Document de travail de la série

Etudes et Documents

E 2005.13

Regional Agreements and Welfare in the South:

When Scale Economies in Transport Matter

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January 2005

I thank Jaime de Melo and Patrick Guillaumont for support and guidance, Olivier Cadot, Stéphane Calipel and Alexandre Skiba for helpful discussions.

Abstract

This paper evidences that the accepted pessimistic view, in terms of welfare, of regional trade agreements between developing countries can be challenged by scale economies in transport. This paper focuses on two main issues. First, how is the standard welfare analysis of regional trade agreement affected by the endogeneity of transport costs (i.e. by the joint determination of trade quantities and transport costs)? Second, what are the long-run consequences of endogenous transport costs for welfare if worldwide free trade is achieved through preferential trade agreements? This paper extends the Spilimbergo and Stein (1998)'s model of interindustry trade (generated by relative factors endowment differences) intraindustry trade (generated by scale and product-diversity effects) and iceberg transport costs. In addition of assuming a "hub-and-spoke" transport network structure, we also consider that transport costs depend on the distance between trade partners (three types of costs are defined: regional, continental and across ocean) and on their development level. Most importantly, we allow for an explicit treatment of the transport sector. The main conclusion is that, with scale economies in transport, regional liberalization will have persistent effect on trade flows through irreversible effect on regional transport costs that improve the final welfare, for a developing country, under regional free trade agreement as well as under worldwide free trade.

JEL Classification: F12, F15, R40.
Keywords: Regional Integration, Welfare, Transport Costs, Economies of Scale.

INTEGRATION REGIONALE ET BIEN-ETRE DANS LES PAYS DU SUD : LE ROLE DES ECONOMIES D'ECHELLE DANS LES TRANSPORTS

Ce papier met en évidence que les conclusions plutôt pessimistes, en termes de bien-être, des effets des accords d'intégration régionale entre pays en développement peuvent être nuancées par l'existence d'économies d'échelle dans les transports. Deux problématiques sont abordées: comment l'analyse traditionnelle de bien-être des accords d'intégration régionale est-elle affectée par l'endogénéité des coûts de transport (i.e. par la détermination conjointe des quantités commercées et des coûts de transport)? Quelles sont les conséquences sur le bien-être à plus long terme de coûts de transport endogènes dans le cas d'un libre-échange mondial qui serait atteint par régionalisme *versus* négociations multilatérales ? Le papier propose une extension du modèle de Spilimbergo et Stein (1998) qui introduit du commerce interindustriel (engendré par des différences de dotations factorielles), du commerce intra-industriel (engendré par des économies d'échelle et des produits différenciés) et des coûts de transport de type "iceberg". En plus de l'hypothèse d'un réseau de transport en étoile (de type "hub and spoke"), les coûts de transport sont supposés fonction de la distance parcourue, et du niveau de développement des pays. Surtout, contrairement à toutes les simulations proposées jusque-là dans la littérature sur les accords régionaux, des économies d'échelle sont introduites dans le secteur des transports. La principale conclusion est qu'avec des économies d'échelle dans les transports, l'intégration régionale a des effets persistants sur les flux de commerce (du fait de nouveaux investissements irréversibles dans le réseau de transport régional) qui permettent d'améliorer le bien-être d'un pays en développement en situation de libéralisation régionale comme de libre-échange mondial.

Classification JEL: F12, F15, R40.
Mots-clefs:Intégration Régionale, Bien-être, coûts de transport, Economies d'échelle.

1. INTRODUCTION

Traditional tools to study Regional Trade Agreements (RTA)'s welfare are Viner's (1950) trade creation and trade diversion. According to this pioneer work, welfare impact of a RTA formation is ambiguous, depending on the relative magnitude of trade creation and trade diversion. Among the factors that can influence this trade-off and then the welfare's conclusion, transport costs have been recently emphasized. Wonnacott and Lutz (1989) first argued that RTAs are more likely to be welfare enhancing when formed among what they called "natural trading partners", i.e. countries geographically closed. This idea has been then developed and popularized by Krugman (1991a, 1991b) and generalized with simulation results by Frankel, Stein and Wei (1996). The former shows, in a monopolistically competitive framework, that continental free trade areas (i) decrease welfare unambiguously with zero intercontinental transport costs, (ii) increase welfare unambiguously with prohibitive intercontinental transport costs. The latter investigates the continuum between zero and prohibitive intercontinental transport costs and concludes that all else constant, a preferential trade agreement is more likely to be welfare enhancing (i) the more remote from the rest of the world continental trading partners are (i.e. the larger intercontinental transport costs are) thereby limiting potential trade diversion and (ii) the more natural (i.e. closer in distance) trading partners are thereby fostering potential trade creation.[1]

This argument of "natural trading partner" may potentially concern 77% of existing RTAs[2]. It is particularly relevant for RTAs between developing countries (or regional "South-South" agreements), most of which are implemented between neighbor countries that are quite remote from major world markets.[3] Actually, though developing countries benefit from some advances in transport costs, they still face considerably high transport costs. Shipping costs, for instance, are dramatically higher for developing countries according to the price quotes from international freight forwarders (see Hummels, 1999, Limao and Venables, 2001 or Busse, 2003). Geographic impediments (such as landlockness), poor transport infrastructure (Limao and Venables, 2001), low competition intensity (problem for instance

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[1] See Baier and Bergstrand (2004) for a complete survey of simulation results.

[2] On the actual 208 PTAs in force in 2004 (i.e. notified to the GATT/WTO), 160 are implemented between countries of a same region. Source: World Trade Organization secretariat and Author's calculation.

[3] Examples include the Andean pact, el Mercado comùn del Sur (MERCOSUR), the Association of Southeast Asian Nations (ASEAN), the South Asian Preferential Trade Agreement (SAPTA), the Southern African Custom Union (SACU), The Economic and Monetary Union of West Africa (UEMOA), the Economic and Monetary Community of Central Africa (CEMAC), Common Market for Eastern and Southern Africa (COMESA), the Southern African Development Community (SADC).

of "cargo reservation scheme", Hummels 1999, Fink, Mattoo and Neagu, 2002), associated with thin traffic densities (which can lag the adoption of new technologies as containerization, see Hummels 1999), contribute to explain these high transport costs in developing countries. Moreover, some important transport problems such as time in shipping or custom clearance can severely increase the costs for developing countries, as developed by Hummels (2001) and Clark, Dollar and Micco (2002). Hence, in general, trade costs can be very large for developing countries (see Anderson and van Wincoop, 2004).

However, if taking into account transport costs is relevant for the analysis of South regional welfare, the above-mentioned models present two important caveats. First, the models in Krugman (1991a, 1991b) and Frankel, Stein and Wei (1996) assume a world with one factor, one industry and identical economies. Then, they ignore comparative advantage and, as noted by Panagariya (1998, p.294), the fact that "distant partners can be efficient suppliers of certain products due to other cost advantages despite the fact that they must incur higher transport costs."[4] This is borne out by simulations in Spilimbergo and Stein (1998) that extend the model of Frankel, Stein and Wei (1996) introducing traditional Heckscher-Ohlin comparative advantage in the model.

Second, trade costs are assumed unaffected by equilibrium quantities of trade. Actually, transport technology is defined with the Samuelson (1954) assumption of "iceberg" transport costs, which supposes that only a constant fraction of the quantity shipped actually arrives (as if "only a fraction of the ice exported reaches its destination as un-melted ice"). Virtually, all simulation models so far analyzing the welfare of regional trade liberalization have relied on this representation of transport costs, thus ignoring the potential effect of scale economies in transport (e.g. Frankel, Stein and Wei, 1996, Nitsch, 1996, Frankel, 1997, Spilimbergo and Stein, 1998, Baier and Bergstrand, 2004). However, recent studies provide some direct evidences of the importance of these scale economies in shipping costs. Hummels and Skiba (2004), based on a dataset covering the bilateral trade of six importers (Argentina, Brazil, Chile, Paraguay, Uruguay, and the United States) with all exporters worldwide in 1994, find that doubling trade quantities along a route reduces shipping costs by 12 percent for all countries on that route. The same order of magnitude is reported by Tomoya and Nishikimi

[4] Krugman (1998, p.115) also notes, in a comment on Frankel, Stein and Wei (1996)'s paper, that the restriction of identical economic size may not be innocuous and "surely makes a major difference when we try to model the effects of integration".

(2002) : a 1% increase in the number of ships on a particular route between Japan and each of the Southeast Asian ports resulted in a 0.12% reduction in the freight rates. Fink, Mattoo and Neagu (2002), studying the liner transport price on all US imports carried by liners from 59 countries in 1998, also conclude to significant economies of scale with regard to traffic originating from the same port.

What are the sources of these scale economies in shipping? Hummels and Skiba (2004) identify three main sources of gains in transport costs as trade quantities increase. First, a densely traded route allows for effective use of "hub-and-spoke" shipping economies.[5] Second, increased quantities encourage the introduction of specialized transport technologies along a route (as standardized containerized shipping for maritime transport). A third source of scale benefits lies in pro-competitive effect on pricing (limiting the monopoly markups of for instance the "liner conferences"). In the model presented in this paper, we focus on the second source of scale economies in transport: the adoption of new transport technology when trade increases. The first source is assumed to be already implemented (we assume a pre-determined "hub-and-spoke" transport network)[6] and the third one still to be explored in further research (we model here transport sector as a monopoly). Hence, in the model, according to the traded quantity, a monopoly shipper decides whether to pay sunk costs (such as investment in infrastructure) in order to adopt a lower marginal cost transport technology.

This paper attempts to answer 2 questions:

First, **how is the standard welfare analysis of regional trade liberalization affected by the endogeneity of transport costs (i.e. if trade quantities and transport costs are jointly determined)?**[7] One can expect that regional liberalization, in boosting the quantity of bilateral trade between members, allows exploiting scale economies along regional routes (through the adoption of new transport technologies) and then leads to a reduction in transport costs. This can represent a significant countervailing force in the traditional welfare

[5] For instance "small container vessels move quantities into a hub where containers are aggregated into much larger and faster containership for longer hauls" (Hummels and Skiba, 2004).
[6] For an endogenous determination of the hubs according to the trade development, see Tomoya and Nishkimi (2002).
[7] Standard welfare analysis refers here to simulation models with iceberg transport costs (e.g. Frankel, Stein and Wei, 1996, Nitsch, 1996, Frankel, 1997, Spilimbergo and Stein, 1998, Baier and Bergstrand, 2004).

analysis of trade creation and trade diversion, notably from a developing country's point of view.

Second, **what are the consequences of endogenous transport costs for welfare if worldwide free trade is achieved through preferential trade agreements?**[8] Suppose that the long-run objective is worldwide free trade. In order to achieve this aim, countries can choose between direct multilateral liberalization and development of a free trade agreement with regional partners first before liberalizing on a multilateral basis. With exogenous transport costs (i.e. transport costs independent to the level of trade), the welfare corresponding to worldwide free trade would be the same whatever the way chosen to achieve it (via regionalism or multilateral liberalization). Now, suppose endogenous transport technology. Regionalism will have persistent effect on trade flows through permanent effect on regional transport costs that may change the final welfare under worldwide free trade.[9]

To address previous issues, we start with the Spilimbergo and Stein (1998)'s framework, with interindustry trade (generated by relative factors endowment differences), intraindustry trade (generated by scale and product-diversity effects), and iceberg transport costs that we extend to introduce an explicit transport sector. We then analyze the welfare impact on the countries most likely to benefit from gains in transport: developing countries. Section 2 presents the model. Section 3 compares the welfare evolution according to the degree of regional preference with exogenous / endogenous transport costs. Section 4 presents welfare results when worldwide free trade is achieved through a regional path or not. Section 5 studies how sensitive the results are to some parameter values or assumptions changes. We also present some extensions such as results for North-South agreements. Section 6 concludes.

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[8]This question is inspired from Freund (2000)'s paper. Using a model with imperfect competition, she finds that a regional agreement before free trade leads to a greater expansion in world output than immediate free trade because of sunk costs to expand trade and investment first realized within the regional borders. Actually, permanent effects from regional agreements arise if firms before free trade is achieved undertake irreversible investments that reduce production and distribution network costs.

[9] The idea in this paper is not to discuss if a developing country should prefer a Most-Favored-Nation (MFN) liberalization or a RIA, but rather to analyze whether, if trade is associated with sunk costs in transport, existing regional "South-South" agreements can generate persistent effects on member countries' trade flows and then on their welfare when they move towards a multilateral liberalization after the regional liberalization.

2. Overview of the Model

In this section, we only present the general framework and main assumptions of the model, focusing on the proposed extensions concerning geography, transport network structure and transport sector. The exhaustive list of equations is reported in appendix.

2.1. Basic Setup of Factor-Endowment and Imperfect-Substitutes Trade Model

Following Spilimbergo and Stein (1998), we assume 3 sectors: agriculture, intermediate inputs, and manufactures, and 2 factors of production: capital (*K*) and labor (*L*). We consider 2 types of countries, which differ only in their capital endowment. In "poor" countries, each individual is endowed with 1 unit of capital, as well as 1 unit of labor. In "rich" countries, each individual owns 1 unit of labor and *k* units of capital (where *k*>1).[10] The symmetry of the model between rich countries on one hand and between poor countries on the other hand allows us to concentrate on a representative rich country (subscript *r*) and on a representative poor country (subscript *p*).

Consumers in country *i* share a Cobb-Douglas utility function given by:

$$U_i = \left(C_{mi}\right)^{\alpha}\left(C_{ai}\right)^{1-\alpha} \quad 0 < \alpha \leq 1 \quad i = \{r; p\} \tag{1}$$

With $C_{m(a)i}$ the consumption of manufactures (agriculture) in country *i*, α the share of consumer's income spent in manufactures and $1-\alpha$ in agriculture.

Agriculture is a homogeneous good produced under constant returns to scale, and labor is the only factor used in its production. Each unit of labor used in this sector (L_{AI}) is transformed into 1 unit of agriculture. Then, the production function is given by:

$$q_{ai} = L_{ai}, \quad i = \{r; p\} \tag{2}$$

Therefore, given perfect competition:

$$p_{ai} = w_i, \quad i = \{r; p\} \tag{3}$$

with p_{ai} the price of agriculture and w_i the wage in country i.[11]

[10] Since every individual within a country is equally endowed, we can set aside distributive considerations and work with a representative agent.

[11] The wage in poor countrys, w_p, is used as numéraire in the model.

Intermediate inputs are produced under monopolistic competition and use only capital as a factor of production. Increasing returns to scale are introduced by assuming a fixed cost, γ, and a constant marginal cost, β:

$$K_{ji} = \gamma + \beta x_{ji} \quad \Leftrightarrow x_{ji} = \frac{K_{ji} - \gamma}{\beta}, \quad j = 1..n_i \;\; i = \{r; p\} \tag{4}$$

x_{ji} is the production of the *j*th variety in country *i*;; n_i is the number of intermediate input varieties produced in country *i*; and K_{ji} is the total amount of capital used in the production of the *j*th variety in country.[12]

Final manufactured good is produced for domestic consumption under a Dixit-Stiglitz technology with constant returns to scale, and each intermediate input enters symmetrically into its production:

$$q_{mi} = \left(\sum c_{ji}^{\theta}\right)^{\frac{1}{\theta}}, \quad 0 < \theta < 1 \quad j = 1..n_i \;\; i = \{r; p\} \tag{5}$$

c_{ji} being the consumption of the *j*th variety of intermediate good produced in country *i*. This production function allows for preference for variety, which becomes stronger as the parameter θ becomes closer to 0 (For θ=1, only differences in factor proportions explain trade; Intra-industry trade is eliminated and only inter-industry trade remains).[13]

Hence, trade in agriculture goods, produced under constant returns to scale with labor responds to a comparative advantage consideration while trade in intermediate goods, produced under increasing returns with capital is driven by love for variety. Note that the number of intermediate good varieties domestically produced depends on the capital endowment of the economy. Consequently it is larger in the rich country than in poor ones by a factor of *k* (the capital to labor ratio).[14]

[12] From the optimization solution of intermediate input producers, we obtain the producer price of the *j*th variety, the output per variety and the number of varieties produced in rich and poor countries. See appendix, equations *(A.1)-(A.3)*.
[13] From the optimization solution of final good producer, we obtain the relative quantities of intermediate inputs demanded by each country and then the per capita production and the price of final manufactured goods. See appendix, equations *(A.6)-(A.9)*.
[14] See appendix, equation (*A.4*).

2.2. Geography and Transport costs

Consider a symmetric world divided into a number of continents, C, equidistant from one another and comprising the same number of countries, regions and blocs. We will work with a world of 4 continents (C=4) and 64 countries, 32 rich countries spread over 2 continents and 32 poor countries over the two other continents. Each continent is decomposed in 4 regions. We assume that each bloc is implemented between the 4 neighbor countries of a same region. Due to the assumed repartition of countries in this stylized world, we then only consider blocs of "North-North" and "South-South" type.[15]

We assume a "hub-and-spoke" transport network structure as usually done in recent literature on economic geography (e.g. Frankel, Stein and Wei, 1996, Spilimbergo and Stein, 1998, Fujita, Krugman, and Venables, 1999). [16] This is in accordance with:

(i) the emergence, observed in the recent decades, of transport hubs as a privileged network structure for many types of transport services, notably for freight and air;[17]

(ii) the assumption of scale economies in transport sector, as this is precisely the search of scale economies (in order to lower transport unit costs) that has generated the development of hub-and-spoke transport network (see Tomoya and Nishkimi, 2002).

Each country represents a "spoke" and two levels of "hub" are assumed: regional and continental. This implies 3 types of freight rates (in % of the quantity traded):

f_b**:** intra-regional (from spoke to spoke via the regional hub);

f_c**:** intra-continental (from a regional hub to another via the continental hub);

f_o**:** intercontinental (from a continental hub to another).

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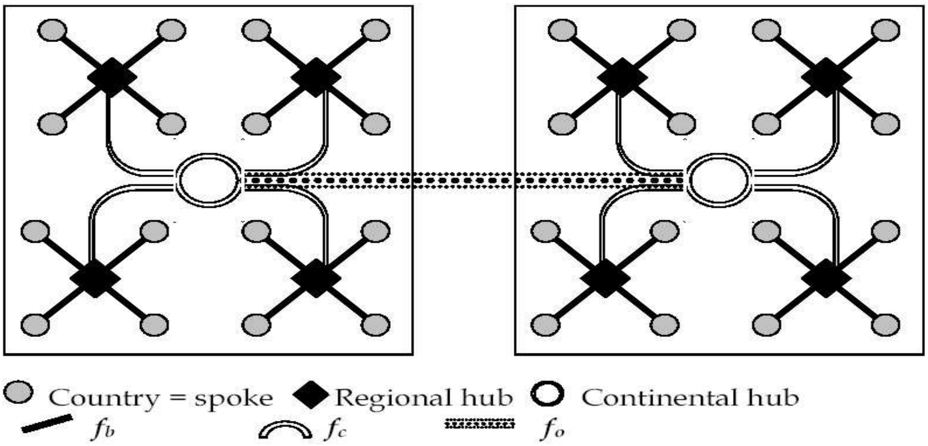
[15] See section 5 for an analysis of "North-South" type blocs.

[16] See section 5 for the analysis of another transport network structure.

[17] In the case of maritime transport that largely dominates international trade, vessels size increased drastically in relation to the development of containerization. Container traffic is moreover essentially concentrated in major hub ports. The 20 largest container ports handled more than 52% of all the traffic in 2002. Examples include the European hub of Rotterdam, as well as Asian hubs in Singapore and Hong Kong (see UNCTAD, Review of Maritime Transport, 2003). The extraordinary development of "hub-and-spoke" networks is also observed in airlines since deregulation.

Figure 1: Illustration of the assumed "hub-and-spoke" transport network in case of 2 continents, 4 regions by continent, 4 countries by region.



Trade between two countries in the same region involves two spokes and one regional hub, which implies transport costs equal to f_b. Similarly, in the case of trade between countries in different regions of a same continent, transport costs are equal to (f_b+f_c) as two spokes, two regional hubs and one continental hub are implied. Finally, across ocean trade generates costs of $(f_b+f_c+f_o)$. Hence, implicitly, transport costs depend positively on distance.

We assume $f_b=f_c=0$ for rich countries. This allows introducing a hierarchy in transport costs according to the development level of countries. Actually, for a given distance, North-North trade is less costly in terms of transport costs than North-South trades, which is in turn less costly than South-South trade.[18] Finally, note that, for simplicity, we assume equal transport costs for intermediate inputs and agriculture products.

Given all these assumptions on geography and transport costs, c.i.f prices of imports can be summarized as follow:

(i) for the intermediate inputs faced by producers of manufactures:

In a rich country

[18] For instance, across ocean trade implies transport costs equal to f_o for North-North trade, to $f_o + \frac{f_c + f_b}{2}$ for North-South trade and to $f_o + f_c + f_b$ for South-South trade.

$$\begin{cases} \text{from bloc members: } p_{br} = p_r \\ \text{from other countries of the continent: } p_{cr} = p_r \\ \text{from across ocean rich countries: } p_{or} = \left(p_r + f_o\right) \\ \text{from across ocean poor countries: } p_{op} = \left(p_p + \dfrac{f_b}{2} + \dfrac{f_c}{2} + f_o\right) \end{cases} \qquad (6r)$$

In a poor country

$$\begin{cases} \text{from bloc members: } p_{bp} = \left(p_p + f_b\right) \\ \text{from other countries of the continent: } p_{cp} = \left(p_p + f_b + f_c\right) \\ \text{from across ocean poor countries: } p_{op} = \left(p_p + f_b + f_c + f_o\right) \\ \text{from across ocean rich countries: } p_{or} = \left(p_r + \dfrac{f_b}{2} + \dfrac{f_c}{2} + f_o\right) \end{cases} \qquad (6p)$$

with $p_{r(p)}$ the producer price in a rich (poor) country.

(ii) for the agriculture good (imported by rich from poor countries):

$$p_{ar} = \left(p_{ap} + \frac{f_b}{2} + \frac{f_c}{2} + f_o\right) \qquad (7)$$

Then, in the same way than tariffs on imports (assumed to be levied on the c.i.f price, see appendix), transport costs increase (i) the prices of foreign intermediate inputs faced by producers of manufactures and (ii) the difference in relative price of agriculture goods (and then the relative wage) between rich and poor countries.

2.3. Transport Sector with Scale Economies

We choose to model transport sector as a monopoly, for two main reasons. First, it allows to take into account the monopoly markup often observed in transport service prices on two types of routes: maritime (corresponding to transport between two continental hubs in our framework) and within the South continent.[19] Maritime transport is characterized by the fact that many trade routes are serviced by a small number of liner companies organized in formal cartels called "liner conferences" (see Hummels, 1999). A movement towards

[19] Note that the monopoly assumption does not concern transport within North continent as we have assumed $f_b=f_c=0$ for rich countries. Transport sector for these countries can then be seen as a competitive one, in accordance with features of transport sector in Europe or North America.

concentration is moreover observed.[20] Of course, according to the contestability theory, the small number of participants is no way indicative of their market power. However, even if the question of whether these companies successfully exert market power in pricing shipping services has not a clear empirical answer, at least one study, by Fink, Mattoo and Neagu (2002), has found evidence that freight rates are sensitive to regulatory changes meant to constrain collusive behavior by liner conferences. Concerning developing countries, some studies indicate that factors such as national policies which severely restrict competition for transport services have a major influence on the level of freight rate in developing countries.[21] The second advantage of the monopoly shipper assumption is that investment in new transport technology can be explicitly introduced in the model as a function of the shipper's profit.

As proposed by Hummels and Skiba (2004), we then assume that a monopoly shipper makes decisions about how to price transport services and which transport technology to use, maximizing the following profit, π:[22]

$$\pi = f_b q_b + f_c q_c + f_o q_o - C_b - C_c - C_o \quad (8)$$

With q_b, q_c, q_o the total traded quantities requiring respectively intra-regional, intra-continental and across ocean transport services and C_b, C_c, C_o the monopoly cost functions associated with the production of f_b, f_c and f_o respectively.

The costs along a given route *h* (regional, continental or intercontinental) are function of the transport technology parameters, F_h, the fixed (or sunk) costs and κ_h the marginal costs per unit shipped:

$$C_h = F_h + \kappa_h q_h, \; h = \{b; c; o\} \quad (9)$$

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[20] Only a dozen firms in the World share 80% of the container traffic (against 40%, 10 years ago). The two leaders accounting for more than 23% of the traffic, reinforced their domination by taking over hub ports and signing agreements (as the Trans Atlantic Container Agreement) thereby forcing loaders to deal with them (see Rodrigue *et al.*, 2004).

[21] For instance, much of Sub-Saharan Africa international transport is cartelized, reflecting the regulations of African governments intended to promote national shipping companies and airlines. Notably, as described by Amjadi and Yeats (1996) or Collier and Gunning (1999), many African governments (especially West African countries) have adopted "cargo reservation schemes" which allow privileged liner operators to set inflated freight rates considerably above those that would prevail in a competitive environment and to extend inferior quality services.

[22] Note that the monopoly is defined as supranational but it actually implicitly belongs to North countries as we assume that its profit is symmetrically distributed to consumers of rich countries (see the budget constraint equation in the optimization problem of a representative North consumer in appendix). One can think of this in terms of payment of stock dividends to consumers of the rich countries.

To produce transport services the monopoly uses labor from the poor country (see appendix, equation *A.19*).

Finally, we assume that a given number of transport technologies are available for the monopoly, each technology being characterized by the combination of parameters $\{F_h;\kappa_h\}$. The initial technology is assumed to require no fixed costs, $F_h = 0$, but has a high marginal cost per unit shipped. Then, as trade quantities along a route increase, the monopoly can choose to improve the transport technology used on that route, i.e. to purchase a reduction in marginal cost of $\Delta\kappa_h$ with an incremental fixed cost F_h, according to the following relation: [23]

$$F_h = e^{\mu\Delta\kappa_h} - 1 \quad , \mu < 0,\, h = \{b, c, o\} \tag{10}$$

Note that changes in technology are *discrete*[24], *irreversible*[25] and occur when the profit associated with the new technology overcomes the profit associated with the old one.

To solve the model, we need to calibrate marginal costs per unit shipped $\kappa_b, \kappa_c, \kappa_o$ and the technology function parameter, μ that determine the corresponding fixed costs F_b, F_c, F_o. The difficulty is that we don't have any estimation of (i) the marginal costs per unit shipped on a representative route within a region, a continent or across ocean, (ii) the costs of new technologies allowing to lower marginal costs. Hence, we try to approximate these parameters according to (i) some estimations on the transport costs level and (ii) some empirical results on economies of scale in transport. See section 3.2.

2.4. Equilibrium

Given the values of the ad-valorem tariff rate *(t)*, the degree of intra-bloc preference *(d)*, the difference in capital endowment *(k)*, the Cobb-Douglas utility function parameter (α), the

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[23] This relation assumes that a given reduction in marginal cost requires greater fixed costs when marginal costs are already small than when marginal costs are high. Note that a given investment generates a similar reduction in marginal costs (μ constant) whatever the route *h* (regional, continental or intercontinental).

[24] As noted by Hummels and Skiba, 2004, "one can think of this choice either as a single yes/no decision on, for example, port infrastructure or [...] as a menu of ship sizes which shipper can select".

[25] F_h being considered as sunk costs, once a new transport technology adopted along a route, the monopoly cannot go back to previous technology if, for instance, trade quantities on that route decrease.

Dixit-Stiglitz technology parameter for manufactures production (θ), the geography (number of continents C, of rich and poor countries N_r and N_p, of countries per bloc B) and the transport sector parameters ($\kappa_b, \kappa_c, \kappa_o, \mu$), together with the normalization w_p=1, we can find the value of the utility of a representative individual in a poor country. All equations of the system are reported in appendix.

2.5. Alternative Version: the Iceberg Transport Costs

Finally, to enable comparison with the existing literature, we define an alternative version of the model developed in the previous Section. Following Frankel, Stein and Wei (1996), Frankel (1997), Spilimbergo and Stein (1998) or Baier and Bergstrand (2004), we assume "iceberg" transport costs: f_b, f_c and f_o do not represent the freight rate fixed by the monopoly (in % of quantity traded) but the fraction of the output exported by a country that is "consumed" (or lost) due to regional, continental and across ocean transports respectively. This assumption is convenient as it avoids modeling a separate transport sector. Under this assumption, c.i.f prices of imports become:

(i) for the intermediate inputs faced by producers of manufactures:

In a rich country

$$\begin{cases} \text{from bloc members: } p_{br} = p_r \\ \text{from other countries of the continent: } p_{cr} = p_r \\ \text{from across ocean rich countries: } p_{or} = \dfrac{p_r}{(1-f_o)} \\ \text{from across ocean poor countries: } p_{op} = \dfrac{p_r}{\left(1-\dfrac{f_b}{2}\right)\left(1-\dfrac{f_c}{2}\right)(1-f_o)} \end{cases} \tag{11r}$$

In a poor country

$$\begin{cases} \text{from bloc members: } p_{bp} = \dfrac{p_p}{(1-f_b)} \\ \text{from other countries of the continent: } p_{cp} = \dfrac{p_p}{(1-f_b)(1-f_c)} \\ \text{from across ocean poor countries: } p_{op} = \dfrac{p_p}{(1-f_b)(1-f_c)(1-f_o)} \\ \text{from across ocean rich countries: } p_{or} = \dfrac{p_r}{\left(1-\dfrac{f_b}{2}\right)\left(1-\dfrac{f_c}{2}\right)(1-f_o)} \end{cases} \tag{11p}$$

with $p_{r(p)}$ the producer price in a rich (poor) country.

(ii) for the agriculture good (imported by rich from poor countries):

$$p_{ar} = \frac{p_{ap}}{\left(1-\frac{f_b}{2}\right)\left(1-\frac{f_c}{2}\right)\left(1-f_o\right)} \tag{12}$$

An important thing to keep in mind is that once "iceberg" transport costs are introduced, there is a gap between consumption and quantity demanded (corresponding to the "lost" output in transport). In such a framework, in addition to the values of t, d, k, α, θ, C, N_r, N_p and B, we need to fix the transport costs f_b, f_c, f_o (with still w_p=1) to proceed to welfare simulations.

3. WELFARE IMPLICATION OF PREFERENTIAL TRADE AGREEMENTS

In this section, we observe the evolution of country welfare when there is a *symmetric formation of equal-sized blocs around the world*. We first briefly consider the role of traditional exogenous "iceberg" transport costs in the theory of regionalism before turning to the more specific concern of this paper: the case of endogenous transport costs. We work with a world of 4 continents (C=4), 2 continents of rich countries and 2 continents of poor ones, 16 countries per continent ($N_r = N_p = 16$). Each continent is decomposed in 4 regions. We assume that blocs are implemented between the 4 neighbor countries of a region ($B = 4$). All countries are assumed to levy the same tariff rate of 30% on imports (t=0.3), and we use the same initial values than Spilimbergo and Stein (1998) for α=0.5 (half of the consumer's income is spent on agriculture goods and the other half on manufactures) and θ=0.75 (corresponding to an elasticity of substitution among intermediate goods of 4).

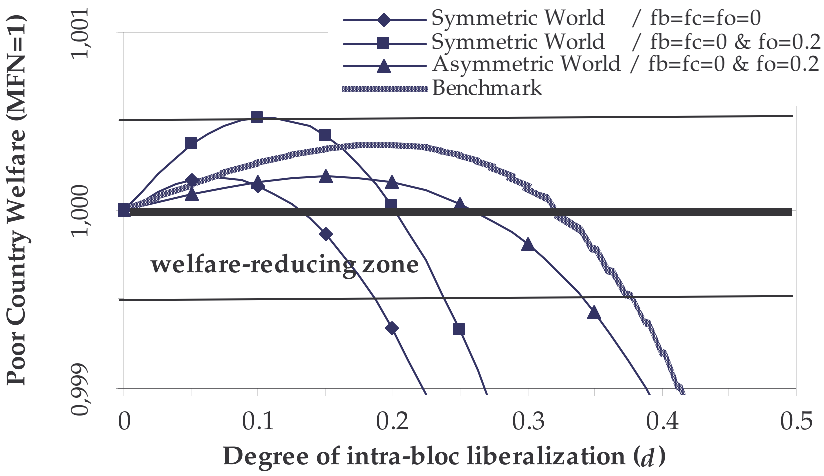
3.1. Traditional "Iceberg" Transport Costs

In this section we use the "iceberg" version of the model previously defined.

Symmetric World

We first assume no difference in factor endowment between countries (k=1). This implies that only intra-industry trade occurs between countries (agriculture is not traded as there is no comparative advantage). All countries being identical in terms of economic size, relative factor endowments, trade, tariffs and transport costs, the specification is very close to the monopolistically competitive framework in a perfect symmetric world proposed by Frankel, Stein and Wei (1996) and Frankel (1997). Figure 2 shows the effects of increasing the intra-bloc preference margin (d) on the welfare of a representative country in case of blocs made of neighbor countries. For each set of parameter values, welfare is normalized to be 1 under the initial situation, i.e. under the Most Favored Nation (MFN) clause.

Figure 2: Welfare Implication of PTA with Traditional Iceberg Transport Costs (t=0.3, α=0.5, θ=0.75, C=4, N_r=N_p=16, B=4)



When there is no transport cost ($f_b = f_c = f_o = 0$), the welfare of a representative country reaches the optimum for a degree of intra-bloc preference of around 7% and becomes lower than the welfare of the initial non-discrimination situation (i.e. MFN with t=0.3) for d=12.6%. The key to this inverted-U path of welfare is the diminishing marginal utility for the consumption of each variety of intermediate goods.[26] With the first reduction in intra-bloc tariffs, trade diversion has a small welfare effect because there is a shift between foreign varieties that were consumed in similar quantities (as in the initial situation, i.e. for d=0, no transport cost and identical tariffs on all imports are assumed). At the same time, trade creation effects are large because domestic varieties (with smaller marginal utility, as they are already consumed in large quantities) are replaced by the bloc members' varieties. With the last reduction in intra-bloc tariffs (d=1) however, consumptions of member and domestic varieties equalize, while the consumption of other foreign varieties reduces: welfare effects of trade creation are then negligible while trade diversion effects are large.

In such a framework, the introduction of positive «iceberg» transport costs changes the relative magnitude of trade creation and trade diversion and the associated welfare gains

[26] The result that PTAs with less than 100% preferences can be superior to FTAs due to the relative magnitudes of trade creation and trade diversion and the associated welfare's gains and losses (i.e. the inverted-U path of welfare) was first suggested by Meade (1955). For a complete survey see Panagariya (2001).

and losses. Hence, they do not challenge the overall inverted-U path of welfare but modify the point where the welfare is maximized. Assume positive intercontinental transport costs, $f_o > 0$, with still zero intra-continental transport costs, $f_b = f_c = 0$. As relative intercontinental transport costs (f_o) increase, the volume of trade with remote countries (on other continents) decreases and that with nearby countries (on the same continent) increases. With less trade with remote countries, the relative tariff distortion introduced towards these countries by the implementation of sub-continental PTAs has less impact on utility; in Vinerian terms, there is less trade diversion. In the same way, with more trade with nearby countries, the elimination of tariff distortion towards these countries has greater utility gain.[27] Consequently, the larger the intercontinental transport costs, the more likely it is that PTAs between the 4 neighbor countries of a same region will have an immediate positive impact. As shown in figure 2, with $f_o = 0.2$, the world reaches the welfare optimum for *d*= 11% and enters the welfare-reducing zone for *d*=20.2%.[28] This result is in the same range than Frankel (1997, p.184).

Asymmetric World

We now assume that *k*=3 (each individual in the rich country is endowed with three units of capital). Transports costs are assumed to be the same whatever the level of development of the countries. We are then in a model identical to the one developed by Spilimbergo and Stein (1998)[29].

Figure 2 reports the evolution of the welfare of a representative "poor" country when blocs are implemented between the 4 neighbor countries of a same region (and of same level of development). The conclusion is quite similar to the one with a symmetric world. Trade based on comparative advantage only occurs between rich and poor countries. As a consequence, the implementation of blocs between countries with similar factor endowment does not modify the relative price of agricultural goods (as transport costs and tariff between

[27] For a given distance between a country pair and the rest of the world, the closer the two countries (i.e. the lower their transport costs) are, the higher the trade volume is between them. Elimination of ad-valorem tariff between close by members alleviates the price distortion on a large amount of trade, improving utility of consumers more in regional PTAs.

[28] In this case, for d>20.2%, we face what Frankel, Stein and Wei (1996) call a "supernatural agreement": a welfare-reducing arrangement in case of natural trading partners.

[29] The only exception is the world geography as we assume 4 continents, each composed of 16 countries of identical development level, while they assume 2 continents, each composed of 15 rich and 15 poor countries.

rich and poor countries remain unchanged). Hence, evolution in trade according to the intra-bloc preference margin is essentially due to changes in intermediate input prices as in the case of symmetric world. Note however that the negative effects of trade diversion are reinforced in this framework as a poor country trades also with rich countries following product variety consideration. In line with relative capital endowment differences, a rich country produces 3 times more intermediate good varieties than a poor country. Trade in these varieties is now diverted (as rich countries are non-members from a poor country point of view).

Benchmark

As a benchmark for the future simulations with endogenous transport costs, we keep the preceding framework (asymmetric world) but with non-zero intra-continental transport costs for poor countries. Hence, transport costs are now function of distance but also of the trade partners development level, as described in section 2, equations *(11)* and *(12)*. We assume $f_o = 0.1$ and for poor countries: $f_b = f_c = 0.1$.[30] Results are reported in figure 2. Compared with Spilimbergo and Stein's simulation results (presented above with $f_o = 0.2$ and $f_b = f_c = 0$), the negative return of regionalism for a representative poor country set in later (i.e. for a larger value of *d*). Actually, for small values of *d*, the positive effects of trade creation are reinforced as transport costs are now larger on all international trade flows - in particular on trade with *all* non members (as now positive transport costs also assumed on imports from continental non-members, i.e. countries in the same continent but not in the same region).[31]

[30] Transport costs are then the following:
- between two poor countries in the same bloc: 1-(1-f_b)=10%;
- between two poor countries of different blocs but of the same continent: 1-(1-f_b) (1-f_c)=19%;
- between two poor countries of different continents : 1-(1-f_b) (1-f_c) (1-f_o)=27.1%;
- between two rich countries of the same continents : 0%;
- between two rich countries of different continents : 1-(1-f_o)=10%;
- between one rich and one poor country: 1-(1-f_b/2) (1-f_c/2) (1-f_o)=18.8%.

[31] For a discussion of the results with non-zero intra-continental transport costs see Nitsch (1996), Frankel (1997, p.320-321), Baier and Bergstrand (2004, p.42-44).

3.2. Endogenous Transport Costs

Traded quantities and transport costs are now jointly determined as proposed in Section 2: a monopoly shipper makes decisions about how to price transport services and which technology to use. To improve the understanding of the implication of this new framework on the evolution of welfare, we proceed in two parts: we first assume that the monopoly shipper fixes transport service prices with *a given* transport technology and second we allow the monopoly to choose between several technologies.

Single transport technology

We choose as first (and for the moment single) technology: $\kappa_h = 5\%$ & $F_h = 0$, $h = \{b, c, o\}$. Under MFN (with t=0.3), with such marginal costs, the prices of transport services that maximize the profit of the monopoly shipper are the following: $f_b = 9.6\%$, $f_c = 10.1\%$, $f_o = 6.5\%$ [32] which is in accordance with some estimations on the level of transport costs sustained by developing countries (see Limao and Venables, 2001, Hummels, 1999, 2001, Amjadi and Winters, 1997, Amjadi and Yeats 1996).

In figure 3 we report the effects of increasing the intra-bloc preference margin (d) on the welfare of a poor country in the case of endogenous transport costs but single transport technology.

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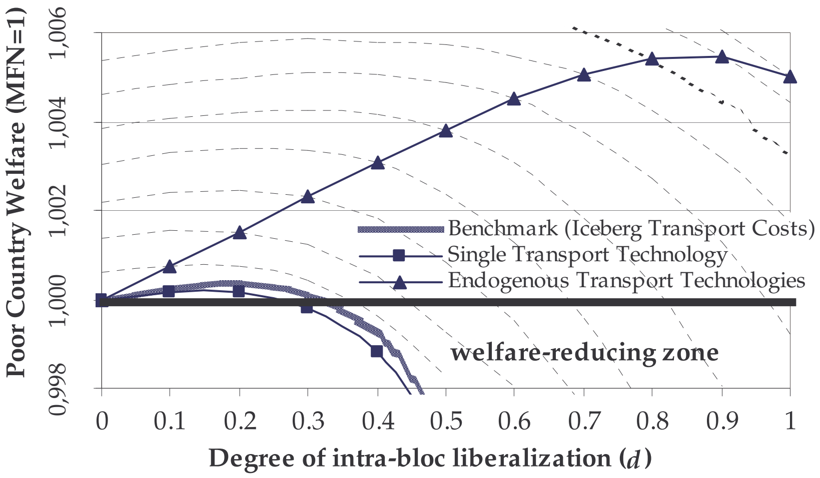
[32] Now transport costs are expressed in % of the quantity traded as defined in Section 2 equations (*6*)-(7). Note that the modelling of "ad-valorem" transport costs (i.e. expressed in % of the value traded) does not change the qualitative results reported in this paper.

Figure 3: Welfare Implication of PTA with Endogenous Transport Costs
(t=0.3, k=3, α=0.5, θ=0.75, C=4, N_r=N_p=16, B=4)



The poor country welfare evolution appears to be less favorable to PTAs under the assumption of monopoly shipper and given single transport technology than that of fixed iceberg transport costs (benchmark in figure 3). Tariff reduction, through the reduction of the elasticity of transport demand, causes the monopolist to charge a higher markup over marginal costs.[33] The increase in intra-bloc preference margin (d) is then associated with increased regional transport costs f_b, which impede trade creation.[34] However, the interesting and more realistic case is to assume that several technologies are available to the monopoly shipper.

[33] This result is evidenced in Hummels and Skiba (2004)'s partial equilibrium model: lowering tariff leads to an outward shift in the demand for transport services thus to an increase in the price charged by the shipper.

[34] The regional price f_b charged by the monopoly shipper increases from 9.6% under MFN (d=0) to 10.2% under FTA (d=1).

Endogenous choice between transport technologies

We now assume that the choice of transport technology is made endogenously: the monopoly shipper decides whether to pay a fixed (sunk) cost in order to adopt a lower marginal costs transport technology as described in section 2 equation (*10*). Recent studies provide some direct assessment of the importance of potential scale economies in shipping costs. As already noted in the introduction, Hummels and Skiba (2004) and Tomoya and Nishikimi (2002) find a remarkably similar estimation (though they study different regions of world): increasing trade quantities by 1% along a route reduces freight rates by 0.12% percent for all countries on that route. Hence, we calibrate changes in transport technologies in order to respect this magnitude of scale economies in our simulation results: we assume that each investment in new technology induces a gain in marginal cost of 0.2 point of percentage and that μ=-15.[35]

As shown in figure 3, once taking into account scale economies in transport and associated changes in technology, **the poor country welfare never enters the welfare-reducing zone when a PTA is implemented.** Actually, a "virtuous circle" is generated: the additive intra-bloc trade (due to the decrease in intra-regional tariff) increases the demand for intra-regional transport services which leads the monopoly to adopt lower marginal costs technologies on these routes and then to offer a lower intra-regional freight rate, f_b, which in turn boosts intra-bloc trade and positively affects trade creation.[36]

The calibration of the model implies that each new increase of 0.1 point of percentage in the intra-bloc preference margin (*d*) allows a sufficient scale of trade (i.e. trade creation) to adopt a new technology along the regional route (and then to benefit from a decrease of 0.2 point of

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[35] Hence, the initial technology being $\kappa = 5\%$ & $F = 0$, the next technology corresponds to a marginal cost of 4.8% and requires a fixed cost around $F_i = e^{(-15)*(-0.2\%)} - 1 = 0.03$ which represents around 10% of the monopoly profit in the initial situation (i.e. under MFN and with $\kappa = 5\%$ & $F = 0$); The technology corresponding to a marginal cost of 4.6% requires a fixed cost around $F_i = e^{(-15)*(-0.4\%)} - 1 = 0.062$ which represents about 21% of the monopoly profit in the initial situation, etc.

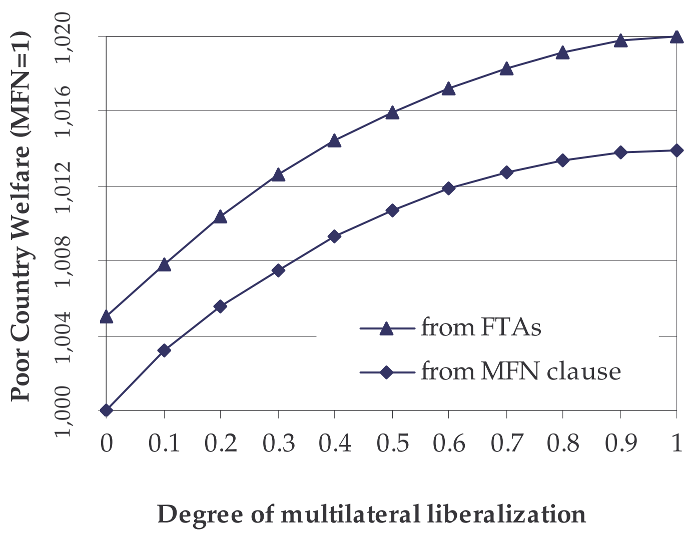
[36] Note that the intra-continental and intercontinental transport services demands, q_c and q_o respectively, decrease due to trade diversion. Hence, no new technology is adopted on routes between two regional hubs and between two continental hubs respectively. However, as all trade flows have to pass through a regional hub, the improvement on regional routes (and then the decrease in f_b) generates positive externalities for *all* routes that lighten the negative effect of trade diversion.

percentage in marginal costs on that route), generating a discrete change in freight price f_b charged and then a jump to the welfare curve associated to the new technology (dotted lines in figure 3, normalized to be 1 under MFN regime and the first technology).[37] Hence, the conclusion (that poor country welfare never enters in the welfare-reducing zone when a PTA is implemented) only holds because of the assumed transport technology parameters. If greater sunk costs are needed to obtain marginal cost gains, then the adoption of the new technologies (and the "jump" to the associated higher welfare curves) occurs later. Then, with more costly technologies, poor countries may *sometimes* and *temporally* enter in the welfare-reducing zone (until the adoption of the next technology). However, the curve reported in figure 3 is in accordance with the econometric assessments of economy of scale in transport previously detailed: between MFN (d=0) and FTA (d=1), total import demand requiring intra-regional transport services has increased by 133% while the price of intra-regional transport services (f_b) has decreased by around 16%. This figure corresponds to the estimation of "doubling trade quantities along a route reduces shipping costs by a 12 percent on that route" evidenced by Hummels and Skiba (2004).

4. WELFARE IMPLICATION OF MULTILATERAL LIBERALIZATION

What are the long-run consequences of endogenous transport costs for welfare if worldwide free trade is achieved through preferential trade agreements as opposed to immediate multilateral negotiation? These two scenarios are reported in figure 4. We report the welfare of a poor country in case of multilateral liberalization from a situation of MFN clause (with t=0.3) and from a situation of FTA. Note that with fixed "iceberg" transport costs, the model would predict the same welfare as under worldwide free trade (i.e. when degree of multilateral liberalization is equal to 1 in figure 4) whatever the way is achieved.

Figure 4: Welfare Implication of Multilateral Liberalization
(k=3, α=0.5, θ=0.75, C=4, N_r=N_p=16, B=4)



[37] T… by marginal costs κ_b = 3% (and then fixed
cos…

With scale economies in transport, poor country welfare in worldwide free trade is superior when obtained from a FTA situation than from a MFN situation. Several factors explained this result. First, at the starting point, welfare with FTAs is already superior to the one with MFN thanks to the adoption of improved transport technologies on regional routes as evidenced in previous section (figure 3).

Second, the gap between the two curves increases during the multilateral liberalization process. Now, trade increases between all countries and then along all the routes (regional, continental and across ocean). According to the repartition of this increase on different routes, the monopoly will choose the combination of technologies that maximizes its profit.[38] From the MFN situation, the multilateral liberalization (i.e. the un-discriminatory decrease in the ad-valorem tariff t) generates an increase in trade with the three types of partners: countries in the same region, countries outside the region but within the same continent and countries from other continents. From the FTA situation, as regional trade is already developed, the additive trade generated by the decrease of multilateral tariff is concentrated on the non-member countries. This increase in trade with non member is all the more important because previous trade diversion was large. This relates to the "catch-up" effect when distortions decrease. Hence, total demand for transport services along continental and across ocean route (f_c and f_o respectively) increases more during the multilateral liberalization from the FTA situation than from MFN. In addition, from a FTA situation, new technology along regional routes is already adopted (thanks to the trade creation generated during the implementation of the FTA) and cannot be reversed by a decrease in trade along regional route as we have assumed sunk costs. Then only two trade routes (continental and across ocean) still need to be developed while, from MFN, the monopoly starts with the first technology on the three routes. All these conditions explain that the monopoly is able to adopt efficient transport technologies more quickly on all routes during the multilateral liberalization from a FTA than from a MFN situation. The new technologies reinforcing the trade increase, the gap between the two curves augments.[39]

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[38] As developed in section 2, the technology is specific to each kind of routes and then each route can use a different level of transport technology.

[39] Note that in figure 4, the poor country welfare reached under worldwide free trade from a MFN situation is clearly superior to the one obtained *under* FTA (this result is challenged in section 5 when the assumption on transport network is modified). Once again, the aim of this section is not to compare multilateral liberalization to regional liberalization but to compare two situations of worldwide free trade achieved with or without a regional path.

Hence, with scale economies in transport costs, regionalism will have a persistent effect on trade flows through a permanent effect on regional transport costs that improves the final welfare under worldwide free trade.

5. Sensitivity Analysis and Extensions

We attempted in sections 3 and 4 to shed some light on the evolution of a poor country welfare that would result from symmetric regional trade blocs, taking into account scale economies in transport costs. Throughout the simulations we worked with the same benchmark set of parameter values (t=0.3, k=3, α=0.5 or θ=0.75) and with some important assumptions on the structure of the transport network ("hub-and-spoke" type). We now study how sensitive the results are to some changes in the parameter values or in assumptions.

5.1. Relative importance of product variety and comparative advantage as sources of gains from trade.

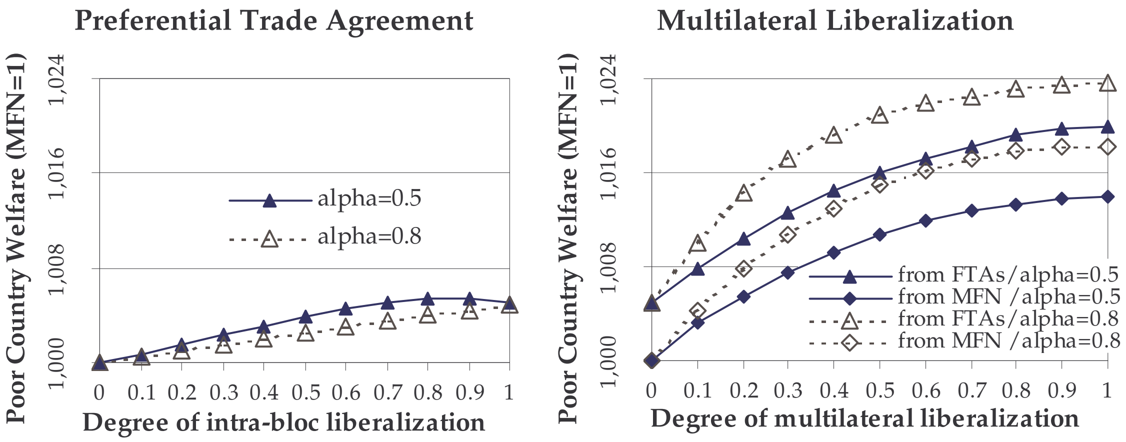
Two parameters are concerned: α (Cobb-Douglas utility function parameter that represents the share of consumer's income spent in manufactures) and θ (Dixit-Stiglitz production function parameter that represents preference for variety in intermediate inputs). An increase in θ, for a given α, results in higher elasticity of substitution between varieties of intermediate input and thus in greater changes in the consumption responses to given changes in relative prices. Hence, the welfare effects of trading blocs become more important for higher values of θ (see details in Spilimbergo and Stein, 1998). The evolution evidenced in figures 3 and 4 is reinforced as traded quantities are more sensitive to tariff changes and new transport technologies are adopted more quickly.[40] An increase (decrease) in α, for a given θ, results in higher relative importance of product variety (comparative advantage) as a source of gains from trade. We report simulations in figures 5a and 5b.

Qualitative results remain. At the first stage (PTAs welfare vs. MFN), with $\alpha = 0.8$, love for variety is increased. This boosts the trade creation within symmetric trade blocs leading to a

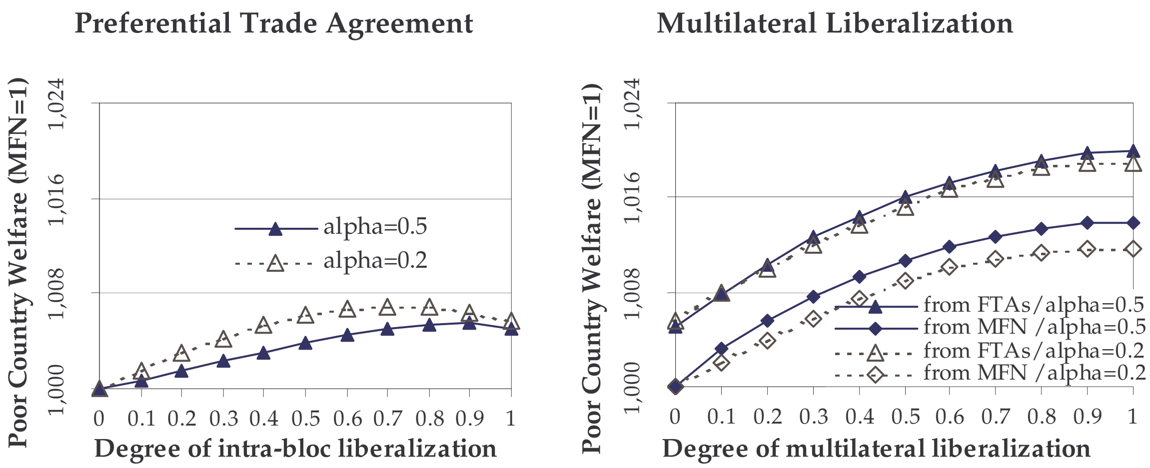
[40] However, for very high values of θ (θ>0.95 in our model), as θ approaches 1, the taste for variety disappears and so does the intra-industry trade, thus reducing the effects of symmetric trading blocs (see figures 2 through 5 in Spilimbergo and Stein, 1998).

regional welfare increase. In the same way, trade diversion is reinforced, in line with the shape of the regional curve in figures 5a. With $\alpha = 0.2$, the share of trade flows based on comparative advantages increases thereby limiting the effect of regional preferential tariff on trade between countries with similar factor endowments. However, Note that in the two cases ($\alpha = 0.8$ and $\alpha = 0.2$), we observe a similar evolution in the demand of regional transport services, q_b, and then similar change in the adoption of new transport technologies.[41] This explains that at the end, for *d*=1, a similar level of regional welfare is reached (relative to MFN welfare).

Figures 5a: higher relative importance of comparative advantage as a source of gains (*t*=0.3, *k*=3, *θ*=0.75, *C*=4, N_r=N_p=16, *B*=4).



Figures 5b: higher relative importance of product variety as a source of gains (*t*=0.3, *k*=3, *θ*=0.75, *C*=4, N_r=N_p=16, *B*=4).



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[41] Remember that, for each country, all trade flows pass through the regional hub. Hence, a FTA **that** generates a strong regional trade creation associated with a strong trade diversion may have the same impact on the evolution q_b than a FTA with little trade impact (weak trade creation as diversion). The results should be different with another assumption on transport network, see next section.

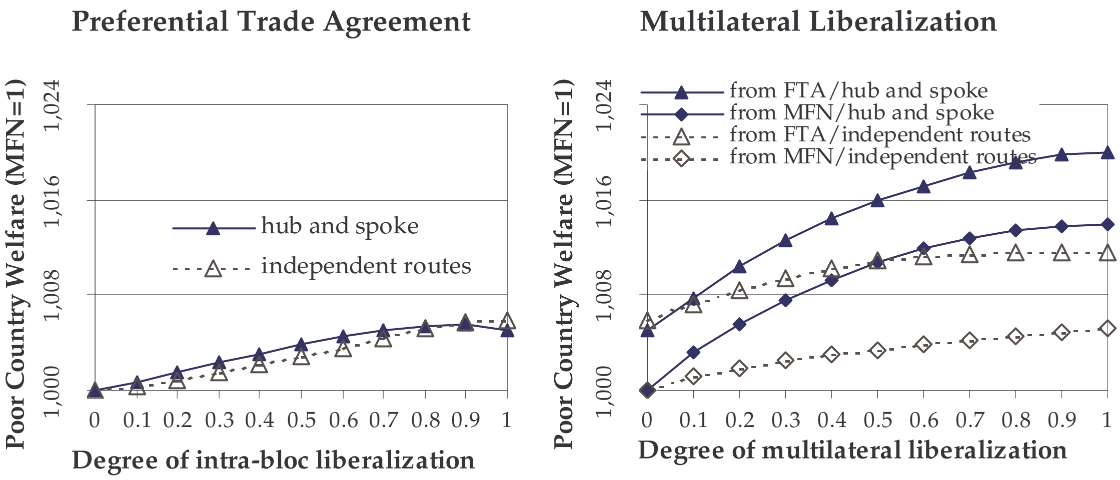
As far as the second stage (multilateral liberalization from FTA or from MFN) is concerned, the increasing gap between the two curves remains. In the model, multilateral liberalization mainly impacts on North-South trade, which is essentially based on comparative advantage. Hence, it is not surprising that increasing the relative importance of comparative advantage as source of gains from trade implies a stronger welfare increase during the multilateral liberalization stage. In any case (i.e. whatever the value of α), the gap between the two curves (multilateral liberalization from regionalism and from MFN) increases during the multilateral liberalization stage, all the more since α (i.e. love for variety) is important.

Finally, note that changes in the relative difference in North / South capital endowment, k, provide similar results than changes in α. Assuming a decrease in k is equivalent to increasing the relative importance of product variety as a source of gains from trade (until k=1 where only intra-industry trade remains). Alternatively, an increase in k corresponds to a boost in trade based on comparative advantage consideration.

5.2. Structure of the Transport Network

We have assumed a "hub-and-spoke" transport network structure: for each country, all trade flows pass through the regional hub and all trade flows with countries outside the bloc pass through the continental hub. On the other extreme, we can assume that, for each country, there exist three independent routes corresponding to the three kinds of trade partners: regional, continental outside the region and across ocean. In such a transport structure, transport costs for trade between two countries in the same region are equal to f_b, transport costs for trade between countries in different regions of a same continent are equal to f_c and across ocean trade costs are equal to f_o. Figures 6 compare results for a "hub-and-spoke" transport network with those for an "independent routes" one.

Figures 6: "hub-and-spoke" vs. "independent routes" transport network.
(*t*=0.3, *k*=3, α=0.5, θ=0.75, *C*=4, N_r=N_p=16, *B*=4)



There is no significant difference between the two transport structures during the implementation of a FTA. Actually, even if demand for regional transport services increases more quickly with the assumption of "independent routes" (with the "hub-and-spoke" network, the increase in demand for regional routes was limited by the trade diversion, which is no more the case with an independent regional route), the total volume of regional imports is smaller (as regional route are now only use by for regional trade). Then, monopoly shipper profits on these routes is smaller than with a "hub-and-spoke" network and new transport technology appears relatively more costly.

Concerning the multilateral liberalization stage, conclusions are quite different depending on the transport network assumption: with an "independent routes" network, FTA's welfare is superior to that for worldwide free trade reached through MFN clause. This is due to the fact that with a MFN liberalization, trade is spread too thinly among all partners so that the improved shipping technology is never adopted.[42] We join the analytical conclusion of Skiba (2004) that finds that "if regional economies of scale in transport are strong enough, then it is possible to improve world welfare relative to free trade by forming preferential trading blocs". In his model, iceberg transport costs depend on the total volume of *bilateral* trade (assuming then that there are as many independent routes as trade partners and no hubbing).

[42] In the simulation reported in figure 6, only change in across ocean trade is sufficient to adopt new technologies that allow a decrease of one point of percentage in across ocean marginal transport costs (instead of a gain of two points of percentage on regional marginal transport costs under FTA stage).

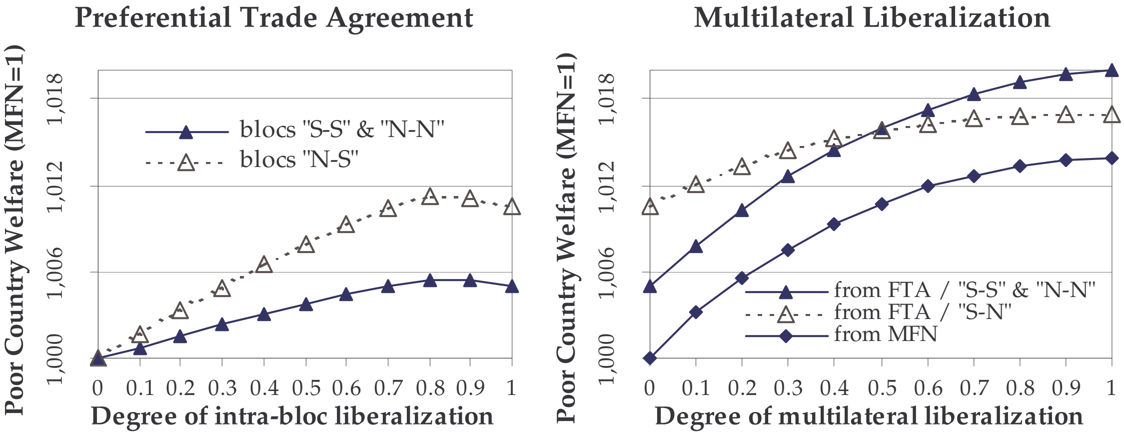
Finally, note that a limit of our analysis is that we have always assumed a "pre-determined" network while we can also imagine an endogenous determination of these hubs according to the trade development. This is done by Tomoya and Nishkimi (2002) who develop a general equilibrium model of a spatial economy in which the structure of the transport network is determined by the interaction between industrial location behavior and increasing returns in transport.

5.3. North/South Trade Blocs

We have assumed that all the blocs were implemented between neighbor countries implying symmetric blocs (i.e. between countries with similar factor endowment). What happens if we assume the formation of North/South blocs? We allow for the formation of a single bloc between two poor and two rich countries.[43] Figures 7 report welfare evolution for a representative poor country in case of North/South blocs.

[43] This forces us to consider two new types of countries in the model: countries in the same region but outside the bloc and countries on other continent but within the bloc.

Figures 7: Symmetric vs. Asymmetric Trade Blocs.
(t=0.3, k=3, α=0.5, θ=0.75, C=4, N_r=N_p=16, B=4)



The evolution of welfare during the North/South bloc implementation is close to the evolution of welfare under multilateral liberalization as now the two sources of gains from trade, product variety and comparative advantage can be exploited within the bloc. However, due to trade diversion, North/South FTA's welfare is inferior to the worldwide free trade notably because trade volume is smaller and transport costs are higher. The trade diversion limits the increase in demand for regional, continental and across ocean transport services compared to worldwide free trade. As such it limits the advances in technology adoption compared to those under worldwide free trade. In terms of transport technology, note that if symmetric blocs, in concentrating trade on regional routes, have allowed a gain of 2% in regional marginal transport costs, North/South blocs, in promoting trade on the 3 routes (regional, continental, across ocean), have allowed gains on these 3 routes but by a smaller amount as trade is spread out. The gain amounts to 1% on each marginal transport costs, which is also smaller than under worldwide free trade.

As far as multilateral liberalization is concerned, the welfare increase following a North/South FTA is smaller than the one following a symmetric FTA or a MFN situation as across ocean trade has already being developed during the first stage of regionalism. At the end, poor country welfare under worldwide free trade when reached through North/South regionalism is (i) higher than through MFN liberalization (thanks to higher volume of trade and then better technology on all 3 routes) but (ii) smaller than through symmetric blocs due to less advanced regional transport technology (which is the base of all kinds of transport costs in our model).

6. CONCLUSION

In broad terms, the simulation results suggest that the accepted pessimistic view of regional trade agreements between developing countries may be exaggerated. RTAs between Southern partners look more favorable once one takes into account scale economies in transport (and the associated changes in transport technology from a profit-maximizing monopoly shipper). The Southern country's welfare never enters in a welfare-reducing zone when an increasingly discriminatory PTA is implemented. This is thanks to a "virtuous circle": the additive intra-bloc trade (due to the decrease in intra-regional tariffs) reduces the intra-regional transport costs. This reduction in turn boosts the intra-bloc trade and the positive effect of trade creation. The model also shows that the persistent effects of a PTA on trade flows (through irreversible effects in terms of investments in regional transport technologies) may improve the final welfare, for a developing country, under worldwide free trade.

While these results are at best suggestive,[44] they could justify the recent priority of "new" agreements like the New Partnership for Africa's Development (NEPAD) that put an emphasis on investments in regional infrastructure and transport networks, as the development of "transport and trade facilitation" agreements that have been recently reached as part of RTAs in most of the "South-South" regional agreements such as MERCOSUR, Andean pact, SADC, COMESA, UEMOA, SAFTA or the ASEAN.

[44] This is due to the fact that several key parameters cannot be directly estimated econometrically such as the marginal costs per unit shipped on a representative route or the costs of new transport technologies.

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APPENDIX. EQUATIONS OF THE MODEL.

As describe in section 2, we assume:

(i) 3 sectors:
Agriculture, produced with labor under constant returns to scale;
Intermediate good, produced with capital under increasing returns to scale;
Manufactures, produced with intermediate good under constant returns to scale;

(ii) 2 types of countries, with a capital to labor ratio of 1 in the poor country and of k>1 in the rich country;[45]

(iii) a World of 4 continents ($C = 4$), 2 continents of rich countries and 2 continents of poor ones, 16 countries per continent ($N_r = N_p = 16$); Each continent comprises 4 regions; We assume that blocs are implemented between the 4 neighbor countries of a same region ($B = 4$);

(iv) a "hub-and-spoke" transport network with 3 types of freight rates:
f_b: intra-regional (from spoke to spoke via the regional hub);
f_c: intra-continental (from a regional hub to another via the continental hub);
f_o: intercontinental (from a continental hub to another);

Optimization Problem of Intermediate Input Producers

$$Max_{p_{ji}} \pi_{ji} = p_{ji} x_{ji} - K_{ji} r_i, \quad j = 1..n_i \;\; i = \{r; p\}$$

With π_{ji} the producer profit of the j^{th} variety in country i, x_{ji} (p_{ji}) the production (producer price) of the j^{th} variety in country i, n_i the number of intermediate input varieties produced in country i and r_i the price of capital in country i. Intermediate inputs are produced under monopolistic competition with capital. The total amount of capital used in the production of the j^{th} variety in country i, K_{ji}, is: $K_{ji} = \gamma + \beta x_{ji}$ with γ the fixed cost and β the constant marginal cost.

From the first order condition for profit maximization (derivation available upon request) we obtain the profit-maximizing price :[46]

$$p_{ji} = p_i = \frac{\beta r_i}{\theta}, \quad j = 1..n_i \;\; i = \{r; p\} \qquad \textbf{(A.1)}$$

which, combined with the free entry condition, gives the output per variety:

[45] For simplicity we assume that labor, L, also represents the population size and that $L_r = L_p = 1$. The total capital is therefore $K_r = kL_r = k$ in a rich economy and $K_p = L_p = 1$ in a poor one.
[46] θ being the parameter of substitution in the final manufactured good production function, see later.

$$x_{ji} = x = \frac{\theta\gamma}{\beta(1-\theta)}, \quad j = 1..n_i \quad i = \{r; p\} \qquad \textbf{(A.2)}$$

Introducing the expression of x into the capital market equilibrium condition of a country i, i.e. $K_i = \sum_{j=1}^{n_i} K_{ji} = \sum_{j=1}^{n_i} \left(\beta x_{ji} + \gamma\right) = n_i\left(\beta x_j + \gamma\right)$, gives the number of varieties produced in country i:

$$n_i = \frac{K_i\left(1-\theta\right)}{\gamma}, \quad i = \{r; p\} \qquad \textbf{(A.3)}$$

Equation *(A.3)* implies that the number of varieties produced in the rich country will be larger than in poor countries by a factor of k:

$$\frac{n_r}{n_p} = \frac{K_r}{K_p} = k \qquad \textbf{(A.4)}$$

The relative price of capital in rich and poor countries will be denoted as ρ. Hence, according to equation *(A.1)*, ρ is also equal to the price of the home varieties in a rich country, p_r, relative to that of the home varieties in a poor countries, p_p:

$$\frac{r_r}{r_p} = \frac{p_r}{p_p} = \rho \qquad \textbf{(A.5)}$$

Optimization Problem of Final Good Producer

The prices of foreign intermediate inputs faced by producers of manufactures, in terms of the ones produced at home, are given by:

In a rich country:

$$\begin{cases} p_{br} = p_r\left(1+(1-d)t\right) \\ p_{cr} = p_r\left(1+t\right) \\ p_{or} = \left(p_r + f_o\right)\left(1+t\right) \\ p_{op} = \left(p_p + \dfrac{f_b}{2} + \dfrac{f_c}{2} + f_o\right)\left(1+t\right) = \dfrac{p_r}{\rho}\left(1 + \dfrac{f_b}{2p_p} + \dfrac{f_c}{2p_p} + \dfrac{f_o}{p_p}\right)\left(1+t\right) \end{cases} \qquad \textbf{(A.6r)}$$

In a poor country

$$\begin{cases} p_{bp} = \left(p_p + f_b\right)\left(1+(1-d)t\right) \\ p_{cp} = \left(p_p + f_b + f_c\right)\left(1+t\right) \\ p_{op} = \left(p_p + f_b + f_c + f_o\right)\left(1+t\right) \\ p_{or} = \left(p_r + \dfrac{f_b}{2} + \dfrac{f_c}{2} + f_o\right)\left(1+t\right) = \rho p_p\left(1 + \dfrac{f_b}{2p_r} + \dfrac{f_c}{2p_r} + \dfrac{f_o}{p_r}\right)\left(1+t\right) \end{cases} \qquad \textbf{(A.6p)}$$

with origin r: rich country/ p: poor country/ b: bloc members/ c: other countries (non members) within the continent/ o: overseas countries;
t represents the MFN ad valorem tariff (uniform across countries);

d represents the degree of intra-bloc liberalization [d=1 (0) free trade area (MFN)].

The producer of the final good faces the following problem:

In a rich country

$$\begin{cases} Max\ q_{mr} = \left(\sum c_i^\theta\right)^{\frac{1}{\theta}} \qquad 0 < \theta \le 1 \\ s.t.\quad \underbrace{n_r c_r p_r}_{home\ varieties} + \underbrace{(B-1)n_r c_{br} p_{br}}_{varieties\ from\ bloc\ members} + \underbrace{(N_r - B)n_r c_{cr} p_{cr}}_{varieties\ from\ other\ countries\ of\ the\ continent} + \underbrace{\left(\frac{C}{2}-1\right)N_r n_r c_{or} p_{or}}_{varieties\ from\ rich\ countries\ overseas} + \underbrace{\frac{C}{2}N_p n_p c_{op} p_{op}}_{varieties\ from\ poor\ countries} \le q_{mr} p_{mr} \end{cases}$$

In a poor country

$$\begin{cases} Max\ q_{mp} = \left(\sum c_i^\theta\right)^{\frac{1}{\theta}} \\ s.t.\quad \underbrace{n_p c_p p_p}_{home\ varieties} + \underbrace{(B-1)n_p c_{bp} p_{bp}}_{varieties\ from\ bloc\ members} + \underbrace{(N_p - B)n_p c_{cp} p_{cp}}_{varieties\ from\ other\ countries\ of\ the\ continent} + \underbrace{\left(\frac{C}{2}-1\right)N_p n_p c_{op} p_{op}}_{varieties\ from\ poor\ countries\ overseas} + \underbrace{\frac{C}{2}N_r n_r c_{or} p_{or}}_{varieties\ from\ rich\ countries} \le q_{mp} p_{mp} \end{cases}$$

with c_i the consumption of an intermediate good variety produced in country i.

Then, the producer of manufactures will demand the following relative quantities of intermediate inputs (from the first order conditions, derivation available upon request):

In a rich country
$$\begin{cases} c_i = c_r\left(\dfrac{p_r}{p_i}\right)^{\frac{1}{1-\theta}} \\ with\ i = \{cr; br; or; op\} \end{cases} \qquad \textbf{(A.7r)}$$

In a poor country
$$\begin{cases} c_i = c_p\left(\dfrac{p_p}{p_i}\right)^{\frac{1}{1-\theta}} \\ with\ i = \{cp; bp; op; or\} \end{cases} \qquad \textbf{(A.7p)}$$

In equilibrium, the per capita production of the manufactured good will be:

In a rich country:
$$q_m = c_r\left(n_p\right)^{\frac{1}{\theta}}\left(\psi_r\right)^{\frac{1}{\theta}} \qquad \textbf{(A.8r)}$$

$$with\ \psi_r = k + k(N_r - B)\left(\frac{1}{1+t}\right)^{\frac{\theta}{1-\theta}} + k(B-1)\left(\frac{1}{1+(1-d)t}\right)^{\frac{\theta}{1-\theta}}$$

$$+k\left(\frac{C}{2}-1\right)N_r\left(\frac{1}{(1+t)\left(1+\dfrac{f_o}{p_r}\right)}\right)^{\frac{\theta}{1-\theta}} + \frac{C}{2}N_p\left(\frac{\rho}{(1+t)\left(1+\dfrac{f_b}{2p_p}+\dfrac{f_c}{2p_p}+\dfrac{f_o}{p_p}\right)}\right)^{\frac{\theta}{1-\theta}}$$

In a poor country:
$$q_m = c_p\left(n_p\right)^{\frac{1}{\theta}}\left(\psi_p\right)^{\frac{1}{\theta}} \qquad \textbf{(A.8p)}$$

$$\textit{with } \psi_p = 1+(N_p - B)\left(\frac{1}{(1+t)\left(1+\frac{f_b}{p_p}+\frac{f_c}{p_p}\right)}\right)^{\frac{\theta}{1-\theta}} + (B-1)\left(\frac{1}{(1+(1-d)t)\left(1+\frac{f_b}{p_p}\right)}\right)^{\frac{\theta}{1-\theta}}$$

$$+\left(\frac{C}{2}-1\right)N_p\left(\frac{1}{(1+t)\left(1+\frac{f_b}{p_p}+\frac{f_c}{p_p}+\frac{f_o}{p_p}\right)}\right)^{\frac{\theta}{1-\theta}} + k\frac{C}{2}N_r\left(\frac{1}{\rho(1+t)\left(1+\frac{f_b}{2p_r}+\frac{f_c}{2p_r}+\frac{f_o}{p_r}\right)}\right)^{\frac{\theta}{1-\theta}}$$

The zero profit condition in the production of manufactures yields the price of final manufactured goods in terms of the intermediate home variety:

In a rich country: $$p_{mr} = p_{hr}\left(n_p \psi_r\right)^{\frac{\theta-1}{\theta}} \quad \textbf{(A.9r)}$$

In a poor country: $$p_{mp} = p_{hp}\left(n_p \psi_p\right)^{\frac{\theta-1}{\theta}} \quad \textbf{(A.9p)}$$

Optimization Problem of Consumer

In a rich country $$\begin{cases} Max \quad U_r = \left(c_{mr}\right)^{\alpha}\left(c_{ar}\right)^{1-\alpha} & 0<\alpha\le 1 \\ s.t. \quad p_{mr}c_{mr} + p_{ar}c_{ar} \le r_r k + w_r + T_r + \dfrac{\pi}{2N_r} & \end{cases}$$

In a poor country $$\begin{cases} Max \quad U_p = \left(c_{mp}\right)^{\alpha}\left(c_{ap}\right)^{1-\alpha} & 0<\alpha\le 1 \\ s.t. \quad p_{mp}c_{mp} + p_{ap}c_{ap} \le r_p + w_p + T_p & \end{cases}$$

with $c_{m(a)}$ the consumption of manufactures (agriculture) in country i, α the share of consumer's income spent in manufactures and $1-\alpha$ in agriculture, π the total transport monopoly profit (see later) and T the per capita tariff receipts that are handed back to consumers as a lump-sum transfer:

In a rich country:

$$T_r = t\left[(1-d)(B-1)n_r p_r c_{br} + (N_r - B)n_r p_r c_{cr} + \left(\frac{C}{2}-1\right)N_r n_r c_{or}\left(p_r + f_o\right)\right.$$
$$\left. + \frac{C}{2}N_p n_p c_{op}\left(p_p + \frac{f_b}{2}+\frac{f_c}{2}+f_o\right) + \left(C_{ar} - q_{ar}\right)\left(p_{ap}+\frac{f_b}{2}+\frac{f_c}{2}+f_o\right)\right] \quad \textbf{(A.10r)}$$

In a poor country:

$$T_p = t\left[(1-d)(B-1)n_p c_{bp}\left(p_p + f_b\right) + (N_p - B)n_p c_{cp}\left(p_p + f_b + f_c\right)\right.$$
$$\left. + \left(\frac{C}{2}-1\right)N_p n_p c_{op}\left(p_p + f_b + f_c + f_o\right) + \frac{C}{2}N_r n_r c_{or}\left(p_r + \frac{f_b}{2}+\frac{f_c}{2}+f_o\right)\right] \quad \textbf{(A.10p)}$$

The first order conditions of the consumer optimization problem yield:

$$\text{In a rich country: } \begin{cases} c_{ar} = \dfrac{1-\alpha}{p_{ar}}\left(r_r k + w_r + T_r + \dfrac{\pi}{2N_r}\right) \\ c_{mr} = \dfrac{\alpha}{p_{mr}}\left(r_r k + w_r + T_r + \dfrac{\pi}{2N_r}\right) \end{cases} \qquad \textbf{(A.11r)}$$

$$\text{In a poor country: } \begin{cases} c_{ap} = \dfrac{1-\alpha}{p_{ap}}\left(r_p + w_p + T_p\right) \\ c_{mp} = \dfrac{\alpha}{p_{mp}}\left(r_p + w_p + T_p\right) \end{cases} \qquad \textbf{(A.11p)}$$

Equilibrium in the Market for an Intermediate Input Variety

Produced in a rich country:

$$\underbrace{\frac{\theta\gamma}{\beta(1-\theta)}}_{supply} = L\left[\underbrace{c_r}_{\substack{demand\\from\ home}} + \underbrace{(B-1)c_r\left(\frac{1}{1+(1-d)t}\right)^{\frac{1}{1-\theta}}}_{from\ bloc\ members} + \underbrace{(N_r-B)c_r\left(\frac{1}{1+t}\right)^{\frac{1}{1-\theta}}}_{from\ other\ countries\ of\ the\ continent}\right.$$
$$\left.+\underbrace{\left(\frac{C}{2}-1\right)N_r c_r\left(\frac{1}{(1+t)\left(1+\dfrac{f_o}{p_r}\right)}\right)^{\frac{1}{1-\theta}}}_{from\ rich\ countries\ overseas} + \underbrace{\frac{C}{2}N_p c_p\left(\frac{1}{\rho(1+t)\left(1+\dfrac{f_b}{2p_r}+\dfrac{f_c}{2p_r}+\dfrac{f_o}{p_r}\right)}\right)^{\frac{1}{1-\theta}}}_{from\ poor\ countries\ overseas}\right] \qquad \textbf{(A.12r)}$$

Produced in a poor country:

$$\underbrace{\frac{\theta\gamma}{\beta(1-\theta)}}_{supply} = L\left[\underbrace{c_p}_{\substack{demand\\from\ home}} + \underbrace{(B-1)c_p\left(\frac{1}{(1+(1-d)t)\left(1+\dfrac{f_b}{p_p}\right)}\right)^{\frac{1}{1-\theta}}}_{from\ bloc\ members} + \underbrace{(N_p-B)c_p\left(\frac{1}{(1+t)\left(1+\dfrac{f_b}{p_p}+\dfrac{f_c}{p_p}\right)}\right)^{\frac{1}{1-\theta}}}_{from\ other\ countries\ of\ the\ continent}\right. \qquad \textbf{(A.12p)}$$
$$\left.+\underbrace{\left(\frac{C}{2}-1\right)N_p c_p\left(\frac{1}{(1+t)\left(1+\dfrac{f_b}{p_p}+\dfrac{f_c}{p_p}+\dfrac{f_o}{p_p}\right)}\right)^{\frac{1}{1-\theta}}}_{from\ poor\ countries\ overseas} + \underbrace{\frac{C}{2}N_r c_r\left(\frac{\rho}{(1+t)\left(1+\dfrac{f_b}{2p_p}+\dfrac{f_c}{2p_p}+\dfrac{f_o}{p_p}\right)}\right)^{\frac{1}{1-\theta}}}_{from\ rich\ countries\ overseas}\right]$$

Equilibrium Condition in Agriculture

The production function in agriculture is given by: $q_{ai} = L_{ai}, \quad i = \{r; p\}$.
Therefore, given perfect competition: $p_{ai} = w_i, \quad i = \{r; p\}$ **(A.13)**

with p_{ai} the price of agriculture and w_i the wage in country *i*.
Since agriculture is a homogeneous good, the law of one price requires the following relative wage between the rich and the poor country:

$$\frac{w_r}{w_p} = (1+t)\left(1+\frac{f_b}{2w_p}+\frac{f_c}{2w_p}+\frac{f_o}{w_p}\right) \quad \textbf{(A.14)}$$

The equilibrium in the agriculture sector is given by:

$$\left[\frac{C}{2}N_r q_{ar} + \frac{C}{2}N_p q_{ap}\right] = \left[\frac{C}{2}N_p Lc_{ap}\right] + \left[\frac{C}{2}N_r Lc_{ar}\right] \quad \textbf{(A.15)}$$

Transport Sector

We assume then that a monopoly shipper makes decisions about how to price transport services and which technology to use, maximizing the following profit, π:

$$Max_{f_b, f_c, f_o}\ \pi = (f_b - \kappa_b)q_b + (f_c - \kappa_c)q_c + (f_o - \kappa_o)q_o - F_b - F_c - F_o \quad \textbf{(A.16)}$$

q_b, q_c, q_o : total traded quantity requiring respectively intra-regional, intra-continental and across ocean transport services
F_b, F_c, F_o: fixed costs required by the technology of transport services between two spokes, two regional hubs and two continental hubs respectively;
κ_b, κ_c, κ_o : marginal cost per unit shipped between two spokes, two regional hubs and two continental hubs respectively.

Demand for transport services (q_b; q_c; q_o) can be written:
q_b: equal to the sum of all demands of foreign goods, i.e. the sum of all consumptions of foreign goods:

$$\begin{aligned} q_b = {} & N_p \frac{C}{2}\left[n_p(B-1)c_{bp} + n_p(N_p - B)c_{cp} + n_p N_p c_{op} + \frac{1}{2}n_r(\frac{C}{2}N_r)c_{or}\right] \\ & + N_r \frac{C}{2}\left[\frac{1}{2}n_p(2N_p)c_{op} + \frac{1}{2}(c_{ar} - q_{ar})\right] \end{aligned} \quad \textbf{(A.17)}$$

q_c: equal to the sum of all demands for foreign goods from outside the bloc, i.e.:

$$\begin{aligned} q_c = {} & N_p \frac{C}{2}\left[n_p(N_p - B)c_{cp} + n_p N_p c_{op} + \frac{1}{2}n_r(\frac{C}{2}N_r)c_{or}\right] \\ & + N_r \frac{C}{2}\left[\frac{1}{2}n_p(2N_p)c_{op} + \frac{1}{2}(c_{ar} - q_{ar})\right] \end{aligned} \quad \textbf{(A.18)}$$

q_o: equal to the sum of imports from other continent countries:

$$\begin{aligned} q_o = {} & N_p \frac{C}{2}\left[n_p N_p c_{op} + n_r(\frac{C}{2}N_r)c_{or}\right] \\ & + N_r \frac{C}{2}\left[n_r N_p c_{or} + n_p(\frac{C}{2}N_p)c_{op} + (c_{ar} - q_{ar})\right] \end{aligned} \quad \textbf{(A.19)}$$

Concerning the monopoly cost function, we assume that the total cost of the transport service production is the following:

$$TC = \sum_{h=b,c,o} F_h + \kappa_h q_h \quad \textbf{(A.20)}$$

To produce transport services the monopoly uses poor country's labor.
Total number of workers hired by the monopoly in *each* poor country is given by:

$$L_{kp} = \frac{1}{2N_p}\left[\frac{TC}{w_p}\right] \qquad \textbf{(A.21)}$$

We also assume that the agriculture sector acts as a "residual employer": $L_{ap} = L - L_{kp}$.[47] Hence, an increasing demand of transport services may slow down the agriculture production (through the decrease in the agriculture labor force) which in turn may increase the agriculture price p_{ap} and then the wage paid in poor countries w_p.[48]

All these equations together with the normalization w_p=1 allow us to determine the prices of production factors $\left(r_r; r_p; w_r; w_p\right)$.[49]

[47] As the monopoly only used poor country' labor, we always have, in rich countries: $L_{kr} = 0$ and then $L_{ar} = L - L_{kr} = 1$.

[48] As w_p is used as numéraire in the model, an increase in w_p is actually reflected by a decrease in prices of other goods.

[49] As, in equations for equilibrium in the intermediate input (equations *A.12*), the consumption of the home variety c_r and c_p can be replaced by an expression in terms of the respective prices of factors in rich and poor countries respectively (obtained from equations *(A.8), (A.9), (A.10), (A.11), (A.14);* derivation available upon request)**:**

In rich country: $$c_r = \frac{\alpha\theta}{\beta n_p}\frac{k\left(1+t\right) + \frac{w_r}{r_r}\left(1 + t\left(1 - L_{ar}\right)\right) + \frac{\pi}{2N_r r_r}}{\psi_r + \alpha t k\left(1 + d\left(B-1\right)\left(\frac{1}{1+(1-d)t}\right)^{\frac{1}{1-\theta}}\right)}$$

In poor country: $$c_p = \frac{\alpha\theta}{\beta n_p}\frac{1 + \frac{w_p}{r_p}}{\psi_p - \alpha\frac{t}{1+t}\left(\psi_p - 1 - d\left(B-1\right)\left(1+\frac{f_b}{p_p}\right)\left(\frac{1}{\left(1+(1-d)t\right)\left(1+\frac{f_b}{p_p}\right)}\right)^{\frac{1}{1-\theta}}\right)}$$