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Trade and FDI Liberalization in an Oligopolistic Model: Partial versus General Equilibrium Effects

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Trade and FDI Liberalization in an Oligopolistic Model: Partial versus General Equilibrium Effects*

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Abstract

This paper studies the effects of liberalization of trade and foreign direct investment (FDI) in a model where multiple oligopolistic sectors compete for a common factor. In contrast to the case of a fixed factor price, trade liberalization is shown to improve the host country's welfare by benefiting the consumers and firms while the opposite applies to FDI liberalization. Then, we find that simultaneous liberalization of trade and FDI improves world welfare since the positive effect of trade liberalization dominates the negative effect of FDI liberalization. This result suggests that trade liberalization must be accommodated in order to promote FDI liberalization.

Keywords: Trade liberalization, FDI liberalization, oligopoly, factor price.

JEL Classifications: F12, F13, F23.

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1 Introduction

The current world economy is characterized by two outstanding facts, among others. First, foreign direct investment (FDI) is playing a growing role, which is stressed in UNCTAD (2014, p. 1) stating that 'Global FDI flows rose by 9 per cent in 2013 to $1.45 trillion, up from $1.33 trillion in 2012 $\cdots$' although they had declined from 2008 to 2012 due to the bankruptcy of Lehman Brothers. WTO (2014, p. 43) also reports that 'Four-fifths of world trade are now channelled through multinationals that locate various stages or tasks of the production process in the most cost-efficient locations around the planet.' Second, protective trade measures have been substantially reduced through multilateral GATT/WTO negotiations and preferential trade agreements.[1] While it is conventionally recognized that trade and/or FDI liberalization benefits an individual country and the world, is the same valid particularly in the presence of multinational firms that have a large market share?[2]

This paper seeks welfare implications of trade and FDI liberalization in an oligopoly model with the following features. First, we endogenize the factor price by supposing that multiple oligopolistic industries compete for a common factor. Second, exports and FDI coexist, and the fraction of FDI is endogenously determined. Within this model, we examine the welfare effect of trade and FDI liberalization on the host and source countries, and the world, and prove the following results. First, trade liberalization increases consumer surplus, firm profits and welfare of the host country, but FDI liberalization decreases all of these. This contrasts with the existing result that both trade and FDI liberalization harms the host country by shifting domestic profits abroad. Second, simultaneous liberalization of trade and FDI

[1] Baier and Bergstrand (2001) empirically find that about 25% of world trade growth is explained by tariff reductions.

[2] According to UNCTAD (2014), the five largest multinationals are General Electric (US), Royal Dutch Shell (UK), Toyota (Japan), Exxon Mobile (US) and Total SA (France) all of which arguably have substantial market power in the world market.

leads to a world welfare improvement although FDI liberalization alone lowers the world welfare. This finding has practical relevance in the sense that it suggests that trade liberalization must be accompanied if FDI liberalization is to be promoted.[3]

Since the literature on FDI is too large, we select the most closely related studies.[4] Dei (1990), Horstmann and Markusen (1992) and Brainard (1997) are the earliest works to analyze the choice between exporting and FDI in an oligopoly model. Since these papers commonly assume that FDI incurs a fixed cost but avoids a trade cost, the incentive and effect of FDI depend on the relative magnitude between the fixed cost of FDI and the trade cost.[5] Markusen (1997) develops a Cournot model with free entry, finding that trade and FDI liberalization has an opposite effect on endogenous variables, and that simultaneous liberalization of trade and FDI has a welfare effect that is quite different from trade or FDI liberalization alone. Markusen (2002) further investigates the welfare effect of FDI liberalization, and concludes that the country with a larger factor endowment is more likely to lose from FDI liberalization.[6]

While the literature above utilizes a partial equilibrium model, Glass and Saggi (1999) compute and characterize the optimal FDI policies by incorporating FDI into the model of Dixit and Grossman (1986). Glass and Saggi (1999) are notable in the sense that they allow the coexistence of exporting and FDI, and that the general equilibrium effect is taken into account by assuming multiple oligopolistic industries that compete for a common fac-

[3]This result may be comparable to Ishikawa et al. (2010) who show that simultaneous reductions of trade and FDI costs are beneficial while trade liberalization alone can be welfare-reducing.

[4]See Wong (1995, Ch. 13), Markusen (1995, 2002, 2010), Antras and Yeaple (2014) for comprehensive surveys.

[5]Helpman et al. (2004) revisit this issue in a Melitz (2003) model of monopolistic competition with firm heterogeneity. Liu and Qiu (2013) and Ahn (2014) extend the model of Helpman et al. (2004) so as to examine the effect of trade and FDI liberalization.

[6]Egger et al. (2007) extend Markusen's (1997, 2002) model, and their simulation shows that bilateral FDI liberalization is more attractive than unilateral FDI liberalization.

tor.[7] While Glass and Saggi (1999, 2004, 2014) assume that (i) only the third country consumes the imperfectly competitive goods, that (ii) all the oligopolistic industries are symmetric, and that (iii) goods trade is free, we consider the effect of trade and FDI liberalization by relaxing these assumptions, and establish some results regarding the welfare effects of trade and FDI liberalization that are not found in the previous works.

This paper is organized as follows. Section 2 presents a model. Section 3 considers the welfare effects of trade and FDI liberalization. Section 4 concludes, and the detailed proofs of the main results are left in Appendix.

2 Model

Mainly resorting to Dixit and Grossman (1986) and Glass and Saggi (1999), this section constructs a model. Suppose a world consisting of Home (host country) and Foreign (source country), and $m + n$ duopolistic industries, which are divided into $m \geq 1$ industries where the Foreign firm engages in both exporting and FDI and $n \geq 1$ industries where the Foreign firm just exports. The utility function of the Home consumer is quasi-linear:

$$\sum_{i=1}^{m+n} u(c_i) + z,$$

where c_i is consumption of oligopolistic good i, z is consumption of the numeraire good, and function $u(\cdot)$ satisfies $u'(\cdot) > 0$ and $u''(\cdot) < 0$. Utility maximization yields an inverse demand function of goods i and j:

$$p_i = p(x_i + x_i^*), \quad p_j = p(x_j + x_j^*),$$

where x_i, x_j and x_i^*, x_j^* are outputs of the Home and Foreign firms in industry i and j, respectively. The Home government imposes an (specific) import

[7] Linking the good and factor markets in a third market model of Brander and Spencer (1985), Dixit and Grossman (1986) endogenize the factor price, and provide a counter-argument on strategic export subsidy. Glass and Saggi (2004, 2014) modify the model in Glass and Saggi (1999) to study the FDI policies between multiple source or host countries.

tariff t and an investment tax τ on good $i \in \{1, \cdots, m\}$ whereas free trade prevails in industry $j \in \{m+1, \cdots, m+n\}$.

The Foreign firm in industry $i \in \{1, \cdots, m\}$ simultaneously undertakes both FDI and exporting so that $\theta \in [0, 1]$ fraction of output is supplied through FDI and $1-\theta$ fraction of output is supplied by exporting. In addition, the factor coefficient of all oligopolistic firms is assumed to be unity. Then, denoting by r and r^* the factor price in Home and Foreign, the profit of the Home and Foreign firms is defined by

$$\pi_i \equiv p(x_i + x_i^*)x_i - rx_i \tag{1}$$

$$\pi_i^* \equiv p(x_i + x_i^*)x_i^* - [(r+\tau)\theta + (r^*+t)(1-\theta)]x_i^*, \tag{2}$$

for industry $i \in \{1, \cdots, m\}$, and the counterparts in industry $j \in \{m+1, \cdots, m+n\}$ are

$$\pi_j \equiv p(x_j + x_j^*)x_j - rx_j \tag{3}$$

$$\pi_j^* \equiv p(x_j + x_j^*)x_j^* - r^*x_j^*. \tag{4}$$

When all the firms play a Cournot-Nash game, the first-order conditions are

$$\begin{aligned}
x_i p'(x_i + x_i^*) + p(x_i + x_i^*) - r &= 0 \\
x_i^* p'(x_i + x_i^*) + p(x_i + x_i^*) - (r+\tau)\theta - (r^*+t)(1-\theta) &= 0 \\
x_j p'(x_j + x_j^*) + p(x_j + x_j^*) - r &= 0 \\
x_j^* p'(x_j + x_j^*) + p(x_j + x_j^*) - r^* &= 0.
\end{aligned}$$

Note here that $r+\tau$ and r^*+t must be equalized if the degree of FDI θ is an interior solution; the Foreign firm specializes in exporting if $r+\tau > r^*+t$ and vice versa if $r+\tau < r^*+t$. And, following Dixit and Grossman (1986), we assume that r is endogenously determined so that the Home factor market

clears but that r^* is exogenous:[8]

$$mx_i + nx_j + m\theta x_i^* = k, \tag{5}$$

where k is the fixed factor supply. In this equation, $mx_i + nx_j$ represents factor demand of the Home firms, and $m\theta x_i^*$ is factor demand of the Foreign multinational firm. The model is closed by substituting $r = r^* + t - \tau$ into the four first-order conditions:

$$\begin{aligned}
x_i p'(x_i + x_i^*) + p(x_i + x_i^*) - r^* - t + \tau &= 0 && (6)\\
x_i^* p'(x_i + x_i^*) + p(x_i + x_i^*) - r^* - t &= 0 && (7)\\
x_j p'(x_j + x_j^*) + p(x_j + x_j^*) - r^* - t + \tau &= 0 && (8)\\
x_j^* p'(x_j + x_j^*) + p(x_j + x_j^*) - r^* &= 0. && (9)
\end{aligned}$$

Our model comprises Eqs. (5)-(9), which determine x_i, x_i^*, x_j, x_j^* and θ.

3 Trade and FDI Liberalization

This section examines the effects of a reduction of t and τ. Note that our model has a recursive structure such that x_i and x_i^* are determined in Eqs. (6) and (7), and x_j and x_j^* are determined in Eqs. (8) and (9), and then Eq. (5) uniquely determines θ, given the predetermined variables x_i, x_i^*, x_j and x_j^*. Therefore, the effects of a small change in t and τ are simply computed as follows.

$$\begin{aligned}
\begin{bmatrix} x_i p_i'' + 2p_i' & x_i p_i'' + p_i' \\ x_i^* p_i'' + p_i' & x_i^* p_i'' + 2p_i' \end{bmatrix} \begin{bmatrix} dx_i \\ dx_i^* \end{bmatrix} &= \begin{bmatrix} 1 \\ 1 \end{bmatrix} dt + \begin{bmatrix} -1 \\ 0 \end{bmatrix} d\tau \\
\begin{bmatrix} x_j p_j'' + 2p_j' & x_j p_j'' + p_j' \\ x_j^* p_j'' + p_j' & x_j^* p_j'' + 2p_j' \end{bmatrix} \begin{bmatrix} dx_j \\ dx_j^* \end{bmatrix} &= \begin{bmatrix} 1 \\ 0 \end{bmatrix} dt + \begin{bmatrix} -1 \\ 0 \end{bmatrix} d\tau.
\end{aligned}$$

At this stage, we make an assumption familiar in the oligopoly theory:

[8]The case in which r and r^* are endogenous is briefly commented in the concluding section; this case yields nothing clear.

Assumption. $x_i p_i'' + p_i', x_i^* p_i'' + p_i', x_j p_j'' + p_j'$ and $x_j^* p_j'' + p_j'$ are all negative.

Then, the comparative statics outcomes are obtained as

$$\frac{\partial x_i}{\partial t} = \frac{-(x_i - x_i^*)p_i'' + p_i'}{\Delta_i} \quad , \quad \frac{\partial x_i^*}{\partial t} = \frac{(x_i - x_i^*)p_i'' + p_i'}{\Delta_i} \tag{10}$$

$$\frac{\partial x_i}{\partial \tau} = -\frac{x_i^* p_i'' + 2p_i'}{\Delta_i} > 0 \quad , \quad \frac{\partial x_i^*}{\partial \tau} = \frac{x_i^* p_i'' + p_i'}{\Delta_i} < 0 \tag{11}$$

$$\frac{\partial x_j}{\partial t} = \frac{x_j^* p_j'' + 2p_j'}{\Delta_j} < 0 \quad , \quad \frac{\partial x_j^*}{\partial t} = -\frac{x_j^* p_j'' + p_j'}{\Delta_j} > 0 \tag{12}$$

$$\frac{\partial x_j}{\partial \tau} = -\frac{x_j^* p_j'' + 2p_j'}{\Delta_j} > 0 \quad , \quad \frac{\partial x_j^*}{\partial \tau} = \frac{x_j^* p_j'' + p_j'}{\Delta_j} < 0, \tag{13}$$

where $\Delta_i \equiv (x_i p_i'' + x_i^* p_i'' + 3p_i')p_i' > 0$ and $\Delta_j \equiv (x_j p_j'' + x_j^* p_j'' + 3p_j')p_j' > 0$ are the coefficient determinant of the totally differentiated systems above. These results will be made use of in deriving and interpreting the welfare effects of trade and FDI liberalization.

We now define welfare of each country. First of all, Home consumer surplus CS is defined by

$$\begin{aligned} CS \equiv\ & m\left[\int_0^{x_i+x_i^*} p(X)dX - (x_i + x_i^*)p(x_i + x_i^*)\right] \\ & + n\left[\int_0^{x_j+x_j^*} p(X)dX - (x_j + x_j^*)p(x_j + x_j^*)\right]. \end{aligned} \tag{14}$$

Next, the profit of oligopolistic firms is defined by

$$\pi_i = [p(x_i + x_i) - r^* - t + \tau]x_i \quad , \quad \pi_j = [p(x_j + x_j^*) - r^* - t + \tau]x_j \tag{15}$$

$$\pi_i^* = [p(x_i + x_i^*) - r^* - t]x_i \quad , \quad \pi_j^* = [p(x_j + x_j^*) - r^*]x_j^*, \tag{16}$$

where use is made of the condition $r + \tau = r^* + t$.

The third welfare component is factor income. Noting that employed factor Home is fixed to k, but that employed factor of Foreign is given by $m(1-\theta)x_i^* + nx_j^*$ and not necessarily equal to the factor endowment k^*, factor income in Home and Foreign is defined as follows.

$$\text{Home factor income} = rk = (r^* + t - \tau)k \tag{17}$$

$$\text{Foreign factor income} = r^*[m(1-\theta)x_i^* + nx_j^*]. \tag{18}$$

Finally, government revenue from trade and investment taxes is

$$\text{Home tax revenue} = tm(1-\theta)x_i^* + \tau m\theta x_i^*. \tag{19}$$

Summing (15), (17) and (19) up leads to national income of Home I:[9]

$$I = mp(x_i + x_i^*)x_i + np(x_j + x_j^*)x_j + r^*(k - mx_i - nx_j) + tmx_i^*. \tag{20}$$

Similarly, summing (16) and (18) yields national income of Foreign, which also represents Foreign welfare W^*:

$$W^* = mp(x_i + x_i^*)x_i^* + np(x_j + x_j^*)x_j^* - r^*(k - mx_i - nx_j) - tmx_i^*. \tag{21}$$

Using these expressions, Home welfare W is given by $W = CS + I$, and world welfare is given by $W + W^*$.

In deriving the welfare effect of trade and FDI liberalization, we employ a convenient strategy of Ishikawa et al. (2010) in which the effects on consumer surplus and firm profits are first addressed, and then the effects on welfare are considered. The first result we establish concerns the effect of trade and FDI liberalization on consumer surplus of Home. This is summarized in:[10]

Proposition 1. *Trade liberalization raises consumer surplus of Home, but FDI liberalization lowers it.*

The intuition behind this result is as follows. From the condition $r = r^* + t - \tau$ and the profit maximization conditions (6) and (7), a tariff reduction decreases marginal cost of both Home and Foreign firms in industry i. Hence, total output necessarily increase while it is ambiguous whether each firm's output increases.[11] Analogously, the first-order conditions (8) and (9) convince us that a tariff reduction also increases total output in industry j

[9] The detailed derivation of (20) and (21) is left in Appendix.
[10] The proofs of all propositions are provided in Appendix.
[11] If demand is linear ($p_i'' = 0$), both firms' output increases.

because output expansion of the Home firm is larger than output contraction of the Foreign firm. As a result, total output in all industries expands, and thus the Home consumer gains from trade liberalization.

If, in contrast, FDI is liberalized, the opposite reasoning applies. From Eqs. (6)-(9), it is obvious that a reduction of investment tax decreases the Home firm's output and increases the Foreign firm's output in industries i and j since the Home firm's marginal cost rises. Because the negative effect on the Home firm's output dominates the positive effect on the Foreign firm's output, both total output and Home consumer surplus decrease as the investment tax is reduced.

Let us next examine how reduced tariffs and investment taxes affect Home firms' profits. This is stated in:

Proposition 2. *Trade liberalization raises the profit of all Home firms, but FDI liberalization lowers it.*

As mentioned earlier, a tariff reduction lowers marginal cost of the Home firm i and the price of Good i. However, the former effect is larger than the latter effect, and thus the Home firm i makes more profits after trade liberalization. In contrast, it is straightforward to find that a tariff reduction also increases the profit of the Home firm j since reduced tariffs increase the Home firm's output by reducing its marginal cost.

Since the Home factor price is endogenously determined in the present model, it makes sense to look at the effect on the factor income rk. Noting the condition $r = r^* + t - \tau$, it is trivial that

Proposition 3. *Trade liberalization lowers the factor income of Home, but FDI liberalization raises it.*

Thus far, we have confined attention to the effects of trade and FDI liberalization on the components of Home welfare. Before turning to considering

the effect on welfare, we now examine the effect on the firm profits and factor income of Foreign. The following two propositions summarize the effects on the firm profits and factor income of Foreign, respectively.

Proposition 4. *Trade and FDI liberalization raises the profit of the Foreign firms that engage in exporting and FDI. Trade liberalization lowers the profit of the Foreign firms that engage in exporting only, but FDI liberalization raises it.*

Proposition 5. *Trade liberalization raises the factor income of Foreign, but FDI liberalization lowers it.*

Proposition 4 straightforwardly comes from Eqs. (6) and (9). On the one hand, tariff reductions lower marginal cost of both the Home and Foreign firms in industry i, yielding a higher profit for the Foreign firm that engage in exporting and FDI. If, on the other hand, the investment tax is reduced, the Home firm's marginal cost rises, and hence the Foreign firm in industry i gains from FDI liberalization as well.

It is easy to understand the competing effect of trade and FDI liberalization on the Foreign firms that specialize in exporting. When a tariff (resp. investment tax) is reduced, marginal cost of the Home firm in industry j decreases (resp. increases), which, in turn, leads to a decrease (resp. an increase) in the Foreign firms' profit in industry j.

Proposition 5 is also a natural observation. If Home reduces an import tariff (resp. investment tax), the Foreign firms in industry i find it more profitable to produce in the source country (resp. host country) by employing the Foreign factor (resp. Home factor). Accordingly, liberalization of trade (resp. FDI) encourages (resp. discourages) the Foreign employment and factor income.

We are now in a position to discuss the effect of trade and FDI liberaliza-

tion on overall welfare of each country, but it is impossible to obtain a clear result under general demand. But, if we assume linear demand, the following proposition can be established.

Proposition 6. *Under linear demand, trade liberalization raises welfare of Home, but FDI liberalization lowers it. The effect of trade and FDI liberalization on Foreign welfare is ambiguous.*

In the case where factor prices are not affected by policy changes, liberalization of trade and/or FDI reduces Home welfare and improves Foreign welfare by shifting the Home firms' profits abroad. However, this argument no longer applies to the present model because the trade and FDI liberalization influences the factor price of Home. In particular, it is worth stressing that trade liberalization improves Home welfare because this finding is sharply contrasting to the conventional outcome mentioned above. The reason for welfare-improving trade liberalization is that tariff reductions increase consumer surplus and the profits of all the Home firms, which dominate the negative effect on the factor income.[12] On the contrary, FDI liberalization inevitably becomes detrimental since the negative effect on consumer surplus and the Home firms' profits are larger than the positive effect on the factor income.

Finally, the effect of trade and FDI liberalization on the world welfare is derived. The following result can hold under general demand.

Proposition 7. *Trade liberalization raises the world welfare, but FDI liberalization lowers it. Simultaneous liberalization of trade and FDI raises the world welfare.*

[12]The effect on government revenue is ambiguous.

This result is comparable with that of Ishikawa et al. (2010). Incorporating post-production services into a Bertrand model, Ishikawa et al. (2010) demonstrate that simultaneous liberalization of trade and FDI benefits the world economy although trade liberalization alone can be world-welfare-reducing. After proving this result, Ishikawa et al. (2010, p. 80) provide a novel implication that 'making progress on the liberalization of service FDI under GATS (General Agreement on Trade and Service) is crucial to secure positive welfare consequences of the trade liberalization under GATT/WTO.' Our result is qualitatively different from theirs in the sense that FDI liberalization alone is welfare-reducing but that liberalization of both trade and FDI is welfare-enhancing. However, both it is worth commenting that the results in Ishikawa et al. (2010) and this paper both point out that the complementary role of GATS and GATT/WTO is quite important for successful trade and FDI liberalization.

4 Concluding Remarks

We have explored welfare effects of trade and FDI liberalization in a two-country oligopolistic model that emphasizes the linkage between the goods and factor markets. By assuming multiple oligopolies that compete for a common factor, we have endogenized the factor price, and shown that trade liberalization can improve welfare of the host country whereas FDI liberalization has the opposite welfare effect. In addition, we have established that simultaneous liberalization of trade and FDI benefits the world whereas FDI liberalization alone is world-welfare-reducing.

While this paper may offer some useful insights into trade and FDI liberalization, they rest on a number of specific assumptions and much needs to be made for a more satisfactory analysis. First, one may wonder if our results are valid when the factor price of both Home and Foreign is endogenized. Although this full general equilibrium in the world economy is possible to

compute, the welfare effects of trade and FDI liberalization turn to be less transparent. All we can say is that the world gains from liberalization of either trade or FDI or both; the welfare effects on each country are ambiguous. Second, it would be interesting to check our results in Bertrand competition. Third, we have focused on an investment tax as a FDI policy, but other types of FDI policies, e.g. local content requirements, are worth addressing. Third, this paper has paid no attention to cross-border merger and acquisition, which are the other important type of FDI. Finally, we have assumed a quasi-linear utility function, following the modeling of Dixit and Grossman (1986) and Glass and Saggi (1999). In contrast, Neary (2009) develops an oligopolistic model that utilizes a non-quasi-linear preference and a linkage between the goods and factor markets. It is quite interesting to consider the welfare effects of trade and FDI liberalization in his general oligopolistic equilibrium model. These tasks are left as important research agenda in the near future.

5 Appendix

5.1 Derivation of (20) and (21)

National income of Home consists of the profits of the oligopolistic firms, factor income, and government revenue from trade and investment taxes:

$$\begin{aligned} I &\equiv m\pi_i + n\pi_j + rk + tm(1-\theta)x_i^* + \tau m\theta x_i^* \\ &= m(p_i x_i - r x_i) + n(p_j x_j - r x_j) + rk + tm(1-\theta)x_i^* + \tau m\theta x_i^* \\ &= mp_i x_i + np_j x_j + r(k - mx_i - nx_j) + tmx_i^* - (t-\tau)m\theta x_i^* \\ &= mp(x_i + x_i^*)x_i + np(x_j + x_j^*)x_j + r^*(k - mx_i - nx_j) + tmx_i^*, \end{aligned}$$

where the second line uses the definition of π_i and π_j, and the last line follows from the factor market-clearing condition of Home (5) and the condition $r - t + \tau = r^*$. In a similar way, national income (welfare) of Foreign is

derived as follows.

$$\begin{aligned} W^* &\equiv m\pi_i^* + n\pi_j^* + r^*[m(1-\theta)x_i^* + nx_j^*] \\ &= m[p_i x_i^* - (r^*+t)x_i^*] + n(p_j x_j^* - r^* x_j^*) + r^* m x_i^* + r^* n x_j^* - r^* m\theta x_i^* \\ &= mp(x_i + x_i^*)x_i^* + np(x_j + x_j^*)x_j^* - r^*(k - mx_i - nx_j) - tmx_i^*. \end{aligned}$$

5.2 Proof of Proposition 1

In what follows, we use a notation of $X_i \equiv x_i + x_i^*$ and $X_j \equiv x_j + x_j^*$. Differentiating (14) with respect to t and τ yields

$$\begin{aligned} \frac{\partial CS}{\partial t} &= -mX_i p_i' \frac{\partial X_i}{\partial t} - nX_j p_j' \frac{\partial X_j}{\partial t} = -\frac{2mX_i (p_i')^2}{\Delta_i} - \frac{nX_j (p_j')^2}{\Delta_j} < 0 \\ \frac{\partial CS}{\partial \tau} &= -mX_i p_i' \frac{\partial X_i}{\partial \tau} - nX_j p_j' \frac{\partial X_j}{\partial \tau} = \frac{mX_i (p_i')^2}{\Delta_i} + \frac{nX_j (p_j')^2}{\Delta_j} > 0, \end{aligned}$$

which leads to Proposition 1.

5.3 Proof of Proposition 2

Differentiating (15) with respect to t and τ and applying the envelope theorem, we have

$$\begin{aligned} \frac{\partial \pi_i}{\partial t} &= \left(p_i' \frac{\partial x_i^*}{\partial t} - 1 \right) x_i = -\frac{2x_i p'(x_i^* p_i'' + p_i')}{\Delta_i} < 0 \\ \frac{\partial \pi_j}{\partial t} &= \left(p_j' \frac{\partial x_j^*}{\partial t} - 1 \right) x_j = -\frac{x_j p_j'(x_j p_j'' + 2x_j^* p_j'' + 4p_j')}{\Delta_j} < 0 \\ \frac{\partial \pi_i}{\partial \tau} &= \left(p_i' \frac{\partial x_i^*}{\partial \tau} + 1 \right) x_i = \frac{x_i p_i'(x_i p_i'' + 2x_i^* p_i'' + 4p_i')}{\Delta_i} > 0 \\ \frac{\partial \pi_j}{\partial \tau} &= \left(p_j' \frac{\partial x_j^*}{\partial \tau} + 1 \right) x_j = \frac{x_j p_j'(x_j p_j'' + 2x_j^* p_j'' + 4p_j')}{\Delta_j} > 0. \end{aligned}$$

These inequalities establish Proposition 2.

5.4 Proof of Proposition 3

This is obvious since (17) is increasing in t and decreasing in τ.

5.5 Proof of Proposition 4

Differentiating (16) with respect to t and τ and using the envelope theorem, we have

$$\begin{aligned}
\frac{\partial \pi_i^*}{\partial t} &= \left(p_i' \frac{\partial x_i}{\partial t} - 1\right) x_i^* = -\frac{2x_i^* p_i'(x_i p_i'' + p_i')}{\Delta_i} < 0 \\
\frac{\partial \pi_j^*}{\partial t} &= x_j^* p_j' \frac{\partial x_j}{\partial t} = \frac{x_j^* p_j'(x_j^* p_j'' + 2p_j')}{\Delta_j} > 0 \\
\frac{\partial \pi_i^*}{\partial \tau} &= x_i^* p_i' \frac{\partial x_i}{\partial \tau} = -\frac{x_i^* p_i'(x_i^* p_i'' + 2p_i')}{\Delta_i} < 0 \\
\frac{\partial \pi_j^*}{\partial \tau} &= x_j^* p_j' \frac{\partial x_j}{\partial \tau} = -\frac{x_j^* p_j'(x_j^* p_j'' + 2p_j')}{\Delta_j} < 0,
\end{aligned}$$

from which Proposition 4 follows.

5.6 Proof of Proposition 5

The Foreign factor income, which is given by (18), is rewritten as

$$r^*[m(1-\theta)x_i^* + nx_j^*] = r^*(mX_i + nX_j - k) \equiv F^*,$$

by noting that $m(1-\theta)x_i^* = mx_i^* + mx_i + nx_j - k$ from (5). Then, the partial derivative of F^* with respect to t and τ is obtained as

$$\begin{aligned}
\frac{\partial F^*}{\partial t} &= r^*\left(m\frac{\partial X_i}{\partial t} + n\frac{\partial X_j}{\partial t}\right) = r^*\left(\frac{2mp_i'}{\Delta_i} + \frac{np_j'}{\Delta_j}\right) < 0 \\
\frac{\partial F^*}{\partial \tau} &= r^*\left(m\frac{\partial X_i}{\partial \tau} + n\frac{\partial X_j}{\partial \tau}\right) = -r^*\left(\frac{mp_i'}{\Delta_i} + \frac{np_j'}{\Delta_j}\right) > 0,
\end{aligned}$$

which implies Proposition 5.

5.7 Proof of Proposition 6

Noting that Home welfare is defined by $W \equiv CS + I$ and that Foreign welfare is defined by (21), tedious manipulations lead to

$$\frac{\partial W}{\partial t} = -mX_i p_i' \frac{\partial X_i}{\partial t} - nX_j p_j' \frac{\partial X_j}{\partial t} + m\left(x_i p_i' \frac{\partial X_i}{\partial t} + p_i \frac{\partial x_i}{\partial t}\right) + n\left(x_j p_j' \frac{\partial X_j}{\partial t} + p_j \frac{\partial x_j}{\partial t}\right)$$

$$
\begin{aligned}
& +r^*\left(-m\frac{\partial x_i}{\partial t}-n\frac{\partial x_j}{\partial t}\right)+mt\frac{\partial x_i^*}{\partial t}+mx_i^* \\
= \;& \frac{2mt}{3p_i'}+\frac{n(p_j-r^*)}{p_j'}<0 \\
\frac{\partial W^*}{\partial t} = \;& m\left(x_i^*p_i'\frac{\partial X_i}{\partial t}+p_i\frac{\partial x_i^*}{\partial t}\right)+n\left(x_j^*p_j'\frac{\partial X_j}{\partial t}+p_j\frac{\partial x_j^*}{\partial t}\right) \\
& +r^*\left(m\frac{\partial x_i}{\partial t}+n\frac{\partial x_j}{\partial t}\right)-mt\frac{\partial x_i^*}{\partial t}-mx_i^* \\
= \;& \frac{2m(p_i-t)}{3p_i'}-\frac{n(2p_j-3r^*)}{3p_j'} \\
\frac{\partial W}{\partial \tau} = \;& -mX_ip_i'\frac{\partial X_i}{\partial \tau}-nX_jp_j'\frac{\partial X_j}{\partial \tau}+m\left(x_ip_i'\frac{\partial X_i}{\partial \tau}+p_i\frac{\partial x_i}{\partial \tau}\right)+n\left(x_jp_j'\frac{\partial X_j}{\partial \tau}+p_j\frac{\partial x_j}{\partial \tau}\right) \\
& +r^*\left(-m\frac{\partial x_i}{\partial \tau}-n\frac{\partial x_j}{\partial \tau}\right)+mt\frac{\partial x_i^*}{\partial \tau} \\
= \;& -\frac{m(3p_i-3r^*-2t)}{3p_i'}-\frac{n(p_j-r^*)}{p_j'}>0 \\
\frac{\partial W^*}{\partial \tau} = \;& m\left(x_i^*p_i'\frac{\partial X_i}{\partial \tau}+p_i\frac{\partial x_i^*}{\partial \tau}\right)+n\left(x_j^*p_j'\frac{\partial X_j}{\partial \tau}+p_j\frac{\partial x_j^*}{\partial \tau}\right) \\
& +r^*\left(m\frac{\partial x_i}{\partial \tau}+n\frac{\partial x_j}{\partial \tau}\right)-mt\frac{\partial x_i^*}{\partial \tau} \\
= \;& \frac{m(2p_i-3r^*-2t)}{3p_i'}+\frac{n(2p_j-3r^*)}{3p_j'},
\end{aligned}
$$

under linear demand such that $p_i''=p_j''=0$.

5.8 Proof of Proposition 7

Summing (14), (20) and (21) up, world welfare takes the form

$$W+W^*=CS+mX_ip(X_i)+nX_jp(X_j).$$

Thus, differentiating this with respect to t and τ, we find that

$$
\begin{aligned}
\frac{\partial(W+W^*)}{\partial t} &= -mX_ip_i'\frac{\partial X_i}{\partial t}-nX_jp_j'\frac{\partial X_j}{\partial t}+m(X_ip_i'+p_i)\frac{\partial X_i}{\partial t}+n(X_jp_j'+p_j)\frac{\partial X_j}{\partial t} \\
&= \frac{2mp_ip_i'}{\Delta_i}+\frac{np_jp_j'}{\Delta_j}<0
\end{aligned}
$$

$$\begin{aligned}\frac{\partial(W+W^*)}{\partial\tau} &= mp_i\frac{\partial X_i}{\partial\tau}+np_j\frac{\partial X_j}{\partial\tau}\\ &= -\frac{mp_ip_i'}{\Delta_i}-\frac{np_jp_j'}{\Delta_j}>0,\end{aligned}$$

implying that trade liberalization raises the world welfare, but FDI liberalization lowers it. If these liberalization policies are simultaneously implemented, world welfare improves because

$$\frac{\partial(W+W^*)}{\partial t}+\frac{\partial(W+W^*)}{\partial\tau}=\frac{mp_ip_i'}{\Delta_i}<0.$$

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