

Hub and spoke bilateralism and the global income distribution

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September 2006

Abstract

We study the effects of hub and spoke liberalization in a model where income matters for consumption patterns. We use 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 a country's income level is of decisive importance for assessing the impact of hub and spoke arrangements on welfare. Hubs do not necessarily gain and spokes do not necessarily lose.

Keywords: Ricardian trade model; asymmetric demand complementarities; nonhomothetic preferences; global income distribution.

JEL classification: F1

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1 Introduction

The recent collapse of the Doha Round is expected to generate an increase in bilateral trade agreements. In particular, a boost in so-called 'hub and spoke bilateralism' is expected, where a big country, the hub, engages in a discriminatory trade agreement with a small country, the spoke. The literature on the static effects of such arrangements has made clear that these are beneficial for the hub and detrimental to the spoke(s), particularly if the hub has many spokes (Kowalczyk and Wonnacott, 1992, Baldwin & Venables, 1995 and Wonnacott, 1996). This insight emerges from analytical frameworks where the difference in income between countries matters only for establishing whether or not bilateral terms of trade changes occur. Whereas changes in tariffs by the hub leads to a terms of trade improvement for the spoke, the changes in tariffs of the spoke do not change the terms of trade of the hub. Accordingly, it is intuitive that a spoke gains if it is the only country the hub establishes a bilateral trade agreement with. If, however, the hub forms such arrangements with more spokes, the benefits of being treated preferentially disappear and spokes might lose.

We argue that there is more to income differences between countries than just having an impact on the bilateral terms of trade. In particular, we argue that one should also include the effect of different income levels on consumption patterns. In standard trade analysis this aspect is ignored by assuming that preferences are homothetic. That is, if income increases, the demand for commodities increases proportionally and consumption patterns do not change. In a world with persistent global income differences, this assumption is too far-fetched. In particular, the similarity in consumption patterns is at odds with a number of stylized facts. First, many new, sophisticated products are developed in countries with high per capita incomes, created by entrepreneurs in response to perceived demand. Individuals in countries with lower per capita income tend to buy relatively unsophisticated products. Recent evidence for this is provided by Schott (2001).¹ Second, sophisticated goods are originally developed and produced in developed countries and only at a later point in their cycle consumed in less developed countries (Vernon, 1966). Third, the volume of trade will be higher between countries with similar per capita income (Burenstam Linder, 1961).

The present paper analyzes the formation of hub and spoke arrangements in a framework that incorporates nonhomothetic preferences. The model builds on Stibora and de Vaal (2006a,b), where we have incorporated nonhomothetic preferences to analyze the consequences of unilateral tariff cuts and PTA formation between countries of different income levels. Assuming a continuum of goods in a three country Ricardian trade model, we rank

¹See also Deaton and Muellbauer (1980), Hunter and Markusen (1987) and Hunter (1991).

countries such that there is a poor country with a comparative advantage in the production of the lower-ranked goods, a rich country with a comparative advantage in the production of the highest-ranked goods, and a medium-rich country with a comparative advantage in the production of intermediate-ranked goods. Nonhomotheticity in demand enters the analysis by assuming that goods are indivisible in consumption. We suppose that the continuum of goods is also ordered according to priority in consumption. The lowest-indexed goods have the highest priority in consumption, whereas the highest-indexed goods have the lowest priority in consumption. Consumers first buy high-priority goods and only when their real income increases will they add higher-indexed goods to their consumption baskets. The higher-indexed goods are therefore only affordable to households with sufficiently high income levels. This implies that the poor (rich) country produces goods with low (high) income elasticities in demand and the medium rich country specializes in goods with intermediate income elasticities in demand.

In such a framework, we find that the income level of a country greatly matters for assessing the impact of hub and spoke arrangements. A hub is most likely to gain if it produces goods with the highest-income elasticities, which is the rich country. A middle-income hub, producing at most goods with intermediate income elasticities, is less ascertained of welfare gains and may even lose. The main reason for this divergence is the inclusion of asymmetric demand complementarities. Due to nonhomothetic preferences, real income gains are spent on goods with higher demand elasticities, which is favorable to rich countries and less so for medium-rich countries. Also for spokes the welfare effects highly depend on income levels. Richer spokes are more likely to gain than poorer spokes. However, if a spoke country is so poor that it cannot afford the higher-indexed goods that the rich country produces, it is either shielded from welfare changes (if the rich country is the hub) or it has a fair chance to gain as well (if the middle-income country is hub). It is therefore not only the income differences per se that matter for the welfare results of hub and spoke arrangements, but also the extent of these income differences.

We proceed with this paper as follows. In Section 2, we provide a brief discussion of the model we introduced in Stibora and de Vaal (2006b). In Section 3 we present the general equilibrium and welfare effects of a hub and spoke arrangement with the rich country as the hub. Likewise, Section 4 discusses welfare effects if the medium-rich country is the hub. Section 5 concludes.

2 The Model²

We consider three countries, countries 1, 2, and 3. In each country there exists 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 each country. 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 .

Initially, trade flows are distorted by tariffs. Let τ_{jk} be one plus the ad valorem tariff in country j on any of the commodities z when it is produced in country k . Assuming perfect competition, a country then exports good z when it can produce that good at the lowest cost. For given relative wages, which we denote by $\omega_i = w_1/w_i$ for $i = 2, 3$, it follows that there will be six equilibrium borderline goods z_k ($k = 1, \dots, 6$), demarcating for each country ranges of own production, exports, and non-traded goods. For given wages and tariffs, these borderline goods are represented by equalities in (1)-(6) (see ACF (1989), p.151).

Country 1 will export to country 2 if and only if $\tau_{21}w_1a_1 \leq w_2a_2$ and $\tau_{21}w_1a_1 \leq \tau_{23}w_3a_3$ with borderline good z_1 determined by

$$\tau_{21}\omega_2 = a_2(z_1)/a_1(z_1); \quad (1)$$

country 1 will export to country 3 iff $\tau_{31}w_1a_1 \leq \tau_{32}w_2a_2$ and $\tau_{31}w_1a_1 \leq w_3a_3$ with

$$\tau_{31}\omega_2 = \tau_{32}a_2(z_2)/a_1(z_2); \quad (2)$$

country 2 will export to country 1 iff $\tau_{12}w_2a_2 \leq w_1a_1$ and $\tau_{12}w_2a_2 \leq \tau_{13}w_3a_3$ with

$$\omega_2 = \tau_{12}a_2(z_3)/a_1(z_3); \quad (3)$$

²This section is a simplified version of the model introduced in Stibora & de Vaal (2006b).

country 2 will export to country 3 iff $\tau_{32}w_2a_2 \leq w_3a_3$ and $\tau_{32}w_2a_2 \leq \tau_{31}w_1a_1$ with

$$\omega_2/\omega_3 = \tau_{32}a_2(z_4)/a_3(z_4); \quad (4)$$

country 3 will export to country 1 iff $\tau_{13}w_3a_3 \leq \tau_{12}w_2a_2$ and $\tau_{13}w_3a_3 \leq w_1a_1$ with

$$\omega_3/\omega_2 = a_3(z_5)\tau_{13}/a_2(z_5)\tau_{12}; \quad (5)$$

and country 3 will export to country 2 iff $\tau_{23}w_3a_3 \leq w_2a_2$ and $\tau_{23}w_3a_3 \leq \tau_{21}w_1a_1$ with

$$\omega_3/\omega_2 = \tau_{23}a_3(z_6)/a_2(z_6). \quad (6)$$

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 satisfies $z_1 < z_2 < z_3 < z_4 < z_5 < z_6$ as long as (i) directly exporting good z costs less than exporting the same good via a third country and (ii) tariff rates do not differ too much between countries. For example, given assumptions 1 and 2 and conditions (5) and (6), $z_5 < z_6$ holds unless $\tau_{13} > \tau_{12}\tau_{23}$ that is, if the direct tariff country 1 pays on imports from country 3 is larger than the tariffs country 1 pays on imports from country 3 when good z is imported via country 2. The exception is $z_3 < z_4$ where $z_4 < z_3$ is also possible. We exclude this possibility and assume $z_3 < z_4$ for the rest of the analysis.³ As we will explain later, the trade patterns depicted only hold when households in all three countries are rich enough to consume the higher-indexed goods country 3 produces, in contrast to ACF.

(insert Figure 1 about here)

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

Turning to the demand side, we assume there are N_j households in country j , each supplying one unit of labor. The potential consumption set of a household includes the

³If $z_4 < z_3$ this would create an additional range of nontraded goods for country 2, but would otherwise not change any of the main results.

continuum of $z \in [0, \infty)$. All households have the same preferences $V = \int_0^\infty b(z)x(z)dz$, where $x(z) = \{0, 1\}$ denotes the consumption indicator and $b(z) > 0$ is the utility index. The budget constraint is given by $\int_0^\infty p(z)x(z)dz \leq I$. A household purchases good z , $x(z) = 1$, if the utility from the last unit income spent $\lambda \leq b(z)/p(z)$. We order goods each household purchases in the same way as the ordering of goods due to comparative advantage. This requires that the marginal utility of income is strictly decreasing in z , that is, we assume that

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

is strictly decreasing in z , for given w_j and τ_{kj} . This implies that 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, so that we can take u_j as a measure of welfare.

Combining assumptions 1 and 2 together with the assumption of falling marginal utility of income leads country 1 to have a comparative advantage in the production of lower-ranked goods that poor households purchase, country 3 to have a comparative advantage in the production of higher-ranked goods that rich households purchase, and country 2 to have a comparative advantage in the production of intermediate-ranked goods.

Define the minimum level of income that allows a household from country j to consume good z as

$$E_j(z) \equiv \int_0^z p_j(s)ds, \quad (7)$$

where $p_j(z)$ is the minimum price of good z in country j , which is inclusive of tariffs whenever relevant. The tariff revenues generated are redistributed across households in a lump-sum fashion. Consequently, households pay a tariff exclusive price for what they import. Denoting the tariff rebates by TR_j , the highest-indexed commodity a household in country j with income $w_j + TR_j$ is able to consume, u_j , is determined by the requirement that

$$E_j[u_j] = w_j + TR_j \quad (8)$$

for $j = 1, 2, 3$.

We now turn to the labor markets. Labor market equilibrium requires that in each country labor supply, N_j , equals labor demand which, in turn, depends upon the demand for final goods. Demand for final good z is determined by the fraction of households with income in excess of $E_j(z)$. Aggregate demand for good z then is the number of households from the three countries whose income is equal or greater than $E_j(z)$. Then integrating the labor required to produce each good in country j over the aggregate demand gives the

quantity of labor in country j which is demanded to produce goods consumed in country i . In line with standard practice in trade theory, we can replace the resulting three labor market equilibrium conditions by two balanced trade conditions, that for country 1 and country 2 (see Appendix A for details).

Recall that goods are indivisible implying that poor households are not able to consume the same number of goods than rich households. To ensure that households from different countries have different income levels we assume that country 2 has an absolute advantage relative to country 1 and that country 3 has an absolute advantage relative to country 2 for all z . As a consequence, $\omega_2 < 1 < \omega_2/\omega_3$, making country 1 the poor country, country 2 the medium rich country, and country 3 the rich country. Taken together, the assumption on absolute productivity and the assumptions on the ranking of goods imply that the poor country has a comparative advantage in the production of lower-ranked goods purchases by poor households, the rich country has a comparative advantage in the production of higher-ranked purchased by rich households, and the medium-rich country has a comparative advantage in the production of intermediate-ranked goods. Put differently, the poor (rich) country produces goods with low (high) income elasticities in demand and the medium rich country specializes in goods with intermediate income elasticities in demand.

How poor country 1 is depends on the income level of households from that country in equilibrium. Suppose that country 1's absolute productivity differences with country 2 are considerable, *ceteris paribus*. To preserve labor market equilibrium country 1's factor terms of trade have to fall, which is equivalent to a decline in real income. The fall in real income forces households from country 1 to cut back their consumption of higher-ranked goods. This generates two possible equilibrium configurations depending on where households from country 1 spend their last unit of income. The first equilibrium outcome holds that households in each country 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 so that we refer to this equilibrium configuration as the *symmetric trade equilibrium* (henceforth: STE). The conditions for balanced trade become, for country 1

$$N_1(1 - \int_0^{z_3} a_1(s)ds) = N_2 \int_0^{z_1} a_1(s)ds + N_3 \int_0^{z_2} a_1(s)ds, \quad (9)$$

and for country 2,

$$N_2(1 - \int_{z_1}^{z_6} a_2(s)ds) = N_1 \int_{z_3}^{z_5} a_2(s)ds + N_3 \int_{z_2}^{z_4} a_2(s)ds. \quad (10)$$

The left-hand-side of (9) [(10)] denotes the value of country 1's [country 2's] imports and the right-hand-side the corresponding value of exports. The highest-indexed good u_j associated with STE, is derived from (8) and is given by

$$\int_0^{z_3} a_1(s)ds + \int_{z_3}^{z_5} \frac{a_2(s)}{\omega_2} ds + \int_{z_5}^{u_1} \frac{a_3(s)}{\omega_3} ds = 1 \quad (11)$$

$$\int_0^{z_1} a_1(s)ds + \int_{z_1}^{z_6} \frac{a_2(s)}{\omega_2} ds + \int_{z_6}^{u_2} \frac{a_3(s)}{\omega_3} ds = \frac{1}{\omega_2} \quad (12)$$

$$\int_0^{z_2} a_1(s)ds + \int_{z_2}^{z_4} \frac{a_2(s)}{\omega_2} ds + \int_{z_4}^{u_3} \frac{a_3(s)}{\omega_3} ds = \frac{1}{\omega_3}. \quad (13)$$

The absence of any tariff terms is due to the fact that households pay a tariff exclusive prices as a result of tariff rebates. We note that STE corresponds to what has been illustrated in Figure 1.

The second equilibrium configuration that may result is when households from country 1 are too poor to consume country 3 goods, so that they 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. As this equilibrium configuration also involves one-way trade flows, we refer to it as the *asymmetric trade equilibrium* (henceforth: ATE).⁴ The conditions for balanced trade become for country 1

$$N_1(1 - \int_0^{z_3} a_1(s)ds) = N_2 \int_0^{z_1} a_1(s)ds + N_3 \int_0^{z_2} a_1(s)ds \quad (14)$$

and for country 2

$$N_2(1 - \int_{z_1}^{z_6} a_2(s)ds) = \omega_2 N_1(1 - \int_0^{z_3} a_1(s)ds) + N_3 \int_{z_2}^{z_4} a_2(s)ds. \quad (15)$$

Since $u_1 < z_5$, the budget constraint of country 1 household, (11), changes into

$$\int_0^{z_3} a_1(s)ds + \int_{z_3}^{u_1} \frac{a_2(s)}{\omega_2} ds = 1, \quad (16)$$

while the budget constraints for country 2 and 3 remain (12) and (13), respectively. ATE therefore satisfies $z_1 < \dots < u_1 < z_5 < z_6 < u_2 < u_3$, making z_5 redundant in the analysis (and in Figure 1).

In contrast to the standard literature on hub and spoke arrangements (see, for example, Wonnacott,1975, Kowalczyk and Wonnacott, 1992, and Krugman, 1993), the assumed preferences in our set-up imply that goods are not gross substitutes. In our model, if the price of lower-indexed goods declines, consumers do not substitute toward relatively cheaper

⁴As such, our framework also provides an alternative, demand-side explanation for the asymmetries in bilateral trade flows Helpman et al. (2005) have recently drawn attention to. They claim that for about 10% of all country pairs trade is one-way only. Taking into account that nearly half of all country pairs do not trade with each other, this implies that roughly 20% of all bilateral trade flows is one-way.

goods but instead expand the consumption basket always toward higher-indexed goods, as a result of the higher purchasing power. On the other hand, if the price of higher-indexed good falls, consumers do not switch expenditures towards lower-ranked goods. The income effect makes higher-ranked goods complements to lower-ranked goods.

Comparing the balanced trade conditions of STE, (9) and (10), with those from ATE, (14) and (15), shows that direct income effects only affect the balanced trade conditions of the latter. This is due to nonhomothetic preferences and the intuition is as follows. Consider the effects of an increase in the factor reward in country 2, *ceteris paribus*.⁵ In STE, this raises the real income of country 2 households with respect to imported goods, which is used to expand consumption baskets with goods from country 3. Likewise, it diminishes real income of country 1 and country 3 households – they face higher import prices for country 2 – which reduces spending on country 3 goods. With trade initially balanced, these spending effects exactly cancel out, leaving a net change in spending on goods from country 3 of zero. A similar reasoning implies for changes in the factor rewards of the other countries, explaining why ω_2 and ω_3 do not enter the STE trade balance conditions. For ATE this is different. Households in country 1 are then too poor to buy the higher-indexed goods from country 3 and the decline in their real incomes affects spending on country 2 goods instead. Since this is unmatched by any of the other spending effects – the real income effects of country 2 and country 3 households still apply to country 3 goods – the net effect on spending on country 2 goods is negative and ω_2 enters the balanced trade condition of country 2.⁶ This novel aspect allows us to analyze the consequences of hub and spoke formations on trade and welfare in a multiregional setting in the presence of significant income effects in a tractable manner.

3 Hub and spoke with the rich country as hub

We now proceed with investigating the effects of a hub and spoke arrangement, with the rich country, country 3, as the hub. This implies that country 3 liberalizes trade with country 2 and 1, but countries 2 and 1 do not liberalize trade between them. The mutual reduction of tariffs on trade flows between the hub and the spokes implies that country 3 enjoys preferential access in both spoke markets. This essentially boils down to considering

⁵Direct income effects due to tariff changes are absent as consumers actually pay tariff-exclusive prices.

⁶Applying analogue reasoning to changes in the factor rewards of the other countries explains why ω_2 does not show up in the trade balance of country 1 and why ω_3 does not show up in either of the two trade balance equations. The former is because none of the spending effects apply to country 1 goods. The latter is because changes in the factor reward of country 3 have no bearing on spending on country 2 goods.

the general equilibrium and welfare effects of a simultaneous and proportional reduction in τ_{13} , τ_{31} , τ_{23} , and τ_{32} . The simultaneous solution of the relevant equations is given in Appendix B.

The effects on efficient production and the terms of trade are given in Table 1. We see that the formation of a hub and spoke system with country 3 as a hub does neither affect efficient production of spoke country 1, that is, z_1 , z_2 and z_3 do not change; nor does it affect the bilateral terms of trade of country 1 vis-à-vis country 2, ω_2 . The bilateral terms of trade of country 3 vis-à-vis both of its spokes improve, provided the population size of country 1 and 2 exceeds that of the hub. Efficient production of both countries changes accordingly.

To understand these effects it is useful to distinguish between two effects. The first effect, the supply side effect, is that when tariffs fall the competitiveness of industries is affected. The second effect, the demand side effect, involves that the change in competitiveness affects the ranges of non-traded goods, leading to real income and concomitant spending effects.⁷ The spending effects either accrue to country 3 (STE) or to country 2 *and* country 3 (ATE). Both the supply side and the demand side effect determine the impact on derived labor demand and relative wages, leading to the comparative static effects that are presented in Table 1.

(insert Table 1 about here)

Consider the initial supply side effect of the tariff cuts when country 3 is the hub. Keeping wages fixed, these are given by:⁸

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

where a hat above a variable indicates a relative change, e.g. $\widehat{\tau}$ is defined as $d\tau/\tau$.⁹ As both spokes do not change tariff between them, their relative competitive position on each other's market is unaffected and z_1 and z_3 do not change. Likewise, their relative competitive position on the market of the hub z_2 does not change, as country 3 reduces its tariffs on the imports from both spokes proportionally. The competitive position of country 3 vis-à-vis country 2 on country 1's market of course enhances (z_5 goes down as country 1 does not reduce tariff on imports from country 2), while the mutual tariff reduction between

⁷Recall that there are no direct spending effects of tariff reductions due to the tariff rebates.

⁸The effect on z_5 only arises in STE.

⁹By concentrating on marginal tariff changes in contrast to complete discrimination our results shed light on the initial effects of the formation of a system of hub and spokes.

country 2 and 3 enhances these countries' competitive position on each other's markets, increasing z_4 and decreasing z_6 .

The extent to which the tariff changes affect competitiveness depends on the degree of comparative advantage at the specific borderline commodity. This is indicated by ζ , which measures the relative comparative advantage of country 3 versus country 2. It is important as it determines the degree of industries lost or gained due to tariff changes. For instance, if ζ is small, country 3's comparative advantage vis-à-vis country 2 is weak at z_5 , enabling country 2 to take over a considerable number of country 3's export industries from country 1.

Next consider the resulting spending effects. The net effect of the competition effects is that solely the ranges of non-traded goods of country 2 and 3 diminish, resulting in real income gains for these two countries. These gains become effective by being used to expand consumption baskets with goods from the hub. This holds for both types of equilibria, as the real income effects only concern country 2 and country 3.

The spending effects exert a positive effect on country 3's terms's of trade, but as indicated in the table, the marginal expenditure effects at the borderline commodities are crucial in determining the eventual signs of ω_2/ω_3 and ω_3 . As we have seen, the competition effects causes country 3 to export more to country 1 and country 2, while country 2 exports less to country 1, but more to country 3. This implies that country 3's terms of trade with both trading partners improve if the increase of country 3's exports to both spokes exceeds the increase of country 3's imports from spoke country 2, that is if $N_1 a_2(z_5) z_5 + N_2 a_2(z_6) z_6 > N_3 a_2(z_4) z_4$.

The welfare effects are presented in Table 2. In our setup, welfare changes can be defined by changes in the highest-indexed good a household consumes, u_j , $j = 1, 2, 3$ (see Matsuyama 2000). These changes are listed in Table 2 (see Appendix C for details of derivations). In general, the expression for measuring the impact on welfare brought about by the formation of a system of hub and spokes can be decomposed into a factor terms of trade effects, weighted by the country's value of imports, and into real income effects, that arises because of changes in the range of non-traded goods. As can be observed from the table, households from country 1 may lose (STE) or are unaffected from this policy change (ATE). While in the former case country 1 suffers a loss as it sees its terms of trade with country 3 deteriorate, since there is no change in its non-traded goods area, in the latter case country 1 is shielded from the negative impact of the terms of trade deterioration as it does not import from country 3. Country 2 and country 3 gain under both equilibrium configurations, provided that the relative comparative advantage vis-à-vis one another is low, that is, for sufficiently small ζ . This implies such large reductions of the non-traded

ranges for both countries that it also compensates the negative terms of trade movements for country 2. Under this condition, the gains from lower prices give households from country 2 and 3 incentive to expand their range of consumption toward higher-indexed goods, that is, $du_2 > 0$, $du_3 > 0$, with the result that new industries in country 3 come into existence.

(insert Table 2 about here)

4 Hub and spoke with middle-income country as hub

Consider next the formation of a hub and spoke system where the middle-income country, country 2, is the hub. This is in line with recent developments in East-Asia, where countries increasingly seek open market access with China, even if their per capita income is higher than China's. This corresponds to a simultaneous reduction in τ_{12} , τ_{21} , τ_{32} and τ_{23} . The general equilibrium effects are given in Table 3.

(insert Table 3 about here)

The direct competition effects are given by

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

where also in this case the effect on z_5 only arises in STE. With the hub country now being contiguous to both spokes, all borderline commodities are affected. Country 1 gains better access to the hub's market (z_1 up), while the hub finds it easier to directly compete with domestic firms in country 1 (z_3 down). Likewise, country 3 loses some of its industries to the hub (z_4 up), but also gains industries from the hub market (z_6 down). The hub, finally, also gains in competitiveness with respect to either spoke country on the market of the other spoke country (z_2 down and z_5 up). The extent of these competition effects depends on the relative comparative advantage of countries at their borderline commodities. The strength of comparative advantage between the hub and country 1 is governed by ζ_2 , affecting z_1 , z_2 and z_3 ; the strength of comparative advantage between the hub and country 3 is governed by ζ , affecting z_4 , z_5 and z_6 .

The net effect of these competition effects is that the two ranges of non-traded goods of the hub diminish, while the effect on the non-traded goods ranges of the spoke countries are unclear. Whatever the case, the real income effects that follow are either not spent in the hub (STE), or only partly (ATE). In the latter case only the real income effects of the poor

country 1 concern changes in spending on the hub's industries. All other spending effects concern spoke country 3. As a consequence, the general equilibrium effects are different compared to the situation with the rich country as hub. In particular, it helps to explain why, despite being a spoke, the bilateral terms of trade of country 3 still tends to improve.

As Table 3 indicates, ζ_2 is important for assessing results. Recall that the model does not impose any restrictions on its value. Suppose that the unit labor requirements between country 1 and country 2 are ceteris paribus more equalized, that is ζ_2 is small for given $\zeta > 0$. In this case, the competitive effects on z_1 , z_2 , and z_3 dominate the initial competition and subsequent spending effects. As z_2 comes down, the derived demand for country 1's labor by country 3 decreases, in favor of demand for country 2's labor. Consequently, ω_3 must decline to restore labor market equilibrium. Likewise, the decrease of z_3 diminishes the derived demand for country 1's labor, though this is countered by the labor market effect of the increase of z_1 . This explains why the negative sign for ω_2 is independent of the particular value of ζ_2 and instead depends on the marginal expenditure of the three countries at the borderline commodities that concern country 1. The effect on the bilateral terms of trade of country 2 versus country 3 is unclear, except if country 1 is too poor to import from country 3. Then the negative real income effects in country 1 that follow the decline in ω_2 and ω_3 imply a reduction in demand for country 2 labor, tipping the terms of trade balance in favor of spoke country 3.

The concomitant welfare effects are presented in Table 4. As before, the welfare effects can be decomposed in factor terms of trade effects, weighted by the country's value of imports, and in a change in real income that arises because of changes in the range of non-traded goods. From the table we infer that welfare of spoke country 3 increases under both equilibrium configurations, $du_3 > 0$, provided the reduction in the non-traded goods ranges of the hub are large enough (ζ and/or ζ_2 are low). The lower prices of lower-indexed goods brought about by integration leads households of country 3 to expand their consumption basket toward higher-indexed goods, thereby creating an environment for new firms to enter the market of the rich country. Similarly, the real income gains in the hub are spent in country 3, explaining the positive welfare effect. By the same token, the hub gains if the decrease in its non-traded goods range with country 3 dominates (that is, if ζ is sufficiently small), but not if the decrease in the non-traded goods range contiguous to country 1 dominates (that is if ζ_2 is sufficiently small and $\zeta \gg 0$). This subtlety disappears in ATE, as then the welfare gains of country 1 accrue to the hub instead to country 3. Country 1 loses unambiguously under STE ($du_1 < 0$).

(insert Table 4 about here)

5 Conclusion

This paper examines the effects of hub and spoke arrangements on resource allocation and welfare when countries differ in their stage of economic development. Traditionally, international economists have made the simplifying assumption of homothetic preferences when analyzing trade liberalization schemes, implying that all goods have the same unitary income elasticities and that poor and rich households consume all available goods in the same proportion. In light of a growing trend towards bilateral trade liberalizations between a rich(er) country (the hub) and poorer countries (the spokes), we analyze such arrangements in a framework that takes the implications of income differences on consumption patterns seriously. We use 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 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 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 it appears that the income level of a country greatly matters for assessing the effects of hub and spoke arrangements on its welfare. A hub is most likely to gain if it produces goods with the highest-income elasticities. In our framework that is the rich country, where all households are rich enough to (also) buy these goods. A middle-income hub, which produces goods with intermediate income elasticities at most, is less ascertained of welfare gains and may even lose. The main reason for this divergence is the inclusion of asymmetric demand complementarities. As a fall in the prices of lower-ranked goods leads to real income gains that are spent on goods with higher demand elasticities, which is favorable to rich countries and less so for medium-rich countries. Also for spokes we find that welfare effects highly depend on income levels. Richer spokes are more likely to gain than poorer spokes. This relation is non-monotonic, however. If a spoke country is so poor that it cannot afford the higher-indexed goods that the rich country produces, it is either shielded from welfare changes (if the rich country is the hub) or it has a fair chance to gain (if the middle-income country is hub). It is therefore not only the income differences per se that matter for the welfare results of hub and spoke arrangements, but also the extent of these income differences.

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A Labor market equilibria

Aggregate demand for good z from country j is $Q_j(z) = N_j E_j(z)$, for $j = 1, 2, 3$. As country 1 produces only goods in $[0, z_3)$, of which $[0, z_1]$ are exported to country 2 and $[0, z_2]$ are exported to country 3, labor market equilibrium in country 1 has to satisfy:

$$N_1 = \int_0^{z_3} a_1(z) Q_1(z) dz + \int_0^{z_2} a_1(z) Q_3(z) dz + \int_0^{z_1} a_1(z) Q_2(z) dz. \quad (\text{A.1})$$

The left hand side denotes labor supply, and the right hand side is the derived demand for country 1's labor. Substituting for $Q_j(z)$ and using the definition of (7), this becomes

$$w_1 L_1 = N_1 E_1(z_3) + \frac{N_2}{\tau_{21}} E_2(z_1) + \frac{N_3}{\tau_{31}} E_3(z_2)$$

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 $E_1(z_3) = \int_0^{z_3} w_1 a_1(s) ds$. Similar reasoning applies to get the labor market equilibrium conditions for country 2 and 3. The three labor market equilibrium conditions can be replaced by the equivalent statement that in equilibrium trade has to be balanced. This yields equations (9)-(10) in the main text for STE and (14), (15) for ATE. The concomitant budget constraints are given by (11)-(13) for STE and by (16) and (12)-(13) for ATE. The six equations that determine efficient production, together with the balanced trade conditions and the budget constraints jointly determine the equilibrium values of the marginal goods $z_1 - z_6$, the relative wage rates ω_i ($\equiv w_1/w_i$) for $i = 2, 3$, and the utility levels u_j for $j = 1, 2, 3$.

B General equilibrium effects of tariff changes

B.1 Symmetric spending equilibrium

The symmetric equilibrium is contained in the six equations for efficient production (1)-(6), the balanced trade conditions (9)-(10), and the budget conditions (11), (12) and (13). Rewriting conditions(1)-(6) in percentage form yields

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

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 (9) and (10), making use of (1)-(6) and (11)-(13) and evaluated at $\tau_{ik} = \tau_{ij}$ for $i, j, k = 1, 2, 3$ and $i \neq j, k$ yields

$$\begin{bmatrix} \widehat{\omega}_2 \\ \widehat{\omega}_3 \end{bmatrix} = \frac{1}{D} \begin{bmatrix} \Omega_{22} & 0 \\ \Omega_{21} & \Omega_{11} \end{bmatrix} \begin{bmatrix} t_{11} & -t_{21} \\ -t_{12} & t_{22} \\ -t_{13} & t_{23} \\ -t_{14} & t_{24} \\ -t_{15} & t_{25} \\ t_{16} & -t_{26} \end{bmatrix}^T \begin{bmatrix} \widehat{\tau}_{12} \\ \widehat{\tau}_{13} \\ \widehat{\tau}_{21} \\ \widehat{\tau}_{23} \\ \widehat{\tau}_{31} \\ \widehat{\tau}_{32} \end{bmatrix}, \quad (\text{B.2})$$

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

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

where we make use of (1)-(6) and the assumption that $\tau_{ik} = \tau_{ij}$ for $i, j, k = 1, 2, 3$ and $i \neq j, k$. Substituting the elements t_{ij} into (B.2) and (B.1) makes it possible to derive the results shown in the tables of the text. For calculating the effects of hub and spokes, it suffices to add the effects of the relevant tariff changes.

B.2 Asymmetric spending equilibrium

The asymmetric equilibrium is contained in the six equations for efficient production (1)-(6), the balanced trade conditions (14) and (15), and the budget conditions (16), (12) and (13). The percentage change in relative wages can then be deduced from the following system:

$$\begin{bmatrix} \widehat{\omega}_2 \\ \widehat{\omega}_3 \end{bmatrix} = \frac{1}{\widetilde{D}} \begin{bmatrix} \widetilde{\Omega}_{22} & 0 \\ \widetilde{\Omega}_{21} & \widetilde{\Omega}_{11} \end{bmatrix} \begin{bmatrix} s_{11} & -s_{21} \\ -s_{13} & s_{23} \\ s_{14} & s_{24} \\ -s_{15} & s_{25} \\ s_{16} & -s_{26} \end{bmatrix}^T \begin{bmatrix} \widehat{\tau}_{12} \\ \widehat{\tau}_{21} \\ \widehat{\tau}_{23} \\ \widehat{\tau}_{31} \\ \widehat{\tau}_{32} \end{bmatrix}, \quad (\text{B.3})$$

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

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

With

$$\begin{aligned} s_{11} &= N_1 a_1(z_3)z_3 & s_{12} &= 0, \\ s_{13} &= N_2 a_1(z_1)z_1, & s_{14} &= 0, \\ s_{15} &= N_3 a_1(z_2)z_2, & s_{16} &= N_3 a_1(z_2)z_2 > 0, \\ s_{21} &= \zeta N_1 \omega_2 a_1(z_3)z_3, & s_{22} &= 0, \\ s_{23} &= \zeta N_2 a_2(z_1)z_1, & s_{24} &= \zeta_2 N_2 a_2(z_6)z_6, \\ s_{25} &= \zeta N_3 a_2(z_2)z_2, & s_{26} &= N_3 [\zeta_2 a_2(z_4)z_4 + \zeta a_2(z_2)z_2]. \end{aligned}$$

It is helpful to recognize that

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

Substituting the elements s_{ij} into (B.3) and (B.1) makes it possible to derive the results for the asymmetric trade equilibrium.

C Welfare expressions

In this part of the appendix we derive the welfare expressions used to derive the welfare effects of hub and spoke arrangements. The welfare effects follow from total differentiation of equations (11)-(13) for the STE and equations (16), (12) and (13) for the ATE. For STE, we calculate for country 1

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

When we use (1)-(6), and apply our assumption that each country imposes the same tariff rate on its imports regardless of the country of origin, we get

$$a_3(u_1)du_1 = \frac{\omega_3}{\omega_2} \int_{z_3}^{z_5} a_2(s)ds\widehat{\omega}_2 + \int_{z_5}^{u_1} a_3(s)ds\widehat{\omega}_3 + \frac{\omega_3}{\omega_2} a_2(z_3)z_3(1 - \tau_{12})\widehat{z}_3 \quad (\text{B.4})$$

Applying analogous methodology to the other two countries, we get for country 2

$$\begin{aligned} a_3(u_2)du_2 &= -\frac{\omega_3}{\omega_2} \left[1 - \int_{z_1}^{z_6} a_2(s)ds \right] \widehat{\omega}_2 + \int_{z_6}^{u_2} a_3(s)ds\widehat{\omega}_3 \\ &\quad + \omega_3 a_1(z_1)z_1(\tau_{21} - 1)\widehat{z}_1 - a_3(z_6)z_6(\tau_{23} - 1)\widehat{z}_6 \end{aligned} \quad (\text{B.5})$$

and for country 3

$$a_3(u_3)du_3 = \frac{\omega_3}{\omega_2} \int_{z_2}^{z_4} a_2(s)ds\widehat{\omega}_2 - \left[1 - \int_{z_4}^{u_3} a_3(s)ds \right] \widehat{\omega}_3 + (\tau_{32} - 1) \frac{\omega_3}{\omega_2} a_2(z_4)z_4\widehat{z}_4. \quad (\text{B.6})$$

For ATE, the expressions for country 2 and country 3 are the same. The expression for country 1 becomes, instead of (B.4):

$$a_2(u_1)du_1 = \int_{z_3}^{u_1} a_2(s)ds\widehat{\omega}_2 - (\tau_{12} - 1)a_2(z_3)z_3\widehat{z}_3. \quad (\text{B.7})$$

Tables and Figures

Table 1: General equilibrium results with country 3 as hub									
	A mutual decline in $d\tau_{23} = d\tau_{13} = d\tau_{31} = d\tau_{32}$ gives rise to:								
	z_1	z_2	z_3	z_4	z_5	z_6	ω_2	ω_3	ω_2/ω_3
symmetric equilibrium:	0	0	0	+	-	-	0	- ¹	+ ¹
asymmetric equilibrium:	0	0	0	+	n.a.	-	0	- ¹	+ ¹

¹if $N_1a_2(z_5)z_5 + N_2a_2(z_6)z_6 > N_3a_2(z_4)z_4$

Table 2: Welfare effects with country 3 as hub		
A mutual decline in $d\tau_{23} = d\tau_{13} = d\tau_{31} = d\tau_{32}$ gives rise to:		
	$\tau_{symmetric}$	$\tau_{asymmetric}$
Country 1 (u_1)	- ¹	0
Country 2 (u_2)	+ ²	+ ²
Country 3 (u_3)	+ ²	+ ²

¹if $N_1a_2(z_5)z_5 + N_2a_2(z_6)z_6 > N_3a_2(z_4)z_4$; ²if $\zeta \rightarrow 0$

Table 3: General equilibrium results with country 2 as hub									
	A mutual decline in $d\tau_{12} = d\tau_{21} = d\tau_{32} = d\tau_{23}$ gives rise to:								
	z_1	z_2	z_3	z_4	z_5	z_6	ω_2	ω_3	ω_2/ω_3
symmetric equilibrium:	+	-	-	+	+	+ ¹ / ⁻²	- ³	- ¹	?
asymmetric equilibrium:	+	-	-	+ ¹ / ⁺ ²	n.a.	+ ¹ / ⁻²	- ³	- ¹	+ ¹

¹if $\zeta_2 \rightarrow 0$; ²if $\zeta \rightarrow 0$; ³if $N_1a_1(z_3)z_3 - N_2a_1(z_1)z_1 + N_3a_1(z_2)z_2 > 0$.

Table 4: Welfare effects with country 2 as hub		
A mutual decline in $d\tau_{12} = d\tau_{21} = d\tau_{32} = d\tau_{23}$ gives rise to:		
	$\tau_{symmetric}$	$\tau_{asymmetric}$
Country 1 (u_1)	- ³	+ ¹
Country 2 (u_2)	- ³ / ⁺ ²	+ ²
Country 3 (u_3)	+ ¹ / ⁺ ²	+ ¹ / ⁺ ²

¹if $\zeta_2 \rightarrow 0$; ²if $\zeta \rightarrow 0$; ³if $\zeta_2 \rightarrow 0$ and $\zeta \gg 0$.

Figure 1: Production and trade patterns

