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Trade Liberalisation with Multinational Firms: Effects on Welfare and Intra-Industry Trade

by

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Abstract

In this paper, we model trade liberalisation as an endogenous process and shed new light on how economic fundamentals like endowments and technology affect potential gains, the welfare effects of liberalisation and its consequences for intra-industry trade. We construct a general equilibrium model of trade and (tariff-jumping) MNEs and augment this by numerical simulation experiments which allow us to abandon some simplifying assumptions. Our insights regarding the welfare effects of tariff reductions motivate an empirical investigation of the determinants of free trade areas, which accounts for factor endowments, trade costs, and investment costs. Further, we study the consequences of trade liberalisation for intra-industry trade shares in the presence of MNEs. We find that formation of free trade areas has significant trade composition effects, with important implications for intra-industry trade.

Key words: Trade liberalisation, Intra-industry trade, Multinational firms

JEL classification: C12, F12, F15, F23

Outline

Non-Technical Summary

The impact of trade policy on multinational activities has interested economists since at least the early 1970s. Theoretical research has explored the role of tariff-jumping FDI and its associated welfare implications. However, optimal trade policy was not a central focus of earlier work. More recently, economists have taken a greater interest in the role of multinational firms for preferential trading agreements (PTAs), for example investigating the role of transport costs for PTA-formation, when tariff-jumping FDI is considered, generating important insights into why adjacent economies are more likely to establish a PTA than more distant ones.

In this paper, we model trade liberalisation as an endogenous process and shed new light on how economic fundamentals like endowments and technology affect potential gains. In particular, we study the welfare effects of liberalisation and its consequences for intra-industry trade. Until recently, this would not have been seen as directly relevant to multinational firms. However, we provide insights which demonstrate how the presence of multinationals is crucially important. For instance, we derive testable hypotheses regarding the role of investment costs for the likelihood of liberalisation. Based on our model, we motivate an empirical analysis of endogenous selection into free trade areas. Our work differs from previous research by investigating selection into free trade areas with multinationals and by studying the consequences for intra-industry trade shares both in theoretical and empirical terms.

In the theoretical part of the paper, we construct a general equilibrium model of trade and (tariff-jumping) MNEs. We incorporate three factors – capital, skilled labour, and unskilled labour –two potentially asymmetric countries, and two goods, one homogeneous and one differentiated. This model enables us to compare the welfare effects of full trade liberalisation with Nash tariff rates analytically.

We augment the theoretical analysis by numerical simulation experiments which allow us to abandon some assumptions adopted for analytical tractability. Our insights regarding the welfare effects of tariff reductions motivate an empirical specification of the determinants of free trade areas, which accounts for factor endowments, trade costs, and investment costs. Further, we study the consequences of trade liberalisation for intra-industry trade shares in the presence of MNEs. This is an important facet of the paper, given the co-existence of high levels of intra-industry trade and pervasive presence of multinationals in OECD countries.

Our theoretical model predicts that intra-industry trade shares tend to rise after trade liberalisation, especially if both endowments of the two economies and investment costs for setting up multinational enterprises are not too different. However, the impact is in general not absolutely clear-cut, which opens the door to empirical research. Based on our selection equation, we investigate the impact of entry into a free trade area on bilateral intra-industry trade. In particular, we look at the change in intra-industry trade shares in countries that have entered a free trade area against a well-defined control group, using difference-in-difference estimates. We find that intra-industry trade shares rose by about three percentage points due to the establishment of free trade areas within the OECD as of 2000. This suggests that free trade areas not only foster bilateral trade between member countries but also significantly change the structure of trade in favour of intra-industry transactions. It also suggests that failure to correct for self-selection into PTAs is associated with a very large downward bias in the trade share effects. Once one corrects for this using matching, the impact of PTA membership becomes substantial, amounting to around 25 percent of the recorded increase in intra-industry trade. These results are robust to changes in the selection equation and matching method deployed.

1 Introduction

The impact of trade policy on multinational activities has interested economists since at least the early 1970s. Starting with Horst (1971) theoretical research has explored the role of tariff-jumping FDI and its associated welfare implications (e.g. Smith, 1987; Motta, 1992). However, optimal trade policy was not a focus of these contributions. More recently, economists have taken a greater interest in the role of multinational firms for preferential trading agreements (PTAs). Ludema (2002) for example investigated the role of transport costs for PTA-formation, when tariff-jumping FDI is considered,[1] generating important insights into why adjacent economies are more likely to establish a PTA than more distant ones.[2]

In this paper, we model trade liberalisation as an endogenous process and shed new light on how economic fundamentals like endowments and technology affect potential gains. In particular, we study the welfare effects of liberalisation and its consequences for intra-industry trade. Until recently, this would not have been seen as directly relevant to multinational firms (see Baier and Bergstrand, 2004b). However, we provide insights which demonstrate how the presence of multinationals is crucially important. For instance, we derive testable hypotheses regarding the role of investment costs for the likelihood of liberalisation. Based on our model, we motivate an empirical analysis of endogenous selection into free trade areas. Our work differs from previous research by investigating selection into free trade areas with multinationals and by studying the consequences for intra-industry trade shares both in theoretical and empirical terms.

In the theoretical part of the paper, we construct a general equilibrium model of trade and (tariff-jumping) MNEs. We incorporate three factors – capital, skilled labour, and unskilled labour –two potentially asymmetric countries, and two goods, one homogeneous and one differentiated. This model enables us to compare the welfare effects of full trade liberalisation

[1] There is of course a huge literature on preferential trading agreements which does not account for the role of multinational firms. For instance, Bagwell and Staiger (1999) analyse Nash equilibrium tariff structures in the presence of preferential and multilateral trade policies and Bond and Syropoulos (1996) in pre- and post-integration situations. Baier and Bergstrand (2004a) study the impact of liberalisation in six asymmetric economies, using numerical simulations but do not compare the liberalisation outcome with Nash equilibrium tariffs. Based on theoretical insights from this, Baier and Bergstrand (2004b) investigate the impact of endogenous free trade areas on bilateral trade volumes but without accounting for the role of multinational firms.

with Nash tariff rates analytically.[3] We augment the theoretical analysis by numerical simulation experiments which allow us to abandon some assumptions adopted for analytical tractability. Our insights regarding the welfare effects of tariff reductions motivate an empirical specification of the determinants of free trade areas, which accounts for factor endowments, trade costs, and investment costs. Further, we study the consequences of trade liberalisation for intra-industry trade shares in the presence of MNEs. This is an important facet of the paper, given the co-existence of high levels of intra-industry trade and pervasive presence of multinationals in OECD countries.

Our theoretical model predicts that intra-industry trade shares tend to rise after trade liberalisation, especially if both endowments of the two economies and investment costs for setting up multinational enterprises are not too different. However, the impact is in general not absolutely clear-cut, which opens the door to empirical research. Based on our selection equation, we investigate the impact of entry into a free trade area on bilateral intra-industry trade. In particular, we look at the change in intra-industry trade shares in countries that have entered a free trade area against a well-defined control group, using difference-in-difference estimates. For this, we apply several matching estimators based on either propensity scores or the Mahalanobis distance metric. We find that intra-industry trade shares rose by about three percentage points due to the establishment of free trade areas within the OECD as of 2000. This suggests that free trade areas not only foster bilateral trade between member countries (Baier and Bergstrand, 2004b) but also significantly change the structure of trade in favour of intra-industry transactions.

The remainder paper is organized as follows. Section 2 introduces an analytically solvable general equilibrium model of trade and multinational activities. Section 3 presents some numerical simulation exercises, which allow us to modify some of the restrictive assumptions of our basic framework. In Section 4, we use insights from the theoretical model to set up an appropriate econometric specification and discuss the empirical relevance of the main theoretical results. Section 5 concludes.

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[2] Markusen (1997, 2002) considers trade and investment liberalisation and their effects on welfare. However, he focuses on variation of iceberg trade costs rather than tariffs. Similar to Baier and Bergstrand (2004a), pre-liberalisation trade impediments are "inherited" rather than optimally chosen.

[3] Analytical tractability compels us to consider a two-country model. Hence, we cannot directly address the issue of preferential trading agreements. Nonetheless, our model points to important results of tariff reduction in the context of multinational enterprises.

2 Theoretical Background: An Analytically Solvable General Equilibrium Model

2.1 Basic Set-Up

Consider two countries with different factor endowments. There are two sectors. The industrial *X*-sector produces differentiated goods, while output in the *Y*-sector is homogeneous. Preferences of the representative consumer are given by a Cobb-Douglas utility function:

$$U = X^{\alpha}\left(Y^{D}\right)^{1-\alpha}, \ \ 0 < \alpha < 1, \tag{1}$$

where $X := \left[\sum_k \left(x_k^D\right)^{(\varepsilon-1)/\varepsilon}\right]^{\varepsilon/(\varepsilon-1)}$, is a CES-index, that accounts for home-produced and imported varieties of the industrial good, and $\varepsilon > 1$ is the elasticity of substitution between varieties. Country indices are neglected for the moment. Superscript *D* refers to consumed quantities. Hence, x_k^D denotes the quantity of variety *k*, consumed by the representative consumer of a particular economy, while Y^D is the respective quantity of the homogeneous good. Production technologies in the two sectors are given by $x = L$ and $Y = L$, respectively, where *L* is low-skilled labour. In addition, production in the *X*-sector requires fixed set-up costs through the use of physical capital *K* and high-skilled non-production labour (human capital) *S*. The three production inputs are inelastically supplied in perfectly competitive and internationally segmented factor markets. We choose Y as the numéraire and obtain $w_{Li} = w_{Lj} = 1$ under diversification of production in both economies (which is assumed from now on). Exports of industrial output are impeded by iceberg transport costs, accounted for by parameter $t>1$. Moreover, there may be (non-negative) tariffs on international transactions of industrial goods. Trade in the numéraire good is frictionless.[4]

We consider two types of firms, namely exporters and horizontal multinationals (Markusen and Venables, 2000; Markusen, 2002). To set up an exporting firm requires one unit of physical capital *K* and one unit of high-skilled labour *S*, whereas one unit of high-skilled labour and $g > 2$ units of physical capital are required to set up a horizontal multinational

[4] The assumption that the numéraire good is not subject to any trade frictions is common in models of the new economic geography and the literature on multinational firms. For instance, Venables (1987), Ludema (2002), Markusen (2002), and Keen and Ligthart (2003) apply this assumption.

with two production plants. To be more precise, we assume that one unit of physical capital and one unit of high-skilled labour are necessary to headquarter a firm (exporter or horizontal multinational) in a particular economy. Local production can start immediately, without further investment. However, if a firm decides to set up a second production plant abroad, $g-1$ units of physical capital must be invested as fixed factor input before production can be started in the foreign economy. In addition, we assume that firms with headquarter in country *i* are restricted to country *i*'s supply of human and physical capital, when setting up production plants. All firms of a particular type, which are headquartered in the same country, are identical. Hence, we can skip firm indices in the following analysis.

Demand in country *i* for a single variety of the differentiated good is given by

$$x_{ii}^D = \frac{\alpha E_i p_{ii}^{-\varepsilon}}{P_i} \quad \text{and} \quad x_{ji}^D = \frac{\alpha E_i p_{ji}^{-\varepsilon} b_{ji}^{-\varepsilon}}{P_i}, \tag{2}$$

where x_{ii}^D is a variety produced and consumed in country *i*, while x_{ji}^D is produced in *j* and exported to *i*. Variable b_{ji} represents country *i*'s ad-valorem tariff on imports of the industrial good from country *j*. p_{ji} denotes the producer price and $p_{ji}b_{ji}$ the respective tariff-including consumer price of a variety produced in country *j* and consumed in country *i*. $E_i := L_i + w_{Ki}K_i + w_{Si}S_i + (b_{ji}-1)p_{ji}n_j x_{ji}^D$ is total income (equal to total expenditures) of country *i* and $P_i = p_{ii}^{1-\varepsilon}\left(h_i + h_j + n_i\right) + \left(p_{ji}b_{ji}\right)^{1-\varepsilon} n_j$ is a price index. n_i, n_j and h_i, h_j are the numbers of exporters and horizontal multinationals of countries *i* and *j*, respectively. Each firm produces one variety so that the number of monopolistically competitive firms is equal to the total number of varieties. Profit maximization leads to a constant price mark-up and, therefore, to prices $p_{ii} = p_{jj} = \varepsilon/\left(\varepsilon-1\right)$ and $p_{ij} = p_{ji} = t\varepsilon/\left(\varepsilon-1\right)$ if both sectors are active in both countries, i.e., $w_{Li} = w_{Lj} = 1$.

In equilibrium, goods markets are cleared, implying[5]

$$x_{ii} = x_{ii}^D \quad \text{and} \quad x_{ji} = t x_{ji}^D = x_{ii}\tau b_{ji}^{-\varepsilon}, \tag{3}$$

[5] Of course, also $Y_i + Y_j = Y_i^D + Y_j^D$ holds in equilibrium, with Y_i, Y_j being homogeneous goods supply of country *i* and country *j*, respectively.

where $\tau = t^{1-\varepsilon}$ is a transformed measure of iceberg transport costs. Zero-profit conditions of country *i* firms are represented by

$$\pi_{ni} = \frac{1}{\varepsilon - 1}\left[x_{ii} + \tau b_{ij}^{-\varepsilon} x_{jj} \right] - w_{Ki} - w_{Si} = 0, \tag{4}$$

$$\pi_{hi} = \frac{1}{\varepsilon - 1}\left[x_{ii} + x_{jj} \right] - g_i w_{Ki} - w_{Si} = 0, \tag{5}$$

due to $w_{Li} = w_{Lj} = 1$. Finally, the three factor market clearing conditions in country *i* are given by

$$L_i = \left(h_i + h_j + n_i \right) x_{ii} + \tau b_{ij}^{-\varepsilon} n_i x_{jj} + Y_i, \tag{6}$$

$$S_i = n_i + h_i, \tag{7}$$

$$K_i = n_i + g_i h_i. \tag{8}$$

From (4)-(8), we obtain

$$w_{Ki} = \frac{1}{\varepsilon - 1} \frac{1 - \tau b_{ij}^{-\varepsilon}}{g_i - 1} x_{jj}, \qquad w_{Si} = \frac{1}{\varepsilon - 1}\left[x_{ii} - x_{jj} \frac{1 - g_i \tau b_{ij}^{-\varepsilon}}{g_i - 1} \right] \tag{9}$$

for equilibrium factor prices in country *i* and

$$h_i = \frac{K_i - S_i}{g_i - 1}, \qquad n_i = \frac{g_i S_i - K_i}{g_i - 1} \tag{10}$$

for the equilibrium number of horizontal multinationals and exporters in country *i*. Equivalent expressions are obtained for wages and firm numbers in *j*.[6]

For analytical tractability, we assume that countries do not differ in their physical capital requirements for setting up foreign plants, i.e., $g_i = g_j \equiv g$. Moreover, countries are presumed to have identical endowments of physical capital and skilled labour, i.e. $K_j = K_i \equiv K$ and $S_j = S_i \equiv S$, but may differ in their endowments of low-skilled labour, i.e. $L_i = \lambda \bar{L}$, $L_j = (1 - \lambda)\bar{L}$ and $\lambda \in (0,1)$.

[6] We focus on a parameter domain leading to positive factor prices w_{Ki}, w_{Si} and a positive number of both firm types. The former is guaranteed, if countries are not too different, while the latter requires $S_i < K_i < g_i S_i$.

2.2 Best-Response Tariff-Setting

Welfare in country *i* is given by the utility of the representative consumer determined in (1).[7] Noting $\left(1-\alpha\right)E_i = Y_i^D$ and using $E_i = P_i p_{ii}^{\varepsilon} x_{ii} / \alpha$, according to (2) and (3), welfare in country *i* as a function of tariff rates b_{ji}, b_{ij} is given by[8]

$$U_i\left(b_{ji}, b_{ij}\right) = \left(\frac{1-\alpha}{\alpha}\frac{\varepsilon}{\varepsilon-1}\right)^{1-\alpha} \underbrace{\left[\left(h_i + h_j + n_i\right) + n_j \tau b_{ji}^{1-\varepsilon}\right]^{1+\alpha/(\varepsilon-1)}}_{=\left[P_i / p_{ii}^{1-\varepsilon}\right]^{1-\alpha} \times \left[X_i / x_{ii}\right]^{\alpha}} x_{ii}\left(b_{ji}, b_{ij}\right). \tag{11}$$

Differentiating (11) with respect to b_{ji} yields

$$\frac{\partial U_i}{\partial b_{ji}} = \frac{U_i}{b_{ji}}\left\{\frac{\partial x_{ii}}{\partial b_{ji}}\frac{b_{ji}}{x_{ii}} - \frac{\left(\varepsilon - 1 + \alpha\right) n_j \tau b_{ji}^{1-\varepsilon}}{\left(h_i + h_j + n_i\right) + n_j \tau b_{ji}^{1-\varepsilon}}\right\}. \tag{12}$$

Lemma 1: *Consider $\varepsilon \geq 2$ and diversification in the production pattern of both economies. Then, for any $b_{ij} \geq 1$, $\partial U_i\left(\cdot\right)/\partial b_{ji} = 0$ has a unique solution in $b_{ji} \in \left(1, \infty\right)$, which is independent of endowment parameter λ.*

Proof. See Appendix.

According to Lemma 1, there exists for any $b_{ij} \geq 1$ a unique best-response tariff rate $b_{ji} \in \left(0,1\right)$ that maximizes welfare in country *i*. This finding is illustrated in Figure 1. If country *j* sets some tariff rate $b_{ij} = \bar{b}_{ij} \geq 1$, then it is optimal for country *i* to set the best response tariff rate $b_{ji} = b_{ji}^{*}\left(\bar{b}_{ij}\right)$. According to Lemma 1, it is always beneficial for governments to set a positive tariff rate. This confirms Venables (1987) result that "domestic welfare can be increased by policies which tax foreign firms (import tariffs)" (p. 716), which was derived in a similar setting, but without accounting for the existence of multinational firms.

A further implication of Lemma 1 is that the tariff-setting problem is independent of a country's endowment of low-skilled labour *L* (as long as diversification of production

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[7] The analysis for country *j* is analogous.

[8] For a derivation, use $X_i = x_{ii}\left[\left(h_i + h_j + n_i\right) + n_j \tau b_{ji}^{1-\varepsilon}\right]^{\varepsilon/(\varepsilon-1)}$, according to (2), and $P_i = p_{ii}^{1-\varepsilon}\left[\left(h_i + h_j + n_i\right) + n_j \tau b_{ji}^{1-\varepsilon}\right]$, according to the definition of the price index.

prevails). This makes tariff-setting in the two economies symmetric and, therefore, facilitates the analytical exposition of the Nash equilibrium in tariff rates, characterized by Lemma 2.

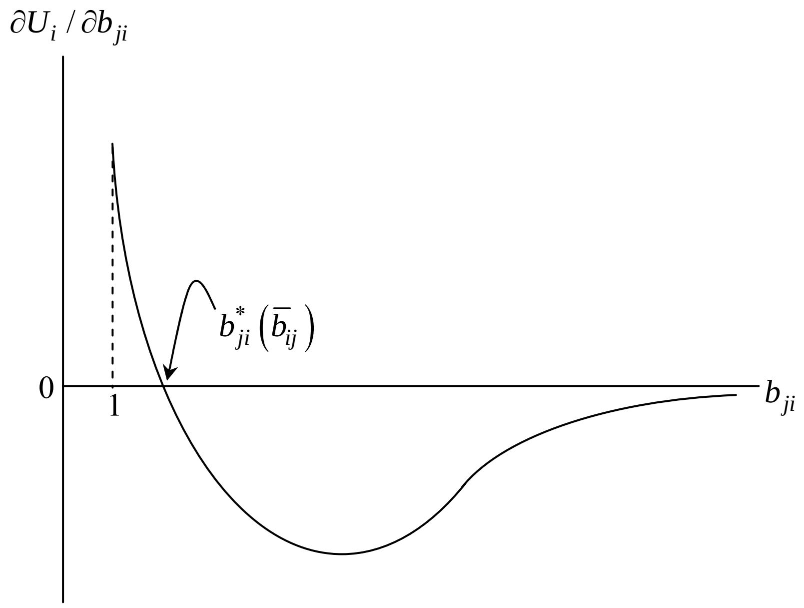

Figure 1: Unique best-response tariff rate $b_{ji} = b^*_{ji}\left(b_{ij}\right)$.

Lemma 2. *Consider* $\varepsilon \geq 2$ *and diversification in production pattern of both economies. Then, there exists a Nash equilibrium in tariff rates* $b^n_{ij} = b^n_{ji} \equiv b^n \in (1, \infty)$.

Proof. See Appendix.

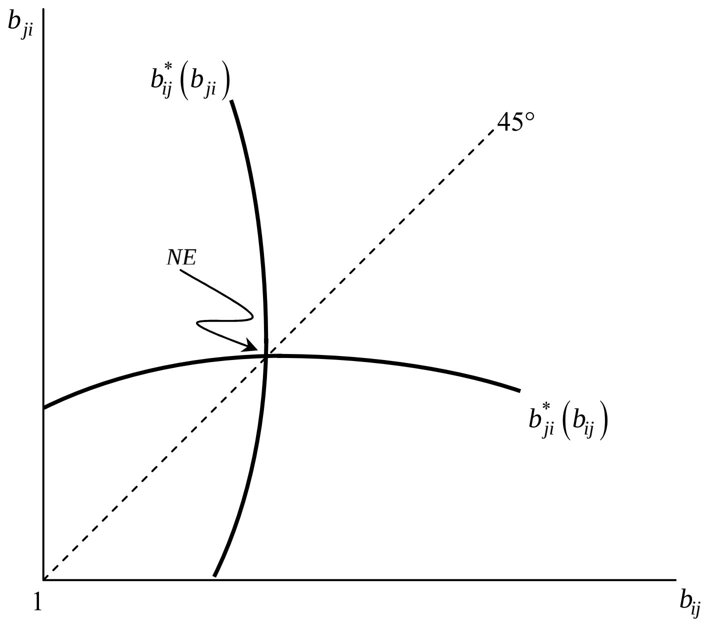

Figure 2: Nash equilibrium in tariff rates

Note that Lemma 2 deals with the *existence* but not *uniqueness* of the Nash equilibrium. Uniqueness is of no interest for our subsequent analysis and a rigorous treatment of it is beyond the scope of the present study. Figure 2 depicts a possible scenario with a unique stable Nash equilibrium in tariff rates.[9]

In any case, it is obvious from Figure 2 (and shown analytically in the Appendix), that the Nash equilibrium is located on the 45°-line. This implies identical tariff rates in the two economies, i.e. $b_{ij}^n = b_{ji}^n = b^n \in (1, \infty)$.

2.3 From Best-Response Tariff-Setting to Free Trade

If *i* and *j* implement a free trade agreement, tariffs fall from b^n to zero.[10] Basically, this has two effects. On the one hand, tariff revenues decline, while on the other hand, imports become cheaper. In general, the respective welfare effects of trade liberalisation may depend on the relative L-endowment of the two economies (even though best-response tariff rates b^n turned out to be independent of *L*). To get insights into the welfare effects, we compare welfare under uncoordinated tariff-setting with welfare under free trade. Since welfare is given by the utility of the representative consumer, we use $b \equiv b_{ji} = b_{ij}$ and evaluate $U_i\big|_{b=b^n}$ ¦ $U_i\big|_{b=1}$.

We first explicitly solve for[11]

$$x_{ii}\big|_{b=b^n} = \frac{\alpha(g-1)(\varepsilon-1)}{\varepsilon} \frac{(1-\lambda)L\left[M\big|_{b=b^n} + \tilde{\lambda} B\big|_{b=b^n}\right]}{\left(B\big|_{b=b^n}\right)^2 - \left(M\big|_{b=b^n}\right)^2}, \tag{13}$$

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[9] The reaction functions in Figure 2 are drawn, according to insights from simulation exercises.

[10] Both countries have an incentive to deviate from a free trade agreement, according to Lemma 1. This implies that free trade requires a binding contract or a supranational institution that enforces the agreement (such as the WTO). As an alternative, Ludema (2002) considers an infinitely repeated game to investigate self-enforcing trade regimes. Of course, we could extend our basic model into this direction. However, the enforcement issue is not in the limelight of interest in the present study. Rather, we analyse the potential gains of trade liberalisation in a setting with multinational firms to get a better understanding of the main driving forces behind bilateral/multilateral agreements on tariff reductions.

[11] Expression (13) is obtained by substituting $b_{ij} = b_{ji} = b^n$ into system (24) in Appendix A.

with $M=(\alpha/\varepsilon)\left[(K-S)+\tau(gS-K)b^{-\varepsilon}\right]$, $B=(1-\alpha/\varepsilon)(g-1)S+(K-S)$ $+\tau(gS-K)\left[(1-\alpha)b^{1-\varepsilon}+\alpha b^{-\varepsilon}\right]$ and $\tilde{\lambda}:=\lambda/(1-\lambda)\text{¦}\ 1$. In a similar way, by setting $b_{ij}=b_{ji}=1$, we obtain

$$x_{ii}\big|_{b=1}=\frac{\alpha(g-1)(\varepsilon-1)}{\varepsilon}\frac{(1-\lambda)L\left[M\big|_{b=1}+\tilde{\lambda}B\big|_{b=1}\right]}{\left(B\big|_{b=1}\right)^{2}-\left(M\big|_{b=1}\right)^{2}}. \tag{14}$$

Moreover, defining

$$\begin{aligned}\beta_0&:=\left\{\frac{h_i+h_j+n_i+n_j\tau\left(b^n\right)^{1-\varepsilon}}{h_i+h_j+n_i+n_j\tau}\right\}^{1+\alpha/(\varepsilon-1)}\\&=\left\{\frac{(g-1)S+(K-S)+\tau(gS-K)\left(b^n\right)^{1-\varepsilon}}{(g-1)S+(K-S)+\tau(gS-K)}\right\}^{1+\alpha/(\varepsilon-1)},\end{aligned} \tag{15}$$

$\phi_n:=\left(M\big|_{b=b^n}+\tilde{\lambda}B\big|_{b=b^n}\right)/\left(M\big|_{b=b^n}+B\big|_{b=b^n}\right)$ and $\phi_1:=\left(M\big|_{b=1}+\tilde{\lambda}B\big|_{b=1}\right)/\left(M\big|_{b=1}+B\big|_{b=1}\right)$, we can conclude that $U_i\big|_{b=b^n}\ \text{¦}\ U_i\big|_{b=1}$ is equivalent to

$$\phi_n\beta_0\left[\left(B\big|_{b=1}\right)-\left(M\big|_{b=1}\right)\right]\text{¦}\ \phi_1\left[\left(B\big|_{b=b^n}\right)-\left(M\big|_{b=b^n}\right)\right], \tag{16}$$

according to (11). Expression (16) can be transformed into

$$\phi_1\left\{\left[\left(B\big|_{b=1}\right)-\left(M\big|_{b=1}\right)-\left(B\big|_{b=b^n}\right)+\left(M\big|_{b=b^n}\right)\right]-\left(1-\beta_0\phi_n/\phi_1\right)\left[\left(B\big|_{b=1}\right)-\left(M\big|_{b=1}\right)\right]\right\}\text{¦}\ 0\ . \tag{17}$$

Substituting for *M* and *B*, we can finally conclude that country *i* benefits from free trade if

$$\begin{aligned}\Phi_i\left(b^n\right)&:=\left(1-\frac{\alpha}{\varepsilon}\right)\left\{\tau(gS-K)\frac{\phi_n}{\phi_1}\beta_0-\left(1-\frac{\phi_n}{\phi_1}\beta_0\right)\left[(g-1)S+(K-S)\right]\right\}\\&\quad-\left[(1-\alpha)\left(b^n\right)^{1-\varepsilon}+\left(\alpha-\frac{\alpha}{\varepsilon}\right)\left(b^n\right)^{-\varepsilon}\right]\tau(gS-K)\le 0\end{aligned}\ . \tag{18}$$

The welfare effects of implementing a free trade agreement are addressed and summarized in Result 1.

Result 1. *Consider* $\varepsilon\ge 2$ *and diversification in the production pattern of both economies, then: a) Full trade liberalisation is the preferred trade regime for symmetric countries. b) If countries differ in their endowments of L, gains from full trade liberalisation are always* *positive for the small trading partner, while the economy with abundant L-supply may lose from the decline in tariff rates.*

Proof. See Appendix.

Result 1 provides our first insights into the role of asymmetries in endowments for possible gains from free trade and contributes to the discussion on gains from trade under imperfect competition with an emphasis on the role of multinational firms. Of particular interest is our result that a *L*-abundant country may lose from a *pari passu* tariff reduction. This confirms the conclusion of Tharakan and Thisse (2002) that "large countries, unlike small ones, should be less inclined towards free trade" (p. 399).[12]

2.4 Trade Liberalisation and the Grubel-Lloyd Index

What about the implications for trade structure? To explore this we use the bias-corrected version of the Grubel-Lloyd index of intra-industry trade developed by Egger et al. (2004). This provides a consistent measure of the intra-industry trade share in the presence of multinational enterprises. With ad-valorem tariffs on industrial goods imports, this index is given by

$$CGLI = \frac{2\varepsilon\tau \min\left[b_{ji}^{-\varepsilon} n_j x_{ii}, b_{ij}^{-\varepsilon} n_i x_{jj}\right]}{\varepsilon\tau\left(b_{ji}^{-\varepsilon} n_j x_{ii} + b_{ij}^{-\varepsilon} n_i x_{jj}\right) + \left|\left(\varepsilon\tau b_{ij}^{-\varepsilon} n_i + h_i\right) x_{jj} - \left(\varepsilon\tau b_{ji}^{-\varepsilon} n_j + h_j\right) x_{ii}\right| - \left|h_i x_{jj} - h_j x_{ii}\right|}, \quad (19)$$

where $\left|\left(\varepsilon\tau n_i + h_i\right) x_{jj} - \left(\varepsilon\tau n_j + h_j\right) x_{ii}\right|$ is *Y*-trade,[13] according to the balance of payment condition. Moreover, $\left|h_i x_{jj} - h_j x_{ii}\right|$ is the balance of repatriated profits for which the denominator of (19) is adjusted, according to the discussion in Egger et al. (2004).

In principle, two scenarios can be distinguished with regard to relative *L*-endowments, namely $L_i < L_j$ (associated with $\tilde{\lambda} < 1$) and $L_i > L_j$ (associated with $\tilde{\lambda} > 1$). However, due to the symmetry of countries in their Nash tariff rates, we can focus on a scenario with $\tilde{\lambda} < 1$,

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[12] Nota bene, Result 1 does not account for side payments which allow to redistribute the gains of trade liberalisation among economies. Such payments increase the likelihood of free trade but may come at the cost of efficiency losses if lump-sum transfers are not available.

[13] By assumption, consumers prefer the home-supplied homogeneous good at identical prices. This implies a unique value of *Y*-trade in the absence of any trade friction for homogeneous goods. Moreover, in (19) consumed quantities (or quantities net of transport costs) of the differentiated goods, i.e. x_{ji}^D and x_{ij}^D, are considered.

implying $x_{ii} < x_{jj}$. (The respective results for a scenario with $\tilde{\lambda} > 1$ are identical.) In the following, we focus on $b \equiv b_{ji} = b_{ij}$. In this case, the Grubel-Lloyd index simplifies to

$$CGLI = \frac{2\varepsilon\tau n x_{ii} b^{-\varepsilon}}{2\varepsilon\tau b^{-\varepsilon} n x_{jj} + h x_{jj} - h x_{ii} - h x_{jj} + h x_{ii}} = \frac{x_{ii}}{x_{jj}}. \tag{20}$$

Differentiating (20) with respect to b, we obtain[14]

$$\begin{aligned}\frac{dCGLI}{db} = -\Big\{&(1-\alpha/\varepsilon)(g-1)S + (1-\alpha)\left[1-(1-1/\varepsilon)b\right](K-S) \\ &+ \quad \tau(gS-K)b^{1-\varepsilon}(1-\alpha)/\varepsilon\Big\}\frac{\left[1-\left(x_{ii}/x_{jj}\right)^2\right]\alpha\tau(gS-K)b^{-\varepsilon-1}}{B^2-M^2}.\end{aligned} \tag{21}$$

From inspection of (21), it is obvious that there exists a unique $\underset{\sim}{b}$, such that $dCGLI/db < 0$ for any $b > \underset{\sim}{b}$, while $dCGLI/db > 0$ for any $b < \underset{\sim}{b}$. Moreover, it is worth noting that $dCGLI/db < 0$ is guaranteed if $b \leq 2$ (which is the relevant domain, when focussing on OECD countries).[15] These insights are summarized in Result 2.

Result 2. *If $\varepsilon \geq 2$ and production is diversified in both economies, we would expect a positive impact of trade liberalisation on the intra-industry trade share (at least if the Nash tariff rates are not too high.)*

Proof. Result 2 follows from the analysis above. ■

Result 2 points to an important trade structure effect of trade liberalisation, which has so far not been rigorously analysed in the empirical literature. Interestingly, the outcome that implementing a free trade agreement raises intra-industry trade flows relative to overall trade flows is robust with respect to the underlying index definition. Even if the correction of Egger et al. (2004) is not applied, the Grubel-Lloyd index is expected to be higher.[16]

[14] For a detailed derivation of (21), see Appendix A.

[15] Use $K - S < (g-1)S$ in (21), to obtain this result.

[16] The uncorrected Grubel-Lloyd index (GLI), as usually applied in empirical research, increases with a *pari passu* decline in tariff rates, whenever the corrected Grubel-Lloyd index (CGLI) increases with such a decline. The formal details are shown in a supplement, available from the authors upon request.

3 Numerical Simulation Analysis

The foregoing results could be challenged on the grounds that they rely on symmetry assumptions for analytical tractability. To get insights in how asymmetries in physical and human capital endowments and differences in the investment cost parameter impact on the results, we undertake numerical simulation exercises. We extend our analysis by allowing for two modifications in the basic model assumptions. First, we consider differences between countries in their endowments of (human and physical) capital. To keep the analysis tractable, we assume $K_i = \mu \bar{K}$, $K_j = (1-\mu)\bar{K}$ and $S_i = \mu \bar{S}$, $S_j = (1-\mu)\bar{S}$, where $\bar{K}$, $\bar{S}$ denote world endowments of physical and human capital, respectively, while $\mu \in (0,1)$ is country *i*'s share of these endowments. Second, we allow for $g_i \neq g_j$ leading to country-specific costs of setting up multinationals. Throughout the simulation exercises, we focus on interior solutions with both exporters and horizontal multinationals being active in equilibrium, which is the empirically relevant case in the context of intra-OECD relations.

Let us first focus on cross-country differences in factor endowments, as indicated by Figure 3.[17] By inspection of Panel (a), we can derive three conclusions: First, greater symmetry in factor endowments make establishment of a free trade agreement more likely. Second, a better endowment of low-skilled labour reduces the potential welfare gains of trade liberalisation.[18] Third, differences in the endowment with (human and physical) capital have a small, negligible impact on the likelihood of a free trade agreement.[19]

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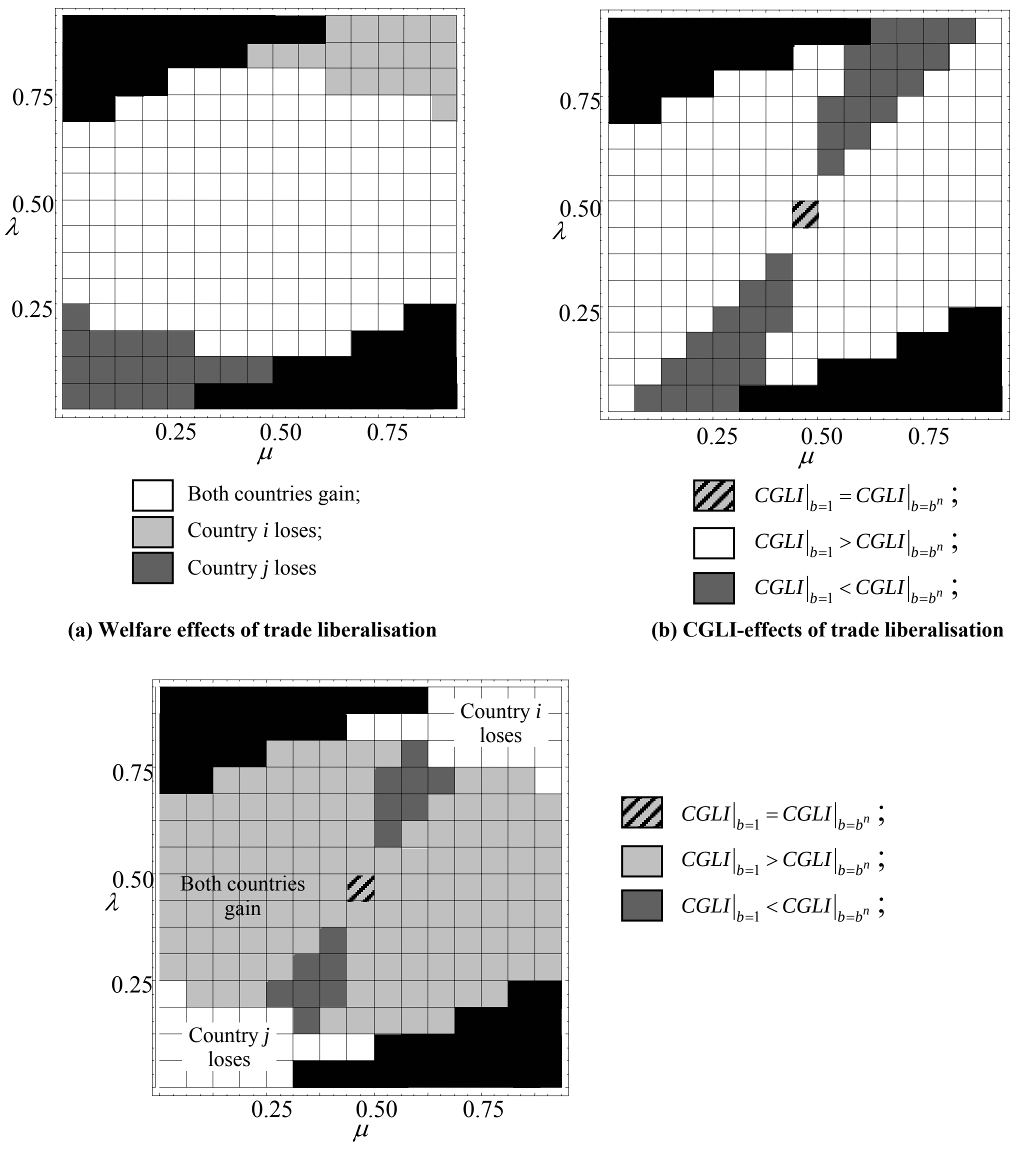
[17] In Figure 3, the following parameter values are considered: $\bar{K}$ =700, $\bar{S}$ =500, $\bar{L}$ =1000, $t = 1.1$, $\alpha = 0.5$, $\varepsilon = 2$, $g_i = g_j = 3.5$, $\mu \in [0.0625, 0.9375]$ and $\lambda \in [0.0625, 0.9375]$. The low value of α is chosen for the purpose of a better graphical exposition. Black colour indicates a parameter domain with perfect specialization in the production pattern of one economy. This parameter domain is of no interest for our analysis, since we focus on diversification in the production pattern.

[18] This confirms Result 1 in Section 2 and is consistent with the idea of home-market effects, most prominently discussed in the literature on new economic geography and the theory of multinational firms.

[19] We have also analysed the impact of transport costs on the gains from trade liberalisation. Thereby, we used identical parameter values as in Figure 3 as a staring point and investigated how a change in transport cost parameter *t* affects the likelihood of a free trade agreement, i.e. we calculated for different values of parameter *t* the share of parameter values that are consistent with a free trade agreement relative to the overall number of parameter values consistent with diversification. Thereby, our focus was on *t*-values in interval $[1.05, 2.1]$. The results of this simulation exercise indicate that there is no monotonous relationship between transport cost parameter *t* and the likelihood of a free trade agreement. For a moderate level of transport costs, a marginal increase of *t* tends to increase the likelihood of a free trade agreement. Opposite effects are triggered if transport costs are sufficiently high.



(a) Welfare effects of trade liberalisation

(b) CGLI-effects of trade liberalisation

(c) Welfare and CGLI-effects of trade liberalisation

Figure 3. Trade liberalisation and factor endowments

With regard to the CGLI-effects, Panel (b) of Figure 3 indicates that a higher asymmetry in overall factor endowments (as represented by the upper right and lower left corner of Panel (b)) makes a positive CGLI-effect of liberalisation less likely. For symmetric countries, i.e., if $\mu = \lambda = 0.5$ and $g_i = g_j$, all trade is intra-industry and the corrected Grubel-Lloyd index is not affected by trade liberalisation. In Panel (c) the results of Panels (a) and (b) are combined.

In a further set of simulations we addressed the interaction of endowment differences and set-up costs of multinationals g_i and associated welfare and trade structure effects of tariff reductions. More specifically, we focus on the interaction between λ and g_i. Restricting the analysis to λ-asymmetries is motivated by the fact that μ-variation alone is unable to explain differences in the likelihood of a free trade agreement (see Panel (a) of Figure 3).

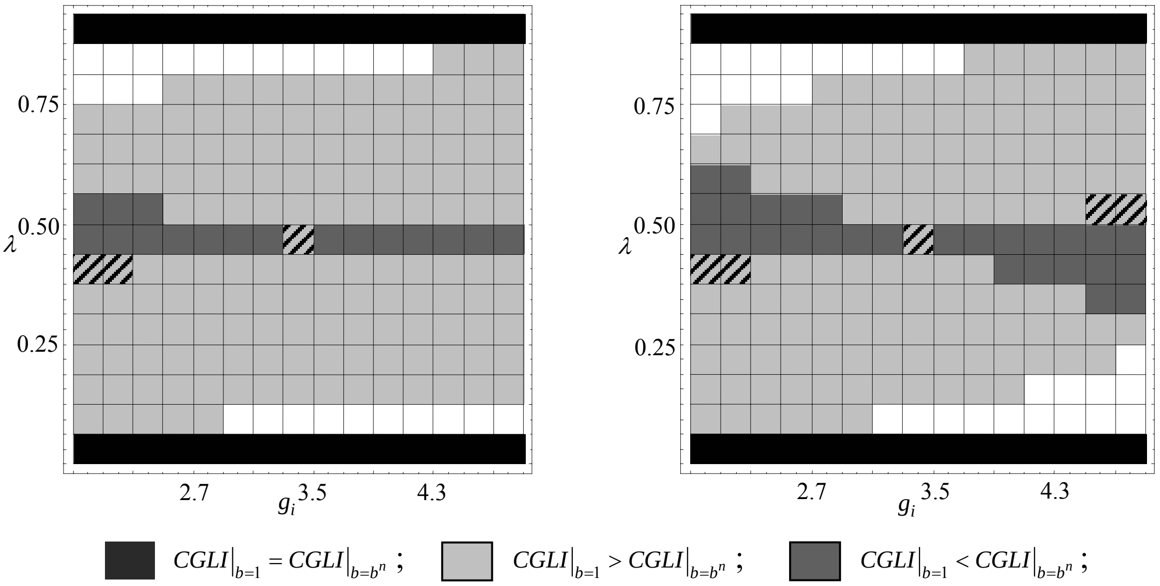


Figure 4. Trade liberalisation and set-up costs of multinational firms[20]

In the left panel of Figure 4, g_i-variation for a given g_j is considered, while in the right a given average level of investment costs is considered, i.e., $g_{av} = 0.5 * g_i + 0.5 * g_j$ is held constant. Therefore, the left panel of Figure 4 has to be interpreted with care, since g_i-variation comprises two effects, an investment cost difference and an investment cost level effect (due to a change in the size of average investment costs g_{av}). Taking "difference" and "level" effects into account, Figure 4 yields the following conclusions. First, greater differences in the endowment of *L* make a free trade agreement less likely, because the *L*-abundant country tends to lose from such an agreement if λ is sufficiently large. However, if multinationals headquartered in the *L*-abundant country face higher investment costs abroad, the positive home market effect is reduced. This renders a free trade agreement more attractive (upper right and lower left corners in Figure 4) and hints at an important interaction between the endowment and investment cost parameters (in spite of a potentially negligible direct effect of g_i, suggested by Figure 4). Second, by comparying the left with the right

[20] The same parameter values as in Figure 3, except of $\mu = 0.5$ and $g_i \in [2.1, 4.9]$. Moreover, $g_j = 3.5$ in the left panel, while $g_{av} = 3.5$ and $g_j = 2g_{av} - g_i$ are considered in the right panel. Black colour indicates that the respective parameter domain is not consistent with diversification in the production pattern, while white colour indicates that in the respective parameter domain the *L*-abundant country loses from a free trade agreement.

panel, we can identify an interesting g-level effect. The higher the average level of investment costs g_{av}, the more likely both countries benefit from a free trade agreement.[21]

With regard to the CGLI implications, we see from Figure 4 that certain g_i-differences can explain a decline in the intra-industry trade share if two countries agree upon bilateral tariff reductions. However, such a decline in the CGLI becomes less likely the higher the asymmetry in L. Anyway, Figures 3 and 4 confirm Result 1, since they show that trade liberalisation in the form of a free trade agreement is likely to increase the intra-industry trade share as measured by the corrected Grubel-Lloyd index in equation (19).

4 Empirical Analysis

Our theoretical model suggests there is endogenous selection into (regional) trade agreement membership. This has been emphasized in previous research on the likelihood of country-pairs participating in a regional trade agreement (Baier and Bergstrand, 2004a) and the consequences of entering such an agreement on bilateral trade volumes (Baier and Bergstrand, 2004b). However, that work derived the empirically implemented specifications from a model without multinationals and focused on overall trade volumes rather than intra-industry trade shares.

Our empirical analysis is focused on the role of trade agreements for bilateral intra-industry trade shares within the OECD, which has several advantages over considering a broader sample of economies. First, trade data and data on trade and investment impediments are generally more reliable. Since our Grubel-Lloyd index variable will be constructed from export data only,[22] reliance on high-quality data is important. Second, country-pair relationships within the OECD that are not characterized by regional trade agreement membership are more likely to form a relevant control group to compare free trade agreement members with.

[21] The likelihood of a free trade agreement is measured by the share of parameter values that are consistent with welfare gains in both economies relative to the overall number of parameter values consistent with diversification.

[22] Egger, Egger and Greenaway (2004) provide a comparison of various Grubel-Lloyd-type measures of intra-industry trade. Their analysis supports the use of a measure that is based on exports only, using data from mirror statistics of developed economies.

4.1 Data

The OECD publishes bilateral export data for 31 reporters at the Standard International Trade Classification, Revision 2, 5-digit level in the International Trade by Commodity Statistics. Data are available from 1960 onwards, but for the early years not all 31 reporters are covered.[23] We compute export-based intra-industry trade shares for each available country-pair and year, using 5-digit data. However, we do not exploit information from all these data. First, the use of consistent annual information on the explanatory variables (physical capital stocks, skilled and low-skilled labour, trade and investment costs) limits our dataset to the period after 1970. Second, for the sake of consistent free trade agreement effects on Grubel-Lloyd indices, we look at differences in the change in intra-industry trade shares between treated (the new members) and untreated (those country pairs that were not members in a given year). This difference-in-difference analysis is able to control for all time-invariant unobserved effects and is most likely to yield consistent free trade area (FTA) parameters after controlling for endogenous selection. However, it is necessary to focus on equal spacing of FTAs in the data set. This means that pre-treatment and post-treatment periods should be of equal length for both the treated and the controls when estimating the FTA effects on the corrected (CGLI) or uncorrected Grubel-Lloyd index (GLI). Thus, we construct a biannual window around the phases where new FTA memberships occur and compare the average annual change in Grubel-Lloyd indices between the treated and the untreated but only for those years where new FTA memberships occur. Such a procedure is necessary to avoid problems associated with autocorrelation in the data[24] (see Bertrand, Duflo and Mulainathan, 2004).

> Table 1 <

Table 1 provides details on 95 new FTA memberships covered by the data, sorted chronologically. Our difference-in-difference set-up requires that we skip all data except those around the five years with new FTA events. Thus we are interested in explaining the selection into new FTAs in 1977, 1981, 1986, 1994, and 1995. Since all new members remained in the respective FTA from the reported year on, we can think of the selection model as a cross-section of new membership events. For this, we include time dummies for all but one of the

[23] A detailed description of the country sample can be found in Appendix B.

[24] e.g., with autocorrelated data, simple fixed effects estimates can be misleading with unequally spaced treatments over time.

five years. In a second step, we construct differences in bilateral Grubel-Lloyd indices (DCGLI for the corrected and DGLI for the uncorrected index) over the periods 1976-1977, 1980-1981, 1985-1986, 1993-1994, and 1994-1995.

> Table 2 <

Table 2 reports the descriptive statistics for the explanatory variables in the selection model. In general, we rely on lagged levels that are assumed predetermined to explain (the switch into) new FTA membership. The definition of all variables is given in Table 2. The basic variables (GLI, GDP, L, H, K, TC, IC, Dut) and their sources are listed in Table A1 in the Appendix.

4.2 Selection Into FTA Membership

Throughout we assume that the difference in intra-industry trade shares between actual FTA members and control country-pairs is fully attributable to FTA membership.[25] Hence, selection is entirely due to observables such as the endowment and trade and investment cost parameters in our theoretical model. To estimate the effect of FTA membership on GLI, we need to determine which observables selection depends on. Since FTA membership is captured by a dummy variable, we face the problem of selection into a binary treatment. One way to eliminate the bias from selection due to observables is through matching.[26] The basic idea is to overcome selection bias by selecting treated and control observations with similar covariates. Since it is impractical to match directly on many covariates due to the "curse of dimensionality", multiple covariates are typically mapped into a scalar through some metric. The most commonly used, unit-free metrics for matching are the Mahalanobis distance metric (Cochran and Rubin, 1973, Rosenbaum and Rubin, 1985, Rosenbaum, 1995) and the propensity score metric (Rosenbaum and Rubin, 1983, 1984).

The Mahalanobis metric weights each coordinate of the matrix of covariates proportionately by the inverse variance of that variable. With propensity score matching, treatment selection

[25] In the statistical and econometric literature, this is referred to as unconfoundedness, selection on observables, or the conditional independence assumption (see Imbens, 2004, for an excellent survey).
[26] Other possibilities are estimating the unknown regression functions of the outcome (in our case, the change in GLI) on the covariates (e.g., Heckman, Ichimura, and Todd, 1998) or weighting (e.g., Hirano, Imbens, and Ridder, 2001), and various combinations of these and the matching estimation techniques (e.g., Abadie and Imbens, 2004).

is specified by either a logit or a probit model, starting with a latent variable model of the form

$$RTA^{*} = \mathbf{x\beta} + e, \quad RTA = 1[RTA^{*} > 0] \tag{22}$$

where e is a continuously distributed error term symmetric about zero and independent of $\mathbf{x}$, the vector of explanatory variables. The probability model to be estimated can be written as

$$P(RTA = 1 \mid \mathbf{x}) = P(RTA^{*} > 0 \mid \mathbf{x}). \tag{23}$$

Below, we estimate both probit and logit models to estimate parameter vector $\boldsymbol{\beta}$. These models provide us with estimates of the propensity score p($\mathbf{x}$). Based on these scores, one is able to construct an appropriate control group, which is essential to estimating treatment effects with matching estimators. Estimated propensity scores $\hat{\mathrm{p}}(\mathbf{x})$ can be used to determine the similarity between treated and untreated units. One or more of the most similar untreated observations for each treated one serve to form the control group. For this approach, it is important to estimate the selection model with a good fit. Otherwise, small sample bias can be important (see Frölich, 2004).

> Table 3 <

Table 3 summarizes the results of various probit model specifications of new FTA membership. In Probits 1-5, we use a common trend and in 6-10 we include time dummies.[27] In Probits 1 and 6, we estimate a specification that uses size and factor endowment variables of the same functional form as Helpman (1987), who estimates the determinants of trade structure. In this case, similarity of countries in factor endowments and overall economic capacity is measured by a single variable, namely the similarity of bilateral GDP. This variable has a positive sign in all specifications and confirms our theoretical insight that higher endowment similarity makes an establishment of an FTA more likely.

In Probits 2-5 and 7-10, we employ similarity indices of all three factors. As expected from our theoretical analysis, higher symmetry in the endowment of low-skilled labour makes an FTA-formation more attractive. Also the insignificant coefficient of human capital is consistent with the negligible (human and physical) capital effect identified in the simulation

[27] We also could have used logit models instead of probits to estimate the propensity score. However, Davidson and MacKinnon (2004) suggest to test probit and logit against each other based on a likelihood ratio test. According to the test statistics summarized in Table 3, Logits 1 and 2 and Logits 6 and 7 reported in Table A2 in the Appendix are rejected against their probit counterparts in Table 3. The other logits perform as well as their probit counterparts.

analysis of Section 3. In contrast, the negative (physical) capital coefficient cannot be explained by our theoretical model.[28]

The bilateral trade cost variable tends to have a negative impact on the probability of joining an FTA (see Probit 1-4 and 6-9). This result is supported by our simulation results only if the level of transport costs is sufficiently high (see Footnote 19). However, the finding is consistent with the argument in Ludema (2002, p. 336) that "geographical proximity facilitates trade policy coordination". Interestingly, when accounting for interaction terms between endowment variables and bilateral transport costs the latter effect becomes insignificant (see Probit 5 and Probit 10).

Motivated by our theoretical results that both the average size of and absolute difference in bilateral investment costs should impact on the attractiveness of establishing an FTA, we separate the "level" from the pure "difference" effect. Although the positive coefficient of the "absolute difference in bilateral investment costs" is somewhat surprising, our theoretical analysis lends support on both the positive coefficient of "average bilateral investment costs" and the positive coefficient of the interaction term between low-skilled labour endowment similarity and the investment cost ratio (Probits 4,5 and 9,10).[29]

Finally, we included duties as a separate control variable. From our model, we know that the size of Nash tariff rates depend on factor endowments, transport costs and investment costs. But other factors may impact on the size of duties. Insofar as these channels are important, a correct econometric specification compels us to control for pre-FTA duties (in addition to the other exogenous variables). The negative sign of the respective coefficients may, therefore, be an indicator that higher duties are associated with a more negative attitude towards bilateral trade liberalisation.

[28] Similarity of pooled factor endowments (instead of each factor endowment separately) in a specification that is in all other espects equal to Probit 9 (our preferred specification, as argued below) exhibits a positive coefficient. This holds true, irrespective of whether factor price weights, i.e. similarity in GDP, or equal weigths are used and supports our theoretical hypotheses of Sections 2 and 3.

[29] We have also estimated specifications that included an interaction term between the similarity in capital endowment and the investment costs of country *i* relative to *j*. As expected from our discussion above Figure 4, the respective coefficient turned out to be insignificant.

Since Probit 9 performs best in terms of explanatory power, it is a natural candidate to rely on for matching.[30] Many of the significant parameters are only supported by a model of multinational firms. This points to the relevance of our theoretical model for empirical trade analysis. MacFadden's Pseudo R^2 indicates that the explanatory power of the model is high. In addition, we note that the null hypothesis of the similarity of the samples of the treated and the control observations with respect to the separate controls is not rejected (see Table A3 in the Appendix). Hence, there is no indication of a violation of the balancing property which suggests that the propensity score metric is an unbiased measure of the similarity between our treated and control units.

4.3 Effect of FTA Membership on the Intra-Industry Trade Share

The number of matched control units is either exogenously imposed (in k-nearest neighbour matching estimators which the frequently used one-to-one matching estimator belongs to) or a critical interval is determined with all unmatched pairs in the corresponding region around a treated observation's propensity score selected in the control group. Some estimators even use a large amount or all untreated units as controls but their weight depend on the distance to the propensity score from the respected treated unit's. Typically, applications of matching estimators focus on the average treatment effect of the treated (ATT). In our case, this is the average effect of new FTA membership on the change in the Grubel-Lloyd index, conditional on countries actually having entered an FTA. The average treatment effect (ATE) is a weighted average of the average treatment effect of the treated and untreated. In contrast to ATT, ATE does not condition on actual entry into an FTA.

Propensity score matching relies on the similarity in propensity scores among the target and matched source observations. We typically observe that high explanatory power in the selection equation can only be achieved with a sufficiently large set of controls. A large number of covariates is problematic however, since matching estimators include a bias term of stochastic order $N^{-1/k}$ with k denoting the number of covariates. To overcome this Abadie and Imbens (2004) suggest a bias-correction that renders a $N^{1/2}$-consistent and asymptotically normal matching estimator. Since propensity score matching requires similarity in each variable in $\mathbf{x}$, even smaller differences in the covariates between the treated and the control

[30] It should also be noted that Probit 6-10 (and, similarly, Probit 2-5) can be tested against each other based on likelihood ratio tests. For instance, Probits 6-8 are rejected against Probit 9, whereas Probit 9 is not rejected

group can lead to biased matching estimates. In this regard, Blundell and Costa Dias (2002) suggest, in the second step, conditioning on those elements of **x** for which the balancing property is violated[31]. In our case, the balancing property is not violated according to t-tests as can be seen from Table A3. Hence, this concern should be of minor importance, but we still can eliminate any remaining differences by conditioning on the covariates.

Table 4 summarizes the findings of descriptive comparison estimates and several matching estimates of ATT. The descriptive comparison is simply an OLS regression of DCGLI and DGLI on FTA. The first two matching estimates – a one-to-one matching and a 5-nearest neighbour matching – rely on the Mahalanobis distance metric. These estimates are bias-corrected as suggested by Abadie and Imbens (2004). The others are based on the propensity score: one-to-one matching, 5-nearest neighbour matching, radius matching, and kernel matching.

ATT with one-to-one matching is equivalent to running a weighted least squares regression of DCGLI and DGLI on FTA where a weight of one is assigned to all treated and control units and zero to all untreated observations. Hence, there are as many control observations as treated ones. This may involve a dramatic decline in the number of observations to estimate ATT. Accordingly, the quality of one-to-one matching comes at the cost of a loss in efficiency. This shortcoming is overcome by matching more than just one – in our case five – nearest neighbours on each treated. This assigns the same weight to each of the five nearest untreated observations regardless of how close they are in terms of their propensity score. This can be improved by determining a radius around each treated country pair's propensity score. In our case, we choose a radius of 0.1 within that untreated pairs would be selected into the control group. This implies an endogenous number of matched controls for each treated unit. Accordingly, the treated will differ in terms of the number of matched controls. Finally, kernel density matching assigns weights that decline in the propensity score difference of the target observation to the controls. In general, one-to-one matching, k-nearest neighbour matching or kernel matching is consistent, since the local neighbourhood of the propensity score for a target observation declines with sample size (see Frölich, 2004). In small samples, the efficiency loss with one-to-one matching or the bias from less exact matching can be serious.

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against Probit 10 at the 10% significance level.

> Table 4 <

We apply each matching approach and, additionally, the descriptive comparison as the benchmark estimator to two different concepts of the intra-industry trade share index. These alternative concepts are the preferable index that is corrected for multilaterally imbalanced trade (Bergstrand, 1983) due to the activity of MNEs (see Egger, Egger and Greenaway, 2004) and, alternatively, the uncorrected Grubel-Lloyd index.

The findings can be summarized as follows. First, for our difference-in-difference analysis it seems of minor importance whether the corrected or uncorrected index is used. The reason for this is probably that the average annual change in CGLI is small as it is for multilateral trade imbalances. Second, the descriptive comparison estimates that ignore selection on observables point to a positive impact on either index of about 1.6 percentage points. Third, ignoring self-selection into FTA membership leads to a downward-biased estimate of the impact on either index. Depending on the matching estimator, this downward bias is estimated at between 35% (kernel matching) and 67% (bias-adjusted one-to-one matching on observables). Since the number of covariates is relatively large, this could affect the quality of the propensity score estimates. The bias-adjusted Mahalanobis metric-based estimates might be more trustworthy in our application. However, the 5-nearest neighbour matching on covariates leads to ATT estimates that are quite similar to those of the propensity score matching estimators. Knowing from Table 2 that the change in the two intra-industry trade share indices was about zero on average within the covered time span, the impact of FTA membership seems quantitatively important, amounting to at least 25% of the corrected index. This significantly positive effect is perfectly consistent with both insights from the analytical model and findings from our simulation exercises.

4.4 Robustness

We can evaluate the robustness of our findings with respect to (i) the specification of the selection equation, (ii) a bias-adjusted matching approach based on the Mahalanobis metric that uses a different set of explanatory variables as in the selection models of Table 3, (iii) the

[31] i.e., running a weighted least squares model of DCGLI and DGLI on FTA that includes the critical covariates of the probit for which the balancing property does not hold.

use of probit versus logit models (a logit will only be used if it is not rejected against the probit counterpart in Table 3, see Footnote 27), and (iv) block matching as an alternative to the methods used in the previous subsection.

> Table 5 <

Table 5 investigates these when using the change in the trade-imbalance-corrected index (DCGLI) as the outcome variable[32]. In general, we can conclude that the ATT estimates are very robust to model specification. ATT is insignificant only if relevant observables are not controlled for in the case of one-to-one matching. This holds true for underspecified Mahalanobis metric based estimates. However, in propensity score metric based matching Logit 8 is rejected against Logit 9 (and Probit 9).

Using block matching instead of nearest-neighbour, radius, or kernel matching, leads to very similar results. The variation in ATT across propensity-metric-based matching estimators is considerably smaller than that of ATT across selection models. However, based on likelihood ratio tests Probits 1-8 (and Logits 1-8) are significantly rejected against Probit 9. Due to the possible relevance of a bias-correction in our sample, the two Mahalanobis-metric-based estimators in the spirit of Abadie and Imbens (2004) might be most reliable among those applied in our case.

> Table 6 <

One question remains. Is the treatment effect of the untreated (ATU) – i.e., the FTA effect that would arise from a hypothetical membership of the actual non-members – different from ATT? This can be implicitly answered by looking at the resulting average treatment effect (ATE), which is a weighted average of ATT and ATU. The results for the preferred, bias-adjusted, nearest neighbour matching estimators are summarized in Table 6. Obviously, ATU is bigger than ATT, because ATE is bigger than ATT. This indicates that country-pairs with below-average annual growth in CGLI (and also GLI) are more likely to select into FTA membership than other country-pairs. However, the main result of downward-biased ATT estimates from ignoring selection on observables extends to ATE. For ATE an even bigger downward bias is detected than for ATT.

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[32] The corresponding results for the uncorrected DGLI are very similar and summarized in Table A4 of the Appendix

5 Conclusions

A great deal of progress has been made in recent years in the simultaneous modelling of the determinants of trade and cross-border investment. In turn this has helped us to better understand the welfare implications of trade liberalisation in a world with multinational enterprises. This paper contributes to that literature in several ways. We have built a general equilibrium model of trade and tariff-jumping FDI, with trade liberalisation modelled as an endogenous process. A novel feature of our model is the explicit analysis of intra-industry trade and the specific prediction of an increase in intra-industry trade shares following liberalisation. We further enriched the outputs of our analysis by conducting complementary simulation analysis, which focused in particular on the role of differences in factor endowments and investment costs.

We then went on to test our model's prediction, in a framework accounting for endowments, trade costs and investment costs, on a large sample of OECD liberalisation events. The determinants and consequences of these events were then investigated using matching analysis and difference-in-difference methods. We found that trade liberalisation leads to a non-negligible increase in the intra-industry trade share, irrespective of whether we use the standard Grubel and Lloyd index or our own index, which adjusts for the effects of multinational activity on trade imbalances. We show that failure to correct for self-selection into FTAs is associated with a very large downward bias in the trade share effects. Once one corrects for this using matching, the impact of FTA membership becomes substantial, amounting to around 25 percent of the recorded increase in intra-industry trade. These results are robust to changes in the selection equation and matching method deployed.

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Appendix

A. Analytical Appendix

Throughout the analytical Appendix, we focus on the case of diversification in the production pattern of the two economies.

Proof of Lemma 1

Let us first determine $\partial x_{ii} / \partial b_{ji} \times b_{ji} / x_{ii}$. Therefore, substitute (6)-(10) into the definitions of E_i, P_i. Then, it follows from (2) and (3) that x_{ii} and x_{jj} are implicitly given by system

$$\begin{aligned} \Gamma_i\left(b_{ji}, b_{ij}\right) &:= \frac{\alpha}{\varepsilon} \frac{\left[(K-S)+\tau(gS-K)b_{ij}^{-\varepsilon}\right]x_{jj} + (g-1)(\varepsilon-1)\lambda\bar{L}}{B_j} - x_{ii} \equiv 0 \\ \Gamma_j\left(b_{ji}, b_{ij}\right) &:= \frac{\alpha}{\varepsilon} \frac{\left[(K-S)+\tau(gS-K)b_{ji}^{-\varepsilon}\right]x_{ii} + (g-1)(\varepsilon-1)(1-\lambda)\bar{L}}{B_i} - x_{jj} \equiv 0 \end{aligned}, \quad (24)$$

with

$$\begin{aligned} B_j &= (1-\alpha/\varepsilon)(g-1)S + (K-S) + \tau(gS-K)\left[b_{ji}^{1-\varepsilon}(1-\alpha) + \alpha b_{ji}^{-\varepsilon}\right] \\ B_i &= (1-\alpha/\varepsilon)(g-1)S + (K-S) + \tau(gS-K)\left[b_{ij}^{1-\varepsilon}(1-\alpha) + \alpha b_{ij}^{-\varepsilon}\right] \end{aligned}. \quad (25)$$

Totally differentiating system (24) with respect to b_{ji}, we obtain

$$\begin{aligned} \frac{\partial \Gamma_i}{\partial x_{ii}} \frac{dx_{ii}}{db_{ji}} + \frac{\partial \Gamma_i}{\partial x_{jj}} \frac{dx_{jj}}{db_{ji}} &= -\frac{\partial \Gamma_i}{\partial b_{ji}} \\ \frac{\partial \Gamma_j}{\partial x_{ii}} \frac{dx_{ii}}{db_{ji}} + \frac{\partial \Gamma_j}{\partial x_{jj}} \frac{dx_{jj}}{db_{ji}} &= -\frac{\partial \Gamma_j}{\partial b_{ji}} \end{aligned}. \quad (26)$$

Applying Cramer's rule to system (26), yields

$$\frac{dx_{ii}}{db_{ji}} = \frac{\partial \Gamma_i / \partial b_{ji} + \partial \Gamma_j / \partial b_{ji} \times \partial \Gamma_i / \partial x_{jj}}{1 - \partial \Gamma_i / \partial x_{jj} \times \partial \Gamma_j / \partial x_{ii}}, \quad (27)$$

$$\frac{dx_{jj}}{db_{ji}} = \frac{\partial \Gamma_j / \partial b_{ji} + \partial \Gamma_i / \partial b_{ji} \times \partial \Gamma_j / \partial x_{ii}}{1 - \partial \Gamma_i / \partial x_{jj} \times \partial \Gamma_j / \partial x_{ii}}. \quad (28)$$

Moreover using partial derivatives

$$\frac{\partial \Gamma_i}{\partial x_{jj}} = \frac{\alpha}{\varepsilon} \frac{(K-S)+\tau(gS-K)b_{ij}^{-\varepsilon}}{B_j}, \quad \frac{\partial \Gamma_j}{\partial x_{ii}} = \frac{\alpha}{\varepsilon} \frac{(K-S)+\tau(gS-K)b_{ji}^{-\varepsilon}}{B_i},$$

$$\frac{\partial \Gamma_i}{\partial b_{ji}} = \frac{x_{ii}}{b_{ji}} \frac{\tau(gS-K)\left[(\varepsilon-1)(1-\alpha)b_{ji}^{1-\varepsilon} + \alpha\varepsilon b_{ji}^{-\varepsilon}\right]}{B_j}, \quad \frac{\partial \Gamma_j}{\partial b_{ji}} = -\frac{x_{ii}}{b_{ji}} \frac{\alpha\tau(gS-K)b_{ji}^{-\varepsilon}}{B_i}.$$

in (27), we obtain

$$\frac{dx_{ii}}{db_{ji}} = \frac{x_{ii}}{b_{ji}} \frac{\tau(gS-K)\left[(1-\alpha)(\varepsilon-1)b_{ji}^{1-\varepsilon} + \alpha\left(\varepsilon - R_i\left(b_{ij}\right)\right)b_{ji}^{-\varepsilon}\right]}{\left(1-\frac{\alpha}{\varepsilon}\right)(g-1)S + (K-S)\left(1-\frac{\alpha}{\varepsilon}R_i\left(b_{ij}\right)\right) + \tau(gS-K)\rho_i\left(b_{ji},b_{ij}\right)}, \tag{29}$$

with $R_i\left(b_{ij}\right) := \partial\Gamma_i / \partial x_{jj} \times B_j / B_i$ and $\rho_i\left(b_{ji},b_{ij}\right) := \left[(1-\alpha)b_{ji}^{1-\varepsilon} + \left(\alpha - \frac{\alpha}{\varepsilon}R_i\left(b_{ij}\right)\right)b_{ji}^{-\varepsilon}\right]$.

Substituting (29) into (12) and using (10), gives

$$\frac{\partial U_i}{\partial b_{ji}} = \frac{U_i\tau(gS-K)}{b_{ji}^{\varepsilon}} \times \left\{ \underbrace{\frac{\left[(\varepsilon-1)(1-\alpha) + b_{ji}^{-1}\alpha\left(\varepsilon - R_i(\cdot)\right)\right]}{\left(1-\frac{\alpha}{\varepsilon}\right)(g-1)S + (K-S)\left(1-\frac{\alpha}{\varepsilon}R_i(\cdot)\right) + \tau(gS-K)\rho_i\left(b_{ji},b_{ij}\right)}}_{:=\chi_i^1\left(b_{ji},b_{ij}\right)} - \underbrace{\frac{(\varepsilon-1+\alpha)}{(g-1)S + (K-S) + \tau(gS-K)b_{ji}^{1-\varepsilon}}}_{:=\chi_i^2\left(b_{ji}\right)} \right\}. \tag{30}$$

We can note that x_{ii} exhibits a finite positive value for any $b_{ji}, b_{ij} \geq 1$, according to system (24). Moreover, considering some $b_{ij} = \overline{b}_{ij} \geq 1$, it can be deduced from (11) that $U_i\tau(gS-K)/b_{ji}^{\varepsilon} > 0$, for any $b_{ji} \in [1,\infty)$, and $\lim_{b_{ji}\to\infty} U_i\tau(gS-K)/b_{ji}^{\varepsilon} = 0$. Hence, as long as $b_{ji} \in [1,\infty)$, it follows from (30) that $\partial U_i(\cdot)/\partial b_{ji} = 0$ can only hold if $\chi_i\left(b_{ji},b_{ij}\right) := \chi_i^1\left(b_{ji},b_{ij}\right) - \chi_i^2\left(b_{ji}\right) = 0$. As a consequence, we can focus on the properties of $\chi_i\left(b_{ji},b_{ij}\right)$ in the following analysis.

With regard to the properties of $\chi_i\left(b_{ji},b_{ij}\right)$, note first that

$$\lim_{b_{ji}\to\infty}\chi_i\left(b_{ij},b_{ji}\right)=\frac{(\varepsilon-1)(1-\alpha)}{\left(1-\frac{\alpha}{\varepsilon}\right)(g-1)S+(K-S)\left(1-\frac{\alpha}{\varepsilon}R_i(\cdot)\right)}-\frac{\varepsilon-1+\alpha}{(g-1)S+(K-S)} \tag{31}$$

is negative.

Second, use

$$\lim_{b_{ji}\to 1}\chi_i\left(b_{ji},b_{ij}\right)=\frac{\varepsilon-1+\alpha\left(1-R_i(\cdot)\right)}{(1-\alpha/\varepsilon)(g-1)S+\left[1-(\alpha/\varepsilon)R_i(\cdot)\right]\left[(K-S)+\tau(gS-K)\right]}-\frac{(\varepsilon-1+\alpha)}{(g-1)S+(K-S)+\tau(gS-K)} \tag{32}$$

to see that $\lim_{b_{ji}\to 1}\chi_i\left(b_{ji},b_{ij}\right)>0$ if $\left[(\varepsilon-1)/\varepsilon+\alpha/\varepsilon-R_i(\cdot)\right](g-1)S$ $-R_i(\cdot)\left[(1-\alpha)/\varepsilon\right]\left[(K-S)+\tau(gS-K)\right]>0$. However, since $R_i\left(b_{ij}\right)<\alpha/\varepsilon$ holds for any $b_{ij}\geq 1$,

$$(\varepsilon-1)(g-1)S-\left[(1-\alpha)\alpha/\varepsilon\right]\left[(K-S)+\tau(gS-K)\right]\geq 0 \tag{33}$$

turns out to be sufficient for $\lim_{b_{ji}\to 1}\chi_i\left(b_{ji},b_{ij}\right)>0$. It is worth noting that there exists a unique $\underline{\varepsilon}(\alpha,t,g,K,S)>1$ such that (33) is fulfilled with strict inequality if $\varepsilon>\underline{\varepsilon}(\cdot)$, while it holds with strict equality if $\varepsilon=\underline{\varepsilon}(\cdot)$. Moreover, considering $(K-S)+\tau(gS-K)<2(g-1)S$ and $(1-\alpha)\alpha\leq 0.25$ in (33), we can conclude that $\underline{\varepsilon}(\cdot)<2$. Hence, if $\varepsilon\geq 2$, our analysis so far proves that, for any $b_{ij}=\overline{b}_{ij}\geq 1$, there exist some $b_{ji}\in(1,\infty)$, such that $\chi_i(\cdot)=0$. This is a direct consequence of $\lim_{b_{ji}\to 1}\chi_i(\cdot)>0$, $\lim_{b_{ji}\to\infty}\chi_i(\cdot)<0$ and the fact that $\chi_i(\cdot)$ is continuous in b_{ji}. (This is taken into account below.)

Third, differentiating $\chi_i\left(b_{ji},b_{ij}\right)$ with respect to b_{ji} and evaluating the respective expression at a pair of tariff rates $\left(b_{ji},b_{ij}\right)$ that guarantees $\chi_i(\cdot)=\chi_i^1(\cdot)-\chi_i^2(\cdot)=0$, we obtain

$$\frac{\partial\chi_i\left(b_{ji},b_{ij}\right)}{\partial b_{ji}}=\left[\frac{\alpha b_{ji}^{-\varepsilon}\tau(gS-K)}{\varepsilon-1+a}\chi_i^2(\cdot)-\frac{b_{ji}^{-2}\alpha\left(\varepsilon-R_i(\cdot)\right)}{(\varepsilon-1)(1-\alpha)+\alpha\left(\varepsilon-R_i(\cdot)\right)b_{ji}^{-1}}\right]\chi_i^1(\cdot), \tag{34}$$

Using the definition of $\chi_i^2\left(b_{ji}\right)$, according to (30), and rearranging terms in (34), we can write

$$\frac{\partial\chi_i\left(b_{ji},b_{ij}\right)}{\partial b_{ji}}=\Bigg\{\tau\left(gS-K\right)\left[\left(\varepsilon-1\right)\left(1-\alpha\right)\left(b_{ji}^{2-\varepsilon}-b_{ji}^{1-\varepsilon}\right)-\left(1-\alpha\right)\left(1-R_i\left(\cdot\right)\right)b_{ji}^{1-\varepsilon}\right] \\ -\left(\varepsilon-R_i\left(\cdot\right)\right)\left[\left(g-1\right)S+\left(K-S\right)\right]\Bigg\}\times T_i\left(b_{ji},b_{ij}\right) \tag{35}$$

with

$$T_i\left(b_{ji},b_{ij}\right):=\frac{\alpha b_{ji}^{-2}\chi_i^1\left(b_{ji},b_{ij}\right)}{\left[\left(\varepsilon-1\right)\left(1-\alpha\right)+\alpha\left(\varepsilon-R_i\left(\cdot\right)\right)b_{ji}^{-1}\right]\left[\left(g-1\right)S+\left(K-S\right)+\tau\left(gS-K\right)b_{ji}^{1-\varepsilon}\right]} \tag{36}$$

Noting $\left(\varepsilon-R_i\left(\cdot\right)\right)-\left(1-\alpha\right)\left(\varepsilon-1\right)=\alpha\left(\varepsilon-1\right)+\left(1-R_i\left(\cdot\right)\right)>0$ and $\left(g-1\right)S>\tau\left(gS-K\right)$ it can be shown that the expression in (35) has a negative sign if $\varepsilon\geq 2$ (implying $b_{ji}^{2-\varepsilon}-b_{ji}^{1-\varepsilon}<1$). Hence, $\partial\chi_i\left(\cdot\right)/\partial b_{ji}<0$ if evaluated at a pair of tariff rates that guarantees $\chi_i\left(\cdot\right)=0$.

Summing up, $\varepsilon\geq 2$ guarantees, for any $b_{ij}\geq 1$, a *unique* best-response tariff rate $b_{ji}=b_{ji}^*\left(b_{ij}\right)$, which is in interval $\left(1,\infty\right)$ and implicitly determined by $\chi_i\left(b_{ji},b_{ij}\right)=0$ (see Figure 1 for a graphical representation). ■

<u>Proof of Lemma 2.</u>

Remember that $\chi_i\left(b_{ji},b_{ij}\right)\equiv 0$, according to (30), implicitly determines reaction function $b_{ji}=b_{ji}^*\left(b_{ij}\right)$ if $\varepsilon\geq 2$, which is considered below. The proof is organized in two steps.

First, use $\lim_{b_{ij}\to 1}b_{ji}^*\left(b_{ij}\right)>1$ and $\lim_{b_{ij}\to\infty}b_{ji}^*\left(b_{ij}\right)<\infty$ and note that (best-response) reaction functions $b_{ji}=b_{ji}^*\left(b_{ij}\right)$, $b_{ij}=b_{ij}^*\left(b_{ji}\right)$ are continuous in their arguments. Then, there must be some $b_{ij}=\overline{b}_{ij}\in\left(1,\infty\right)$ such that $b_{ji}^*\left(\overline{b}_{ij}\right)=\overline{b}_{ij}$. In analogy, there must be some $b_{ji}=\overline{b}_{ji}\in\left(1,\infty\right)$ such that $b_{ij}^*\left(\overline{b}_{ji}\right)=\overline{b}_{ji}$. (Graphically, this means that reaction functions intersect in Figure 2.) Second, it follows from the proof of Lemma 1 that best-response tariff setting of the two economies is symmetric if countries only differ in their endowments with factor L, i.e. λ-variation does not impact on the best-response tariff rate $b_{ji} = b_{ji}^*\left(b_{ij}\right)$ ($b_{ij} = b_{ij}^*\left(b_{ji}\right)$) for a given foreign rate $b_{ij} \geq 1$ ($b_{ji} \geq 1$, respectively). This guarantees existence of a Nash equilibrium with $b^n = b_{ji} = b_{ij}$ and completes the proof of Lemma 2. (Indeed, the symmetry in best-response tariff-setting implies that reaction functions are mirrored at the 45°-line in Figure 2, such that a point of intersection must lie at this line.) ■

Proof of Result 1.

Let us first focus on the case of full symmetry with $\phi_n = \phi_1$. We define

$$\begin{aligned}\Phi_i^{FS}\left(b^n\right) &:= \Phi_i\left(b^n\right)\Big|_{\lambda=0.5} \\ &= (1-\alpha/\varepsilon)\left\{\tau(gS-K)\beta_0 - (1-\beta_0)\left[(g-1)S+(K-S)\right]\right\} \\ &\quad -\left[(1-\alpha)\left(b^n\right)^{1-\varepsilon} + (\alpha-\alpha/\varepsilon)\left(b^n\right)^{-\varepsilon}\right]\tau(gS-K)\end{aligned}, \tag{37}$$

according to (18). In view of (37), we can calculate $\lim_{b^n \to 1} \Phi_i^{FS}\left(b^n\right) = 0$. Moreover, since Φ_i^{FS} is increasing in β_0, we can substitute

$$\tilde{\beta}_0 := \beta_0^{(\varepsilon-1)/(\varepsilon-1+\alpha)} = \frac{(g-1)S+(K-S)+\tau(gS-K)\left(b^n\right)^{1-\varepsilon}}{(g-1)S+(K-S)+\tau(gS-K)},$$

according to (15), for β_0 in (37) and obtain

$$\begin{aligned}\tilde{\Phi}_i^{FS}\left(b^n\right) &:= (1-\alpha/\varepsilon)\left\{\tau(gS-K)\tilde{\beta}_0 - \left(1-\tilde{\beta}_0\right)\left[(g-1)S+(K-S)\right]\right\} \\ &\quad -\left[(1-\alpha)\left(b^n\right)^{1-\varepsilon} + (\alpha-\alpha/\varepsilon)\left(b^n\right)^{-\varepsilon}\right]\tau(gS-K)\end{aligned}. \tag{38}$$

Since $\lim_{b^n \to \infty} \tilde{\Phi}_i^{FS}\left(b^n\right) = 0$, we can conclude $\lim_{b^n \to \infty} \Phi_i^{FS}\left(b^n\right) < 0$. Finally, using

$$\begin{aligned}\frac{d\Phi_i^{FS}\left(b^n\right)}{db^n} = -\Bigg[&\underbrace{(1-\alpha/\varepsilon)(\varepsilon-1+\alpha)\beta_0^{\alpha/(\varepsilon-1+\alpha)}}_{:=\zeta_1\left(b^n\right)} \\ &-\underbrace{\left[(\varepsilon-1)(1-\alpha)+\alpha(\varepsilon-1)\left(b^n\right)^{-1}\right]}_{:=\zeta_2\left(b^n\right)}\Bigg]\tau(gS-K)\left(b^n\right)^{-\varepsilon}\end{aligned}, \tag{39}$$

according to (37), it follows that $\lim_{b^n \to 1} d\Phi_i^{FS}\left(b^n\right)/db^n = -\left(1-\alpha\right)\left(\alpha/\varepsilon\right)\tau\left(gS-K\right) < 0$.

Now assume that there exists some $b_0^n \in \left(1,\infty\right)$ such that $\zeta_1\left(b_0^n\right) = \zeta_2\left(b_0^n\right)$ and, thus, $d\Phi_i^{FS}\left(b^n\right)/db^n\Big|_{b^n=b_0^n} = 0$. Calculating the second derivative of $\Phi_i^{FS}\left(\cdot\right)$ with respect to b^n and evaluating the resulting expression at $b^n = b_0^n$, we come up with

$$\left.\frac{d^2\Phi_i^{FS}\left(b^n\right)}{d\left(b^n\right)^2}\right|_{b^n=b_0^n} = \left\{\begin{array}{l}\left(1-\dfrac{\alpha}{\varepsilon}\right)\dfrac{\alpha\left(\varepsilon-1+\alpha\right)\beta_0^{\alpha/\left(\varepsilon-1+\alpha\right)}\tau\left(gS-K\right)\left(b_0^n\right)^{-\varepsilon}}{\left(g-1\right)S+\left(K-S\right)+\tau\left(gS-K\right)\left(b_0^n\right)^{1-\varepsilon}} \\ \qquad -\alpha\left(\varepsilon-1\right)\left(b_0^n\right)^{-2}\end{array}\right\}\times\tau\left(gS-K\right)\left(b_0^n\right)^{-\varepsilon}. \tag{40}$$

Substituting $\zeta_1\left(b_0^n\right) = \zeta_2\left(b_0^n\right)$, we obtain

$$\left.\frac{d^2\Phi_i^{FS}\left(b^n\right)}{d\left(b^n\right)^2}\right|_{b^n=b_0^n} = \left\{\begin{array}{l}\dfrac{\alpha\left[\left(\varepsilon-1\right)\left(1-\alpha\right)+\alpha\left(\varepsilon-1\right)\left(b_0^n\right)^{-1}\right]\tau\left(gS-K\right)\left(b_0^n\right)^{-\varepsilon}}{\left(g-1\right)S+\left(K-S\right)+\tau\left(gS-K\right)\left(b_0^n\right)^{1-\varepsilon}} \\ \qquad -\alpha\left(\varepsilon-1\right)\left(b_0^n\right)^{-2}\end{array}\right\}\times\tau\left(gS-K\right)\left(b_0^n\right)^{-\varepsilon} \tag{41}$$

which can be reformulated to

$$\left.\frac{d^2\Phi_i^{FS}\left(b^n\right)}{d\left(b^n\right)^2}\right|_{b^n=b_0^n} = -\frac{\alpha\left(\varepsilon-1\right)\tau\left(gS-K\right)\left(b_0^n\right)^{-2-\varepsilon}}{\left(g-1\right)S+\left(K-S\right)+\tau\left(gS-K\right)\left(b_0^n\right)^{1-\varepsilon}}\times\left[\begin{array}{l}\left(g-1\right)S+\left(K-S\right) \\ \quad +\left(1-\alpha\right)\tau\left(gS-K\right)\left(\left(b_0^n\right)^{1-\varepsilon}-\left(b_0^n\right)^{2-\varepsilon}\right)\end{array}\right]. \tag{42}$$

Hence, noting $\left(g-1\right)S > \left(gS-K\right)$, it is obvious that $\varepsilon \geq 2$ guarantees $d^2\Phi_i^{FS}\left(b^n\right)/d\left(b^n\right)^2\Big|_{b^n=b_0^n} < 0$.

Since $\Phi_1^{FS}\left(b^n\right)$ is a continuous, twice differentiable function, we can conclude from (42) that, in the case of $\varepsilon \geq 2$, $d\Phi_i^{FS}\left(b^n\right)/db^n$ must be negative (non-positive) for any $b^n > 1$ since it is negative at $b^n = 1$. As a consequence, $\Phi_i^{FS}\left(b\right)$ is negative for any $b > 1$ since it is zero at $b = 1$. This proves part a) of Result 1.

Consider now countries that differ in their *L*-endowments, i.e. $\tilde{\lambda} = \lambda/\left(1-\lambda\right)$¤ 1. According to the definitions of ϕ_1 and ϕ_n, we can calculate

$$\begin{aligned}\frac{d\left(\phi_n/\phi_1\right)}{d\tilde{\lambda}} = \frac{M\big|_{b=1} + B\big|_{b=1}}{M\big|_{b=b_n} + B\big|_{b=b_n}} \frac{\left(\alpha/\varepsilon\right)\tau\left(gS-K\right)}{\left[\left(M\big|_{b=1} + \tilde{\lambda}\,B\big|_{b=1}\right)\right]^2} &\left\{\left(1-\frac{\alpha}{\varepsilon}\right)\left(g-1\right)S\left(1-\left(b^n\right)^{-\varepsilon}\right)\right. \\ &\left. + \left(1-\alpha\right)\left[\left(K-S\right)+\tau\left(gS-K\right)\right]\left(\left(b^n\right)^{1-\varepsilon} - \left(b^n\right)^{-\varepsilon}\right)\right\}\end{aligned}, \quad (43)$$

which is positive for any $b^n > 1$. Hence, we can conclude that, for any $b^n > 1$, $\Phi_i\left(b^n\right)$ increases in $\tilde{\lambda}$. Together with the results for symmetric countries, this proves that the country with scarce *L*-endowment always gains from a free trade agreement. Moreover, it indicates that the *L*-abundant country may lose from such an agreement. Such an outcome has been verified in a simulation exercise (see Figure 3). This completes the proof of part b) of Result 1. ■

<u>Derivation of formula (21).</u>

We use the definition of *M*, *B* and consider $b \equiv b_{ji} = b_{ij}$. Then, $M/B = \partial\Gamma_j/\partial x_{ii} = \partial\Gamma_i/\partial x_{jj}$. Moreover, we substitute

$$\frac{\partial\Gamma_i}{\partial b} = \left\{\left[\left(\varepsilon-1\right)\left(1-\alpha\right)+\alpha\left(\varepsilon-1\right)b^{-1}\right]x_{ii} - \alpha\left(x_{jj}-x_{ii}\right)b^{-1}\right\}\frac{\tau\left(gS-K\right)b^{-\varepsilon}}{B}, \quad (44)$$

$$\frac{\partial\Gamma_j}{\partial b} = \left\{\left[\left(\varepsilon-1\right)\left(1-\alpha\right)+\alpha\left(\varepsilon-1\right)b^{-1}\right]x_{jj} - \alpha\left(x_{ii}-x_{jj}\right)b^{-1}\right\}\frac{\tau\left(gS-K\right)b^{-\varepsilon}}{B} \quad (45)$$

for $\partial\Gamma_i/\partial b_{ji}$ and $\partial\Gamma_j/\partial b_{ji}$, respectively, in (27) and (28), to obtain

$$\frac{dx_{ii}}{db}=\left\{\frac{\left[(\varepsilon-1)(1-\alpha)+\alpha(\varepsilon-1)b^{-1}\right]\left[1+(M/B)x_{jj}/x_{ii}\right]}{1-(M/B)^2}\right.$$
$$\left.-\frac{\alpha b^{-1}\left(x_{jj}/x_{ii}-1\right)(1-M/B)}{1-(M/B)^2}\right\}\frac{\tau(gS-K)b^{-\varepsilon}x_{ii}}{B} \tag{46}$$

and similarly

$$\frac{dx_{jj}}{db}=\left\{\frac{\left[(\varepsilon-1)(1-\alpha)+\alpha(\varepsilon-1)b^{-1}\right]\left[1+(M/B)x_{ii}/x_{jj}\right]}{1-(M/B)^2}\right.$$
$$\left.-\frac{\alpha b^{-1}\left(x_{ii}/x_{jj}-1\right)(1-M/B)}{1-(M/B)^2}\right\}\frac{\tau(gS-K)b^{-\varepsilon}x_{jj}}{B}. \tag{47}$$

Substituting (46) and (47) into

$$\frac{dCGLI}{db}\equiv\frac{d\left(x_{ii}/x_{jj}\right)}{db}=\frac{x_{jj}\left(dx_{ii}/db\right)-x_{ii}\left(dx_{jj}/db\right)}{x_{jj}^2}, \tag{48}$$

according to (20), we come up with the following result

$$\frac{dCGLI}{db}=\left[\left((\varepsilon-1)(1-\alpha)+\alpha\varepsilon b^{-1}\right)\frac{M}{B}-\alpha b^{-1}\right]\frac{\left[1-\left(x_{ii}/x_{jj}\right)^2\right]\tau(gS-K)b^{-\varepsilon}}{B\left(1-(M/B)^2\right)}, \tag{49}$$

which can be reformulated to (21), when substituting for *M* and *B*. ■

B. Empirical Appendix

Country Sample

The regression results are based on bilateral trade flows between the following 31 countries: Australia, Austria, Belgium, Canada, China, Czech Republic, Denmark, Finland, France, Germany, Greece, Hong Kong, Hungary, Iceland, Ireland, Italy, Japan, Republic of Korea, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkey, United Kingdom, USA.

Appendix Tables

> Tables A1-A4 <

Supplement 1: Trade Liberalisation and the Corrected Grubel-Lloyd Index

If the uncorrected Grubel-Lloyd index GLI as usually applied in the literature were considered instead of CGLI, the following expression would be relevant:

$$GLI = \frac{2\varepsilon\tau \min\left[b_{ji}^{-\varepsilon} n_j x_{ii}, b_{ij}^{-\varepsilon} n_i x_{jj}\right]}{\varepsilon\tau\left(b_{ji}^{-\varepsilon} n_j x_{ii} + b_{ij}^{-\varepsilon} n_i x_{jj}\right) + \left|\left(\varepsilon\tau b_{ij}^{-\varepsilon} n_i + h_i\right) x_{jj} - \left(\varepsilon\tau b_{ji}^{-\varepsilon} n_j + h_j\right) x_{ii}\right|}. \tag{50}$$

Consider $b \equiv b_{ij} = b_{ji}$ and $\lambda_i < 1$ (implying $x_{ii} < x_{jj}$). Then the uncorrected Grubel-Lloyd index simplifies to[33]

$$GLI = \frac{2\varepsilon\tau n_j x_{ii} b^{-\varepsilon}}{2\varepsilon\tau b^{-\varepsilon} n_i x_{jj} + h_i x_{jj} - h_j x_{ii}} = \frac{2\varepsilon\tau\left(x_{ii}/x_{jj}\right)}{2\varepsilon\tau + b^{\varepsilon}\left(1 - x_{ii}/x_{jj}\right)\left(K - S\right)/\left(gS - K\right)}. \tag{51}$$

Differentiating (51) with respect to b, we come up with

$$\begin{aligned} \frac{dGLI}{db} = & \frac{2\varepsilon\tau\left[2\varepsilon\tau + b^{\varepsilon}\left(K - S\right)/\left(gS - K\right)\right] dCGLI/db}{\left[2\varepsilon\tau + b^{\varepsilon}\left(1 - x_{ii}/x_{jj}\right)\left(K - S\right)/\left(gS - K\right)\right]^2} \\ & - \frac{2\varepsilon^2\tau b^{\varepsilon-1}\left(1 - CGLI\right) CGLI}{\left[2\varepsilon\tau + b^{\varepsilon}\left(1 - x_{ii}/x_{jj}\right)\left(K - S\right)/\left(gS - K\right)\right]^2} \frac{K - S}{gS - K} \end{aligned}, \tag{52}$$

where $CGLI = x_{ii}/x_{jj}$ has been considered, according to (20). Thus, $dGLI/db < 0$, whenever $dCGLI/db < 0$ (at least if $b \equiv b_{ij} = b_{ji}$ prevails and production is diversified in both economies). ■

[33] Use $n_i = n_j$ and $h_i/n_j = h_j/n_j = \left(K - S\right)/\left(gS - K\right)$, according to (10).

Table 1: Covered New Regional Trade Agreement Memberships

Country 1	Country 2	Entry	Country 1	Country 2	Entry	Country 1	Country 2	Entry
Austria	Belgium	1977	Italy	Portugal	1977	Portugal	Spain	1986
Austria	Denmark	1977	Italy	Sweden	1977	Spain	Sweden	1986
Austria	France	1977	Netherlands	Norway	1977	Spain	Switzerland	1986
Austria	Ireland	1977	Netherlands	Portugal	1977	Spain	United Kingdom	1986
Austria	Italy	1977	Netherlands	Sweden	1977	Canada	Mexico	1994
Austria	Netherlands	1977	Norway	United Kingdom	1977	Denmark	Hungary	1994
Austria	United Kingdom	1977	Austria	Greece	1981	France	Hungary	1994
Belgium	Finland	1977	Belgium	Greece	1981	Germany	Hungary	1994
Belgium	Norway	1977	Finland	Greece	1981	Greece	Hungary	1994
Belgium	Portugal	1977	France	Greece	1981	Hungary	Ireland	1994
Belgium	Sweden	1977	Germany	Greece	1981	Hungary	Italy	1994
Denmark	Finland	1977	Greece	Iceland	1981	Hungary	Netherlands	1994
Denmark	Iceland	1977	Greece	Ireland	1981	Hungary	Portugal	1994
Denmark	Norway	1977	Greece	Italy	1981	Hungary	Spain	1994
Denmark	Portugal	1977	Greece	Netherlands	1981	Hungary	United Kingdom	1994
Denmark	Sweden	1977	Greece	Norway	1981	Mexico	USA	1994
Finland	France	1977	Greece	Portugal	1981	Austria	Czech Republic	1995
Finland	Germany	1977	Greece	Sweden	1981	Austria	Hungary	1995
Finland	Ireland	1977	Greece	Switzerland	1981	Czech Republic	Denmark	1995
Finland	Italy	1977	Greece	United Kingdom	1981	Czech Republic	Finland	1995
Finland	Netherlands	1977	Austria	Spain	1986	Czech Republic	France	1995
Finland	United Kingdom	1977	Belgium	Spain	1986	Czech Republic	Germany	1995
France	Norway	1977	Denmark	Spain	1986	Czech Republic	Greece	1995
France	Portugal	1977	Finland	Spain	1986	Czech Republic	Ireland	1995
Germany	Iceland	1977	France	Spain	1986	Czech Republic	Italy	1995
Germany	Norway	1977	Germany	Spain	1986	Czech Republic	Netherlands	1995
Iceland	Ireland	1977	Greece	Spain	1986	Czech Republic	Portugal	1995
Iceland	United Kingdom	1977	Iceland	Spain	1986	Czech Republic	Sweden	1995
Ireland	Norway	1977	Ireland	Spain	1986	Czech Republic	United Kingdom	1995
Ireland	Portugal	1977	Italy	Spain	1986	Finland	Hungary	1995
Ireland	Sweden	1977	Netherlands	Spain	1986	Hungary	Sweden	1995
Italy	Norway	1977	Norway	Spain	1986			

Table 2: Descriptive Statistics

Variable	Observations	Mean	Std. dev.	Minimum	Maximum
	Controls used in probit models (lagged levels)				
Total bilateral GDP: ln $TGDP_{ij,t-1}$:=ln($GDP_{i,t-1}$+$GDP_{j,t-1}$)	1426	27.209	1.331	23.835	30.099
Similarity in bilateral GDP: ln $SGDP_{ij,t-1}:=\ln\{1-[GDP_{i,t-1}/(GDP_{i,t-1}+GDP_{j,t-1})]^2-[GDP_{i,t-1}/(GDP_{i,t-1}+GDP_{j,t-1})]^2\}$	1426	-1.594	1.008	-6.204	-0.693
Similarity in bilateral unskilled endowment: ln $SL_{ij,t-1}:=\ln\{1-[L_{i,t-1}/(L_{i,t-1}+L_{j,t-1})]^2-[L_{i,t-1}/(L_{i,t-1}+L_{j,t-1})]^2\}$	1426	-1.610	1.038	-6.124	-0.693
Similarity in bilateral skilled endowment: ln $SH_{ij,t-1}:=\ln\{1-[H_{i,t-1}/(H_{i,t-1}+H_{j,t-1})]^2-[H_{i,t-1}/(H_{i,t-1}+H_{j,t-1})]^2\}$	1426	-0.867	0.290	-2.531	-0.693
Similarity in bilateral capital endowment: ln $SK_{ij,t-1}:=\ln\{1-[K_{i,t-1}/(K_{i,t-1}+K_{j,t-1})]^2-[K_{i,t-1}/(K_{i,t-1}+K_{j,t-1})]^2\}$	1426	-1.564	0.957	-6.095	-0.693
Absolute bilateral difference in skilled-to-unskilled endowment ratios: $AHL_{ij,t-1}:=\lvert(H_{i,t-1}/L_{i,t-1})-(H_{j,t-1}/L_{j,t-1})\rvert$	1426	21.712	17.307	0.000	85.530
Absolute bilateral difference in capital-to-unskilled endowment ratios: $AKL_{ij,t-1}:=\lvert\ln(K_{i,t-1}/L_{i,t-1})-\ln(K_{j,t-1}/L_{j,t-1})\rvert$	1426	0.780	0.807	0.002	3.418
Bilateral trade costs: $TC_{ij,t-1}$	1426	1.058	0.104	0.786	1.287
Interaction term: ln $SL_{ij,t-1}\times TC_{ij,t-1}$	1426	-1.729	1.192	-7.175	-0.546
Interaction term: ln $SK_{ij,t-1}\times TC_{ij,t-1}$	1426	-1.666	1.059	-7.161	-0.545
Average bilateral investment costs:$0.5*IC_{i,t-1}+0.5*IC_{j,t-1}$	1426	37.513	6.449	21.160	58.099
Absolute difference in bilateral investment costs: abs($IC_{i,t-1}$-$IC_{j,t-1}$)	1426	10.564	7.533	0.036	33.183
Interaction term: ln $SL_{ij,t-1}\times(IC_{i,t-1}/IC_{j,t-1})$ if $L_{j,t-1}>L_{i,t-1}$ else ln $SL_{ij,t-1}\times(IC_{j,t-1}/IC_{i,t-1})$	1426	-1.623	1.382	-13.839	-0.351
Exporter duties: $Dut_{i,t-1}$	1266	3.464	3.439	0.000	14.920
Importer duties: $Dut_{j,t-1}$	1266	3.464	3.439	0.000	14.920
	Dependent and control variables in second stage (changes)				
Change in bilateral Grubel-Lloyd index: $DGLI_{ijt}$	1366	-0.009	0.083	-0.640	0.259
Change in trade-imbalance-adjusted bilateral Grubel-Lloyd index (Bergstrand, 1983): $DCGLI_{ijt}$	1366	-0.009	0.088	-0.716	0.275
New regional trade agreement membership: FTA_{ijt}	1426	0.135	0.341	0.000	1.000

Table 3: Selection Into Entering a Regional Trade Agreement

Explanatory variables:	Probit 1	Probit 2	Probit 3	Probit 4	Probit 5	Probit 6	Probit 7	Probit 8	Probit 9	Probit 10
Total bilateral GDP: ln $TGDP_{ij,t-1}$	-0.291	-0.432	-1.178	-1.195	-1.236	-0.268	-0.404	-1.226	-1.245	-1.290
	5.71 ***	7.48 ***	11.95 ***	11.96 ***	11.82 ***	5.21 ***	6.91 ***	11.36 ***	11.36 ***	11.25 ***
Similarity in bilateral GDP: ln $SGDP_{ij,t-1}$	0.224	-	-	-	-	0.249	-	-	-	-
	2.94 ***	-	-	-	-	3.20 ***	-	-	-	-
Similarity in bilateral unskilled endowment: ln $SL_{ij,t-1}$	-	0.562	1.15	0.915	-0.628	-	0.569	1.211	0.979	-0.633
	-	4.56 ***	7.27 ***	4.88 ***	0.60	-	4.56 ***	7.30 ***	4.98 ***	0.60
Similarity in bilateral skilled endowment: ln $SH_{ij,t-1}$	-	0.235	-0.011	-0.015	3.458	-	0.299	-0.134	-0.152	2.878
	-	0.64	0.02	0.03	0.76	-	0.78	0.27	0.32	0.62
Similarity in bilateral capital endowment: ln $SK_{ij,t-1}$	-	-0.542	-1.515	-1.630	-1.666	-	-0.517	-1.58	-1.688	-1.727
	-	4.44 ***	8.87 ***	9.14 ***	9.16 ***	-	4.20 ***	8.66 ***	8.92 ***	8.95 ***
Absolute bilateral difference in skilled-to-unskilled endowment ratios: $AHL_{ij,t-1}$	-0.011	-	-	-	-	-0.011	-	-	-	-
	2.58 ***	-	-	-	-	2.69 ***	-	-	-	-
Absolute bilateral difference in capital-to-unskilled endowment ratios: $AKL_{ij,t-1}$	0.124	-	-	-	-	0.10	-	-	-	-
	1.34	-	-	-	-	1.03	-	-	-	-
Bilateral trade costs: $TC_{ij,t-1}$	-3.416	-3.277	-1.286	-1.338	-2.147	-3.505	-3.358	-1.501	-1.546	-1.947
	6.96 ***	6.62 ***	1.93 *	2.02 **	0.62	7.02 ***	6.67 ***	2.23 **	2.32 **	0.55
Interaction term: ln $SL_{ij,t-1} \times TC_{ij,t-1}$	-	-	-	-	1.490	-	-	-	-	1.557
	-	-	-	-	1.50	-	-	-	-	1.55
Interaction term: ln $SK_{ij,t-1} \times TC_{ij,t-1}$	-	-	-	-	-3.290	-	-	-	-	-2.875
	-	-	-	-	0.77	-	-	-	-	0.65
Average bilateral investment costs: $0.5*IC_{i,t-1}+0.5*IC_{j,t-1}$	0.038	0.043	0.06	0.058	0.059	0.042	0.046	0.061	0.059	0.059
	4.65 ***	5.20 ***	5.08 ***	4.93 ***	4.94 ***	5.00 ***	5.45 ***	4.90 ***	4.74 ***	4.75 ***
Absolute difference in bilateral investment costs: $abs(IC_{i,t-1}-IC_{j,t-1})$	0.017	0.018	0.04	0.049	0.049	0.019	0.019	0.044	0.049	0.049
	2.57 **	2.63 ***	5.01 ***	5.31 ***	5.28 ***	2.76 ***	2.75 ***	4.94 ***	5.22 ***	5.19 ***
Interaction term: ln $SL_{ij,t-1} \times (IC_{i,t-1}/IC_{j,t-1})$ if $L_{j,t-1}>L_{i,t-1}$ else ln $SL_{ij,t-1} \times (IC_{j,t-1}/IC_{i,t-1})$	-	-	-	0.209	0.200	-	-	-	0.204	0.194
	-	-	-	1.82 *	1.70 *	-	-	-	1.73 *	1.61
Exporter duties: $Dut_{i,t-1}$	-	-	-0.142	-0.146	-0.148	-	-	-0.153	-0.156	-0.159
	-	-	7.42 ***	7.5 ***	7.55 ***	-	-	7.68 ***	7.75 ***	7.79 ***
Importer duties: $Dut_{j,t-1}$	-	-	-0.147	-0.150	-0.151	-	-	-0.159	-0.161	-0.163
	-	-	7.63 ***	7.71 ***	7.73 ***	-	-	7.90 ***	7.97 ***	7.99 ***
Year Dummies	NO	NO	NO	NO	NO	YES	YES	YES	YES	YES
Trend	YES	YES	YES	YES	YES	NO	NO	NO	NO	NO
Observations	1426	1426	1112	1112	1112	1426	1426	1112	1112	1112
Log-likelihood	-427.56	-418.60	-287.33	-285.62	-284.39	-421.37	-413.39	-281.50	-279.97	-278.68
Pseudo R^2	0.24	0.26	0.42	0.42	0.42	0.25	0.27	0.43	0.43	0.43
Probit versus logit (Davidson and MacKinnon, 2004; distributed as $\chi^2(1)$)	7.05 ***	9.30 ***	-0.25	-1.24	-0.98	8.22 ***	10.18 ***	-0.05	-0.69	-0.27

Note: Figures below coefficients are z-statistics. Constant, time trend and year dummies are not reported. ***, **, * denote significance levels of 1%, 5%, and 10%, respectively.

Table 4: Treatment Effect of the Treated From Entering a Regional Trade Agreement on the Intra-Industry Trade Share (Based on Probit 9 of Table 3)

Estimator	Corrected GLI	Uncorrected GLI
Descriptive comparison (no endogenous selection)	0.016 **	0.016 ***
Standard error	0.006	0.006
Mahalanobis distance metric (bias-adjusted):		
One-to-one matching	0.050 ***	0.047 ***
Standard error	0.012	0.012
Five nearest neighbor matching	0.027 ***	0.025 ***
Standard error	0.009	0.009
Propensity score metric:		
One-to-one matching	0.026 ***	0.024 ***
Standard error	0.008	0.008
Five nearest neighbor matching	0.026 ***	0.024 ***
Standard error	0.008	0.007
Radius matching (radius is 0.1)	0.029 ***	0.027 ***
Standard error	0.005	0.005
Kernel matching (Epanechnikov kernel; bandwidth=0.06)	0.025 ***	0.023 ***
Standard error	0.005	0.004

Note: ***, **, * denote significance levels of 1%, 5%, and 10%, respectively.

Table 5: Sensitivity Analysis of the Treatment Effect of the Treated From Entering a Regional Trade Agreement on the Intra-Industry Trade Share
(Dependent is the Trade-Imbalance-Corrected Grubel-Lloyd Index; Estimates Based on Propensity Score Metric)

Estimator	Probit 1	Probit 2	Logit 3	Logit 4	Logit 5	Probit 6	Probit 7	Logit 8	Logit 9	Logit 10
Mahalanobis distance metric (bias-adjusted):										
One-to-one matching	0.019	0.026	0.044 ***	0.052 ***	0.048 ***	0.011	0.021	0.047 ***	0.050 ***	0.053 ***
Standard error	0.015	0.016	0.011	0.012	0.012	0.029	0.020	0.012	0.012	0.013
Five nearest neighbor matching	0.027 ***	0.030 ***	0.039 ***	0.040 ***	0.042 ***	0.022 *	0.022 *	0.024 ***	0.027 ***	0.027 ***
Standard error	0.010	0.010	0.009	0.009	0.009	0.013	0.012	0.010	0.009	0.009
Propensity score metric:										
One-to-one matching	0.022 **	0.027 ***	0.038 ***	0.038 ***	0.038 ***	0.026 ***	0.023 **	0.014	0.042 ***	0.037 ***
Standard error	0.009	0.009	0.009	0.01	0.009	0.010	0.010	0.010	0.01	0.009
Five nearest neighbor matching	0.029 ***	0.030 ***	0.038 ***	0.040 ***	0.037 ***	0.019 **	0.025 ***	0.024 ***	0.033 ***	0.027 ***
Standard error	0.008	0.007	0.008	0.007	0.008	0.008	0.008	0.008	0.008	0.008
Radius matching (radius is 0.1)	0.025 ***	0.029 ***	0.036 ***	0.040 ***	0.04 ***	0.022 ***	0.027 ***	0.027 ***	0.030 ***	0.030 ***
Standard error	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Kernel matching (Epanechnikov kernel; bandwidth=0.06)	0.026 ***	0.029 ***	0.035 ***	0.040 ***	0.039 ***	0.021 ***	0.028 ***	0.024 ***	0.031 ***	0.030 ***
Standard error	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
An alternative - block-matching:										
Stratification	0.024 ***	0.029 ***	0.036 ***	0.045 ***	0.040 ***	0.023 **	0.027 ***	0.028 ***	0.033 ***	0.030 ***
Standard error	0.004	0.005	0.009	0.009	0.010	0.009	0.009	0.010	0.011	0.010

Note: ***, **, * denote significance levels of 1%, 5%, and 10%, respectively.

Table 6: Average Treatment Effect From Entering a Regional Trade Agreement on the Intra-Industry Trade Share (Specification as in Probit 9 of Table 3: Mahalanobis distance metric: bias-adjusted)

Estimator	Corrected GLI	Uncorrected GLI
One-to-one matching	0.116 ***	0.112 ***
	0.009	0.008
Five nearest neighbours	0.092 ***	0.088 ***
	0.008	0.008

Note: ***, **, * denote significance levels of 1%, 5%, and 10%, respectively.

Table A1: Basic Variables and Their Sources

Label	Definition	Source
GLI	Grubel-Lloyd-index	OECD, International Trade by Commodity Statistics
GDP	Gross domesitic product in real U.S. dollars (base 1995)	World Bank, World Development Indicators
L	Unskilled labor (labor force)	World Bank, World Development Indicators
H	Skilled labor (tertiary school enrolment)	World Bank, World Development Indicators
K	Physical capital (perpetual inventory; gross fixed capital formation)	World Bank, World Development Indicators
TC	Bilateral trade costs (bilateral trade-weighted c.i.f./f.o.b.)	OECD, International Trade by Commodity Statistics
IC	Investment costs	BERI
Dut	Import duties	World Bank, World Development Indicators

Table A2: Selection Into Entering a Regional Trade Agreement - Logit Models

Explanatory variables:	Logit 1	Logit 2	Logit 3	Logit 4	Logit 5	Logit 6	Logit 7	Logit 8	Logit 9	Logit 10
Total bilateral GDP: ln $TGDP_{ij,t-1}$	-0.55	-0.776	-2.150	-2.216	-2.279	-0.507	-0.729	-2.226	-2.286	-2.354 ***
	5.80 ***	7.44 ***	11.31 ***	11.21 ***	11.11 ***	5.32 ***	6.93 ***	10.95 ***	10.86 ***	-10.77
Similarity in bilateral GDP: ln $SGDP_{ij,t-1}$	0.404	-	-	-	-	0.445	-	-	-	-
	2.74 ***	-	-	-	-	2.98 ***	-	-	-	-
Similarity in bilateral unskilled endowment: ln $SL_{ij,t-1}$	-	1.048	2.033	1.529	-1.179	-	1.06	2.175	1.691	-0.985
	-	4.39 ***	6.88 ***	4.33 ***	0.63	-	4.39 ***	6.97 ***	4.52 ***	-0.52
Similarity in bilateral skilled endowment: ln $SH_{ij,t-1}$	-	0.732	0.875	0.710	2.114	-	0.816	0.602	0.405	0.875
	-	1	0.86	0.73	0.22	-	1.08	0.59	0.41	0.09
Similarity in bilateral capital endowment: ln $SK_{ij,t-1}$	-	-0.985	-2.764	-3.018	-3.056	-	-0.942	-2.888	-3.109	-3.148 ***
	-	4.27 ***	8.46 ***	8.74 ***	8.67 ***	-	4.07 ***	8.29 ***	8.58 ***	-8.52
Absolute bilateral difference in skilled-to-unskilled endowment ratios: $AHL_{ij,t-1}$	-0.022	-	-	-	-	-0.023	-	-	-	-
	2.74 ***	-	-	-	-	2.8 ***	-	-	-	-
Absolute bilateral difference in capital-to-unskilled endowment ratios: $AKL_{ij,t-1}$	0.216	-	-	-	-	0.19	-	-	-	-
	1.28	-	-	-	-	1.08	-	-	-	-
Bilateral trade costs: $TC_{ij,t-1}$	-5.993	-5.784	-2.501	-2.630	-0.436	-6.277	-6.034	-2.913	-2.998	-0.123
	6.74 ***	6.52 ***	2.07 **	2.18 **	0.06	6.86 ***	6.6 ***	2.38 **	2.45 **	-0.02
Interaction term: ln $SL_{ij,t-1} \times TC_{ij,t-1}$	-	-	-	-	2.621	-	-	-	-	2.590
	-	-	-	-	1.45	-	-	-	-	1.43
Interaction term: ln $SK_{ij,t-1} \times TC_{ij,t-1}$	-	-	-	-	-1.294	-	-	-	-	-0.387
	-	-	-	-	0.14	-	-	-	-	-0.04
Average bilateral investment costs: $0.5*IC_{i,t-1}+0.5*IC_{j,t-1}$	0.068	0.079	0.099	0.094	0.095	0.074	0.084	0.103	0.098	0.099 ***
	4.52 ***	5.23 ***	4.55 ***	4.31 ***	4.33 ***	4.81 ***	5.45 ***	4.47 ***	4.24 ***	4.25
Absolute difference in bilateral investment costs: $abs(IC_{i,t-1}-IC_{j,t-1})$	0.028	0.029	0.07	0.081	0.081	0.03	0.031	0.075	0.082	0.082 ***
	2.32 **	2.41 **	4.55 ***	4.87 ***	4.86 ***	2.47 **	2.51 **	4.57 ***	4.86 ***	4.83
Interaction term: ln $SL_{ij,t-1} \times (IC_{i,t-1}/IC_{j,t-1})$ if $L_{j,t-1}>L_{i,t-1}$ else ln $SL_{ij,t-1} \times (IC_{j,t-1}/IC_{i,t-1})$	-	-	-	0.441	0.422	-	-	-	0.412	0.389 *
	-	-	-	2.05 **	1.92 *	-	-	-	1.90 *	1.75
Exporter duties: $Dut_{i,t-1}$	-	-	-0.254	-0.262	-0.265	-	-	-0.274	-0.281	-0.284 ***
	-	-	7.34 ***	7.43 ***	7.45 ***	-	-	7.58 ***	7.64 ***	-7.65
Importer duties: $Dut_{j,t-1}$	-	-	-0.259	-0.267	-0.268	-	-	-0.281	-0.287	-0.288 ***
	-	-	7.5 ***	7.59 ***	7.60 ***	-	-	7.73 ***	7.79 ***	-7.79
Year Dummies	NO	NO	NO	NO	NO	YES	YES	YES	YES	YES
Trend	YES	YES	YES	YES	YES	NO	NO	NO	NO	NO
Observations	1426	1426	1112	1112	1112	1426	1426	1112	1112	1112
Log-likelihood	-431.09	-423.24	-287.21	-285.00	-283.90	-425.47	-418.48	-281.48	-279.63	-278.54
Pseudo R^2	0.23	0.25	0.42	0.42	0.42	0.24	0.26	0.43	0.43	0.43

Note: Figures below coefficients are z-statistics. Constant, time trend and year dummies are not reported. ***, **, * denote significance levels of 1%, 5%, and 10%, respectively.

Table A3: Differences Between Matched and Control Country-Pairs (Based on Probit 9 in Table 3)

Variable	Treated	Controls	Difference: p>|t|
Total bilateral GDP: ln $TGDP_{ij,t-1}$:=ln($GDP_{i,t-1}$+$GDP_{j,t-1}$)	26.226	26.144	0.696
Similarity in bilateral unskilled endowment: ln $SL_{ij,t-1}:=\ln\{1-[L_{i,t-1}/(L_{i,t-1}+L_{j,t-1})]^2-[L_{i,t-1}/(L_{i,t-1}+L_{j,t-1})]^2\}$	-1.129	-1.069	0.579
Similarity in bilateral skilled endowment: ln $SH_{ij,t-1}:=\ln\{1-[H_{i,t-1}/(H_{i,t-1}+H_{j,t-1})]^2-[H_{i,t-1}/(H_{i,t-1}+H_{j,t-1})]^2\}$	-0.784	-0.775	0.693
Similarity in bilateral capital endowment: ln $SK_{ij,t-1}:=\ln\{1-[K_{i,t-1}/(K_{i,t-1}+K_{j,t-1})]^2-[K_{i,t-1}/(K_{i,t-1}+K_{j,t-1})]^2\}$	-1.256	-1.212	0.712
Bilateral trade costs: $TC_{ij,t-1}$	0.989	0.982	0.683
Average bilateral investment costs:0.5*$IC_{i,t-1}$+0.5*$IC_{j,t-1}$	41.520	42.823	0.290
Absolute difference in bilateral investment costs: abs($IC_{i,t-1}$-$IC_{j,t-1}$)	11.825	11.836	0.941
Interaction term: ln $SL_{ij,t-1}\times(IC_{i,t-1}/IC_{j,t-1})$ if $L_{j,t-1}>L_{i,t-1}$ else ln $SL_{ij,t-1}\times(IC_{j,t-1}/IC_{i,t-1})$	-1.189	-1.186	0.980
Exporter duties: $Dut_{i,t-1}$	3.675	4.134	0.482
Importer duties: $Dut_{j,t-1}$	3.689	4.219	0.427
Year dummy for 1981	0.149	0.131	0.792
Year dummy for 1986	0.171	0.189	0.747
Year dummy for 1994	0.137	0.097	0.518
Year dummy for 1995	0.171	0.114	0.429

Table A4: Sensitivity Analysis of the Treatment Effect of the Treated From Entering a Regional Trade Agreement on the Intra-Industry Trade Share
(Dependent is the Trade-Imbalance-Uncorrected Grubel-Lloyd Index; Estimates Based on Propensity Score Metric)

Estimator	Probit 1	Probit 2	Logit 3	Logit 4	Logit 5	Probit 6	Probit 7	Logit 8	Logit 9	Logit 10
Mahalanobis distance metric (bias-adjusted):										
One-to-one matching	0.018	0.024	0.043	0.050 ***	0.046 ***	0.010	0.020	0.045 ***	0.047 ***	0.050
Standard error	0.014	0.015	0.011	0.011	0.011	0.027	0.019	0.012	0.012	0.012
Five nearest neighbor matching	0.026 ***	0.029 ***	0.037 ***	0.038 ***	0.039 ***	0.021 *	0.021 ***	0.023 ***	0.025 ***	0.026 ***
Standard error	0.010	0.009	0.008	0.008	0.008	0.012	0.011	0.009	0.009	0.009
Propensity score metric:										
One-to-one matching	0.020 **	0.024 ***	0.037 ***	0.036 ***	0.035 ***	0.023 **	0.020 **	0.013	0.039 ***	0.034 ***
Standard error	0.009	0.009	0.009	0.009	0.008	0.009	0.009	0.009	0.009	0.009
Five nearest neighbor matching	0.027 ***	0.027 ***	0.036 ***	0.037 ***	0.035 ***	0.017 **	0.022 ***	0.023 ***	0.031 ***	0.026 ***
Standard error	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.008	0.008	0.007
Radius matching (radius is 0.1)	0.023 ***	0.027 ***	0.034 ***	0.037 ***	0.038 ***	0.020 ***	0.025 ***	0.026 ***	0.029 ***	0.029 ***
Standard error	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Kernel matching (Epanechnikov kernel; bandwidth=0.06)	0.024 ***	0.027 ***	0.033 ***	0.037 ***	0.037 ***	0.019 ***	0.025 ***	0.022 ***	0.029 ***	0.029 ***
Standard error	0.005	0.005	0.004	0.004	0.005	0.005	0.005	0.004	0.004	0.005
An alternative - block-matching:										
Stratification	0.022 ***	0.029 ***	0.036 ***	0.045 ***	0.040 ***	0.023 **	0.027 ***	0.028 ***	0.033 ***	0.030 ***
Standard error	0.004	0.005	0.009	0.009	0.010	0.009	0.009	0.010	0.011	0.010

Note: ***, **, * denote significance levels of 1%, 5%, and 10%, respectively.