = z_{ij}$ because it provides the simplest and most transparent algebraic expressions.

[6]We shall see shortly that the threat point in international bargaining is the same for all types within a country, so it is not clear that anything could be gained by misrepresenting one's type if this were possible.

in which each producer selects the producer opposite him on the circle (and at the same height on the cylinder). This is an equilibrium since no producer has an incentive to change his behavior after he has chosen and been chosen by his perfect complement. In this equilibrium $z_{ij} = 1/2$ for every partnership. Domestic partnerships are assumed to have access to domestic labor only. Since each producer receives half of the profits, a home producer forming a domestic partnership earns $(1/2)(1/2)\pi(w) = \pi(w)/4$. Similarly, a foreign producer forming a domestic partnership earns $\pi(w^*)/4$.

We now turn to international matching. At this point we must distinguish between tied and untied producers. We assume that travel of home country producers to the foreign country is costless, and hence only consider equilibria in which all home country producers attempt the foreign market. We also assume that a fraction *m* of every type of producer is tied, in the sense that each home producer in this subset knows the location of the foreign producer that is opposite it on the circle and at the same height on the cylinder. Untied home producers, in contrast, are completely uninformed about the locations of foreign producer types and can therefore meet with any foreign producer type at the same height on the cylinder with equal probability, given the uniform distribution of types over the circle.[7] All tied home producers will choose to use their ties since they obtain the maximum match quality by doing so, yet lose nothing in bargaining power because the threat point (the value of a domestic match) of all foreign producers is the

[7]It is not necessary to assume that untied home country producers are completely uninformed about the locations of foreign producer types. For example, in Rauch and Trindade (2000) each home producer draws a potential foreign partner from a distribution over the circle of types that is uniform with support of length $k \in (0,1]$ and has its median at the producer's opposite type, effectively allowing the home producer to rule out the worst 100(1-*k)* percent of foreign types in advance. This alternative assumption would not change the qualitative results of this paper.

same.[8]

International partnerships differ from domestic partnerships in two ways. First, an international partnership has the option to locate its operation in either country and can therefore have access to the labor force of either country. Second, the producer that manages the international joint venture from abroad loses a fraction t or $t^* \in (0,1)$ of its profits. This reflects the transportation costs and trade taxes incurred when repatriating profits in terms of the numeraire good. Inclusion of trade taxes means that t or t^* can be varied by unilateral government action, which will allow us to use our model to analyze the impact of a government decision to (partially) liberalize or to further restrict trade.[9]

C. International bargaining

If both domestic markets are active, the threat points in international bargaining of every home and every foreign producer are $\pi(w)/4$ and $\pi(w^*)/4$, respectively, where w and w^* are the international trade equilibrium wages.[10] It is then easy to see that partners in any confirmed international match will choose to locate their operation and employ labor in the low wage

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[8]This result differs from Rauch and Casella (1998), where some tied producers choose not to use their ties. The difference arises because in that paper types are arrayed along a line rather than around a circle and every tied producer knows the location of every other tied producer. With match quality increasing in distance, types near the endpoints of the line are inherently more attractive match partners than types near the center of the line. Use of the ties is shown to ensure that a producer realizes a match value that is perfectly correlated with his distance from the center of the line, so that tied producers located near the center of the line prefer to take their chances on random matching with untied producers.

[9]Just as in conventional trade models, the "melting ice" model of transportation costs is nothing more than a convenient simplification and "transportation costs" is an elastic concept that might include expenses of managing an operation in another country other than the cost of transporting goods. Our results are invariant to the division of the lost profits between tax revenue collected by the government and "melting" that is lost to society.

[10]Uniformly distributed, atomless producers and the symmetry of the position of every producer (tied or untied) on the circle ensure that the height of the remaining cylinder of producers in each country is the same for every type and thus domestically every producer can still match with his opposite type.

country, even if the partner in the low wage country would have lost a smaller fraction of its profits upon repatriation from the high wage country (due to lower trade taxes, say). If the operation were located in the high wage country, the partner from the low wage country would have to receive more than half of the profits from the partnership to do as well as with a domestic partner, but then the partner from the high wage country must do strictly worse than with a domestic partner. From the point of view of the partner from the high wage country, then, the attraction of international matching is access to cheaper labor, whereas from the point of view of the partner from the low wage country, the attraction is greater relative bargaining power than with a domestic partner.

It is now clear that the home country cannot be the low wage country. If it were, international partnerships would demand only home labor, and demand for home labor would be relatively greater than demand for foreign labor, generating a contradiction given that supply of home labor is relatively smaller. We can also rule out $w = w^*$, since in this case because of the tax/transport cost at least one partner to an international match must do strictly worse than with a domestic partner and no international matches would be confirmed, yielding equal demand for home and foreign labor but a greater supply of the latter. It follows that in equilibrium $w > w^*$ and that all confirmed international matches will employ foreign labor. International matching thus serves to transfer labor demand from the labor-scarce to the labor-abundant country, just as does trade in the standard one-good, two-factor model. Also as in this standard model, we can think of producers and workers as using their income to purchase their own production, generating balanced international trade of producer services for numeraire output.

We can now use Figures 1 and 2 to determine the cutoff match quality for successful

international partnerships. If a home country producer of type *i* draws a potential foreign partner of type *j*, denote their distance on the circle of types by z_{ij}, as represented in Figure 1. z_{ij} is uniformly distributed on the interval [0, 1/2]. Given the symmetry of the circle we can drop the subscripts from z_{ij}: every home country producer faces a uniform distribution of partner distance z, with support [0, 1/2] on the circle. We represent in Figure 2 the possibilities set that results from a potential international partnership. An international match is acceptable if the threat point is not outside the Pareto frontier (the case shown in Figure 2). For symmetry with domestic partnerships we apply the Nash bargaining solution to the division of the surplus from international partnerships, yielding the (net) profits to the home and foreign producers depicted in Figure 2.[11]

The condition that the threat point is not outside the Pareto frontier can be expressed as:

$\pi(w^*)/4 \leq -\pi(w)/[4(1-t)] + z\pi(w^*)$, or alternatively as

$$z \geq 1/4 + \psi/[4(1-t)], \qquad \textbf{(4)}$$

where $\psi(w^*/w) \equiv \pi(w)/\pi(w^*)$ and $\psi' > 0$. This cutoff condition is represented in Figure 1. Note that we can write ψ as a function of only the ratio of wages because π is a constant elasticity function. In what follows we will loosely speak of the function ψ as the "wage ratio," which should not cause any confusion because it is just a scaling of the wage ratio. Note that the smaller is the wage ratio the more likely is an international match to be of acceptable quality, reflecting the greater gains from international trade.

The key feature of our search and bargaining model is that some home producers draw foreign producers that yield match quality $z < 1/4 + \psi/[4(1-t)]$ and then return home, with both

[11]Equal division of the surplus from international partnerships is used only in Proposition 9 and subsection IV.B.

the home and foreign parties to the failed international matches finding domestic partners instead. This is consistent with the considerable heterogeneity that exists at the firm level regarding involvement in foreign transactions. Only a minority of firms even in high wage countries like the United States have investments abroad, and in all countries studied many firms that produce tradeable goods have zero exports (Roberts and Tybout 1997, Bernard and Jensen 1999).[12] The result that some firms that search abroad return home empty-handed would also be obtained in a dynamic search model with an increasing marginal cost of search, but both the closeness to standard static trade models and tractability would be reduced.[13]

III. Basic Results

We begin with a definition.

Definition 1. *A Complete Information (Equivalent) Equilibrium (CIE) is one in which all producers match with their perfect complements.*

Definition 1 implies that, in a CIE, $z = 1/2$ for every confirmed match. We include the qualifier "equivalent" in the definition of a CIE because, in fact, complete information does not exist in our model of the world economy.

We now establish a preliminary result.

Proposition 1. *A CIE obtains if and only if* $\psi \geq 1\text{-t}$. Proof: We see that if $\psi \geq 1\text{-}t$, we have the

[12]Clearly some of these firms attempted the foreign market. Swedish Trade Council export consultant Kent Goldmann (quoted in Nothdurft 1992, p. 32) stated of his clients that are marginal or failed exporters, "Sometimes their product isn't right for the market, or the country they chose was not a good fit, or their approach or agents are not right."

[13]Why should the marginal cost of search be increasing? In order to judge the quality of a match with a foreign producer a manager must be intimately familiar with his own firm's operations, and thus involved in them. If he travels abroad for a week, say, someone can cover for him, but the longer he is absent the more crucial and pressing are the unmade decisions that pile up. In other words, the opportunity cost of the manager's time is increasing.

right-hand side of equation (4) $\geq 1/2$, so only international matches with $z = 1/2$ can possibly be accepted. All producers either confirm such matches or match domestically with their perfect complements, yielding a CIE. Conversely, if a CIE obtains, we can prove $\psi \geq 1\text{-}t$ by contradiction. If $\psi < 1\text{-}t$, we have the right-hand side of equation (4) $< 1/2$, but then some international matches with $z < 1/2$ are strictly preferred to domestic matching by both producers and will be confirmed.■

We can divide CIEs into two classes.

Definition 2. *A Prohibitive Tax/Transport Cost Equilibrium (PTE) is a CIE in which no international matches are confirmed.* From Proposition 1 and equation (4) we can see that $\psi > 1\text{-}t$ is a sufficient condition for a PTE to obtain.

Definition 3. *A Perfect Arbitrage Equilibrium (PAE) is a CIE in which a positive measure of international matches is confirmed.* From Proposition 1 and equation (4) we see that $\psi = 1\text{-}t$ is a necessary condition for a PAE to obtain.

Note that labor demand is transferred from the home to the foreign country in a PAE but not in a PTE.

Next we define the remaining type of equilibrium:

Definition 4. *An Imperfect Arbitrage Equilibrium (IAE) is one in which a positive measure of international matches between producers that are not perfect complements is confirmed.*

An IAE obtains if and only if a CIE does not obtain:

Proposition 2. *An IAE obtains if and only if* $\psi < 1\text{-t}$. Proof: See the proof of Proposition 1.■

Now we wish to establish the conditions under which a PTE, PAE, or IAE obtains in terms of the underlying parameters of the model such as labor endowments rather than in terms of the wage ratio, which is endogenous. We will show that very similar labor-producer endowment ratios (L/L^* close to one) yield a PTE, very different endowment ratios (L/L^* small) yield an IAE, and intermediate levels of L/L^* yield a PAE.

We begin by finding the smallest value of L/L^* consistent with existence of a Prohibitive Tax/Transport Cost Equilibrium. To do so we solve for the labor-market clearing conditions

when no international matches are confirmed. In this case there will be a mass $1/2$ of domestic partnerships in each country. Labor demand in each country can then be computed using equation (3), yielding the labor-market clearing conditions $-(1/4)\pi'(w) = L$ and $-(1/4)\pi'(w^*) = L^*$ for the home and foreign countries, respectively. Combining these two equations gives us $g(\psi) = L/L^*$, where $g(\psi) \equiv \pi'(w)/\pi'(w^*)$. Note that we can write g as a function of the wage ratio ψ because π' is a constant elasticity function. Furthermore, g is an increasing function of ψ, with $g(0) = 0$ and $g(1) = 1$. These properties tell us that, as we would expect, $L/L^* = 1$ implies $\psi = 1$ and as L/L^* falls so must ψ. A sufficient fall in L/L^*, however, drives ψ below $1-t$, conflicting with the assumption that no international matches are confirmed. It follows that equation (5) defines the smallest endowment ratio consistent with existence of a PTE:

$$\overline{L/L^*} \equiv g(1-t). \qquad \textbf{(5)}$$

Next, we find the endowment ratio below which an Imperfect Arbitrage Equilibrium must obtain. To do so we solve for the labor-market clearing conditions when $\psi < 1-t$.

We begin with tied producers. Every international match between a home producer and the foreign producer to which it is tied yields match quality $z = 1/2$. From equation (4) we see that with $\psi < 1-t$ all of these matches will be strictly preferred to domestic matching by both producers and will be confirmed. We can then compute, using equation (3), that international partnerships between tied producers will generate a demand for foreign labor equal to $-(m/2)\pi'(w^*)$, where we have used the fact that m tied home producers and m tied foreign producers generate m international partnerships.

By contrast, for untied producers $\psi < 1-t$ does not guarantee that all international matches

will be successful. Home producers whose international matches were broken are the sole source of demand for home labor. Each partnership between such producers generates demand for home labor equal to $-(1/2)\pi'(w)$. The mass of such partnerships, if all untied home producers formed them, would be $(1-m)/2$. From figure 1, however, we can see that the probability that any untied home producer will make an unacceptable international match is equal to $2(1 - t + \psi)/4(1 - t)$. Multiplying these three terms together thus gives us the demand for home labor generated by home producers whose international matches were unsuccessful, which we can equate to the home labor endowment to give us the home labor-market clearing condition:

$$(1-m)\left(\frac{1-t+\psi}{8(1-t)}\right)(-\pi'(w)) = L\,. \qquad \textbf{(6)}$$

As expected, home labor demand is increasing in ψ: as the wage ratio increases, the share of international matches that are acceptable falls.

Using the same reasoning, we can show that the demand for foreign labor by foreign producers whose international matches were unsuccessful is given by the left-hand side of equation (6), replacing w with w^*. To this must be added the demand for foreign labor by tied producers and the demand generated by successful partnerships between untied home and foreign producers. This last source of demand can be computed using equations (3) and (4):

$$2(1-m)\left(\int_{\frac{1-t+\psi}{4(1-t)}}^{1/2} z(-\pi'(w^*))dz\right) = (1-m)\left(\frac{1}{4} - \frac{[(1-t)+\psi]^2}{16(1-t)^2}\right)(-\pi'(w^*))\,,$$

where we used the symmetry of the problem to integrate over only half the interval in Figure 1 and multiplied by 2. Summing the three sources of foreign labor demand and equating the result to the foreign labor endowment yields the foreign labor-market clearing condition:

$$\left(\frac{1+m}{4}+\frac{(1-m)[(1-t)^2-\psi^2]}{16(1-t)^2}\right)(-\pi'(w^*))=L^*. \qquad \textbf{(6*)}$$

Foreign labor demand is decreasing in the wage ratio ψ, as expected.

Combining equations (6) and (6*) yields, after a little manipulation,

$$\frac{2+2[\psi/(1-t)]}{4[(1+m)/(1-m)]+1-[\psi/(1-t)]^2}\,g(\psi)=L/L^*. \qquad \textbf{(7)}$$

Given the properties of g, we know the left hand side of equation (7) is increasing in ψ. We then claim that equation (8) defines the value of L/L^* below which an IAE must obtain:

$$\underline{L/L^*} \equiv [(1-m)/(1+m)]g(1-t), \qquad \textbf{(8)}$$

where we have substituted $\psi = 1-t$ into equation (7).[14] We prove this claim in Proposition 3:

Proposition 3. *An IAE obtains if and only if* $L/L^* < \underline{L/L^*}$. Proof: From Proposition 2, an IAE is an equilibrium in which $\psi < 1-t$. From the derivations of equations (7) and (8) we see that $\psi < 1-t$ implies that the ratio of home to foreign labor demand is less than $\underline{L/L^*}$, so an IAE cannot obtain unless the ratio of home to foreign labor supply is less than $\underline{L/L^*}$. We can prove that $L/L^* < \underline{L/L^*}$ implies $\psi < 1-t$ by contradiction. If $\psi \geq 1-t$ a CIE obtains, and the right-hand side of equation (8) gives the smallest ratio of home to foreign labor demand that can prevail in a CIE,

[14] An alternative derivation of equation (8) helps to build intuition. Let us assume $\psi = 1-t$. The smallest possible ratio of home to foreign labor demands consistent with this assumption is constructed by having all tied producers demand foreign labor, since we cannot have a positive measure of confirmed international partnerships between untied producers. The demand for home labor is then given by $-[(1-m)/4]\pi'(w)$ and the demand for foreign labor is given by $-[(1-m)/4]\pi'(w^*) - (m/2)\pi'(w^*) = -[(1+m)/4]\pi'(w^*)$. Dividing home by foreign labor demand and substituting in $\psi = 1-t$ yields the right-hand side of equation (8).

since all producers that make international matches with their perfect complements confirm them and demand foreign labor.■

Lemma. *The home and foreign wage rates* w *and* w* *are uniquely determined in an IAE.* Proof: A given $L/L^* < \underline{L/L^*}$ determines a unique $\psi < 1\text{-}t$ by equation (7). This solution can be substituted into equations (6) and (6*). Since $\psi < 1\text{-}t$, the coefficients on π' in these equations are positive. Then, because π' is a monotonic constant elasticity function, a unique w exists that solves equation (6) and a unique w^* exists that solves equation (6*).[15]

The next proposition states which types of equilibrium correspond to endowment ratios greater than $\underline{L/L^*}$:

Proposition 4. *A CIE obtains if and only if* $L/L^* \geq \underline{L/L^*}$. *More specifically, a PTE obtains if and only if* $L/L^* \geq \overline{L/L^*}$ *and a PAE obtains if and only if* $\underline{L/L^*} \leq L/L^* < \overline{L/L^*}$. Proof: Propositions 1, 2, and 3 together imply that $L/L^* \geq \underline{L/L^*}$ requires $\psi \geq 1\text{-}t$ and hence a CIE. If a PTE obtains, we prove by contradiction that $L/L^* \geq \overline{L/L^*}$: the derivation of equation (5) shows that $L/L^* < \overline{L/L^*}$ requires a positive measure of confirmed international matches to achieve labor-market equilibrium. Similarly, if $L/L^* \geq \overline{L/L^*}$, the derivation of equation (5) shows that we cannot have a high enough ratio of labor demands to equal this ratio of labor supplies if there is a positive measure of confirmed international matches. The same reasoning in combination with Proposition 3 proves that a positive measure of international matches is confirmed and $\psi = 1\text{-}t$, i.e., a PAE obtains, if and only if $\underline{L/L^*} \leq L/L^* < \overline{L/L^*}$.■

The intuition for Proposition 4 is that with a sufficiently small difference in labor-producer endowment ratios, tied producers can transfer enough labor demand to realize all the gains from trade that are available given the conventional trade barrier. Untied producers only match domestically, where they know the location of their perfect complements. Note that as m approaches zero we see from equations (5) and (8) that $\underline{L/L^*}$ approaches $\overline{L/L^*}$ and the PAE vanishes: tied producers who eliminate the international matching friction are needed to maintain the perfect arbitrage condition $\psi = 1\text{-}t$. On the other hand, as m approaches one we see

[15]The assumption that $\pi(w)$ is a constant elasticity function is not necessary to prove existence or uniqueness but is used to save space. Uniqueness can be proved without adding to the standard properties of a profit function by using an appropriate adaptation of Figure 1 in Rauch and Casella (1998). To demonstrate existence it is sufficient for the profit function to have been derived from an underlying production function (equation (1)) that satisfies the Inada conditions.

from equation (8) that $\underline{L/L^*}$ approaches zero and the IAE vanishes. Also note that for any given endowment ratio less than $\overline{L/L*}$, we can use equation (8) to solve for a value of $m < 1$ that yields a PAE by substituting the actual value of L/L^* for $\underline{L/L^*}$: only a strict subset of producers who know the locations of their perfect foreign complements is sufficient to eliminate the information problem in the world economy for any country endowments.

In a CIE, our model is isomorphic to the standard one-good, two-factor model with a world capital stock equal to $1/2$, the ownership of which is divided equally between the two countries. The number $1/2$ equals the world mass of partnerships multiplied by the maximum match quality per partnership. More specifically, in a Perfect Arbitrage Equilibrium the model is isomorphic to this standard model with the arbitrage condition $r = (1-t)r^*$, where r is the rental rate on capital. With $\underline{L/L^*} < L/L^* < \overline{L/L*}$, our model inherits all the static *and* comparative static properties of the standard model with $r = (1-t)r^*$.

Here we note the properties of the model given $\underline{L/L^*} < L/L^* < \overline{L/L*}$ whose failures to hold in an IAE are of greatest interest. These properties also obtain (qualitatively) in an incomplete specialization equilibrium of the 2×2 Heckscher-Ohlin-Samuelson model. First, ties are irrelevant in the sense that a change in m leaves the equilibrium unchanged.[16] Second, the ratio of the foreign to the home wage is fixed by the conventional trade barrier (the tax/transport cost) and the underlying production technology. As a consequence, relative country wages are independent of country labor endowments: a change in the labor endowment of either country causes wages in both countries to change by an equal percentage, and migration from the low-

[16] Although ties are effectively invisible in a PAE they underpin the smooth functioning of the economy, performing the role claimed for them by sociologists such as Granovetter (1985).

wage, labor-abundant country to the high-wage, labor-scarce country does not affect relative country wages.[17] As another consequence, the extent to which changes in the conventional trade barrier affect relative country wages is determined entirely by the underlying production technology. We can be more specific after making the change in variable $T \equiv 1\text{-}t$ and denoting the elasticity of producer profits with respect to the wage by ε. Note that an increase in T represents trade liberalization and leads to convergence between foreign and home wage rates, and that ε is determined by the underlying production technology:

Proposition 5. *Given* $\underline{L/L^*} < L/L^* < \overline{L/L^*}$, $d[\ln(w^*/w)]/d[\ln(T)] = 1/\varepsilon$. Proof: From Proposition 4 we saw that $\psi(w^*/w) = T$ must hold when $\underline{L/L^*} < L/L^* < \overline{L/L^*}$. But $\psi(w^*/w) = (w^*/w)^{\varepsilon}$. The result then follows from logarithmic differentiation.■

We now turn to the contrasting properties of an IAE. We first consider the impacts of changes in labor endowments:

Proposition 6. *Given* $L/L^* < \underline{L/L^*}$, $d(w^*/w)/d(L/L^*) > 0$ *and* dw/dL, dw^*/dL, dw/dL^*, $dw^*/dL^* < 0$. Proof: From Proposition 3 we know that equations (6), (6*), and (7) hold when $L/L^* < \underline{L/L^*}$. Equation (7) yields $d\psi/d(L/L^*) > 0$, demonstrating the first result in the Proposition. Now consider the results dw/dL, $dw^*/dL < 0$. From equation (7) we have $d\psi/dL > 0$, and from equation (6*) we have $dw^*/d\psi < 0$, yielding $dw^*/dL < 0$. In turn, $dw^*/dL < 0$ and $d\psi/dL > 0$ imply $dw/dL < 0$. The results dw/dL^*, $dw^*/dL^* < 0$ can be proved analogously, using equations (7) and (6).■

Proposition 6 implies that, in an IAE, as factor endowment ratios move farther apart so do wages. It also implies that when the labor endowment of one country increases, the wage rates in both countries fall, but the wage rate in the country whose endowment increased falls more. In this sense, in an IAE a country displays excess sensitivity to changes in its own labor supply, or is partially insulated from changes in its trading partner's labor supply, unlike in a PAE. Another consequence of Proposition 6 is that migration from the low-wage, labor-abundant country to the

[17]Following Leamer (1995), we can call this property "relative factor-price insensitivity."

high-wage, labor-scarce country causes wages in the latter to fall relative to wages in the former. Trade is thus a less effective substitute for factor movements in an IAE than in a PAE.

Next we consider the effect in an IAE of changes in the conventional trade barrier:

Proposition 7. *Given* $L/L^* < \underline{L/L^*}$, $0 < d[\ln(w^*/w)]/d[\ln(T)] < 1/\varepsilon$. Proof: From Proposition 3 we know that equation (7) holds when $L/L^* < \underline{L/L^*}$. Make the change of variable $T \equiv 1\text{-}t$ in equation (7). Since the left-hand side of equation (7) is decreasing in T we know that $d\psi/dT > 0$, hence $d[\ln(w^*/w)]/d[\ln(T)] > 0$. Moreover, to keep the left-hand side of equation (7) constant when T changes, the ratio ψ/T must fall when T rises and rise when T falls. Since $\psi(w^*/w) = (w^*/w)^{\varepsilon}$, it follows that $d[\ln(w^*/w)]/d[\ln(T)] < 1/\varepsilon$.■

Comparing Propositions 7 and 5, we see that trade liberalization (an increase in T) causes less convergence in country wages in an IAE than in a PAE. Again, matching friction "delinks" the two economies in an IAE compared to a PAE.

The intuition for Propositions 6 and 7 is the same. Consider an increase in L^* or an increase in T. Each tends to generate more trade, which requires more international matches to be confirmed. If untied producers confirm more international matches, however, the quality of the marginal confirmed match must fall, requiring a fall in ψ relative to T by equation (4).[18]

Given the share of producers that are tied, we have seen that if the factor endowment ratios of the two countries are sufficiently similar, relative country wages are determined only by the conventional trade barrier and production technology, whereas if the factor endowment ratios are sufficiently different, relative country wages become a function of relative labor supplies. This is reminiscent of the shift from an incomplete to a complete specialization equilibrium in the 2 × 2 Heckscher-Ohlin-Samuelson model. It is thus instructive to compare the properties of the complete specialization equilibrium with those of the Imperfect Arbitrage Equilibrium. One

[18]This intuition is sufficiently robust that we conjecture that Propositions 6 and 7 would hold for any model of search by untied producers for foreign partners in which the marginal cost of search is increasing.

key difference is that in the complete specialization equilibrium, a change in one country's labor endowment causes *no* change in the wage of the other country measured in terms of its output. A second key difference is that in the complete specialization equilibrium, trade liberalization causes *no* convergence of country wages measured in terms of domestic output: indeed, country wage rates measured in terms of domestic output are not a function of the conventional trade barrier at all.

The other major property of the IAE that distinguishes it not only from a PAE but also from any equilibrium of a standard trade model is that international ties are important:

Proposition 8. *Given* $L/L^* < \underline{L/L^*}$, $dw/dm < 0$ *and* $dw^*/dm > 0$. Proof: We see from equation (7) that $d\psi/dm > 0$, so that w^* rises relative to w. We can therefore rule out the combination of $dw/dm > 0$ and $dw^*/dm < 0$, and can also rule out the combinations dw/dm, $dw^*/dm > 0$ and dw/dm, $dw^*/dm < 0$ by proving that $(dw/dm)(dw^*/dm) < 0$. The most straightforward way to do this is simply to substitute the definition $\psi(w^*/w) \equiv \pi(w)/\pi(w^*)$ into equations (6) and (6*), and then to totally differentiate the resulting two equations. The results can be summarized as follows:

$$\begin{pmatrix} A & B \\ C & D \end{pmatrix}\begin{pmatrix} dw \\ dw^* \end{pmatrix} = \begin{pmatrix} E \\ F \end{pmatrix} dm\,,$$

where the matrix coefficients are functions of w, w^*, and the parameters of the model. Then a straightforward use of Cramer's rule reduces the proof to showing that $(D\,E - B\,F)\,(A\,F - C\,E) < 0$. The proof of this inequality, as well as the explicit expressions for the coefficients, are relegated to an appendix available upon request.■

A rise in the share of producers that are tied increases the transfer of labor demand from the labor-scarce to the labor-abundant country in an IAE but not in a PAE.

Proposition 9. *Given* $L/L^* < \underline{L/L^*}$, *in each country tied producers are strictly better off than the average untied producer.* Proof: We see from Figure 2 that the profits received by producers in the home and foreign countries, conditional on concluding their international matches, are $((1-t)(z-1/4)\pi(w^*) + \pi(w)/4)/2$ and $(z\pi(w^*) - \pi(w)/4(1-t) + \pi(w^*)/4)/2$, respectively. For all tied producers $z = 1/2$, and given $\psi \equiv \pi(w)/\pi(w^*) < 1-t$ this yields profits strictly greater than $\pi(w)/4$ and $\pi(w^*)/4$ for home and foreign tied producers, respectively. Hence all tied producers confirm their international matches and tied producers are strictly better off than untied producers in their respective countries who match domestically. Moreover, the average z obtained by

untied producers who confirm international matches is strictly less than $1/2$, so tied producers are strictly better off than the average untied producer in their respective countries that confirms its international match.■

In contrast, tied and untied producers are equally well off in a PAE.

Proposition 9 helps to explain the extremely disproportionate share of wealth, measured by stock market capitalization, held by the Overseas Chinese in Southeast Asian countries such as Indonesia, the Philippines, and Thailand.[19] Rauch and Trindade (forthcoming) find that the Overseas Chinese network creates a large amount of trade between these countries and other countries with substantial ethnic Chinese populations that are much more labor-scarce, including Australia, Canada, Hong Kong, New Zealand, Singapore, Taiwan, and the United States.

IV. Discussion and Extensions

A. The impact of international trade on wages: Margins versus volumes

Should the impact of international trade on wages be measured by computing the volume of trade in factor services or by examining cost competition at the margin? Freeman (1995, pp. 21-22) elegantly summarizes the debate:

> If the West can import children's toys produced by low-paid Chinese workers at bargain basement prices, surely low-skilled westerners, who produce those toys at wages 10 times those of the Chinese, will face a difficult time in the job market. It isn't even necessary that the West import the toys. The threat to import them or to move plants to less-developed countries to produce the toys may suffice to force low-skilled westerners to take a cut in pay to maintain employment. In this situation, the open economy can cause lower pay for low-skilled workers even without trade: to save my job, I accept Chinese-level pay, and that prevents imports. The invisible hand would have done its job, with proper invisibility.

[19]The Economist Intelligence Unit reports the following population and market capitalization shares, respectively, for the Overseas Chinese in Southeast Asia: Indonesia, 3-4 and 73 percent; the Philippines, 2 and 50-60 percent; and Thailand, 14 and 81 percent (Kluth 2001).

> ...These predictions [of factor-price equalization] run counter to a wide body of evidence that domestic developments do affect wages: for instance, that the baby boom affected the pay of young workers; that the relative number of college graduates altered the premium paid for education ....[20]

Having considered the theoretical point that cost competition from labor in low-wage countries could set the wages of comparably skilled labor in high-wage countries, the empirical method for quantifying the impact of international trade on wages that is preferred by Freeman (1995, p. 23) and many others (see, e.g., Sachs and Shatz 1994) remains *factor content analysis*:

> if the United States imported 10 additional children's toys, which could be produced by five American workers, the effective supply of unskilled workers would increase by five .... This five-worker shift in the supply-demand balance would put pressure on unskilled wages to fall, causing those wages to fall in accord with the relevant elasticity.

Here the impact of low wage competition depends entirely on the volume of net trade and not at all on comparison of costs at the margin.

We have seen that in the Perfect Arbitrage Equilibrium of our model the ratio of the home to the foreign wage is determined by the conventional trade barrier and production technology independent of country labor supplies. In this equilibrium margins operate perfectly, in the sense that any incipient rise in the home wage relative to the foreign wage above this ratio would be eliminated by a shift in labor demand of tied producers from the home to the foreign country, just as the first quotation above suggests. With labor-producer endowment ratios sufficiently far apart, however, tied producers cannot transfer enough labor demand to maintain the perfect arbitrage condition and the Imperfect Arbitrage Equilibrium of our model obtains: elimination of

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[20]We might take the liberty of clarifying Freeman's statement to add that the baby boom affected the pay of young workers *more in the United States than in China* and the relative number of college graduates *in the United States* altered the premium paid for education *more in the United States than in China*.

an incipient rise in the home wage requires that untied home producers shift from matching in a complete information environment domestically to an incomplete information environment abroad. Margins now operate imperfectly, and relative labor demand is no longer infinitely elastic with respect to relative country wages: the "relevant elasticity" is finite. In other words, relative wages become a downward-sloping rather than horizontal function of relative labor supplies in the two countries, and we must therefore take into account the volume of (implicit) net trade in labor services when computing the impact of international trade on domestic wages. This is presumably the pertinent case for trade between more and less developed countries, given the very large differences in endowments of unskilled labor relative to other factors of production.

B. Ties and World Welfare

In our two-country model, international ties must complement the ability of price signals to induce transfer of labor demand from the country where labor is scarce to the country where labor is abundant. We can thus expect world welfare (equal to income in our model) to be greater in the presence of ties than in their absence because the gains from trade are more fully realized. A more interesting situation in which to investigate the impact of ties on world welfare is where ties and price signals act at cross purposes. This kind of situation can arise in a model with more than two countries if, for example, ties are *not* most dense between the countries between which the wage differentials in the absence of ties are largest.

This is not a purely hypothetical situation. Consider the movement offshore of the Korean and Taiwanese apparel industries, which accelerated in the late 1980s and early 1990s in response to sharply rising domestic wages. Gereffi (1999, p. 59) states, "The preference of

Korean firms for investment in Latin America (Guatemala, Honduras, the Dominican Republic, etc.) is stimulated by its proximity to the U.S. market and easy quota access. The pull of Asian nations such as Indonesia, Sri Lanka, and Bangladesh comes mainly from their wage rates, which are among the lowest in the world." In contrast, Taiwanese firms invested most heavily in China, Malaysia, the Philippines, and Thailand as well as Indonesia. Ethnic Chinese ties are important in all of these countries, and in at least two (Malaysia and Thailand) wages are well above South Asian levels. Gereffi concludes (p. 63), "social ties shape sourcing networks."

To create a situation in our model in which price signals and ties can act at cross purposes, we add a third country with a greater labor-producer endowment ratio than either of the other two countries. We relabel the home country as country 1 and the foreign country as country 2, and label the new country as country 3. For country 3 there is a continuum of producers of every type of mass 2, so that the total mass of producers in country 3 equals the sum of the masses of producers in countries 1 and 2. We assume that producers in country 1 search abroad for partners first, followed by producers in country 2. As before, producers who form unsuccessful international partnerships must return home and match domestically,[21] and labor markets clear after all labor demands from international and domestic partnerships are received.

We will investigate the impact of ties on world welfare relative to a baseline solution of this three-country model. In the baseline solution there are no ties, and t is the same between all three pairs of countries. We further assume that t is a pure melting transport cost, so that we do not have to keep track of tax revenues. It is easy to show that, given appropriate labor

[21]We could thus allow any unmatched producers in country 3 to search abroad for partners as well, but it would not matter because all partners would already have been taken.

endowments, an IAE exists in which country 1 has the highest and country 3 the lowest wage. In this equilibrium we can think of country 1 producers as matching with the bottom half of the cylinder of country 3 producers, and country 2 producers as matching with the remainder of country 3 producers. It is easily shown that the expected profit of country 1 producers is decreasing in the wage prevailing in the partner's country, so that the choice of all country 1 producers to seek partners in country 3 rather than country 2 is equilibrium behavior.

Starting from this base, we explore the impact on world welfare of ties between a proportion *m* of country 1 and country 2 producers. When deciding in which country to search for a partner, tied country 1 producers now face a tradeoff between a guarantee of maximum match quality in country 2 and a guarantee of the lowest wage in country 3. They choose to use their ties when the following inequality holds:

$$\frac{2(1-t+\psi^{13})}{4(1-t)}\frac{\pi(w^1)}{4}+2\int_{\frac{1-t+\psi^{13}}{4(1-t)}}^{1/2}\frac{[(1-t)(z-\frac{1}{4})\pi(w^3)+\frac{\pi(w^1)}{4}]}{2}dz<\frac{(1-t)\pi(w^2)+\pi(w^1)}{8} \quad \textbf{(9)},$$

where w^i denotes the wage in country i and $\psi^{13} \equiv \pi(w^1)/\pi(w^3)$. On the right-hand side of (9) we have applied the Nash bargaining solution in Figure 2 to compute the profit of the country 1 producer if he uses his tie in country 2. On the left-hand side of (9) we have applied the cutoff match quality in Figure 1 and the Nash bargaining solution in Figure 2 to compute the expected profit of the country 1 producer if he makes a random match in country 3. Untied producers in country 1 will seek partners in country 3 as in the baseline solution, as must untied producers in country 2 since there will again be no unmatched country 1 producers. When tied country 1 producers choose to use their ties, a proportion *m* of country 3 producers (2*m* divided by 2) never

has the opportunity to form international partnerships and therefore matches domestically.

The sign of the effect of ties on world welfare is now determined by whether or not their effect through creation of trade between countries 1 and 2 dominates their effect through diversion of trade that would have occurred between countries 1 and 3. It is easy to see that if wages in countries 2 and 3 are sufficiently close in the baseline solution, ties between countries 1 and 2 must raise world welfare. Since the source of gains from trade is the transfer of labor demand from a high-wage to a low-wage country, as the baseline wage of country 2 approaches that of country 3 the loss of gains from trade from the "trade diversion effect" approaches zero while the gains from trade from the "trade creation effect" get larger. The same argument implies that the increase in world welfare from ties between countries 1 and 2 declines as the country 2 wage rises relative to the country 3 wage in the baseline solution. This argument cannot establish the possibility of a decrease in world welfare from ties, however, because the trade creation effect cannot be made arbitrarily small relative to the trade diversion effect: country 1 producers choose not to use their ties when the wages in countries 2 and 1 get too close, so the effect of ties on world welfare goes to zero. We have instead established this possibility through simulation.

In the simulation we assume a Cobb-Douglas production function with labor share = $1/2$, yielding $\pi(w) = 1/w$. We set $m = 0.1$, $t = 0.1$, and the world labor endowment equal to 3. We then change the allocation of this endowment across the three countries so as to maintain $w^1/w^3 = 4$ in the baseline solution while increasing w^2/w^3. World welfare with ties falls below world welfare without ties when w^2 becomes slightly more than double w^3 in the baseline solution, but country 1 producers do not abandon use of their ties until w^2 reaches nearly two and one quarter

times w^3 in the baseline solution.[22] It follows that, for allocations of the world labor endowment that yield baseline solutions in this range, a prohibitive tax on trade between countries 1 and 2 will increase world welfare.

The key distortion that puts us in the world of the second best is that country 1 producers choose whether to use their ties on the basis of their shares of the values of their international matches, rather than on the basis of the entire values of their matches. Their bargaining power is lower in country 3 than in country 2 because the wages of the labor to which country 3 producers are guaranteed access are lower than the wages in country 2. In effect, the producers in country 2 to which country 1 producers are tied give the latter too good a deal from the point of view of world welfare.

C. Ties and trade in differentiated versus homogeneous products

Rauch and Trindade (forthcoming) find that ethnic Chinese networks increase bilateral trade most for differentiated products, least for products traded on organized exchanges, and an intermediate amount for products with reference prices[23] (hence relatively homogenous) but not traded on organized exchanges. This suggests that products could be arrayed on a continuum from most differentiated to most homogeneous, with the impact of ties on trade decreasing as one moves from the differentiated to the homogeneous end of this continuum. Our model is not set up to compare the impact of ties on trade across different goods, however, as it is a model of trade in factor services with trade in the one produced good occurring as a byproduct of the need

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[22]In other words, condition (9) fails in the equilibrium with ties for the allocation of the world labor endowment that yields this baseline solution. Note that the value of w^2/w^3 in this equilibrium must be higher than in the equilibrium without ties (the baseline solution) because the ties divert labor demand of country 1 producers from country 3 to country 2.

[23]A reference price is a price that is quoted (in a trade publication, for example) without an identifying brand name.

to repatriate profits. In this subsection we will show how the model can address this issue quite naturally after some reinterpretation of the agents and variables.

We begin by reinterpreting "producers" as wholesalers engaged in both domestic distribution and import-export activities. Instead of purchasing "labor," wholesalers purchase goods from manufacturers, and "wages" can then be interpreted as producer prices. Wholesaler "types" can be interpreted as reflecting their (possibly contractual) affiliations with certain manufacturers and end users (retailers or purchasers of intermediate goods). Match quality is then increasing in the suitability of the product varieties supplied by the underlying manufacturers for the end users the wholesalers wish to serve. Equation (1) now gives the production function for wholesale services for a given product. Match quality is a more important component of wholesale services, the greater is the level of product differentiation, and this can be usefully captured by a relatively greater exponent on z_{ij} in a Cobb-Douglas specification of the production function F. It is easily shown that this implies a smaller elasticity of the profit function in equation (2) with respect to the producer price w. Intuitively, the more "commodified" is the product, the more price sensitive are the profits of the wholesalers that handle it. The continuum of products from most differentiated to most homogeneous that we seek can thus be indexed by ε, with increasing ε corresponding to increasing homogeneity.

In this interpretation of the model, the volume of trade in any good is given by the purchases of internationally matched foreign wholesalers from their affiliated manufacturers for resale by their partner home wholesalers to their affiliated end users. We are interested in how the percentage change in this volume with respect to m, the share of wholesalers of that good that are tied, varies with ε. In order to isolate the effect of ε we assume that m, t, and the foreign cost

advantage given by the ratio of producer prices w^*/w, are the same across all goods. We then consider only the case where $\psi = (w^*/w)^{\varepsilon} < 1\text{-}t$ for all goods, since $\psi > 1\text{-}t$ yields no trade in that good and $\psi = 1\text{-}t$ can hold for at most one good. In this case, the volume of trade for any good for which there is a unit mass of wholesalers in each country[24] is given by

$$V = \left(\frac{1+m}{4} - \frac{(1-m)[(1-t)+\psi]^2}{16(1-t)^2} \right)(-\pi'(w^*)), \qquad \textbf{(10)}$$

where we have simply followed the derivation of the demand for foreign labor (the left-hand side of equation (6*)) but omitted the contribution of domestic partnerships.

Physical production is no longer in the model, so we have a partial rather than a general equilibrium framework for comparing the impact of ties on trade across many goods. In this partial equilibrium framework we assume that producer prices are determined by the costs of primary factors of production, which cannot be affected by changes in demand for any one good.[25] We can then prove:

Proposition 10. $(dV/dm)/V$ *is decreasing in* ε. Proof: With producer prices fixed, we have

$$\frac{dV}{dm} = \left(\frac{1}{4} + \frac{[(1-t)+\psi]^2}{16(1-t)^2} \right)(-\pi'(w^*)).$$

Dividing by V yields

[24]Since we are examining percentage changes in the volume of trade, scaling by the mass of wholesalers in each country for the particular good will obviously not affect the results.

[25]It therefore does not matter whether we consider percentage changes in the volume or value of trade. We must view Proposition 10 as referring to the impact of changing the share of wholesalers that are tied for the product in question only, starting from an equal share of tied wholesalers for all products.

$$\frac{dV}{dm}\Big/V = \left(\frac{1}{4} + \frac{[(1-t)+\psi]^2}{16(1-t)^2}\right)\Big/\left(\frac{1+m}{4} - \frac{(1-m)[(1-t)+\psi]^2}{16(1-t)^2}\right).$$

The numerator is increasing in ψ and the denominator is decreasing in ψ. Since ψ is decreasing in ε, the result follows.■

Proposition 10 shows that the impact of international ties between wholesalers on bilateral trade decreases with the level of product homogeneity. The intuition for Proposition 10 is that price signals and ties are both sources of information: as price signals strengthen, the need for ties decreases. The strengthening of the price signal in Proposition 10 is reflected by the reduction in ψ as ε increases.

V. Conclusions

It is more difficult in the international than in the domestic market for producers to find the right distributors for their consumer goods, for assemblers to find the right suppliers for their components, for investing firms to find the right partners for their joint ventures, and so on. Ties through international information-sharing networks or parent-subsidiary relationships help producers to solve their matching problems and find suitable trade or investment partners in other countries. In our basic model we find that, when the difference between the factor-endowment ratios of the two countries is small relative to the share of producers that is tied, efficient arbitrage and the standard properties of neoclassical trade models prevail. When the difference between factor-endowment ratios is sufficiently large, this equilibrium breaks down and the two countries become partially insulated from each other in the sense that each country's wage (resource price) is more sensitive to changes in domestic than foreign labor supply and trade

liberalization causes less convergence in country wage rates. Efficient arbitrage fails because price signals convey incomplete information to the complete set of producers whereas ties convey complete information to an incomplete set of producers.

The imperfect operation of margins that occurs when endowment ratios are far apart suggests that, when evaluating the impact on domestic wages of trade between more and less developed countries, the volume of (implicit) trade in labor services must be taken into account. An extension of the model to three countries shows that when ties are denser between countries with small wage differences than between countries with large wage differences, they can worsen the allocation of resources and reduce the value of world output. An adaptation of the model to trade in many goods shows that ties between wholesalers increase the volume of bilateral trade more for differentiated than for homogeneous products.

The simplicity and tractability of the basic model of sections II and III facilitate yet other modifications that allow its application to issues beyond the scope of this paper. Rauch and Trindade (2000) show how the basic model can be modified to address the effects of a reduction in informational barriers to trade through improved information technology (the Internet). Ideally, the basic model could be sufficiently enriched that, for example, it would be possible through calibration to use the estimated effect of ties on bilateral trade to compute the share of the shortfall in world trade relative to a frictionless counterfactual that can be attributed to informational barriers.[26]

[26]Eaton and Kortum (2000) compute a very large total shortfall, but cannot allocate it between various causes.

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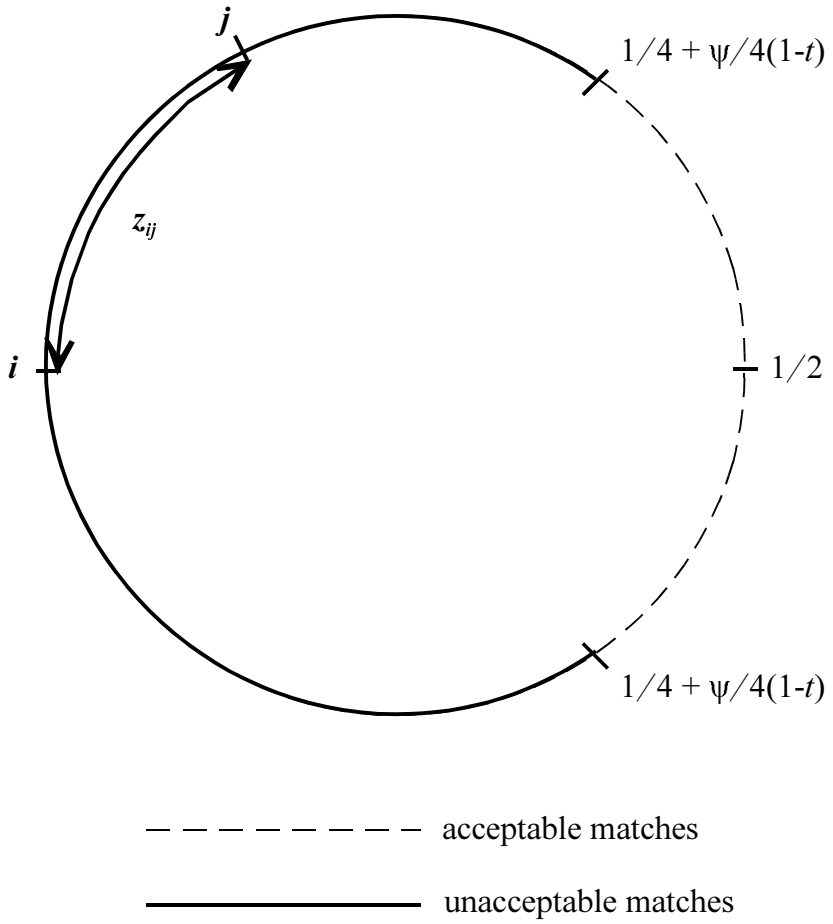

Figure 1

International matching: Distances between home producer *i* and foreign producer *j*.

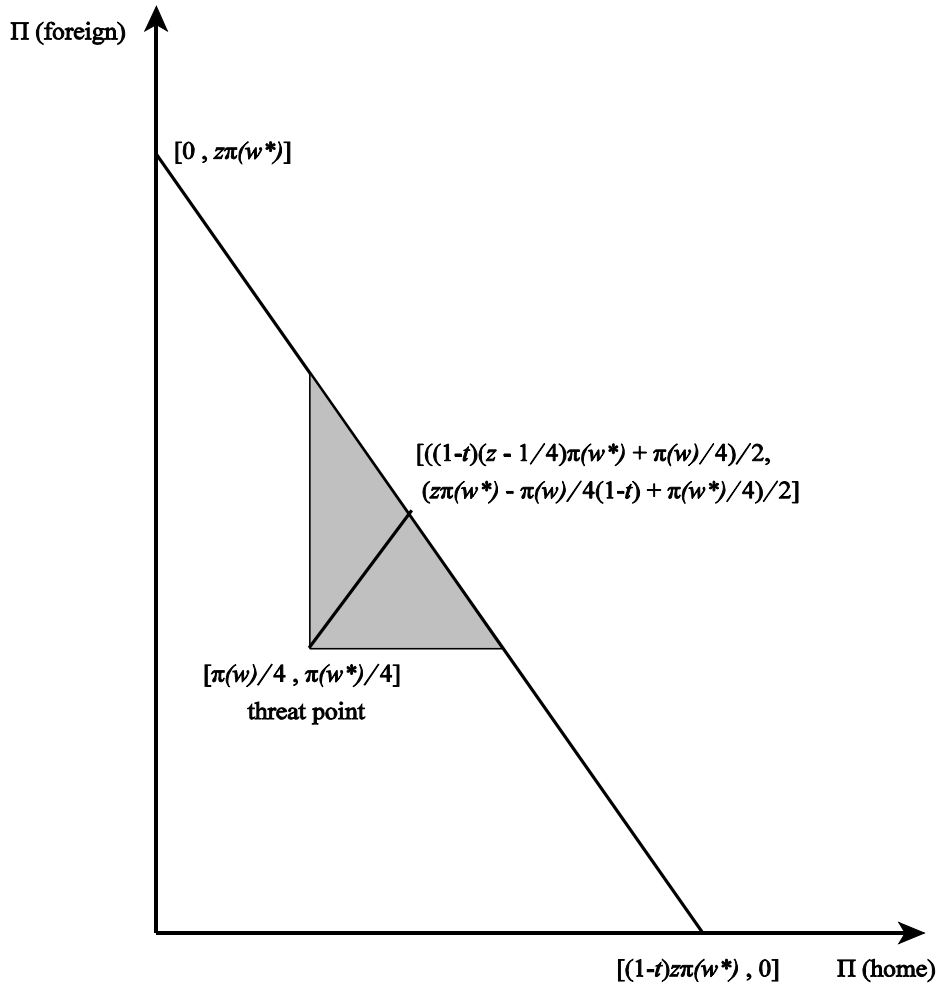

Figure 2

The bargaining problem.