

# Does Preferential Trade Benefit Poor Countries? A General Equilibrium Assessment with Nonhomothetic Preferences \*

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## Abstract

We study the effects of preferential trade agreements (PTA) in a model where the income matters for consumption patterns. We develop a three-country Ricardian trade model in which goods are ranked according to priority and where economies differ in their income level. The poorest (richest) country has a comparative advantage in the production of lowest-ranked (highest-ranked) goods, specializing in goods with low (high) income elasticities in demand. The medium rich country specializes in the production of the intermediate-ranked commodities. We find that being excluded from a PTA is detrimental for a low-income country, but not for the high-income country. Becoming a member of a PTA does also not guarantee welfare gains for the low income country, unless it is so poor that it cannot import the higher-ranked goods that the rich country produces.

**Keywords:** Ricardian trade model; asymmetric demand complementarities; Customs Union; income distribution.

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## 1. Introduction

In May 2004, eight new countries from central Europe (Estonia, Latvia, Lithuania, Poland, Czech Rep. Slovakia, Hungary, and Slovenia) have joined the European Union (EU), along with the Mediterranean islands of Cyprus and Malta. These countries have a significantly lower per capita income and are also much more specialized in agriculture than the average of the pre-accession EU-15 (see Baldwin and Wyplosz, 2003).<sup>1</sup> This is just one example of integration between countries that differ significantly in their level of economic development. Another example is, of course, the North American Free Trade Agreement (Nafta), which includes the United States of America, Canada and Mexico.

As has been reported by World Trade Organization (WTO, 2002), this exemplifies a growing trend towards preferential trade agreements (PTAs) between countries of substantially different income levels. The theoretical connection between the level of per capita income and preferential trade has however not received adequate attention. In particular, it has ignored the fact that countries with different levels of development may have quite different priorities regarding which goods to consume. Whereas the standard literature focuses on comparative advantage as the main difference between countries, we argue that in a world where income differences between countries persist and widen, one cannot longer ignore the impact of nonhomothetic preferences on trade patterns and welfare.<sup>2</sup> Indeed, the assumed similarity in consumption patterns is at odds with a number of stylized facts. Firstly, many new, sophisticated products are developed in countries with high per capita incomes, created by entrepreneurs in response to a perceived demand. Individuals in countries with lower per capita income tend to buy relatively simple products. Recent evidence for this is provided by Schott (2001).<sup>3</sup> Secondly, new goods are originally developed and

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<sup>1</sup>Even if the annual growth rate of these countries would exceed that of the rest of the EU by two percentage points, it will take them on average 50 years to catch up. (The Economist Intelligence Unit, "Europe Enlarged: Understanding the Impact.")

<sup>2</sup>There are of course good reasons for this gap in the literature. The first wave of PTAs in the 1950s was almost exclusively among countries with similar per capita income and effective arrangements were restricted to Western Europe. Assuming homothetic preferences is then a natural choice, which indeed has been the case without exception (see Baldwin & Venables (1995), Bhagwati and Panagariya (1996a, 1996b), and Panagariya (2000) for an overview of the literature). The recent emergence of vast numbers of new PTAs led economists and policy analysts to focus exclusively on the implications of such blocs for the global trading system (see, for example, Levy (1997) and Krishna (1998)). Finally, a complicating factor has been that until recently the possibility of relaxing the homotheticity assumption on demand rendered the analysis difficult, if not intractable (see for example Wilson, 1980).

<sup>3</sup>See Deaton and Muellbauer (1980), Hunter and Markusen (1987) and Hunter (1991).

produced in developed countries and only at a later point in their cycle consumed in less developed countries (Vernon, 1966). Thirdly, the volume of trade will be higher between countries with similar per capita income (Linder, 1961).

The present paper develops a model for analyzing PTAs that assigns a central role to income differences and nonhomothetic preferences. The model builds on Matsuyama (2000) who incorporates nonhomothetic preferences in a two country Ricardian trade model with a continuum of goods. We extend his framework and apply it to the issue of preferential trade arrangements when countries differ with respect to income levels. Countries are ranked such that the poorest country has a comparative advantage in the production of the lower-ranked goods with low income elasticities in demand, the richest country has a comparative advantage in the production of the highest-ranked goods with high income elasticities in demand, and the medium rich country has a comparative advantage in the production of intermediate-ranked commodities with intermediate income elasticities of demand. Nonhomothetic preferences are incorporated by ordering goods according to priority in consumption. Goods at the lower end of the spectrum are consumed by all households. When real income increases households add higher-ranked goods to their consumption basket, instead of buying more of the goods they already consume. As such, our model also exhibits the property of asymmetric demand complementarities: as the price of lower-ranked goods falls, due to lower tariffs say, the resulting real income gain induces households to expand their consumption baskets by adding goods of higher priority. If, by contrast, the price of higher-ranked goods decline, the demand for low priority goods is however unaffected by the real income gain.

In our analysis we focus on the effects of PTAs when there are substantial income differences between countries. The following insights emerge. First, a PTA does not necessarily deteriorate the terms of trade of the country that is left outside of the agreement, though this very much depends on the income level of the non-member. We show that while being a non-member is typically bad for the terms of trade of a poor country, for a rich country the terms of trade still improves. Second, being left outside of a PTA agreement is also typically bad for welfare, except for the rich country. This is due to the presence of asymmetric demand complementarities. Whereas the outside country suffers as the PTA members' expenditure switching goes at their expense, for a rich country this might be compensated by the fact that the real income gains are typically spent on country 3 goods. Third, being a member of a PTA is no guarantee for welfare improvements. Only countries that are too poor to import the whole range of world products can be assured that opening up their

borders preferentially leads to welfare gains. For the other countries it depends to a large extent on how comparative advantages differ across the world.<sup>4</sup> Consequently, the income level of a country greatly matters for assessing the welfare effects of PTAs. Moreover, we find that it is not only the income differences *per se* that matter, but also the *extent* of these income differences. While being a low income country leads to different inferences regarding the costs and benefits of preferential trading agreements than being a medium or high income country, it also holds that these results depend highly on whether or not the low-income country is partly insulated from world trade. In fact, our analysis shows that the very poor countries have most to gain by joining a preferential trade agreement with a rich counterpart.

Our paper is related to Appleyard, Conway and Field (1989) and the twin paper Conway, Appleyard and Field (1989) in terms of focus (on preferential trade agreements) and the modelling of the supply side (a Ricardian trade model with a continuum of goods). Our model clearly differs with respect to the demand side, however. In short, both construct a similar model to ours but assume preferences to be Cobb-Douglas over a fixed range of goods. This implies that each household spends a constant expenditure share on each good regardless of the level of income. Consequently, in their models income differences — within and across countries — do not matter for the aggregate variables, ruling out an adequate analysis of PTAs between countries that differ in their stage of economic development.

The structure of this paper is as follows. In Section 2, we use Matsuyama (2000) and discuss how to extend his set-up to three countries plus the inclusion of initial tariffs. Section 3 discusses some novel features of our model and focuses it on income differences between countries. Our analysis starts in Section 4 with the analyses of the general equilibrium and welfare effects of unilateral tariff reductions. In Section 5, we use these results to consider the effects of various formations of preferential trading arrangements in the wake of income differences between countries. Section 6 discusses the concomitant welfare effects. Section 7 briefly discusses multilateral tariff reductions and Section 8 concludes.

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<sup>4</sup>Bhagwati and Panagariya (1996, Chapter 1) suggest that the formation of PTA among unequal partners could be to the detriment of the less developed partner country. They do, however, not provide a formal analysis for this claim.

## 2. The Model

We consider three countries, countries 1, 2, and 3. In each of the countries we assume the existence of a continuum of competitive industries, indexed by  $z \in [0, \infty)$ , each producing a homogeneous good also indexed by  $z$ . There is one factor of production, labor, which is supplied in fixed quantity in country  $j$  ( $j = 1, 2, 3$ ) and denoted by  $L_j$ . For good  $z$ , let  $a_j(z)$  be the unit labor requirement in country  $j$  ( $j = 1, 2, 3$ ). We follow Appleyard, Conway and Field (1989) (hereafter: ACF) and make the following assumptions on technology:

**Assumption 1.**  $\frac{a_i(z)}{a_1(z)} \equiv A_i(z)$  with  $-\frac{z}{A_i} \frac{\partial A_i}{\partial z} \equiv \zeta_i > 0$  for  $i = 2, 3$  and all  $z$ .

**Assumption 2.**  $\zeta_2 < \zeta_3$  for all  $z$ .

Assumption 1 is standard and requires that  $A_i$  ( $i = 2, 3$ ) is smooth, continuous, and strictly decreasing in  $z \in [0, \infty)$ . It ensures that commodities can be ranked in order of diminishing comparative advantage of country 1 relative to both country 2 and 3. Assumption 2 implies that  $A_3(z)$  is relatively steeper than  $A_2(z)$  so that  $A_3(z)/A_2(z)$  is strictly decreasing in  $z$ . Assumption 2 ensures that country 3 has an increasing comparative advantage relative to country 2 for higher  $z$ .

We start from a situation in which trade flows are distorted by tariffs. Let  $\tau_{jk} = 1 + t_{jk}$  be one plus the ad valorem tariff in country  $j$  on any of the commodities  $z$  when it is produced in country  $k$  ( $t_{jk} > 0$  for  $j \neq k$  and for all  $z$ ). We assume that a country initially levies uniform tariff rates on all imports regardless of the source, i.e.,  $\tau_{jk} = \tau_{jk'}$  for  $j, k, k' = 1, 2, 3$  and  $k \neq k'$ . This assumption is not only for sake of analytical convenience but uniform tariffs on all imports are in keeping with the ‘‘most favoured nation’’ (MFN) clause of the GATT Articles of Agreement. Assuming perfect competition, a country then exports good  $z$  when it can produce that good at the lowest cost. Let the relative wages be  $\omega_i = w_1/w_i$  for  $i = 2, 3$ , the range of goods a country exports is defined by two inequalities. It follows that there will be six equilibrium borderline goods  $z_k$  for  $k = 1, \dots, 6$ , which demarcate for each country the range of own production, range of exports, and the range of nontraded goods. These borderline goods are represented by equalities in (2.1)-(2.6) (see ACF (1989), p.151).

Country 1 will export to country 2 iff :

$$\tau_{21}w_1a_1 \leq w_2a_2 \text{ and } \tau_{21}w_1a_1 \leq \tau_{23}w_3a_3 \text{ implies } \tau_{21}\omega_2 = \frac{a_2(z_1)}{a_1(z_1)}. \quad (2.1)$$

Country 1 will export to country 3 iff

$$\tau_{31}w_1a_1 \leq \tau_{32}w_2a_2 \text{ and } \tau_{31}w_1a_1 \leq w_3a_3 \text{ implies } \tau_{31}\omega_2 = \tau_{32}\frac{a_2(z_2)}{a_1(z_2)}. \quad (2.2)$$

Country 2 will export to country 1 iff

$$\tau_{12}w_2a_2 \leq w_1a_1 \text{ and } \tau_{12}w_2a_2 \leq \tau_{13}w_3a_3 \text{ implies } \omega_2 = \tau_{12}\frac{a_2(z_3)}{a_1(z_3)}. \quad (2.3)$$

Country 2 will export to country 3 iff

$$\tau_{32}w_2a_2 \leq w_3a_3 \text{ and } \tau_{32}w_2a_2 \leq \tau_{31}w_1a_1 \text{ implies } \frac{\omega_2}{\omega_3} = \tau_{32}\frac{a_2(z_4)}{a_3(z_4)}. \quad (2.4)$$

Country 3 will export to country 1 iff

$$\tau_{13}w_3a_3 \leq \tau_{12}w_2a_2 \text{ and } \tau_{13}w_3a_3 \leq w_1a_1 \text{ implies } \frac{\omega_3}{\omega_2} = \frac{a_3(z_5)\tau_{13}}{a_2(z_5)\tau_{12}}. \quad (2.5)$$

Country 3 will export to country 2 iff

$$\tau_{23}w_3a_3 \leq w_2a_2 \text{ and } \tau_{23}w_3a_3 \leq \tau_{21}w_1a_1 \text{ implies } \frac{\omega_3}{\omega_2} = \tau_{23}\frac{a_3(z_6)}{a_2(z_6)}. \quad (2.6)$$

Figure 1 gives a graphical representation of the trade patterns in terms of the borderline goods. Country 1 produces all  $z \in [0, z_3)$ , of which  $[z_2, z_3]$  are not traded and  $[0, z_1]$  and  $[0, z_2]$  are exported respectively to country 2 and 3. Country 2 produces all  $z \in [z_1, z_6)$ , of which  $[z_1, z_2]$  and  $[z_5, z_6]$  are not traded and  $[z_3, z_5]$  and  $[z_2, z_4]$  are respectively exported to country 1 and 3. Country 3, finally, produces all  $z \in [z_4, u_3]$ , of which  $[z_4, z_5]$  are not traded, while  $[z_5, u_1]$  and  $[z_6, u_2]$  are respectively exported to country 1 and 2. Here  $u_j$  denotes the highest-indexed good  $z$  a household from country  $j$ ,  $j = 1, 2, 3$ , consumes. The resulting trade pattern  $z_1 < z_2 < z_3 < z_4 < z_5 < z_6$  holds under the assumption that directly importing good  $z$  costs less than importing the same good via a third country.<sup>5</sup> More importantly, and in contrast to ACF, the trade patterns depicted only hold when households in all three countries are rich enough to consume the higher indexed goods country 3 produces. We will elaborate on this further below.

*(insert Figure 1 about here)*

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<sup>5</sup>The exception is  $z_3 < z_4$  where  $z_4 < z_3$  is also possible. Moreover, even though we allow tariff rates to differ between trading partners, these differences should not be too significant.

As country 1 exports all goods of the lower spectrum of commodities, country 3 the higher-ranked commodities, and country 2 the middle-ranked goods, local prices are determined by

$$p_k(z) = \min_j [\tau_{kj} w_j a_j(z)].$$

Even if traded, the local price of good  $z$  does not need to be identical. The equilibrium  $z_k$  and  $u_j$  are determined by the interaction of technology and demand, to which we now turn.

On the demand side, we assume there are  $N_j$  households in country  $j$ . In line with Matsuyama (2000) and Stibora & de Vaal (2006), we assume that the income distribution is nondegenerate and brought about by tariff rebates and by differences in skills reflected in differences in effective labor supply. We let  $F_j(h_j)$  denote the distribution of effective (skill based) labor supply across households in country  $j$ . The total labor supply thus equals  $L_j = N_j \int_0^\infty h_j dF_j(h_j)$  in each country.

The consumption set of a household includes a continuum of  $z \in [0, \infty)$ . All households have the same preferences and maximize  $V = \int_0^\infty b(z)x(z)dz$  subject to the budget constraint  $\int_0^\infty p(z)x(z)dz \leq I$ . In these expressions,  $x(z) = \{0, 1\}$  denotes the ‘quantity’ a household consumes and  $b(z) > 0$  the utility it receives from consuming good  $z$ . Thus, following Murphy, Shleifer, and Vishny (1989), goods come in discrete units and a household’s desire to consume good  $z$  is satiated after the consumption of one unit. This has the strong implication that, in contrast to standard analysis, an increase in utility is reflected in the consumption of an increased number of goods rather than in the consumption of higher quantities of a fixed number of goods. As such, wealthier households consume all the goods consumed by poor households, plus some. Moreover, the linearity of the utility function in  $b$  implies the absence of any substitution effects and that only income effects are important for our results.

The order in which each household purchases goods is assumed to be the same as the ordering of goods due to comparative advantage. Hence, we assume that households consider lower-indexed goods to be of higher priority. These are purchased first and when income increases they add goods with lower priority to their consumption baskets. This requires that the order of utility per unit price is strictly decreasing in  $z$ , that is, we assume that

**Assumption 3.**  $\frac{b(z)}{p_k(z)} = \frac{b(z)}{\min_j [\tau_{kj} w_j a_j(z)]}$

is strictly decreasing in  $z$ , for given  $w_j$  and  $\tau_{kj}$ .

The combination of assumptions 1, 2, and 3 implies that (i) country 1 has a comparative advantage in the production of lower-ranked goods that poor households purchase; (ii) country 3 has a comparative advantage in the production of higher-ranked goods that rich households purchase; (iii) country 2 has a comparative advantage in the production of intermediate-ranked goods that are purchased by households richer than those purchasing goods from country 1 but poorer than those purchasing goods from country 3.

We now define

$$E_j(z) \equiv \int_0^z p_j(s) ds = \int_0^z \min\{\tau_{jk} w_k a_k(z)\} ds \quad (2.7)$$

as the minimum level of income that allows a household from country  $j$  to consume good  $z$ . As the consumption set will typically include imported goods, tariff revenues also affect the income distribution. We assume that the tariff revenue each household generates by purchasing imported goods, if any, is collected by the government and redistributed across households in a lump-sum fashion. Let us denote these tariff rebates in country  $j$  by  $TR_j$  and let us also assume that households take those rebates from the government as given. The highest-indexed commodity a household in country  $j$  with skill level  $h_j$  is able to consume,  $u_j(h_j)$ , is determined by the requirement that

$$E_j[u_j(h_j)] = w_j h_j + TR_j \quad (2.8)$$

for  $j = 1, 2, 3$ . The utility level a household in country  $j$  attains when consuming  $u_j(h_j)$  is  $V_j(h_j) = B(u_j(h_j))$  where  $B(z) \equiv \int_0^z b(s) ds$ .  $V_j(h_j)$ , the level of utility attained by a household from country  $j$ , maps one-to-one into  $u_j(h_j)$ , the highest-indexed good it consumes. We therefore use the latter as a measure of utility (see Matsuyama (2000)).

Good  $z$  is purchased by households only if their income is not lower than  $E_j(z)$ , or equivalently if their skill is such that  $w_j h_j + TR_j$  exceeds  $E_j(z)$ . The fraction of households with income (skills) in excess of  $E_j(z)$ , or with  $w_j h_j > E_j(z) - TR_j$ , is given by  $1 - F_j([E_j(z) - TR_j]/w_j)$ . Aggregate demand for good  $z$  consists of all those households from all three countries whose income is equal or greater than  $E_j(z)$ :

$$Q_j(z) = N_j \left[ 1 - F_j \left( \frac{E_j(z) - TR_j}{w_j} \right) \right] \quad \text{for } j = 1, 2, 3. \quad (2.9)$$

In contrast to the standard literature, equation (2.9) indicates that total demand for good  $z$  does not depend on the aggregate income but on the number of households that have a sufficient level of income (skill) to consume it.



In the presence of tariffs, country 1 produces only goods in  $[0, z_3)$ , of which  $[0, z_1]$  are exported to country 2 and of which  $[0, z_2]$  are exported to country 3. Consequently, labor market equilibrium in country 1 has to satisfy:

$$\begin{aligned} L_1 &= N_1 \int_0^\infty h_1 dF_1(h_1) \\ &= \int_0^{z_3} a_1(z) Q_1(z) dz + \int_0^{z_2} a_1(z) Q_3(z) dz + \int_0^{z_1} a_1(z) Q_2(z) dz. \end{aligned} \quad (2.10)$$

The left hand side of (2.10) represents country 1's effective labor supply and the right hand side is the derived demand for its labor. Combining (2.10) and (2.9), and using (2.7), country 1's labor market equilibrium can be expressed as (see Appendix 9.1.1 for details)

$$\begin{aligned} w_1 L_1 &= N_1 \int_0^\infty \min[w_1 h_1 + TR_1, E_1(z_3)] dF_1(h_1) \\ &\quad + \frac{N_2}{\tau_{21}} \int_0^\infty \min[w_2 h_2 + TR_2, E_2(z_1)] dF_2(h_2) \\ &\quad + \frac{N_3}{\tau_{31}} \int_0^\infty \min[w_3 h_3 + TR_3, E_3(z_2)] dF_3(h_3), \end{aligned} \quad (2.11)$$

with  $E_2(z_1) = \tau_{21} \int_0^{z_1} w_1 a_1(s) ds$ ,  $E_3(z_2) = \tau_{31} \int_0^{z_2} w_1 a_1(s) ds$ , and  $E_1(z_3) = \int_0^{z_3} w_1 a_1(s) ds$ . Equation (2.11) defines national income for country 1, which has to be equal to the total spending on goods produced in that country (including tariffs). Total spending, in turn, is the sum of country 1's expenditure on its own goods,  $N_1 \min[w_1 h_1 + TR_1, E_1(z_3)]$  and country  $j = 2, 3$ 's expenditure on country 1 goods. We note that the country 1's tariff rebate as a result of imports from country 2,  $TR_1$ , is only positive if the income of (some of the) households in country 1 exceeds  $E_1(z_3)$ , otherwise tariff revenues are zero. The tariff rebates for country 2 and country 3 ( $TR_2$  and  $TR_3$ ) are always positive, since households from those countries always import the lower-indexed goods produced in country 1.

Similar reasoning applies to the labor market equilibrium condition for country 2 and 3, which we derive in Appendix 9.1.1. As is typical in the literature of pure trade theory, the three labor market equilibrium conditions are replaced by the equivalent statement that in equilibrium trade has to be balanced (see Appendix). For the trade balance condition of country 1, we obtain

$$\begin{aligned} &\frac{N_2}{\tau_{21}} \int_0^\infty \min[w_2 h_2 + TR_2, E_2(z_1)] dF_2(h_2) + \frac{N_3}{\tau_{31}} \int_0^\infty \min[w_3 h_3 + TR_3, E_3(z_2)] dF_3(h_3) \\ &= \int_0^\infty \left\{ \frac{N_1}{\tau_{12}} \min[w_1 h_1 + TR_1 - E_1(z_3), E_1(z_5) - E_1(z_3)] \right. \\ &\quad \left. + \frac{N_1}{\tau_{13}} \max[w_1 h_1 + TR_1 - E_1(z_5), 0] \right\} dF_1(h_1) \end{aligned} \quad (2.12)$$

and for country 2:

$$\begin{aligned}
& \int_0^\infty \left\{ \frac{N_2}{\tau_{21}} \min [w_2 h_2 + TR_2, E_2(z_1)] + \frac{N_2}{\tau_{23}} \max [w_2 h_2 + TR_2 - E_2(z_6), 0] \right\} dF_2(h_2) \\
&= \frac{N_1}{\tau_{12}} \int_0^\infty \min [w_1 h_1 + TR_1 - E_1(z_3), E_1(z_5) - E_1(z_3)] dF_1(h_1) \\
&+ \frac{N_3}{\tau_{32}} \int_0^\infty \min [w_3 h_3 + TR_3 - E_3(z_2), E_3(z_4) - E_3(z_2)] dF_3(h_3),
\end{aligned} \tag{2.13}$$

where  $E_1(z_5) - E_1(z_3) = \tau_{12} \int_{z_3}^{z_5} w_2 a_2(s) ds$  and  $E_3(z_4) - E_3(z_2) = \tau_{32} \int_{z_2}^{z_4} w_2 a_2(s) ds$ . Notice, both (2.12) and (2.13) give a representation of the demand side only. The first row in (2.12) [(2.13)] represents the value of country 1's (2's) exports, which, in equilibrium, has to equal its value of imports due to the static nature of the model.

The six equations that determine efficient production, (2.1)-(2.6), together with the balanced trade conditions (2.12)-(2.13) and the three budget conditions, given by (2.8), define a system of 11 equations which jointly determine the equilibrium values of the marginal goods  $z_1 - z_6$ , the relative wage rates  $\omega_i$  ( $\equiv w_1/w_i$ ) for  $i = 2, 3$ , and the utility levels  $u_j$  for  $j = 1, 2, 3$ .

As is apparent from (2.12) and (2.13), the skill distribution of  $h_j$  and the distribution of  $TR_j$  affect the endogenous variables. This is a direct result of incorporating nonhomothetic preferences. While the income of some households (in some countries) will be sufficient to buy the highest-indexed good, for other households income may only suffice to buy lower-indexed goods. This affects the precise form of the trade balance conditions as we show in the next section.

### 3. Discussion of the model

Before we proceed we would like to highlight some novel aspects of the present model. This is facilitated by making two further assumptions:<sup>6</sup>

**Assumption 4.**  $h_j = 1, j = 1, 2, 3$ .

**Assumption 5.**  $a_2(z)/a_1(z) < 1$  and  $a_3(z)/a_2(z) < 1$  for all  $z \in [0, \infty)$ .

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<sup>6</sup>Similar assumptions have been made by Flam and Helpman (1987) and Stokey (1991) in the context of a simple North-South model of trade with nonhomothetic preferences. Additionally, those authors assume that goods are ranked according to product quality and that goods are gross substitutes. However, they do not analyze the formation of PTAs.

Assumption 4 states that households in country  $j$  are homogenous.<sup>7</sup> As such assumption 4 eliminates income differences within countries but not across countries. Assumption 5 ensures that  $\omega_2 < 1 < \omega_2/\omega_3$ . When combined with assumptions 1-3, it follows that country 1 (3) is the low-income (high-income) country, which specializes in lower-ranked (high-ranked) goods with low (high) income elasticities in demand; and country 2 is the middle-income country, which specializes in the intermediate range of goods with intermediate income elasticities in demand.<sup>8</sup>

Given assumptions 1-3, the model always generates a unique equilibrium, but two equilibrium configurations turn out to be of special interest. The first equilibrium outcome holds that all households spend their last unit of income on goods produced in country 3. The resulting trade pattern is characterized by two-way bilateral trade flows between any pair of countries. We refer to this equilibrium configuration as the symmetric trade equilibrium. The conditions for balanced trade become (see 9.2), in place of (2.12) and (2.13):

$$N_1(1 - \int_0^{z_3} a_1(s)ds) = N_2 \int_0^{z_1} a_1(s)ds + N_3 \int_0^{z_2} a_1(s)ds \quad (3.1)$$

and

$$N_2(1 - \int_{z_1}^{z_6} a_2(s)ds) = N_1 \int_{z_3}^{z_5} a_2(s)ds + N_3 \int_{z_2}^{z_4} a_2(s)ds \quad (3.2)$$

where the first row in (3.1) [(3.2)] denotes the value of country 1's (country 2's) imports and the second row the corresponding value of exports. The highest-indexed good,  $u_j$ , and thus the utility attained by a household in country  $j$  ( $j = 1, 2, 3$ ) associated with the symmetric trade equilibrium is derived from (2.8) and given by

$$\int_0^{z_3} a_1(s)ds + \int_{z_3}^{z_5} \frac{a_2(s)}{\omega_2} ds + \int_{z_5}^{u_1} \frac{a_3(s)}{\omega_3} ds = 1 \quad (3.3)$$

$$\int_0^{z_1} a_1(s)ds + \int_{z_1}^{z_6} \frac{a_2(s)}{\omega_2} ds + \int_{z_6}^{u_2} \frac{a_3(s)}{\omega_3} ds = \frac{1}{\omega_2} \quad (3.4)$$

$$\int_0^{z_2} a_1(s)ds + \int_{z_2}^{z_4} \frac{a_2(s)}{\omega_2} ds + \int_{z_4}^{u_3} \frac{a_3(s)}{\omega_3} ds = \frac{1}{\omega_3}. \quad (3.5)$$

The absence of any tariff terms in (3.3)-(3.5) is due to the fact that households actually pay a tariff exclusive price as a result of the proportional tariff rebates. The symmetric

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<sup>7</sup>In a companion paper de Vaal & Stibora (2006b), we allow for nondegenerate income distributions across countries.

<sup>8</sup>Violation of assumption 5 could imply that country 3 households become so poor that they are only able to consume goods from countries 1 and 2. All the high-indexed goods country 3 produces are then exported to the two richer countries. For obvious reasons, we do not pursue this parameter constellation.

equilibrium satisfies  $z_1 < \dots < z_6 < u_1 < u_2 < u_3$ , and corresponds to what is illustrated in Figure 1.

The second equilibrium configuration we consider is when households from country 1 are not rich enough to consume goods produced in country 3. In this case households in country 1 spend their last unit of income on goods produced in country 2, while households in country 2 and 3 still spend their marginal income on goods produced in country 3, that is,  $w_1 + TR_1 - E_1(z_3) < E_1(z_5) - E_1(z_3)$ . Consequently, country 1 runs a trade surplus vis-à-vis country 3, country 2 has a bilateral trade surplus vis-à-vis country 1, and country 3 has a bilateral trade surplus vis-à-vis country 2. We will refer to this outcome as the asymmetric trade equilibrium. The conditions for balanced trade become:

$$N_1(1 - \int_0^{z_3} a_1(s)ds) = N_2 \int_0^{z_1} a_1(s)ds + N_3 \int_0^{z_2} a_1(s)ds \quad (3.6)$$

and

$$N_2(1 - \int_{z_1}^{z_6} a_2(s)ds) = \omega_2 N_1(1 - \int_0^{z_3} a_1(s)ds) + N_3 \int_{z_2}^{z_4} a_2(s)ds. \quad (3.7)$$

As before, the left hand side of (3.6) [(3.7)] represents country 1's (country 2's) value of import which equals country 1's (country 2's) value of exports, the right hand side. The noteworthy difference with the symmetric trade equilibrium is of course the inclusion of  $\omega_2$  in (3.7), to which we will come back below. Since  $u_1 < z_5$ , the budget constraint of a country 1 household changes into

$$\int_0^{z_3} a_1(s)ds + \int_{z_3}^{u_1} \frac{a_2(s)}{\omega_2} ds = 1, \quad (3.8)$$

while the budget constraints for country 2 and 3 are still given by (3.4) and (3.5). Consequently, the asymmetric equilibrium satisfies  $z_1 < \dots < u_1 < z_5 < z_6 < u_2 < u_3$ , thus making  $z_5$  redundant in the analysis (and in Figure 1).

Many features of these two equilibrium configurations deserve emphasis. Let us concentrate on the most important two.

First, the fundamental difference with the literature on the formation of preferential trade agreements is that the assumed preferences in the present model imply that goods are not gross substitutes. That is, if the price of lower indexed goods declines, consumers do not substitute toward relatively cheaper goods but instead expand the consumption basket toward higher-indexed goods, as a result of the higher purchasing power. The immediate implication of this is visible in the balanced trade conditions of either equilibrium constellation. With regard to the balanced trade conditions of the symmetric trade equilibrium

(3.1) and (3.2), when all households are rich enough to consume some goods from country 3, small changes in  $\omega_i$  for  $i = 2, 3$ , do not affect the demand for goods produced in countries 1 and 2, and hence the demand for labor in those countries. Look, for example, at an increase in  $\omega_2$ , which, *ceteris paribus*, improves country 1's and country 3's relative factor terms of trade with country 2. At initial trade flows, country 3's value of imports from country 2 falls which matches the increase in country 1's imports from country 3 and the fall country 2's imports from country 3. An analogue argument applies to small changes in the other factor prices. However, if the income of some households of country 1 is not sufficient to purchase goods from country 3, country 2's trade balance will depend explicitly on  $\omega_2$ . The intuition for this is as follows. Suppose that the relative factor price of country 1 with respect to country 2 declines (lower  $\omega_2$ ). This loss in purchasing power of country 1 households reduces directly their demand for country 2 goods and indirectly the demand for country 2's labor. To keep country 2's labor market in equilibrium, country 2 either has to increase the range of goods its exports to country 3 (higher  $z_4$ ) and to decrease its imports from country 3 (higher  $z_6$ ) or a combination of both to clear its labor market.

Second, the distinction between symmetric and asymmetric trade patterns arises endogenously in our model. The distinction itself is of course not new as several authors have used it to facilitate their analysis, see, for instance, Meade (1955), Mundell (1964), ACF, and Berglas (1979). The notable difference is, therefore, that in our framework the (a)symmetry in trade patterns is a general equilibrium outcome, rather than a structure that is being imposed to facilitate the analysis. This novel aspect allows us to analyze the consequences of trade policy on trade and welfare in a multiregional setting in the presence of significant income effects in a tractable manner.

## 4. Unilateral Tariff Policy among Heterogeneous Countries

Let us now examine the effects of unilateral tariff reductions in a three country setting. For the purpose at hand we assume that assumptions 4 and 5 hold. We contrast our results with those of ACF, whose analysis is the closest parallel to the present model.<sup>9</sup> ACF assume that all households have identical and homothetic preferences over a fixed range of commodities, which can be represented by  $V_j = \int_0^1 \beta(z) \ln e_j(z) dz$ , with real expenditure on good  $z$  denoted by  $e_j(z)$  and constant expenditure shares  $\beta(z) > 0$ , which are uniform

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<sup>9</sup>As the ACF framework does not allow for asymmetric spending patterns, the comparison is only relevant for the symmetric spending equilibrium.

across all three countries, and  $\int_0^1 \beta(z)dz = 1$ . This assumption implies that each household spends the fraction  $\theta(z_i) = \int_0^{z_i} \beta(z)dz$  of income on a subset of goods regardless of the level of income. The qualitative impact of tariff changes is summarized in Table 1, with mathematics relegated to Appendix 9.3.

*(insert Table 1a/b about here)*

From Table 1a, it is immediately apparent that in the present model a unilateral change of either country 1 or 2's tariff on imports from country 3 ( $\tau_{13}$  and  $\tau_{23}$ ) does neither affect efficient production of country 1 nor its relative wage ratio with country 2,  $\omega_2$ . Consider, for instance, the reduction in country 2's tariff on exports from country 3 ( $d\tau_{23} < 0$ ). This lowers the price of those goods in country 2. At initial factor prices, country 2 loses some industries to country 3 that were in direct competition ( $z_6$  falls). Since this competition effect also reduces country 2's range of nontraded goods, real income gains accrue for households from country 2 in terms of those goods only, to which they respond by adding higher-indexed goods produced in country 3 to their consumption basket, that is  $du_2 > 0$ . The real income in terms of previously traded goods remains unchanged because the gain from lower prices is exactly compensated by the reduction in tariff rebate. Due to the absence of substitution effects, demand for country 1's produce is unaffected and thus no change in  $\omega_2$  is required. The ensuing trade deficit for country 2 requires a deterioration in country 2's terms of trade with respect to country 3 (higher  $\omega_2/\omega_3$ ) to restore equilibrium, implying a deterioration in country 1's terms of trade with respect to country 3 (lower  $\omega_3$ ).

These results are in sharp contrast to the ones derived by ACF that are given in the lower panel of Table 1a for comparison. Considering the same reduction in  $\tau_{23}$ , country 3's terms of trade with respect to country 2 and 1 improve (higher  $\omega_2/\omega_3$  and lower  $\omega_3$ ). In contrast to our model, however, country 1's terms of trade vis-à-vis country 2 changes too (higher  $\omega_2$ ) as a consequence of substitution effects. Lower prices of country 3's goods in country 2 induces households to substitute away from the relatively more expensive domestic and country 1 goods. Because of this substitution effect, the bilateral trade balance of country 3 with 2 moves into surplus and the bilateral trade balance of country 1 with 2 into deficit. Next to these direct demand side effects on the trade balances comes the supply side effect of the lower  $\tau_{23}$  on efficient production. At initial prices the reduction of  $\tau_{23}$  allows country 2 to import goods that previously were nontraded ( $z_6$  falls), thereby widening the trade deficit (surplus) for country 2 (3). The reduction in the range of nontraded goods increases the real income of households from country 2, increasing the demand for all goods, while

the reduction in tariff rebate reduces the demand for all goods. Assuming that goods are gross substitutes implies that the substitution effect dominates the income effect. To restore equilibrium this necessitates a deterioration in country 2's terms of trade relative to country 3 (higher  $\omega_2/\omega_3$ ). This also reduces country 1's imports from country 3, requiring an increase in  $\omega_2$ .

The difference in the demand structure has important implications for the analysis to follow. Comparing our results in Table 1a with those of ACF shows that our results are often determined by (i) the degree of comparative advantage a country has at a particular borderline good  $z_k$  - represented by the parameters  $\zeta_2 > 0$  and  $\zeta > 0$ , and (ii) the size of real income changes, which are decisively determined by the population size.

Consider, for example, a reduction in country 1's tariff on imports from country 2, that is,  $d\tau_{12} < 0$ , ceteris paribus. At initial relative wages, a fall in  $\tau_{12}$  reduces the price of country 2 goods in country 1, and its range of imports from country 2 increases at the expense of (some) domestic firms (lower  $z_3$ ) and of some firms from country 3 that directly compete with country 2 firms on country 1's market (higher  $z_5$ ). Note that these competition effects do not correspond with the real income effects since only the reduction in  $z_3$  increases the real income of country 1's households. In the symmetric trade equilibrium, these real income gains are spent exclusively on country 3's goods, that is  $du_1 > 0$ .<sup>10</sup> The direct impact of lower  $\tau_{12}$  for country 1 is a trade deficit. To restore equilibrium country 1's factor terms of trade have to improve unambiguously (lower  $\omega_2$ ). The effect of lower  $\tau_{12}$  on the trade balance of country 3, on the other hand, is ambiguous and depends on  $\zeta_2$  and  $\zeta$ . Note, both  $\zeta_2$  and  $\zeta$  can be any positive number. Suppose that  $\zeta_2$  is small, for a given positive value of  $\zeta \equiv \zeta_3 - \zeta_2$ . The smaller is  $\zeta_2$ , the weaker is country 1's comparative advantage in comparison to country 2 at  $z_3$ , the larger is the loss of industries to country 2, and the larger the concomitant real income gains experienced by households from country 1. Due to the asymmetry of demand complementarities these real income gains become effective in country 3 only, generating a trade surplus. To restore equilibrium country 3's relative factor terms of trade have to improve (higher  $\omega_2/\omega_3$ ). Suppose now that  $\zeta_2$  is given, and that  $\zeta$  is small but positive. This, in turn, implies that country 2's comparative advantage vis-à-vis country 3 is strong at  $z_5$ : lower  $\tau_{12}$  causes a considerable increase in the range of goods taken over by country 2 at the expense of country 3. In this case, the

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<sup>10</sup>As shown in the appendix, the change in  $du_1$  for given relative wages is affected by both the change in  $z_3$  and  $z_5$ . Assuming that country 1 imposes the same tariff on imports from country 2 and 3 in the original equilibrium, that is  $\tau_{12} = \tau_{13}$ , the later effect cancels.

expansion of country 1's households' range of consumption toward country 3 goods due to the real income effect is smaller in comparison to the loss in the range of goods country 3 exports to country 1. At initial factor prices, therefore, country 3's balance of trade turns into a deficit. To restore equilibrium, country 3's factor terms of trade have to deteriorate (lower  $\omega_2/\omega_3$ ). Since the real income effect and the competition effect have opposing effects on the trade balance of country 3 and thereby indirectly the demand for labor the values of  $\zeta_2$  and  $\zeta$  are crucial in the present model to determine the signs of endogenous variables.<sup>11</sup>

Some of the ambiguity is resolved when considering the asymmetric trade equilibrium. Recall that this equilibrium configuration implies that country 1 spends its last unit of income on goods produced in country 2 instead of country 3. Consequently, the real income gain due to, for example, lower  $\tau_{12}$  becomes effective in country 2 and country 3's trade balance turns unambiguously into a deficit, at initial factor prices (see Table 1b).

To see the importance of the size of real income changes and thus the size of the population on the endogenous variables, let us consider the discriminate tariff reduction  $d\tau_{31} < 0$ , *ceteris paribus*. This reduces the price of country 1's imports in country 3. Firms from country 1 competing with firms from country 2 gain in competitiveness and exports to country 3 increase. At initial factor prices, country 1 experiences a trade surplus that is exactly matched by an equivalent deficit for country 2. Country 1's terms of trade vis-a-vis country 2 has to improve (higher  $\omega_2$ ) to restore equilibrium. This indirectly reduces  $z_2$ . The direct effect overcomes the indirect effect and  $z_2$  increases. Recall that the change in  $\omega_2$  has no direct effect on country 3's initial trade balance. However, the change in  $\omega_2$  affects all other borderline goods in addition to  $z_2$ . In particular, country 1's range of domestic production falls (lower  $z_3$ ) and previously nontraded goods are now imported from country 2. Thus, country 1's real income increases and its imports from country 3 increase by  $N_1 a_2(z_3) z_3 (\tau_{12} - 1)$ . On the other hand, country 2's range of production increases at the lower end (lower  $z_1$ ) and households replace goods previously imported from country 1 with domestic goods that are now nontraded. As a result, country 2's real income falls and so are its imports from country 3 to the extent of  $N_2 a_1(z_1) z_1 (\tau_{21} - 1)$ . Assuming that  $N_1 a_2(z_3) z_3 (\tau_{12} - 1) > N_2 a_1(z_1) z_1 (\tau_{21} - 1)$ , country 3's trade balance turns into a surplus. The fall in  $\tau_{31}$  leads to a higher  $\omega_2$  which in turn affects also the upper range of the borderline goods  $z_k$  for  $k = 4, 5, 6$ . From the point of view of country 3,

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<sup>11</sup>Another implication of our set-up is that also redistribution policies within a country and/or a customs union affect aggregate variables, as is apparent from (2.12) and (2.13). We have elaborated extensively on the consequences of this in Stibora and de Vaal (2006).



imports from country 2 increase (higher  $z_4$ ), while exports to countries 2 and 1 decrease (higher  $z_5$  and  $z_6$ ). With imports increasing on net, country 3's trade balance turns into a deficit. The improvement of  $\omega_2$  for given  $\omega_3$  has an ambiguous effect on country 3's trade balance and hence on the required change in  $\omega_3$ . For given positive  $\zeta$ , and letting  $N_1 a_2(z_3) z_3 (\tau_{12} - 1) > N_2 a_1(z_1) z_1 (\tau_{21} - 1)$ , if  $\zeta_2$  is small the real income effect dominates the competition effect and country 3's trade balance turns into a surplus. As a consequence,  $\omega_3$  has to fall for country 3's relative wage ratio with country 2 to improve (higher  $\omega_2/\omega_3$ ). On the other hand, for  $\zeta_2$  positive and  $\zeta$  small, the real income effect is negligible and the increase in imports dominate. Country 3's trade balance turns into a deficit and it's terms of trade with country 1 have to deteriorate (higher  $\omega_3$ ) relative to the higher  $\omega_2$  to reduce the increase in country 3's imports.<sup>12</sup>

In the asymmetric trade equilibrium, the net outcome of the real income effect of changes in  $\omega_2$  on country 3's trade balance is absent for reasons given above. The same fall in  $\tau_{31}$  that improves country 1's relative wage ratio with country 2, *ceteris paribus*, increases country 1's imports from country 2 but reduces country 2's imports from country 3, thereby generating a trade deficit for country 3. To restore equilibrium country 3's relative wage ratio with country 2 has to deteriorate (lower  $\omega_2/\omega_3$ ) implying that country 1's relative wage ratio with country 3 to improve (higher  $\omega_3$ ). The change in the relative factor price affects indirectly all other borderline goods  $z_k$ , as illustrated in Table 1b.

In contrast to the standard literature on the formation of preferential trade agreements and in particular to ACF the range of industries producing in the world economy is not fixed. This additional aspect of our framework can best be seen by examining the effect of tariff changes on the highest indexed good consumed  $u_j$ , and hence on the change in utility. This is accomplished by differentiation of the budget constraints (3.3)-(3.5), assuming  $\tau_{jk} = \tau_{jk'}$  for  $j, k, k' = 1, 2, 3$ , for given productivity parameters (see Appendix 9.4 for details). For the symmetric trade equilibrium this yields for country 1

$$a_3(u_1) du_1 = \frac{\omega_3}{\omega_2} \int_{z_3}^{z_5} a_2(s) ds \widehat{\omega}_2 + \int_{z_5}^{u_1} a_3(s) ds \widehat{\omega}_3 + \frac{\omega_3}{\omega_2} a_2(z_3) z_3 (1 - \tau_{12}) \widehat{z}_3 \quad (4.1)$$

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<sup>12</sup>Note, in case that the real income change of country 2 is larger in comparison to country 1, that is,  $N_1 a_2(z_3) z_3 (\tau_{12} - 1) < N_2 a_1(z_1) z_1 (\tau_{21} - 1)$ , country 3's trade balance turns into a deficit, regardless of the values for  $\zeta$  and  $\zeta_2$ . We exclude this possibility and assume for the remainder of the paper that  $N_1 > N_2 > N_3$ , ensuring that country 1 is the poorest country while country 3 the richest.

for country 2

$$a_3(u_2)du_2 = -\frac{\omega_3}{\omega_2} \left[ 1 - \int_{z_1}^{z_6} a_2(s)ds \right] \widehat{\omega}_2 + \int_{z_6}^{u_2} a_3(s)ds \widehat{\omega}_3 + \omega_3 a_1(z_1)z_1(\tau_{21} - 1)\widehat{z}_1 - a_3(z_6)z_6(\tau_{23} - 1)\widehat{z}_6 \quad (4.2)$$

and for country 3

$$a_3(u_3)du_3 = \frac{\omega_3}{\omega_2} \int_{z_2}^{z_4} a_2(s)ds \widehat{\omega}_2 - \left[ 1 - \int_{z_4}^{u_3} a_3(s)ds \right] \widehat{\omega}_3 + (\tau_{32} - 1) \frac{\omega_3}{\omega_2} a_2(z_4)z_4 \widehat{z}_4. \quad (4.3)$$

For the asymmetric equilibrium, the expressions for country 2 and country 3 are the same. The expression for country 1 becomes, instead of (4.1):

$$a_2(u_1)du_1 = \int_{z_3}^{u_1} a_2(s)ds \widehat{\omega}_2 - (\tau_{12} - 1)a_2(z_3)z_3 \widehat{z}_3. \quad (4.4)$$

The ‘hat’ notation is used to express relative changes, e.g.  $\widehat{\tau}$  is defined as  $d\tau/\tau$ . The first term(s) on the right hand side in (4.1)-(4.3) and (4.4) represent the factor terms of trade effect(s) weighted by the country’s value of imports. The second terms reflect the impact on real income via changes in the range of nontraded goods. This latter term can also be interpreted as the change in deadweight loss caused by the change in the import volume as a result of the change in the range of nontraded goods. Since we started from a tariff-ridden equilibrium there is also a price effect of lower tariffs on the tariff revenues, holding quantity constant. This price effect drops out since, with homogeneous population, the gains of lower prices of imported goods is exactly matched by lower tariff rebates. The absence of  $\omega_3$  in (4.4) in comparison to (4.1) follows from the fact that country 1 does only export but not import goods from country 3 in the asymmetric trade equilibrium. The welfare effects of unilateral tariff changes are presented in Tables 2a and 2b for the symmetric and asymmetric case, respectively.

Table 2a for the symmetric case indicates that the poorest country, country 1, is in general worse off from unilateral tariff changes the more uniform are unit labor requirements in industries across country 1 and country 2 (small  $\zeta_2$ ) and the larger is  $\zeta$ . In this case the deterioration in country 1’s relative wage with country 3 dominates all other effects. As a consequence, households from country 1 experience significant real income losses inducing them to reduce their range of consumption,  $du_1 < 0$ . The exceptions are the fall in  $\tau_{21}$  and  $\tau_{32}$ . Under the same conditions, country 3 in general gains from unilateral tariff changes. From (4.3),  $du_3 > 0$ : households from country 3 expand their consumption basket and their welfare goes up. The real income gains of those households is an incentive for entrepreneurs

to invent new products. We note therefore, that because of differences in income elasticities, the present model can explain the emergence of new industries in the world economy as well as the emergence of product life cycles as discussed by Vernon (1966).

## 5. Formation of Preferential Trade Agreements between Heterogeneous Countries

We now proceed with investigating the effects of the formation of preferential trade agreements (PTAs) on global specialization and terms of trade. Before we discuss our main findings, it is useful to point out that establishing the effects of PTAs essentially boils down to adding the general equilibrium effects of the relevant unilateral tariff reductions that were discussed in the previous section.<sup>13</sup> The reasoning we will employ therefore consists of the same two main effects as before. The first effect is that when tariffs come down the competitiveness of countries is affected, and thereby the derived demand for labour. The second effect is that the formation of PTAs also affects the ranges of nontraded goods, real income effects accrue, affecting spending on goods from either country 3 (as in the symmetric trade equilibrium) or from country 2 and country 3 (as in the asymmetric trade equilibrium). Both effects have consequences for the relative wages in the three countries, leading to the general equilibrium effects discussed below. As we will see, however, it typically suffices to apply our simple two-step reasoning to explain the effect of PTA formation

*PTA between countries 2 and 3 (PTA<sub>23</sub>).*

Consider first the formation of a PTA between the high-income country 3 and the middle-income country 2, a situation which would resemble the recent enlargement of the EU to the east. This implies a reduction of the bilateral tariffs  $\tau_{23}$  and  $\tau_{32}$ , while leaving all other tariffs at their initial value. Consequently, at initial factor prices, the member countries will expand their imports from each other, that is  $z_2 - z_4$  increases while  $z_6$  falls:

$$\frac{\widehat{z}_2}{\widehat{\tau}_{32}} = \frac{1}{\zeta_2} > 0, \quad \frac{\widehat{z}_4}{\widehat{\tau}_{32}} = -\frac{1}{\zeta} < 0, \quad \frac{\widehat{z}_6}{\widehat{\tau}_{23}} = \frac{1}{\zeta} > 0,$$

These competition effects are the same regardless the type of equilibrium we consider

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<sup>13</sup>A detailed appendix containing all the derivatives is available in an appendix upon request from the authors.

(symmetric, asymmetric)<sup>14</sup> and are the result of the change in competitiveness of country 2 and country 3 producers on each other's markets. As before, the extent to which the tariff changes affect competitiveness depends on the degree of comparative advantage at the specific borderline commodity, as indicated by  $\zeta$  and  $\zeta_2$ . The initial competition effects influence the labor market of countries and adjustments in the bilateral terms of trade of countries are required to restore equilibrium. The general equilibrium effects of PTA<sub>23</sub> are given in Table 3. We note that the results are typically the same for both equilibrium settings, except for some slight but telling changes in conditions.

*(insert Table 3 about here)*

The effects on  $z_1$ ,  $z_2$ ,  $z_3$  and  $\omega_2$  are unambiguous, which is of course related to the fact that the effect of a fall in  $\tau_{23}$  on these variables is zero. In determining the signs for the other variables we see that  $\zeta$  and  $\zeta_2$  play a key role. We therefore discuss the table by considering the effects when  $\zeta$  is small (for  $\zeta_2 > 0$ ), to then verify the results if instead  $\zeta_2$  is small (for given  $\zeta > 0$ ).

Suppose then that  $\zeta_2 > 0$  and that  $\zeta$  is small, that is unit labor requirements between countries 2 and 3 are very similar. This implies that the initial competition effects are dominated by the upward effect on  $z_4$  and the downward effect on  $z_6$  (of course the effect on  $z_2$  is still there and indeed nicely explains the negative impact on  $\omega_2$ ). The upward effect on  $z_4$  increases the derived demand for country 2's labour and lowers it for country 3's labour, while the downward effect on  $z_6$  does exactly the opposite. Consequently, the net competition effect on  $\omega_2/\omega_3$  depends on each country's marginal expenditure rate: if  $N_3 a_2(z_4) z_4 > N_2 a_2(z_6) z_6$  the effect on  $z_6$  dominates and  $\omega_2/\omega_3$  increases, deteriorating country 2's factor terms of trade vis-à-vis country 3. The real income effects that accrue are positive, as both country 2 and country 3 may welcome a decline in their non-traded goods ranges. These real income gains are spent on country 3 goods for both equilibrium settings, which increases demand for country 3 labour, yielding additional upward pressure on country 3's relative wage.

Suppose now that the unit labor requirements between country 1 and country 2 are ceteris paribus more equalized, that is  $\zeta_2$  is small for given  $\zeta > 0$ . In this case, the competitive effect on  $z_2$  dominates the initial effects. As  $z_2$  comes down, the derived

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<sup>14</sup>By concentrating on marginal tariff changes in contrast to complete discrimination our results shed light on the initial effects of PTAs.

demand of country 3 households for country 2's labour increases at the expense of demand for country 1's labour. This explains the negative signs for  $\omega_2$  and  $\omega_3$ . As both effects are related to country 3 households, the relative size of country 2 and country 3 does not play a role. Rather it is the relative size of country 1 and country 2 that matters. The decline in  $z_2$  lowers the non-traded goods range for country 2, but increases it for country 1. In the symmetric trade equilibrium, both countries spend their marginal income on goods from country 3, explaining why the general equilibrium effect on  $\omega_2/\omega_3$  depends on the relative size of country 1 and country 2: the bigger (smaller) country 1 is, the bigger (smaller) the reduction in spending on country 3 goods, yielding a negative (positive) effect on the bilateral factor terms of trade of country 3 vis-à-vis country 2, i.e.  $\omega_2/\omega_3$  goes down (up). By contrast, in the asymmetric trade equilibrium, the negative real income effect in country 1 leads to less spending on country 2 goods, whereas the positive real income effect in country 2 still accrues to country 3 goods. This explains why in the asymmetric equilibrium configuration the relative size of country 1 and country 2 does not matter when  $\zeta_2 \rightarrow 0$ . Moreover, the spending effects give rise to an upward pressure on the bilateral factor terms of trade of country 3 vis-à-vis country 2, explaining why  $\omega_2/\omega_3$  is positive.

*PTA between countries 1 and 2 (PTA<sub>12</sub>)*

Consider next the formation of a PTA between the low-income country 1 and the middle-income country 2. This implies a reduction of the bilateral tariffs  $\tau_{12}$  and  $\tau_{21}$ , *ceteris paribus*. The general equilibrium effects of PTA<sub>12</sub> are presented in Table 4 and can be explained by focusing on the initial competition and real income effects.

The initial competition effects on  $z_1$ ,  $z_3$  and  $z_5$ , while keeping relative wages constant, are

$$\frac{\hat{z}_1}{\hat{\tau}_{21}} = -\frac{1}{\zeta_2} < 0, \quad \frac{\hat{z}_3}{\hat{\tau}_{12}} = \frac{1}{\zeta_2} > 0, \quad \frac{\hat{z}_5}{\hat{\tau}_{12}} = -\frac{1}{\zeta} < 0,$$

where we note that the effect on  $z_5$  only arises in the symmetric equilibrium configuration. The changes in competitiveness yield both countries better access to each other's markets, the extent of which is determined by the indicator of comparative advantage at both marginal goods,  $\zeta_2$ . In the symmetric trade equilibrium, the improved access to each other's markets goes at the expense of the country that remains outside the agreement. For this effect  $\zeta$  is the important parameter.

If  $\zeta \rightarrow 0$ , the upward effect on  $z_5$  dominates the effects for the symmetric trade equilibrium. It increases demand for country 2 labour and decreases that for country 3 labour. The real income effects accrue because of changes in non-traded goods areas. In this case, the non-traded goods range of country 2 decreases while that of country 3 increases. As both

countries spend their marginal income on country 3 goods, the net effect will typically be negligible compared to the competition effect, explaining the negative general equilibrium effect on  $\omega_2/\omega_3$  and the fact that it is independent on the relative size of countries.<sup>15</sup>

If  $\zeta_2 \rightarrow 0$ , the competitive effect on  $z_1$  and  $z_3$  dominates the initial effects. As  $z_1$  goes up, the derived demand of country 2 households for country 1's labour increases at the expense of demand for its own labour force. Likewise, as  $z_3$  goes down, the derived demand of country 1 households for country 2 labour increases at the expense of their labour. This explains the negative sign for  $\omega_2$  and why it depends on the relative size of country 1 with respect to country 2, also when  $\zeta_2 > 0$ . The income effects are as follows. The increase of  $z_1$  reduces the non-traded goods range for country 2, just like the decrease in  $z_3$  reduces it for country 1. In the symmetric trade equilibrium both countries spend their marginal income on country 3 goods, explaining the increase of the bilateral factor terms of trade of country 3 vis-à-vis country 1 ( $\omega_3$  down). Taking the competition effects and the spending effects together implies that  $\omega_2/\omega_3$  goes up for  $\zeta_2 \rightarrow 0$ . In the asymmetric equilibrium setting, the spending effects of country 1 accrue instead to country 2 goods. This has no effect on the sign for  $\omega_3$ , though the magnitude of its positive effect will be less than before as only the spending effect of country 2 remains. Consequently, also the sign for  $\omega_2/\omega_3$  remains clear.

*(insert Table 4 about here)*

#### *PTA between countries 1 and 3 (PTA<sub>13</sub>)*

Consider finally the formation of a PTA between the low-income country 1 and the high-income country 3. As an examples might serve the preferential trade arrangements the EU has with the ACP countries under the Lome convention. This implies, ceteris paribus, a reduction of the bilateral tariffs  $\tau_{13}$  and  $\tau_{31}$ , leading to an increase in trade between member countries due to the increase in  $z_2$  and fall in  $z_5$  at initial factor prices:

$$\frac{\widehat{z}_2}{\widehat{\tau}_{31}} = -\frac{1}{\zeta_2} < 0, \quad \frac{\widehat{z}_5}{\widehat{\tau}_{13}} = \frac{1}{\zeta} > 0,$$

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<sup>15</sup>Of course, we realise that the simple reasoning we continuously apply can never give the exact story behind the results. In a way, this is proven by the unclear sign that arises in the asymmetric case. The question mark appears because we can derive that when  $\zeta$  equals zero, the general equilibrium effect on  $\omega_2/\omega_3$  is zero as well. If  $\zeta$  approaches zero, however, we are not sure from which side  $\omega_2/\omega_3$  approaches zero. The complex condition we could derive for that in fact includes relative sizes of countries.

where the impact on  $z_5$  again only holds for the symmetric trade equilibrium. The general equilibrium effects of PTA<sub>13</sub> are presented in Table 5. We note that the effects are to a large extent opposite to that of PTA<sub>23</sub> and that the asymmetric trade equilibrium involves no ambiguities. The latter is due to the fact that country 1 does not import from country 3 in the asymmetric trade equilibrium. For both types of equilibria, the competition effects imply that trade between the two member countries expands. Since both countries are non-contiguous, this trade expansion goes completely at the expense of country 2. If  $\zeta \rightarrow 0$ , the downward effect on  $z_5$  dominates the effects (the positive effect on  $z_2$  again nicely serves to explain the positive impact on  $\omega_2$ ). It decreases demand for country 2 labour and increases demand for country 3 labour. The effect is that  $\omega_2/\omega_3$  should go up. For the real income effects it is important that in this case the non-traded goods range of country 2 increases and that of country 3 decreases. As households in both countries spend their marginal income in country 3, the net effect will typically be negligible compared to the competition effect, explaining the general equilibrium effect on  $\omega_2/\omega_3$  and the fact that it is independent of the relative size of countries. If  $\zeta_2 \rightarrow 0$ , the competitive effect on  $z_2$  dominates the initial competition effects. As it increases, the derived demand of country 3 households for country 2 labour decreases in favour of demand for country 1 labour. This explains the positive signs for  $\omega_2$  and  $\omega_3$ . The increase of  $z_2$  increases the non-traded goods range for country 2, but lowers it for country 1. In the symmetric trade equilibrium both countries spend their marginal income on country 3 goods, explaining why the general equilibrium effect on  $\omega_2/\omega_3$  depends on the relative size of country 1 and country 2. The bigger (smaller) country 2, the bigger (smaller) the reduction in spending on country 3 goods, yielding a negative (positive) effect on the bilateral factor terms of trade of country 3 vis-à-vis country 2, i.e.  $\omega_2/\omega_3$  down (up). By contrast, in the asymmetric equilibrium setting the income effect in country 1 leads to increased spending on country 2 goods, whereas the income effect in country 2 still reduces spending on country 3 goods. This explains that in the asymmetric trade equilibrium the relative size of country 1 and country 2 does not matter anymore when  $\zeta_2 \rightarrow 0$ . Moreover, the spending effects give rise to a further downward pressure on the bilateral factor terms of trade of country 3 with respect to country 2, explaining that  $\omega_2/\omega_3$  is negative.

*(insert Table 5 about here)*

Having established the general equilibrium effects for the alternative PTA arrangements, a first general insight that appears is that the formation of a PTA affects factor prices and

efficient production by and large similarly for both the symmetric trade equilibrium and the asymmetric trade equilibrium. Except for some telling differences in conditions, the signs we obtain are typically invariant to the equilibrium configuration under consideration. The implication is of course that at this stage we therefore cannot say anything on the quantitative impact of having big income differences in the world or not. Numerical simulations might shed further light on this matter, which we reserve for future work.

A second insight that emerges, is that a PTA does not necessarily deteriorate the terms of trade of the country that is left outside the agreement.<sup>16</sup> Here the income level of the non-member is crucial, however. Leaving the specific conditions aside, it appears that whereas a poor country can be pretty sure to see both of its bilateral factor terms of trade decline, for a rich country there is fair chance that it sees its bilateral terms of trade improve. The medium-income country is somewhere in between. Of course, this is directly related to the asymmetric demand complementarities that are present in our framework. These ensure that the positive real income effects that result from switching from non-traded goods to traded goods typically accrue to increased demand for country 3's labour.

A third and final insight is that in establishing the general equilibrium effects of PTAs it is important to know the extent of the difference in comparative advantages between countries. It matters a great deal for the results whether there are similar comparative advantages between the medium-income and high-income country, that is: when  $\zeta$  is low, or when there are similar comparative advantages between the low-income and medium-income country, as is the case when  $\zeta_2$  is low. In fact, these differences are key to understanding the bilateral terms of trade effects between the high-income country and either the medium-income or the low-income country ( $\omega_2/\omega_3$  and  $\omega_3$ ). It has no bearing on the effect of PTAs on the bilateral terms of trade of the low-income and medium-income country ( $\omega_2$ ).

## 6. Welfare effects of PTA formation

In the previous section we have looked at the resource allocation and terms of trade effects of economic integration when countries differ significantly in their level of income. One of the main outcomes has been that the formation of a PTA affects factor prices and efficient productions by and large similarly, regardless of whether we considered the symmetric

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<sup>16</sup>In this regard it is interesting to mention the empirical analysis of Winters and Chang (2000), who find that PTAs can significantly diminish the terms of trade for nonparticipating countries.



trade equilibrium or the asymmetric trade equilibrium. It thus seems that the global income distribution does not qualitatively matter for results. In this section we will show that it does when we consider the welfare implications of PTAs. The welfare effects of PTA formation crucially depend on the stage of economic development of the partner countries.

To derive the welfare implications of PTAs, we recall the expressions for  $du_j$  ( $j = 1, 2, 3$ ) that were given when we discussed the welfare effects of unilateral tariff reductions. As stated there, the main difference between (4.1) and (4.4) is the absence of  $\widehat{\omega}_3$  from the latter equation, since country 1 does not import with country 3 in the asymmetric equilibrium. Moreover, we recall that the welfare effects relates to changes in a country's terms of trade and to changes in trade volumes. The welfare effects are presented in Table 6.

*(insert Table 6 about here)*

We first consider the case where the poor country is not part of a PTA, that is PTA<sub>23</sub>. When country 1 is too poor to import from country 3, as in the asymmetric trade equilibrium, welfare of households from country 1 deteriorates on account of the increase in the range of goods produced locally ( $z_3$  increases) and on account of the deterioration of its terms of trade with country 2 ( $\omega_2$  falls). As country 1's terms of trade with country 3 tends to deteriorate —  $\omega_3$  goes down for low enough  $\zeta_2$  —  $du_1 < 0$  and welfare falls. This result also holds when country 1 is rich enough to import from country 3, be it under similar conditions as were needed to resolve the ambiguities in the effect on  $\omega_3$ .

On the other hand, the poorest country is likely to gain when forming a PTA itself. In case country 1 is so poor that it does not import from country 3, a PTA with either country 2 or country 3 is beneficial as long as  $\zeta_2$  is sufficiently small. A union with country 3 is to the benefit of country 1, and depends only on the degree of comparative advantage, that is:  $du_1 > 0$  if  $\zeta_2$  is sufficiently small. When  $\zeta$  is small this also holds for PTA<sub>13</sub>. The welfare effect for PTA<sub>12</sub> is then unclear, which is related to the positive effect on  $\omega_3$  when  $\zeta$  is low. We note that when country 1 can afford imports from country 3, the welfare effects are typically reversed or ambiguous. Clearly, it pays off to be poor when engaging in preferential trade!

What can we say about the welfare effects for the other two countries? We infer from the table that PTA<sub>23</sub> gives the clearest results on the welfare of country 2 and country 3. An agreement between the medium rich and the rich country is welfare improving for both country 2 and 3 if  $\zeta$  is small (this holds for both equilibrium settings). Being contiguous, a low  $\zeta$  implies that the range of non-traded goods in both countries reduces considerably

and large real income gains result,  $du_2 > 0$ ,  $du_3 > 0$ . When  $\zeta_2$  is low, the importance of where country 1 households spend their marginal income is important for understanding the welfare effects. If the real income losses in country 1 imply reduced spending on country 3 goods (symmetric trade equilibrium), country 3 loses; if they imply reduced spending on country 2 goods (asymmetric trade equilibrium), country 2 loses. With respect to the effects of the other two PTAs the noteworthy result is that when country 1 is too poor to import from country 3, the preferred strategy for country 3 is not to engage in a PTA with country 1, but to encourage a PTA<sub>12</sub>. The absence of a positive spending effect of country 1 consumers on country 3 goods once again explains why this is the case. A similar reasoning holds of course for country 2. When country 1 households are rich enough to afford country 3 goods, some of these results reverse, emphasizing the importance of income differences on understanding the welfare effects of PTAs.

This leads to the following general insights. First, being a member of a PTA is no guarantee for welfare improvements. The only exception seems to be when a country is too poor to afford the whole range of products the world has to offer. Else the welfare effects of being a member or not depend on the extent to which comparative advantages differ, both between the member countries and with respect to non-member countries. Secondly, it appears that being left outside of a PTA agreement does not necessarily lead to welfare losses. The odds are now against the poorer countries, however. The more one produces at the higher end of the goods spectrum (here country 3), the more likely it is that being left outside is not detrimental for welfare. This is due to the presence of asymmetric demand complementarities. Whereas the outside country suffers as the PTA members' expenditure switching goes at the expense of the outside country, the ensuing real income gains of the members may compensate for this. Third, it appears that not only the income differences *per se* matter for the welfare results of PTAs, but also the *extent* of these income differences matter. While being a low income country leads to different inferences regarding the costs and benefits of preferential trading agreements than being a medium or high income country, it also holds that these results depend highly on whether or not the low-income country is partly insulated from world trade. Consequently, income differences between countries are of crucial importance to gauge the welfare effects of preferential trade liberalization.

## 7. Multilateral Tariff Reductions

Countries also participate in multilateral trade negotiations. The general equilibrium effects are given in Table 7a. At initial relative wages, this yields the following impact effect on competitiveness

$$\frac{\hat{z}_1}{\hat{\tau}} = -\frac{1}{\zeta_2} < 0, \quad \frac{\hat{z}_2}{\hat{\tau}} = 0, \quad \frac{\hat{z}_3}{\hat{\tau}} = \frac{1}{\zeta_2} > 0, \quad \frac{\hat{z}_4}{\hat{\tau}} = -\frac{1}{\zeta} < 0, \quad \frac{\hat{z}_5}{\hat{\tau}} = 0, \quad \frac{\hat{z}_6}{\hat{\tau}} = \frac{1}{\zeta} > 0,$$

for  $\hat{\tau}_{ij} = \hat{\tau} < 0$  for  $i, j = 1, 2, 3$  and  $i \neq j$ . Reducing tariff rates proportionally across all nations of course only affects the borderline commodities that delineate non-traded goods and traded goods. Accordingly, labour demand for country 1's labor force declines because its highest-ranked goods are lost to country 2, while at the same time it increases because country 2 loses some of its lower-ranked goods to country 1. Likewise labour demand effects arise for country 2 and 3. The effect of these competition effects on the bilateral factor terms of trade of each country is of course related to the strength of their respective comparative advantages at the borderline commodities  $\zeta_2$  and  $\zeta$ . As all countries see their ranges of non-traded goods decline, the initial real income effects work in favor of country 3's labor (symmetric trade equilibrium) or in favour of both country 2's and country 3's labor (asymmetric trade equilibrium). This implies that if  $\zeta_2 \rightarrow 0$ , so that country 3's competitiveness is initially unaffected, country 3's bilateral factor terms of trade will improve across the board for both equilibrium settings. The effect on  $\omega_2$  logically depends on the relative size of country 1 and country 2, as the condition indicates. If  $\zeta \rightarrow 0$ , it is country 1 that is initially shielded from the competition effects. The initial impact on  $z_4$  and  $z_6$  dominate effects, and consequently the relative sizes of country 2 and 3 are important for  $\omega_2/\omega_3$ . Absent initial effect, the impact on country 1's terms's of trade still depends on its relative size with respect to country 2. The concomitant welfare effects are given in Table 7b. When the income differences between countries are not too big (symmetric trade equilibrium), it appears that the rich country is most likely to gain from multilateral trade liberalization, while the poor country stands a fair chance to lose. When the poor country's income is so low that it cannot afford country 3 goods, also country 1 will gain.

## 8. Conclusion

This paper examines the effects of preferential trade agreements (PTAs) on resource allocation and welfare when countries differ in their stage of economic development. Traditionally, international economists make the simplifying assumption of homothetic preferences when

analyzing the formation of preferential trade agreements. The homotheticity assumption implies that all goods have the same unitary income elasticities and that poor and rich households alike consume all available goods in the same proportion. However, in light of a growing trend towards regional integration agreements between countries of substantially different income levels, assuming homothetic preferences may be too far-fetched. We therefore develop a three-country Ricardian trade model in which consumers rank goods according to priority. The poorest country, country 1, has a comparative advantage in the production of lower ranked goods, and, hence specializes in goods with lower income elasticities in demand. The richest country, country 3, has a comparative advantage in the production of the highest-ranked goods, and hence, specializes in goods with higher income elasticities in demand. The medium rich country, country 2, has a comparative advantage in the production of the intermediate-ranked commodities. Goods at the lower end of the spectrum are consumed by all households and when income increases households add higher-ranked goods to their consumption basket.

Within this framework the following insights emerge. First, a PTA does not necessarily deteriorate the terms of trade of the country that is left outside of the agreement, though this very much depends on the income level of the non-member. We show that being a nonmember implies for the poor country that its terms of trade typically deteriorate, while for a rich country the terms of trade may still improve. Second, being left outside a PTA agreement is typically bad for welfare, except for the rich country. This is due to the presence of asymmetric demand complementarities. Whereas the outside country suffers as the PTA members' expenditure switching goes at their expense, for a rich country this might be compensated by the way the PTA members spend their real income gains. As these are typically spent on country 3 goods only, it explains why the chances on a welfare improvement for a nonmember are higher the richer is the country. Third, being a member of a PTA is no guarantee for welfare improvements. Only countries that are too poor to import the whole range of world products can be assured that opening up their borders preferentially leads to welfare gains. For the other countries it depends to a large extent on how comparative advantages differ across the world.

The general conclusion is that the income level of a country greatly matters for assessing the welfare effects of PTAs. Being a low income country leads to different inferences regarding the costs and benefit of preferential trading agreements than being a medium or high income country. Moreover, it is not only the income differences per se that matter for the welfare results of PTAs, but also the extent of these income differences. For instance,

if the poor country's income level is so low that it is partly insulated from world trade, our analysis shows that it will gain by joining a preferential trade agreement with a richer counterpart. If instead the poor country's income level is such that it also imports the higher-ranked goods, we show that it loses from PTA formation.

Of course, there are several ways to extend our current analysis. One issue is that we have considered small changes in tariffs, thus ruling out the possibility of switching from an asymmetric trade equilibrium to a symmetric trade equilibrium (or vice versa). Intuitively, we would expect that such regime switches will not qualitatively affect our results, but quantitatively they might of course. By performing simulations we hope to shed some light on this matter. Simulations are also useful to compare the welfare outcomes of the different trade regimes we have considered (PTA, multilateral, unilateral). Comparing the PTA results with the multilateral results, we see that a truly poor country will prefer a PTA with a rich country over multilaterally liberalizing its trade, but that for the rich country the extensive poorness of its counterpart is a reason not to engage in such a PTA. Rather it rather would form a PTA with poor countries that are rich enough to import their goods prior to PTA formation. But then the poor country would face a welfare loss. Simulations might help to unravel the specific circumstances under which either of the integration regimes is to be preferred. By the same token, simulations will be helpful for assessing the quantitative differences between the two equilibrium configurations of our analysis. Finally, we note that by assuming homogenous population in each country, we have focussed on the world income distribution and have ignored the potential consequences of the income distribution within countries. This issue is part of our current research agenda.

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## 9. Appendix

### 9.1. Labor market equilibria

#### 9.1.1. Labor market condition for country 1

Here we derive equation (2.11) given in the main text. Using (2.10), we note

$$\begin{aligned} L_1 &= N_1 \int_0^\infty h_1 dF_1(h_1) \\ &= \int_0^{z_3} a_1(z) Q_1(z) dz + \int_0^{z_2} a_1(z) Q_3(z) dz + \int_0^{z_1} a_1(z) Q_2(z) dz. \end{aligned} \quad (9.1)$$

For clarity, let us expand the expenditure expressions, given in equation (2.7), as follows

$$\begin{aligned} E_1(z) &= \int_0^z w_1 a_1(s) ds && \text{for } z \leq z_3 \\ E_2(z) &= \tau_{21} \int_0^z w_1 a_1(s) ds && \text{for } z \leq z_1 \\ E_3(z) &= \tau_{31} \int_0^z w_1 a_1(s) ds && \text{for } z \leq z_2 \end{aligned} \quad (9.2)$$

and

$$\begin{aligned} E_1(z) &= E_1(z_3) + \tau_{12} \int_0^z w_2 a_2(s) ds && \text{for } z_3 < z \leq z_5 \\ E_2(z) &= E_2(z_1) + \int_0^z w_2 a_2(s) ds && \text{for } z_1 < z \leq z_6 \\ E_3(z) &= E_3(z_2) + \tau_{32} \int_0^z w_2 a_2(s) ds && \text{for } z_2 < z \leq z_4 \end{aligned} \quad (9.3)$$

Applying Leibniz's rule for differentiation of definite integrals, we derive the following useful relations from (9.2) and (9.3):

$$\begin{aligned} dE_1(z) &= w_1 a_1(z) dz && \text{for } z \leq z_3 \\ dE_2(z) &= \tau_{21} w_1 a_1(z) dz && \text{for } z \leq z_1 \\ dE_3(z) &= \tau_{31} w_1 a_1(z) dz && \text{for } z \leq z_2 \\ \\ dE_1(z) &= \tau_{12} w_2 a_2(z) dz && \text{for } z_3 < z \leq z_5 \\ dE_2(z) &= w_2 a_2(z) dz && \text{for } z_1 < z \leq z_6 \\ dE_3(z) &= \tau_{32} w_2 a_2(z) dz && \text{for } z_2 < z \leq z_4 \end{aligned}$$



Substituting these relationships into (9.1) we obtain

$$\begin{aligned}
w_1 L_1 &= \int_0^{z_3} Q_1(z) dE_1(z) + \int_0^{z_1} \frac{1}{\tau_{21}} Q_2(z) dE_2(z) + \int_0^{z_2} \frac{1}{\tau_{31}} Q_3(z) dE_3(z) \\
&= \int_0^{z_3} N_1 \left[ \int_{\frac{E_1(z) - TR_1}{w_1}}^{\infty} dF_1(h_1) \right] dE_1(z) + \int_0^{z_1} \frac{N_2}{\tau_{21}} \left[ \int_{\frac{E_2(z) - TR_2}{w_2}}^{\infty} dF_2(h_2) \right] dE_2(z) \\
&\quad + \int_0^{z_2} \frac{N_3}{\tau_{31}} \left[ \int_{\frac{E_3(z) - TR_3}{w_3}}^{\infty} dF_3(h_3) \right] dE_3(z) \\
&= N_1 \int_0^{\infty} \left[ \int_0^{\min\{E_1^{-1}(w_1 h_1 + TR_1), z_3\}} dE_1(z) \right] dF_1(h_1) \\
&\quad + \frac{N_2}{\tau_{21}} \int_0^{\infty} \left[ \int_0^{\min\{E_2^{-1}(w_2 h_2 + TR_2), z_1\}} dE_2(z) \right] dF_2(h_2) \\
&\quad + \frac{N_3}{\tau_{31}} \int_0^{\infty} \left[ \int_0^{\min\{E_3^{-1}(w_3 h_3 + TR_3), z_2\}} dE_3(z) \right] dF_3(h_3) \\
w_1 L_1 &= N_1 \int_0^{\infty} \min\{w_1 h_1 + TR_1, E_1(z_1)\} dF_1(h_1) \\
&\quad + \frac{N_2}{\tau_{21}} \int_0^{\infty} \min\{w_2 h_2 + TR_2, E_2(z_1)\} dF_2(h_2) \\
&\quad + \frac{N_3}{\tau_{31}} \int_0^{\infty} \min\{w_3 h_3 + TR_3, E_3(z_2)\} dF_3(h_3),
\end{aligned}$$

where the second equality uses equation (2.9), the third equality applies a change in variables as in Lederman (1966) and the final equality explicitly expresses the inner integrals. In a similar way, the labor market conditions for country 2 and 3 can be derived.

### 9.1.2. Labor market conditions for countries 2 and 3

Similar to the derivation of the labor market condition for country 1, we obtain for country 2:

$$\begin{aligned}
w_2 L_2 &= \frac{N_1}{\tau_{12}} \int_0^{\infty} \min[w_1 h_1 + TR_1 - E_1(z_3), E_1(z_5) - E_1(z_3)] dF_1(h_1) \\
&\quad + N_2 \int_0^{\infty} \min[w_2 h_2 + TR_2 - E_2(z_1), E_2(z_6) - E_2(z_1)] dF_2(h_2) \\
&\quad + \frac{N_3}{\tau_{32}} \int_0^{\infty} \min[w_3 h_3 + TR_3 - E_3(z_2), E_3(z_4) - E_3(z_2)] dF_3(h_3),
\end{aligned} \tag{9.4}$$

where  $E_1(z_5) - E_1(z_3) = \tau_{12} \int_{z_3}^{z_5} w_2 a_2(s) ds$ ,  $E_2(z_6) - E_2(z_1) = \int_{z_1}^{z_6} w_2 a_2(s) ds$ , and  $E_3(z_4) - E_3(z_2) = \tau_{32} \int_{z_2}^{z_4} w_2 a_2(s) ds$ .

For country 3, we obtain

$$\begin{aligned}
w_3 L_3 = & \frac{N_1}{\tau_{13}} \int_0^{\infty} \max [w_1 h_1 + TR_1 - E_1(z_5), 0] dF_1(h_1) \\
& + \frac{N_2}{\tau_{23}} \int_0^{\infty} \max [w_2 h_2 + TR_2 - E_2(z_6), 0] dF_2(h_2) \\
& + N_3 \int_0^{\infty} \max [w_3 h_3 + T_3 - E_3(z_4), 0] dF_3(h_3).
\end{aligned} \tag{9.5}$$

## 9.2. Balanced Trade Conditions

This appendix sketches the derivation of (3.1) from (2.12). All other trade balance conditions can be derived in an analogous way. We start from the assumption that, in the symmetric equilibrium, all consumers spend their last unit of income on goods produced in country 3. Making use of assumption 4 the following inequalities apply:

$$\begin{aligned}
w_2 + TR_2 &> E_2(z_1), \\
w_3 + TR_3 &> E_3(z_2), \\
w_1 + TR_1 - E_1(z_3) &> E_1(z_5) - E_1(z_3), \\
w_1 + TR_1 - E_1(z_5) &> 0.
\end{aligned}$$

Hence the trade balance condition becomes:

$$\frac{N_2}{\tau_{21}} E_2(z_1) + \frac{N_3}{\tau_{31}} E_3(z_2) = N_1 \int_{z_3}^{z_5} w_2 a_2(s) ds + \frac{N_1}{\tau_{13}} [w_1 h_1 + TR_1 - E_1(z_5)],$$

and after making use of country 1's budget constraint yields (3.1) as given in the main text.

## 9.3. Effects of unilateral tariff reductions

### 9.3.1. Symmetric spending equilibrium

The symmetric equilibrium is contained in the six equations for efficient production (2.1)-(2.6), the balanced trade conditions (3.1), (3.2), and the budget conditions (3.3)-(3.5). Rewriting conditions(2.1)-(2.6) in percentage form yields

$$\begin{aligned}
\hat{z}_1 &= -\frac{1}{\zeta_2} [\hat{\omega}_2 + \hat{\tau}_{21}], & \hat{z}_4 &= \frac{1}{\zeta} [\hat{\omega}_2 - \hat{\omega}_3 - \hat{\tau}_{32}], \\
\hat{z}_2 &= -\frac{1}{\zeta_2} [\hat{\tau}_{31} + \hat{\omega}_2 - \hat{\tau}_{32}], & \hat{z}_5 &= \frac{1}{\zeta} [\hat{\omega}_2 - \hat{\omega}_3 + \hat{\tau}_{13} - \hat{\tau}_{12}], \\
\hat{z}_3 &= -\frac{1}{\zeta_2} [\hat{\omega}_2 - \hat{\tau}_{12}], & \hat{z}_6 &= \frac{1}{\zeta} [\hat{\omega}_2 - \hat{\omega}_3 + \hat{\tau}_{23}].
\end{aligned} \tag{9.6}$$

where  $\zeta_2 > 0$ ,  $\zeta \equiv \zeta_3 - \zeta_2 > 0$ , and where we have applied our assumption that  $\zeta_2(z_i) = \zeta_2$  and  $\zeta_3(z_i) = \zeta_3, \forall i$ .

Total differentiation of (3.1) and (3.2), making use of (2.1)-(2.6) and (3.3)-(3.5) and evaluated at  $\tau_{ik} = \tau_{ij}$  for  $i, j, k = 1, 2, 3$  and  $i \neq j, k$  yields

$$\begin{bmatrix} \widehat{\omega}_2 \\ \widehat{\omega}_3 \end{bmatrix} = \frac{1}{D} \begin{bmatrix} \Omega_{22} & 0 \\ \Omega_{21} & \Omega_{11} \end{bmatrix} \begin{bmatrix} t_{11} & -t_{21} \\ -t_{12} & t_{22} \\ -t_{13} & t_{23} \\ -t_{14} & t_{24} \\ -t_{15} & t_{25} \\ t_{16} & -t_{26} \end{bmatrix}^T \begin{bmatrix} \widehat{\tau}_{12} \\ \widehat{\tau}_{13} \\ \widehat{\tau}_{21} \\ \widehat{\tau}_{23} \\ \widehat{\tau}_{31} \\ \widehat{\tau}_{32} \end{bmatrix}, \quad (9.7)$$

where the superscript “ $T$ ” represents the transpose of a vector. The determinant  $D = \Omega_{11}\Omega_{22} > 0$  since

$$\begin{aligned} \Omega_{11} &= N_1 a_1(z_3)z_3 + N_2 a_1(z_1)z_1 + N_3 a_1(z_2)z_2 > 0, \\ \Omega_{21} &= \Omega_{22} + \zeta [N_1 a_2(z_3)z_3 + N_2 a_2(z_1)z_1 + N_3 a_2(z_2)z_2] > 0, \\ \Omega_{22} &= \zeta_2 [N_1 a_2(z_5)z_5 + N_2 a_2(z_6)z_6 + N_3 a_2(z_4)z_4] > 0. \end{aligned}$$

With

$$\begin{aligned} t_{11} &= N_1 a_1(z_3)z_3, & t_{12} &= 0, \\ t_{13} &= N_2 a_1(z_1)z_1, & t_{14} &= 0, \\ t_{15} &= N_3 a_1(z_2)z_2, & t_{16} &= N_3 a_1(z_2)z_2, \\ t_{21} &= N_1 [\zeta_2 a_2(z_5)z_5 + \zeta a_2(z_3)z_3], & t_{22} &= \zeta_2 N_1 a_2(z_5)z_5, \\ t_{23} &= \zeta N_2 a_2(z_1)z_1, & t_{24} &= \zeta_2 N_2 a_2(z_6)z_6, \\ t_{25} &= \zeta N_3 a_2(z_2)z_2, & t_{26} &= N_3 [\zeta_2 a_2(z_4)z_4 + \zeta a_2(z_2)z_2]. \end{aligned}$$

It is helpful to recognize that

$$\begin{aligned} \Omega_{22} - \Omega_{21} &= -\zeta [N_1 a_2(z_3)z_3 + N_2 a_2(z_1)z_1 + N_3 a_2(z_2)z_2] < 0, \\ &= -\zeta \omega_2 [N_1 a_1(z_3)z_3/\tau_{12} + N_2 a_1(z_1)z_1\tau_{21} + N_3 a_1(z_2)z_2] < 0, \\ \Omega_{21} - \Omega_{11}\zeta\omega_2 &= \Omega_{22} + \zeta\omega_2 [N_1 a_1(z_3)z_3(\frac{1}{\tau_{12}} - 1) + N_2 a_1(z_1)z_1(\tau_{21} - 1)], \\ &= \Omega_{22} + \zeta [N_1 a_2(z_3)z_3(1 - \tau_{12}) + N_2 a_1(z_1)z_1\omega_2(\tau_{21} - 1)], \\ \Omega_{21} - \Omega_{11}\zeta\omega_2/\tau_{12} &= \Omega_{22} + \zeta\omega_2 [N_2 a_1(z_1)z_1(\tau_{21} - \frac{1}{\tau_{12}}) + N_3 a_1(z_2)z_2(1 - \frac{1}{\tau_{12}})] > 0, \\ \Omega_{21} - \Omega_{11}\zeta\omega_2\tau_{21} &= \Omega_{22} - \zeta\omega_2 [N_1 a_1(z_3)z_3(\tau_{21} - \frac{1}{\tau_{12}}) + N_3 a_1(z_2)z_2(\tau_{21} - 1)], \end{aligned}$$

where we make use of (2.1)-(2.6) and the assumption that  $\tau_{ik} = \tau_{ij}$  for  $i, j, k = 1, 2, 3$  and  $i \neq j, k$ . Now, substituting the elements  $t_{ij}$  into (9.7) and (9.6) makes it possible to derive

the results shown in Table 1 of the text. The comparable results obtained by ACF are given in the same table by the panel on the right. These results coincide with those as given in Table 1, p. 154 of ACF.

### 9.3.2. Asymmetric spending equilibrium

The asymmetric equilibrium is contained in the six equations for efficient production (2.1)-(2.6), the balanced trade conditions (3.6) and (3.7), and the budget conditions (3.8), (3.4), and (3.5). The percentage change in relative wages can then be deduced from the following system:

$$\begin{bmatrix} \hat{\omega}_2 \\ \hat{\omega}_3 \end{bmatrix} = \frac{1}{\tilde{D}} \begin{bmatrix} \tilde{\Omega}_{22} & 0 \\ \tilde{\Omega}_{21} & \tilde{\Omega}_{11} \end{bmatrix} \begin{bmatrix} s_{11} & -s_{21} \\ -s_{13} & s_{23} \\ s_{14} & s_{24} \\ -s_{15} & s_{25} \\ s_{16} & -s_{26} \end{bmatrix}^T \begin{bmatrix} \hat{\tau}_{12} \\ \hat{\tau}_{21} \\ \hat{\tau}_{23} \\ \hat{\tau}_{31} \\ \hat{\tau}_{32} \end{bmatrix}, \quad (9.8)$$

with  $\tilde{D} = \tilde{\Omega}_{22}\tilde{\Omega}_{11} > 0$  and

$$\begin{aligned} \tilde{\Omega}_{11} &= N_1 a_1(z_3)z_3 + N_2 a_1(z_1)z_1 + N_3 a_1(z_2)z_2 > 0, \\ \tilde{\Omega}_{22} &= \zeta_2 [N_2 a_2(z_6)z_6 + N_3 a_2(z_4)z_4] > 0, \\ \tilde{\Omega}_{21} &= \zeta \omega_2 N_1 [\zeta_2 (1 - \int_0^{z_3} a_1(s)ds) + a_1(z_3)z_3] \\ &\quad + N_2 [\zeta a_2(z_1)z_1 + \zeta_2 a_2(z_6)z_6] + N_3 [\zeta a_2(z_2)z_2 + \zeta_2 a_2(z_4)z_4] > 0. \end{aligned}$$

With

$$\begin{aligned} s_{11} &= N_1 a_1(z_3)z_3 & s_{12} &= 0, \\ s_{13} &= N_2 a_1(z_1)z_1, & s_{14} &= 0, \\ s_{15} &= N_3 a_1(z_2)z_2, & s_{16} &= N_3 a_1(z_2)z_2 > 0, \end{aligned}$$

$$\begin{aligned} s_{21} &= \zeta N_1 \omega_2 a_1(z_3)z_3, & s_{22} &= 0, \\ s_{23} &= \zeta N_2 a_2(z_1)z_1, & s_{24} &= \zeta_2 N_2 a_2(z_6)z_6, \\ s_{25} &= \zeta N_3 a_2(z_2)z_2, & s_{26} &= N_3 [\zeta_2 a_2(z_4)z_4 + \zeta a_2(z_2)z_2]. \end{aligned}$$

It is helpful to recognize that

$$\begin{aligned} \tilde{\Omega}_{21} &= \tilde{\Omega}_{22} + \zeta \omega_2 N_1 [\zeta_2 (1 - \int_0^{z_3} a_1(s)ds) + a_1(z_3)z_3] \\ &\quad + \zeta [N_2 a_2(z_1)z_1 + N_3 a_2(z_2)z_2] > 0, \\ \tilde{\Omega}_{21} - \zeta \omega_2 \tilde{\Omega}_{11} &= \tilde{\Omega}_{22} + \zeta \omega_2 [\zeta_2 N_1 (1 - \int_0^{z_3} a_1(s)ds) + N_2 a_1(z_1)z_1 (\tau_{21} - 1)] > 0, \\ \tilde{\Omega}_{21} - \tau_{21} \zeta \omega_2 \tilde{\Omega}_{11} &= \tilde{\Omega}_{22} + \zeta \omega_2 [\zeta_2 N_1 (1 - \int_0^{z_3} a_1(s)ds) - (N_1 a_1(z_3)z_3 + N_3 a_1(z_2)z_2) (\tau_{21} - 1)]. \end{aligned}$$

Substituting the elements  $s_{ij}$  into (9.8) makes it possible to derive the results shown in Table 1b. This also determines the signs of  $\widehat{\omega_2/\omega_3}$ . The signs for  $\widehat{z}_i$ ,  $i = 1..6$ , follow by applying (9.6). This leads to the comparative statics results for unilateral tariff reductions as given in Table 1b in the main text (left panel).

#### 9.4. Welfare expressions

In this part of the appendix we derive the welfare expressions used to derive the results illustrated in Tables 2, 6, and 7b (8b). The welfare effects follow from total differentiation of equations (3.3)-(3.5) for the symmetric equilibrium and equations (3.4)-(3.5) plus (3.8) for the asymmetric equilibrium and making use of the assumption that each country imposes the same tariff rate on its imports regardless of the country of origin, i.e.,  $\tau_{jk} = \tau_{jk'}$  for  $j, k, k' = 1, 2, 3$ . We confine ourselves to discussing the welfare effects for the symmetric spending equilibrium and for country 1. Those for the other countries and the asymmetric spending equilibrium follow by applying analogous methodology. These, as well as more detailed calculations can be obtained from the authors upon request. For country 1, we calculate

$$\begin{aligned} a_3(u_1)du_1 &= a_3(z_5)z_5\widehat{z}_5 - \omega_3 a_1(z_3)z_3\widehat{z}_3 - \frac{\omega_3}{\omega_2} [a_2(z_5)z_5\widehat{z}_5 - a_2(z_3)z_3\widehat{z}_3] \\ &\quad + \frac{\omega_3}{\omega_2} \int_{z_3}^{z_5} a_2(s)ds\widehat{\omega}_2 + \int_{z_5}^{u_1} a_3(s)ds\widehat{\omega}_3. \end{aligned}$$

When we use (2.1)-(2.6), the expression can be rewritten to

$$\begin{aligned} a_3(u_1)du_1 &= \left(1 - \frac{\tau_{13}}{\tau_{12}}\right) a_3(z_5)z_5\widehat{z}_5 + (1 - \tau_{12}) \frac{\omega_3}{\omega_2} a_2(z_3)z_3\widehat{z}_3 \\ &\quad + \frac{\omega_3}{\omega_2} \int_{z_3}^{z_5} a_2(s)ds\widehat{\omega}_2 + \int_{z_5}^{u_1} a_3(s)ds\widehat{\omega}_3 \end{aligned}$$

so that when  $\tau_{12} = \tau_{13}$  it reduces to the expression as given in the main text.

## 10. Tables and Figures

**Table 1a: Effects of unilateral tariff changes, symmetric case**

<i>Our analysis</i>	A rise in :					
	$\tau_{12}$	$\tau_{13}$	$\tau_{21}$	$\tau_{23}$	$\tau_{31}$	$\tau_{32}$
$z_1$	-	0	-	0	+	-
$z_2$	-	0	+	0	-	+
$z_3$	+	0	+	0	+	-
$z_4$	$-^1/+^2$	-	-	-	$-^4$	$+^3/-^2$
$z_5$	-	+	-	-	$-^4$	$+^3/+^2$
$z_6$	$-^1/+^2$	-	-	+	$-^4$	$+^3/+^2$
$\omega_2$	+	0	-	0	-	+
$\omega_3$	$+^1/?^2$	+	$+^1/-^2$	+	$+^3/-^2$	$-^3/?$
$\omega_2/\omega_3$	$-^1/+^2$	-	-	-	$-^4$	$+^3/+^2$

<sup>1</sup>if  $\zeta_2 \rightarrow 0$ ;      <sup>2</sup>if  $\zeta \rightarrow 0$ ;  
<sup>3</sup>if  $\zeta_2 \rightarrow 0$  and  $N_1 a_1(z_3) z_3 (1 - \frac{1}{\tau_{12}}) > N_2 a_1(z_1) z_1 (\tau_{21} - 1)$ ;  
<sup>4</sup>if  $N_1 a_1(z_3) z_3 (1 - \frac{1}{\tau_{12}}) > N_2 a_1(z_1) z_1 (\tau_{21} - 1)$ ;

<i>ACF</i>	A rise in:					
	$\tau_{12}$	$\tau_{13}$	$\tau_{21}$	$\tau_{23}$	$\tau_{31}$	$\tau_{32}$
$z_1$	-	+	-	+	+	-
$z_2$	-	+	+	+	-	+
$z_3$	+	+	+	+	+	-
$z_4$	+	-	-	-	-	-
$z_5$	-	+	-	-	-	+
$z_6$	+	-	-	+	-	+
$\omega_2$	+	-	-	-	-	+
$\omega_3$	$\pm$	+	-	+	-	$\pm$
$\omega_2/\omega_3$	+	-	-	-	-	+

**Table 1b: Effects of unilateral tariff changes, asymmetric case**

<i>Our analysis</i>	A rise in:				
	$\tau_{12}$	$\tau_{21}$	$\tau_{23}$	$\tau_{31}$	$\tau_{32}$
$z_1$	-	-	0	+	-
$z_2$	-	+	0	-	+
$z_3$	+	+	0	+	-
$z_4$	-	- <sup>1</sup>	-	+	-
$z_6$	-	- <sup>1</sup>	+	+	- <sup>1</sup> / <sup>+</sup> <sup>2</sup>
$\omega_2$	+	-	0	-	+
$\omega_3$	+	+ <sup>1</sup> / <sup>-</sup> <sup>2</sup>	+	-	+ <sup>1</sup> / <sup>?<sup>2</sup></sup>
$\omega_2/\omega_3$	-	- <sup>1</sup> / <sup>?<sup>2</sup></sup>	-	+	- <sup>1</sup> / <sup>+</sup> <sup>2</sup>

<sup>1</sup> if $\zeta_2 \rightarrow 0$ ; <sup>2</sup> if $\zeta \rightarrow 0$ ;
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The results obtained by ACF are taken from Table 1, p. 154 of ACF (1989). The comparison with ACF is not relevant for the asymmetric case, as in their framework spending is symmetric by definition.

### 10.1. Welfare effects of unilateral tariff changes

<i>Table 2a</i>	Welfare: Unilateral tariff reduction gives rise to					
<i>symmetric</i>	$\tau_{12}$	$\tau_{13}$	$\tau_{21}$	$\tau_{23}$	$\tau_{31}$	$\tau_{32}$
$u_1$	$-^3$	$-$	$?^1/+^2$	$-$	$-^4/+^2$	$+^4/?^2$
$u_2$	$?^1/+^2$	$-$	$?^1/?^2$	$?^1/+^2$	$-^6$	$+^5/+^2$
$u_3$	$+^1/-^2$	$+$	$+^1/?^2$	$+$	$+^5/?^2$	$-^5/+^2$

<sup>1</sup>if  $\zeta_2 \rightarrow 0$ ;

<sup>2</sup>if  $\zeta \rightarrow 0$ ;

<sup>3</sup>if  $\zeta_2 \rightarrow 0$  and  $\zeta \gg 0$ ;

<sup>4</sup>if  $\zeta_2 \rightarrow 0$ ,  $\zeta \gg 0$  and  $N_1 a_1(z_3) z_3 (1 - \frac{1}{\tau_{12}}) > N_2 a_1(z_1) z_1 (\tau_{21} - 1)$ ;

<sup>5</sup>if  $\zeta_2 \rightarrow 0$  and  $N_1 a_1(z_3) z_3 (1 - \frac{1}{\tau_{12}}) > N_2 a_1(z_1) z_1 (\tau_{21} - 1)$ ;

<sup>6</sup>if  $N_1 a_1(z_3) z_3 (1 - \frac{1}{\tau_{12}}) > N_2 a_1(z_1) z_1 (\tau_{21} - 1)$ ;

<i>Table 2b</i>	Welfare: Unilateral tariff reduction gives rise to				
<i>asymmetric</i>	$\tau_{12}$	$\tau_{21}$	$\tau_{23}$	$\tau_{31}$	$\tau_{32}$
$u_1$	$+^1/?^2$	$+$	$0$	$+$	$-$
$u_2$	$-^3/?^2$	$-^3/?^2$	$+^2$	$+^3/?^2$	$-^3/+^2$
$u_3$	$+^1/+^2$	$+^1/?^2$	$+$	$-^1/-^2$	$+^1/+^2$

<sup>1</sup>if  $\zeta_2 \rightarrow 0$ ;  
<sup>2</sup>if  $\zeta \rightarrow 0$ ;  
<sup>3</sup>if  $\zeta_2 \rightarrow 0$  and  $\zeta \gg 0$ ;



## 10.2. General equilibrium effects of PTAs

<b>Table 3: General equilibrium results for PTA<sub>23</sub>:</b>									
	A mutual decline in tariffs gives rise to:								
	$z_1$	$z_2$	$z_3$	$z_4$	$z_5$	$z_6$	$\omega_2$	$\omega_3$	$\omega_2/\omega_3$
symmetric equilibrium:	+	-	+	$-^4/+^2$	$-^4/+^3$	$-^4/-^2$	-	$+^4/-^3$	$-^4/+^3$
asymmetric equilibrium:	+	-	+	$+^1/+^2$	n.a.	$+^1/-^2$	-	$-^1/-^3$	$+^1/+^3$
<sup>1</sup> if $\zeta_2 \rightarrow 0$ ; <sup>2</sup> if $\zeta \rightarrow 0$ ; <sup>3</sup> if $\zeta \rightarrow 0$ and $N_2a_2(z_6)z_6 > N_3a_2(z_4)z_4$ ; <sup>4</sup> if $\zeta_2 \rightarrow 0$ and $N_1a_1(z_3)z_3(1 - \frac{1}{\tau_{12}}) > N_2a_1(z_1)z_1(\tau_{21} - 1)$ ;									

<b>Table 4: General equilibrium results for PTA<sub>12</sub>:</b>									
	A mutual decline in tariffs gives rise to:								
	$z_1$	$z_2$	$z_3$	$z_4$	$z_5$	$z_6$	$\omega_2$	$\omega_3$	$\omega_2/\omega_3$
symmetric equilibrium:	+	$+^4$	-	$+^1/-^2$	+	$+^1/-^2$	$-^4$	$-^1/?^2$	$+^1/-^2$
asymmetric equilibrium:	+	$+^4$	-	$+^1/?^2$	n.a.	$+^1/?^2$	$-^4$	$-^1/-^3$	$+^1/?^2$
<sup>1</sup> if $\zeta_2 \rightarrow 0$ ; <sup>2</sup> if $\zeta \rightarrow 0$ ; <sup>3</sup> if $\zeta \rightarrow 0$ and $N_1a_1(z_3)z_3 > N_2a_1(z_1)z_1$ ; <sup>4</sup> if $N_1a_1(z_3)z_3 > N_2a_1(z_1)z_1$ ;									

<b>Table 5: General equilibrium results for PTA<sub>13</sub></b>									
	A mutual decline in tariffs gives rise to:								
	$z_1$	$z_2$	$z_3$	$z_4$	$z_5$	$z_6$	$\omega_2$	$\omega_3$	$\omega_2/\omega_3$
symmetric equilibrium:	-	+	-	$+^3/+^2$	$+^3/-^2$	$+^3/+^2$	+	$-^3$	$+^3/+^2$
asymmetric equilibrium:	-	+	-	-	n.a.	-	+	+	-
<sup>1</sup> if $\zeta_2 \rightarrow 0$ ; <sup>2</sup> if $\zeta \rightarrow 0$ ; <sup>3</sup> if $\zeta_2 \rightarrow 0$ and $N_1a_1(z_3)z_3(1 - \frac{1}{\tau_{12}}) > N_2a_1(z_1)z_1(\tau_{21} - 1)$ ;									

### 10.3. Welfare effects of PTAs

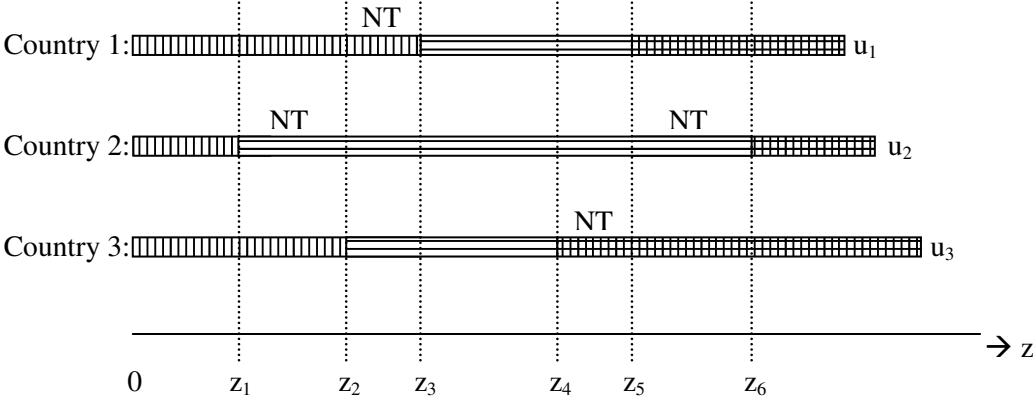
<b>Table 6: Welfare effects of PTAs for uniform tariff structures</b>			
	$u_1$ $(\zeta_2 \rightarrow 0/\zeta \rightarrow 0)$	$u_2$ $(\zeta_2 \rightarrow 0/\zeta \rightarrow 0)$	$u_3$ $(\zeta_2 \rightarrow 0/\zeta \rightarrow 0)$
<i>PTA<sub>12</sub></i>			
Symmetric	$-^1/?$	$-^1/+$	$+/-$
Asymmetric	$+/?$	$-^1/?$	$+/+^5$
<i>PTA<sub>13</sub></i>			
Symmetric	$-^3/?$	$-^4/-$	$+^4/+$
Asymmetric	$+/+$	$+^1/?$	$-/-$
<i>PTA<sub>23</sub></i>			
Symmetric	$-^3/-^2$	$+^4/+$	$-^4/+$
Asymmetric	$-/-$	$-^1/+$	$+/+$
<sup>1</sup> if $\zeta_2 \rightarrow 0$ and $\zeta \gg 0$ ; <sup>2</sup> if $\zeta \rightarrow 0$ and $N_3 a_2(z_4) z_4 < N_2 a_2(z_6) z_6$ ; <sup>3</sup> if $\zeta_2 \rightarrow 0$ , $\zeta \gg 0$ , and $N_1 a_1(z_3) z_3 (1 - \frac{1}{\tau_{12}}) > N_2 a_1(z_1) z_1 (\tau_{21} - 1)$ ; <sup>4</sup> if $\zeta_2 \rightarrow 0$ and $N_1 a_1(z_3) z_3 (1 - \frac{1}{\tau_{12}}) > N_2 a_1(z_1) z_1 (\tau_{21} - 1)$ ; <sup>5</sup> if $\zeta \rightarrow 0$ and $N_1 a_1(z_3) z_3 > N_2 a_1(z_1) z_1$ ;			

## 10.4. Multilateral tariff reductions

Table 7a: General equilibrium results for multilateral tariff reductions									
	A mutual decline in tariffs gives rise to:								
	$z_1$	$z_2$	$z_3$	$z_4$	$z_5$	$z_6$	$\omega_2$	$\omega_3$	$\omega_2/\omega_3$
symmetric equilibrium:	+	+ <sup>3</sup>	-	+	+ <sup>1</sup> / <sup>+</sup> <sup>4</sup>	+ <sup>1</sup> / <sup>-</sup> <sup>2</sup>	- <sup>3</sup>	- <sup>1</sup> / <sup>?</sup> <sup>2</sup>	+ <sup>1</sup> / <sup>+</sup> <sup>4</sup>
asymmetric equilibrium:	+	+ <sup>3</sup>	-	+ <sup>1</sup> / <sup>+</sup> <sup>2</sup>	n.a.	+ <sup>1</sup> / <sup>-</sup> <sup>2</sup>	- <sup>3</sup>	- <sup>1</sup> / <sup>?</sup> <sup>2</sup>	+ <sup>1</sup> / <sup>+</sup> <sup>4</sup>
<sup>1</sup> if $\zeta_2 \rightarrow 0$ ; <sup>2</sup> if $\zeta \rightarrow 0$ ; <sup>3</sup> if $N_1 a_1(z_3) z_3 > N_2 a_2(z_1) z_1$ ; <sup>4</sup> if $\zeta \rightarrow 0$ and $N_2 a_2(z_6) z_6 > N_3 a_2(z_4) z_4$ ;									

Table 7b: Welfare effects of multilateral tariff reductions		
A mutual decline in all tariff rates gives rise to:		
	$\mathcal{T}_{symmetric}$	$\mathcal{T}_{asymmetric}$
$u_1$	- <sup>3</sup> / <sup>?</sup> <sup>2</sup>	+ <sup>1</sup>
$u_2$	- <sup>3</sup> / <sup>+</sup> <sup>2</sup>	- <sup>3</sup> / <sup>+</sup> <sup>2</sup>
$u_3$	+ <sup>1</sup> / <sup>+</sup> <sup>2</sup>	+ <sup>1</sup> / <sup>+</sup> <sup>2</sup>
<sup>1</sup> if $\zeta_2 \rightarrow 0$ ; <sup>2</sup> if $\zeta \rightarrow 0$ ; <sup>3</sup> if $\zeta_2 \rightarrow 0$ and $\zeta \gg 0$ ;		

**Figure 1: Production and trade patterns**



Country 1 production  
Country 2 production  
Country 3 production  
NT: not traded goods