Persistent Uneven Spread of Economic Activities Within Developing RIAs

Souleymane Coulibaly[1,2]

Abstract

One of the striking features of many developing Regional Integration Areas (RIAs) is the strong asymmetry between countries. In this paper, we consider a three-country two-sector model in a footloose capital framework. Two of these countries are involved in a regional integration process while the third is left out of the union. They are "port-like" economies where only one region is endowed with international infrastructures, so that imports and exports between trading partners necessarily pass through this transit region. The comparative statics of our model show that better domestic transport infrastructure helps to attract a higher share of footloose activity when trade costs within the RIA are lowered, inducing a persistent uneven spread of the mobile sector between the member countries. If the domestic infrastructure levels of these countries are both raised towards a high-quality level, a convergence process is triggered to the disadvantage of the country left outside the RIA.

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[1]DEEP-HEC, University of Lausanne and TEAM, University of Paris 1, souleymane.coulibaly@unil.ch

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1 Introduction

A glance at developing regional integration areas (RIAs henceforth) worldwide points to hub-and-spokes patterns, where the hub country of the RIA serves as the main gateway to the outside world. Motta and Norman (1996) and Puga and Venables (1997) among others have shown that integrated countries attract more firms because they offer better access to regional markets. However, a hub and spoke configuration leads to an uneven spread of economic activities within the RIA, and it induces higher administration and transportation costs (Kowalcyk and Wonnacott, 1992). This can create conflicts of interest among RIA members, and in the past some RIAs collapsed because of dissatisfied members complaining about having to share integration gains. The two following cases illustrate the situation.

The Central American Common Market (CACM) was first established in December 1960 as a result of ten years of collaboration among El Salvador, Guatemala, Honduras and Nicaragua.[3] The CACM contributed to a boom in intra-regional trade, but despite this success, it faced periodic difficulties due to complaints on the redistribution of benefits by Honduras and to some extent Nicaragua. If the collapse of the CACM in 1969 was directly caused by what has become known as the "soccer war", the deep underlying reason was the conflicting situation due to the favored place of El Salvador in the RIA because of its better infrastructure endowment.[4] Another interesting case is

[3] http://www.oneworld.org/acpsec/gb/summit/eca/eca.htm

[4] The "soccer war" is a five-day war triggered after the expulsion of thousands of immigrant Salvadorans by Honduras during the 1970 World Cup preliminary tournament. See Vargas-

the collapse of the East African Community (comprising three East African countries: Kenya, Tanzania and Uganda) in 1977. In an article titled “Rebirth of the East Africa Cooperation”, Percival (1997) argues that “the final collapse of the East African Community, which survived for a decade up until 1977, was provoked by disagreements over the benefits gained by each state from the operation of common regional services such as the airline, harbours and telecommunication”. Hazlewood (1979) analyzes these tensions within the East African Community (EAC) and posits that the hub position of Kenya was a key reason for this collapse (ideological differences between pro-communist and pro-capitalists being another important source of discord).

The seminal paper by Krugman (1981) explains North-South development gaps with a two-country two-factor model in which the initial discrepancy in capital-labor ratio between (the) two countries cumulates over time and yields a persistent uneven development. This paper stimulated many others trying to explain North-South uneven development by different mechanisms. Dutt (1986) shows that trade in intermediate goods can support uneven development between a core country exporting technologically advanced goods and a peripheral country which does not benefit from learning effects induced by such goods. Kubo (1995) adds regional externalities to the common increasing returns to scale sector of the Krugman model and derives different regional development patterns. Desmet (2000, 2002) introduces localized learning-by-doing effects leading to specialization and uneven development. All these papers address the

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Hidalgo (1979) and Wionczek (1970).

issue of the internal geography of a country or a union when trade is liberalized with external partners, and many other recent papers also deal with this topic: Krugman (1993), Krugman and Livas-Elizondo (1996), Montfort and Nicolini (2000), Montfort and van Ypersele (2003), Behrens et al. (2003), Ago et al. (2004) and Crozet and Koenig (2004).

However, none of these papers focuses on developing RIAs. One exception is the paper by Golley (2002) that identifies two related factors that yielded uneven regional development of Chinese regions: on the one hand, the historical uneven spread of the Chinese population due to the fact that it is a very large country and on the other hand, the political choice of decentralization that maintained this inequality over time. The paper by Martin and Rogers (1995) also gives a first insight into the topic. Examining the impact of public infrastructures within RIAs, they found that firms tend to locate within countries with better domestic infrastructures.

In this paper, we build a footloose capital model that extends the paper by Martin and Rogers (1995) to address the specific issue of developing RIAs. We consider a RIA formed by two developing countries and a third country representing the rest of the developing world, each of the three countries comprising two regions: one principal region endowed with international trade infrastructures and a hinterland region. This configuration characterizes most developing countries where capital cities play a major role in international transaction because of their geographical locations and their endowment in international infrastructures such as ports, airports, telecommunication equipment and administrative facilities.[5] A comparative statics exercise help us to keep track of the industrial share of each of the six regions under consideration. We find that as the intra-RIA trade costs decrease, the principal region of the member with better domestic infrastructures attracts firms first from its hinterland region, then from the other RIA member, and finally from the third developing country outside the RIA. If domestic infrastructures of the RIA members are harmonized to a higher level, a convergence process of the industrial shares of their principal regions is triggered, to the disadvantage of their hinterland regions and the third developing country left out of the RIA.

The remainder of the paper proceeds as follows. In Section 2, we build a footlose capital model inspired by Ottaviano and Thisse (2003) to analyze firms' location as intra-RIA trade costs decrease. We then analyze the comparative statics of the industrial shares of each region along with different infrastructure levels in Section 3, and Section 4 concludes the chapter.

2 The model

Let us consider a RIA formed by two developing countries denoted C_1 and C_2 and a third country C_3 representing the rest of the developing world, each having two regions. The domestic trade costs are respectively τ_1, τ_2 and τ_3, and trade costs between these countries are τ_{12}, τ_{13} and τ_{23}. These costs are all of the

[5] One can argue that even in developed countries, this differentiation exists. However, in developing countries, the situation is typically exacerbated by the fact that all the administrative facilities are concentrated in the principal region, so that importers and exporters need to be physically present there to finalize their trade operations. Venables (2003) theoretically explains such a situation.

iceberg type, that is a fixed proportion of the traded good melts away during the trading process. Transport infrastructure is assumed better in country 1 than in country 2. That of country 3 can be better or worse than that of country 2. Thus, the domestic transport costs are ranked as follows: $\tau_1 < \tau_2 < \tau_3$ or $\tau_1 < \tau_3 < \tau_2$. The graph below resumes the situation:

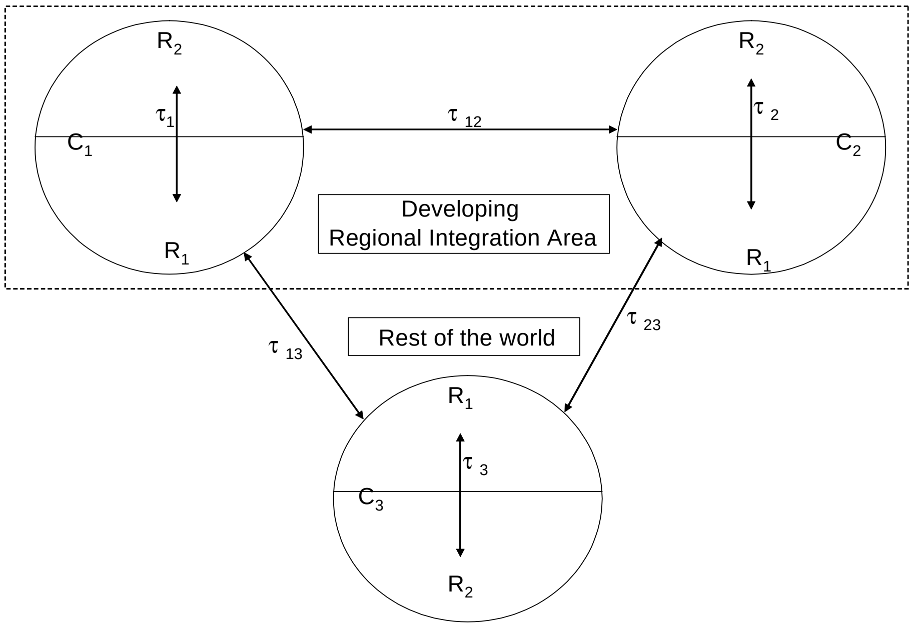

Figure 1: Internal and external trade costs within a developing RIA.

Within each country, region 1 is the only one endowed with international infrastructures, that is, all imports or exports between the trading partners necessarily pass through region 1. For instance if a consumer located in region 2 of country 2 wants to import a good produced in region 2 of country 1, he has to support the domestic trade cost within country 1 (τ_1), the external trade cost between country 1 and country 2 (τ_{12}) and the domestic trade cost within country 2 (τ_2).

We develop a home market effect model in which the market advantage of a location is due to a better market access through lower trade costs. All the trade costs are thus exogenously set. We particularly focus on the intra-RIA trade cost and make it continuously decrease. This variation induces a relocation of the physical capital leading to a variation of the industrial share of each of the six regions under consideration. We make the assumption that a higher industrial share increases consumers welfare, so that the absence of an industrial sector within a RIA member intensifies conflicts of interest with other members, and the RIA may collapse. This assumption holds if the cost of investing in infrastructures is counterbalanced by the gains induced by firms relocation. This issue is beyond the scope of this chapter which only tries to analyze firms relocation within a RIA when domestic and international infrastructure are improved.

2.1 When countries are in autarky

Let us consider that international trade costs are prohibitive so that all the countries are in autarky. We can thus focus on a given country (country C_1), the case of the other countries being analogous. We have said that country C_1 has two regions, R_1 and R_2, only region R_1 being endowed with international transaction infrastructures.

There are two sectors producing two goods, an agricultural good (A) traded costlessly and a manufacture good (M). There are two production factors: labor (L) that is immobile and capital (K) that is perfectly mobile. In the footloose capital setting, the capital is owned by workers so that the return of this factor is spent in the region where the owner lives. The A sector is perfectly competitive and produces a homogenous good under constant return to scale using only labor. As in Baldwin et al (2004), we assume that the non-full-specialization condition holds for this sector, which implies that each of the six regions will receive some A-sector.[6] The M sector is monopolistically competitive, producing a differentiated good under increasing return to scale and using labor (L) and capital (K). The distribution of workers and capital is θ for region R_1 and $1-\theta$ for region R_2. In this study, we assume an even distribution of workers and capitalists within the two regions (that is $\theta = 1/2$), and concentrate on the impact of domestic and international infrastructures discrepancy on the location of M-firms.

Since good A is produced under constant return to scale and traded costlessly, the wage in this sector will be equal to the price of good A at equilibrium ($w = p_A$) in both region R_1 and R_2.

To produce $x_1(s)$ units of variety s of the differentiated good in region R_1 for instance, we need a fixed amount f of capital and a variable amount $\alpha x_1(s)$ of labor, α being the marginal labor requirement to produce one unit of good M. We can set $f = 1$ without any loss of generalization, and the total cost of a

[6] This condition is: $(1-\mu)(Y_1 + Y_2) > p_A (\max\{\theta, 1-\theta\})(L_1 + L_2)$.

firm producing variety s in region R_1 is thus:

$$TC_1\left(s\right) = r_1 + w\alpha x_h\left(s\right) \tag{1}$$

where r_1 is the rental rate of capital in region R_1. We assume no scope economy so that in equilibrium, each firm of the M-sector will produce only one variety and consequently, the number of varieties will also be the number of firms operating in the sector. We assume the following Cobb-Douglas utility function for the representative consumer in region R_1:

$$U_1 = M_1^{\mu} A_1^{1-\mu}\ ,\ M_1 = \left(\int_{s\in n_h} m_{1,1}\left(s\right)^{\frac{\sigma-1}{\sigma}} ds + \int_{s\in n_l} m_{1,2}\left(s\right)^{\frac{\sigma-1}{\sigma}} ds \right)^{\frac{\sigma}{\sigma-1}} \tag{2}$$

where A_1 is the homogenous good, M_1 is a composite of differentiated goods, $m_{1,1}\left(s\right)$ is the demand of variety s in region R_1 from region R_1, $m_{1,2}\left(s\right)$ is the demand of variety s in region R_1 from region R_2, n_1 is the number of varieties produced in region R_1, n_2 is the number of varieties produced in region R_2, μ is the share of the consumer's income addressed to the differentiated good and σ is the elasticity of substitution between varieties ($\sigma > 1$). The consumer's problem is to maximize his utility function under budget constraint so as to derive his optimal demand for each good. If G_1 is the price index of the differentiated good in region R_1, then the optimal demand of good A and good M in region R_1 are:

$$M_1^* = \frac{\mu Y_1}{G_1} \ , \ A_1^* = \frac{(1-\mu)\, Y_1}{p_A} \tag{3}$$

where Y_1 is the consumer's income in region R_1. M_1^* is in fact a CES aggregate of the optimal demand of all the varieties produced in region R_1 and R_2:

$$m_{1,1}(s) = \frac{p_{1,1}(s)^{-\sigma}}{G_1^{1-\sigma}} \mu Y_1 \ , \ m_{1,2}(s) = \frac{p_{1,2}(s)^{-\sigma}}{G_1^{1-\sigma}} \mu Y_1 \tag{4}$$

where $p_{1,1}$ is the price set in region R_1 by a representative firm located in region R_1, $p_{1,2}$ is the price set in region R_1 by a representative firm located in region R_2, Y_1 is the income in region R_1 and G_1 is the price index in the same region defined as follows:

$$G_1^{1-\sigma} = \int_{s \in n_1} p_{1,1}(s)^{1-\sigma}\, ds + \int_{s \in n_2} p_{1,2}(s)^{1-\sigma}\, ds. \tag{5}$$

At equilibrium, all the firms set the same free on board price p and final consumers bear transport costs. The price index in the two regions of country C_1 can be written as:

$$G_{1,1} = (n_1 + n_2\phi_1)^{\frac{1}{1-\sigma}}\, p \ , \ G_{1,2} = (\phi_1 n_1 + n_2)^{\frac{1}{1-\sigma}}\, p \tag{6}$$

where $\phi_1 = \tau_1^{1-\sigma}$ is a measure of trade "freeness". Since τ is defined on the range $[1;+\infty)$ and $\sigma > 1$, ϕ_1 will be close to 0 for very high transport costs and close to 1 for very low transport costs.

The profit of a typical firm located in region R_1 of country C_1 is:

$$\pi_{1,1} = (m_{1,1} + \tau_1 m_{1,2})(p - \alpha w) - r_1. \tag{7}$$

If the A good is the numeraire, we will have $w = p_A = 1$. The maximization of the profit function yields the optimal price to be set by this representative firm: $p = \alpha\sigma/(\sigma - 1)$. We assume free entry and exit in the M-sector so that at equilibrium, profit should be zero and thus equation (7) leads to the following condition on the rental rate:

$$r_1 = \frac{\alpha}{(\sigma - 1)}(m_{1,1} + \tau_1 m_{1,2}) \tag{8}$$

and if we replace $m_{1,1}$ and $m_{1,2}$ by their expression in (4), we find:

$$r_1 = \frac{\mu}{\sigma}\left(\frac{Y_1}{(n_1 + n_2\phi_1)} + \frac{Y_2\phi_1}{(\phi_1 n_1 + n_2)}\right) \tag{9}$$

and symmetrically:

$$r_2 = \frac{\mu}{\sigma}\left(\frac{Y_2}{(\phi_1 n_1 + n_2)} + \frac{Y_1\phi_1}{(n_1 + n_2\phi_1)}\right). \tag{10}$$

Since capital moves freely between the two regions, the equilibrium rental rate is necessary such that $r_1 = r_2 = r$, that is no firm in the M-sector has any incentive to relocate to another region. Hence the equilibrium income within each region is $Y_1 = \theta(rK + L)$ and $Y_2 = (1 - \theta)(rK + L)$. These conditions combined with the last two equations some algebra yield:

$$\frac{n_1}{n} = \theta + (2\theta - 1)\frac{\phi_1}{1 - \phi_1} \tag{11}$$

where $n = n_1 + n_2$. Let us denote $\lambda_1 = n_1/n$, with $0 \leq \lambda_1 \leq 1$, which also represents the fraction of capital employed in region R_1 of country C_1 so that $(\theta - \lambda) K$ measures the extent of capital inflow or outflow in this region. This suggests that a spatial equilibrium arises at λ_1 if the differential in the rental rate $\Delta r = (r_1 - r_2)$ is equal to zero.

Equation (11) shows the home market effect: $\lambda_1 > \theta$ if $\theta > 1/2$, that is the large region attracts an industrial share that is higher than the share of capitalists located in this region. Equation (11) also indicates that λ_1 increases with the degree of freeness of trade (ϕ_1) within country C_1.

In this paper, we assume an even spread of workers and capital $(\theta = 1/2)$ and it is obvious that the equilibrium spread of the M-firms reflects this symmetry when prohibitive external trade costs hinder international trade. However, the interesting point is to analyze how M-firms relocate as these international trade costs decrease towards free trade level. This question is explored in the following subsection.

2.2 When international trade occurs

Now, we consider that trade costs between countries are assumed non-prohibitive within and outside the RIA. The point here is to extend the previous $2 \times 2 \times 2$ model to a more complex model of three countries and six regions (see Figure 1 above). The three countries are denoted C_1, C_2 and C_3, and within each country, the regions will be denoted by the indices $(1,1)$ (region R_1 of country C_1), $(1,2)$ (region R_2 of country C_1), $(2,1)$ (region R_1 of country C_2), $(2,2)$ (region R_2 of country C_2), $(3,1)$ (region R_1 of country C_3) and $(3,2)$ for region R_2 of country C_3. The description of the two production sectors when countries are in autarky also prevails here and a firm located in a given region of a given country will face six segmented markets. The optimal demand of a consumer located in region R_1 of country C_1 from an M-firm located in region R_2 of country C_2 will then be:

$$m_{(1,1),(2,2)} = \frac{\left[p_{(1,1),(2,2)}\right]^{-\sigma}}{\left[G_{(1,1)}\right]^{1-\sigma}} \mu Y_{(1,1)} \tag{12}$$

where $p_{(1,1),(2,2)}$ and $G_{(1,1)}$ are defined analogously to price and price index in Section 2.1: $p_{(1,1),(2,2)}$ represents the price set by a firm located in region R_2 of country C_2 selling in region R_1 of country C_1 and $G_{(1,1)}$ is the price index in region R_1 of country C_1. All the key variables have to be defined in the six regions and we need a matrix formulation to encompass them in a simple expression. Let G, N, λ and RR denote column vectors of dimension six, their elements representing respectively price index (G), number of varieties or M-firms (N), share of the M-sector (λ) and rental rate (RR) for each of the six regions:

$$G = \begin{pmatrix} G_{(1,1)} \\ G_{(1,2)} \\ G_{(2,1)} \\ G_{(2,2)} \\ G_{(3,1)} \\ G_{(3,2)} \end{pmatrix}, N = \begin{pmatrix} n_{(1,1)} \\ n_{(1,2)} \\ n_{(2,1)} \\ n_{(2,2)} \\ n_{(3,1)} \\ n_{(3,2)} \end{pmatrix}, \lambda = \begin{pmatrix} \lambda_{(1,1)} \\ \lambda_{(1,2)} \\ \lambda_{(2,1)} \\ \lambda_{(2,2)} \\ \lambda_{(3,1)} \\ \lambda_{(3,2)} \end{pmatrix} \text{ and } RR = \begin{pmatrix} r_{(1,1)} \\ r_{(1,2)} \\ r_{(2,1)} \\ r_{(2,2)} \\ r_{(3,1)} \\ r_{(3,2)} \end{pmatrix}.$$

Let Φ be a 6×6 matrix defined as follows:

$$\Phi = \begin{pmatrix} 1 & \phi_1 & \phi_{12} & \phi_{12}\phi_2 & \phi_{13} & \phi_{13}\phi_3 \\ \phi_1 & 1 & \phi_{12}\phi_1 & \phi_{12}\phi_1\phi_2 & \phi_{13}\phi_1 & \phi_{13}\phi_1\phi_3 \\ \phi_{12} & \phi_{12}\phi_1 & 1 & \phi_2 & \phi_{23} & \phi_{23}\phi_3 \\ \phi_{12}\phi_2 & \phi_{12}\phi_1\phi_2 & \phi_2 & 1 & \phi_{23}\phi_2 & \phi_{23}\phi_2\phi_3 \\ \phi_{13} & \phi_{13}\phi_1 & \phi_{23} & \phi_{23}\phi_2 & 1 & \phi_3 \\ \phi_{13}\phi_3 & \phi_{13}\phi_1\phi_3 & \phi_{23}\phi_3 & \phi_{23}\phi_2\phi_3 & \phi_3 & 1 \end{pmatrix}$$

where $\phi_{ij} = \tau_{ij}^{1-\sigma}$ and $\phi_i = \tau_i^{1-\sigma}$, τ_{ij} and τ_i defined as in Figure 1. This symmetric matrix is a trade cost matrix indicating that for instance the total import of a consumer located in region R_1 of country C_1 (first line of Φ) comprises its import from region R_1 of country C_1 (no trade costs incurred), from region R_2 of country C_1 (ϕ_1 incurred), from region R_1 of country C_2 (ϕ_{12} incurred), from region R_2 of country C_2 ($\phi_{12}\phi_2$ incurred), from region R_1 of country C_3 (ϕ_{13} incurred) and from region R_2 country C_3 ($\phi_{13}\phi_3$ incurred).

Finally, let Y be a 6×6 diagonal matrix, representing the total income within each of the six regions:

$$Y = \begin{pmatrix} Y_{1,1} & 0 & 0 & 0 & 0 & 0 \\ 0 & Y_{1,2} & 0 & 0 & 0 & 0 \\ 0 & 0 & Y_{2,1} & 0 & 0 & 0 \\ 0 & 0 & 0 & Y_{2,2} & 0 & 0 \\ 0 & 0 & 0 & 0 & Y_{3,1} & 0 \\ 0 & 0 & 0 & 0 & 0 & Y_{3,2} \end{pmatrix}$$

With these new variables, the price index matrix is now defined as:

$$G = (\Phi N)^{\frac{1}{1-\sigma}}\, p \tag{13}$$

where p is a scalar representing the equilibrium free-on-board price as in Section 2.1.[7] The capital market clearing condition is:

$$N = \lambda K \tag{14}$$

where K is the stock of capital (assumed the same in any of the six regions) owned by the consumers. The zero-profit condition yields the following expression for the equilibrium rental rate:

$$RR = \mu\,(p-\alpha)\,(\Phi Y)\,(\Phi N)^{-1} \tag{15}$$

where μ, p and α are scalars defined as in Section 2.1.[8] Plugging (14) in (15)

[7] Notice that in the previous expression, ΦN is a column vector and thus $(\Phi N)^{\frac{1}{1-\sigma}}$ is also a column vector formed by the the elements of ΦN raised to the power $1/(1-\sigma)$.

[8] Notice that in the previous expression, ΦN is a column vector and thus $(\Phi N)^{-1}$ is also a column vector formed by the inverse of the elements of ΦN.

yields the following expression:

$$RR = \frac{\mu \left(p-\alpha\right)}{K} \left(\Phi Y\right) \left(\Phi \lambda\right)^{-1}. \tag{16}$$

In fact, in the right hand side of equation (16), the term $\mu \left(p-\alpha\right)/K$ is a constant and will cancel out in the resolution of the equation system. We can thus drop it. At equilibrium the rental rates are identical in the six regions (r) and the income in each region will also be the same and characterized by the parameter θ. Under these conditions, equation (16) becomes:

$$r\mathbf{1} = \left(\Phi \Theta\right) \left(\Phi \lambda\right)^{-1} \tag{17}$$

where $\mathbf{1}$ is the vector whose components are all equal to one and Θ is a 6×6 diagonal matrix representing the distribution of workers and capital between the six regions,

$$\Theta = \begin{pmatrix} \theta_{11} & 0 & 0 & 0 & 0 & 0 \\ 0 & \theta_{12} & 0 & 0 & 0 & 0 \\ 0 & 0 & \theta_{21} & 0 & 0 & 0 \\ 0 & 0 & 0 & \theta_{22} & 0 & 0 \\ 0 & 0 & 0 & 0 & \theta_{31} & 0 \\ 0 & 0 & 0 & 0 & 0 & \theta_{32} \end{pmatrix}.$$

Equation (17) represents in fact six equations in seven unknowns, the equilibrium rental rate r and the six industrial shares λ_{11}, λ_{12}, λ_{21}, λ_{22}, λ_{31} and λ_{32}. We need one closure equation that is given by λ_{32}=1-(λ_{11}+λ_{12}+λ_{21}+λ_{22}+λ_{31}).

Thus, equation (17) will now depend on the six unknowns λ_{11}, λ_{12}, λ_{21}, λ_{22}, λ_{31} and r and on the set of parameters defined by Φ and Θ. This system of six equations in six unknowns yields the equilibrium distribution of the M-sector between the six regions when international transaction costs are non-prohibitive. As usual, the questions of the existence and the uniqueness of the equilibrium yielded by this system of equations have to be clearly addressed.

Ginsburgh et al (1986) demonstrated that such an equilibrium always exists when the rental rate is a continuous function of λ, which is the case here since capital is allowed to move freely across all the six regions. We need more algebra to state the uniqueness of the equilibrium.

First, we have to re-express equation (17) by operating a suitable change of variables to obtain a linear system of the form $Y = \Phi X$. Let us mention the basic change of variables needed:

$$\begin{aligned}
a &= (\lambda_{11} + \lambda_{12}\phi_1) + (\lambda_{21}\phi_{12} + \lambda_{22}\phi_{12}\phi_2) + (\lambda_{31}\phi_{13} + \lambda_{32}\phi_{13}\phi_3) \\
b &= (\phi_1\lambda_{11} + \lambda_{12}) + (\lambda_{21}\phi_{12}\phi_1 + \lambda_{22}\phi_{12}\phi_1\phi_2) + (\lambda_{31}\phi_{13} + \lambda_{32}\phi_{13}\phi_1\phi_3) \\
c &= (\lambda_{21} + \lambda_{22}\phi_2) + (\lambda_{11}\phi_{12} + \lambda_{12}\phi_{12}\phi_1) + (\lambda_{31}\phi_{23} + \lambda_{32}\phi_{23}\phi_3) \\
d &= (\phi_2\lambda_{21} + \lambda_{22}) + (\lambda_{11}\phi_{12}\phi_2 + \lambda_{12}\phi_{12}\phi_1\phi_2) + (\lambda_{31}\phi_{23}\phi_2 + \lambda_{32}\phi_{23}\phi_2\phi_3) \\
e &= (\lambda_{31} + \lambda_{32}\phi_3) + (\lambda_{11}\phi_{13} + \lambda_{32}\phi_{13}\phi_1) + (\lambda_{21}\phi_{23} + \lambda_{22}\phi_{23}\phi_2) \\
f &= (\phi_3\lambda_{31} + \lambda_{32}) + (\lambda_{11}\phi_{13}\phi_3 + \lambda_{32}\phi_{13}\phi_1\phi_3) + (\lambda_{21}\phi_{23}\phi_3 + \lambda_{22}\phi_{23}\phi_2\phi_3) .
\end{aligned}$$

We then re-express equation (17) in an extensive form (equation by equation), use the relations above to make six changes of variables, and re-arrange the six equations so as to obtain the linear form $Y = \Phi X$. This system yields a unique solution if the rank of matrix Φ is 6. A closer inspection of the definition of this matrix shows that none of the six columns forming matrix Φ can be expressed as a linear combination of the others, a result that proves that matrix Φ is of rank 6 and consequently, that the linear system has a unique solution.

The second step consists in using the change of variables expressions to evaluate λ_{11}, λ_{12}, λ_{21}, λ_{22}, λ_{31} and r. After some tedious algebra, we obtain six polynomial equations of degree 6. Building on the "Abel Theorem", which states that it is impossible to solve a polynomial equation of degree higher than 4 analytically, we have to resort to numerical simulations to obtain the equilibrium distribution of firms described by equation (17). In the following Section, we study the impact of a continuous reduction of the intra-RIA trade costs within the RIA (ϕ_{12}), the level of trade costs with the ROW being maintained at a high level so as to accommodate with the developing context we are addressing.

3 Comparative statics analysis

Let us recall the geographical structure of our model. We have three developing "port-like economies" in which only the three principal regions are involved in international transaction. Their hinterland regions face additional trade costs to engage in international trade. We assume an even spread of capital and labor within the six regions of the model, $(\theta_{11}, \theta_{12}, \theta_{21}, \theta_{22}, \theta_{31}, \theta_{32})$ = (1/6,1/6,1/6,1/6,1/6,1/6). In the simulations, we assume that the internal trade costs in country C_1 is $\phi_1 = 0.9$, which corresponds to a very good domestic infrastructure level. The internal trade costs in country C_3 is set to

$\phi_3 = 0.1$, which corresponds to a quite bad domestic infrastructure level. The international trade costs between the RIA's members and country C_3 are assumed very high (we set $\phi_{13} = \phi_{23} = 0.2$). We then play on the intra-RIA trade costs and the domestic trade costs of the second RIA member (country C_2). For the intra-RIA trade costs, we assume a continuous decrease reflecting a reinforcement of the integration process (ϕ_{12} runs from 0, which corresponds to autarky, to 1, which corresponds to free trade within the RIA).[9] For the RIA member facing higher domestic trade costs, we set different values for ϕ_2 that illustrates an improvement of country C_2's domestic infrastructure towards the level of country C_1's domestic infrastructure (here we only present three cases: $\phi_2 = 0$, $\phi_2 = 0.8$ and $\phi_2 = 0.9$). We used the software GAMS to solve the equations system and to perform all the following simulations.[10]

3.1 Impact of a continuous decrease of the intra-RIA trade costs

In Figure 2-4, the y-axis represents the share of the industrial sector within the three countries: $\lambda_{11} + \lambda_{12}$ represents the sum of the industrial share of regions R_1 and R_2 within country C_1, $\lambda_{21} + \lambda_{22}$ represents the sum of the industrial share of regions R_1 and R_2 within country C_2 and $\lambda_{31} + \lambda_{32}$ represents the sum of the industrial share of regions R_1 and R_2 within country C_3. The dashed

[9] It is obvious that if all the ϕs in matrix Φ are equal to one, the determinant of matrix Φ will be equal to zero and the system will not have a unique solution. Furthermore, when lots of the elements of matrix Φ are equal or close to one, the determinant will be closer to zero and the solution will be spurious. This is why in graphs 2-7, ϕ_{12} is less than 1 on the x-axis.

[10] See a presentation of this software on the website www.gams.com.

curve specifies country C_3 left outside the RIA. The x-axis represents intra-RIA trade costs ϕ_{12}.

Let us first assume that the domestic trade costs of our three countries are such that $\phi_1 > \phi_3 > \phi_2$, which means that the hinterland region of country C_2 faces higher trade costs than that of country C_3 left out the RIA. Figure 2 focuses on some specific parameter values. We have performed the same simulation exercise for many other values corresponding to this ranking of domestic trade costs and the outcome is the same.

In this configuration, when trade costs are prohibitive within the RIA ($\phi_{12} = 0$), countries C_1 and C_3 attract the same industrial share to the disadvantage of country C_2. At this point, trade is freer between the RIA's members and the ROW than within the RIA ($\phi_{12} < \phi_{13} = \phi_{23}$) and this gives the ROW a market advantage. However, when trade costs are lowered within the RIA, country C_1, which possesses the best domestic infrastructure, takes advantage of its integration with country C_2 to attract a higher industrial share. This leading position reinforces its attractiveness to the disadvantage of country C_3 left outside the RIA, and as ϕ_{12} keeps increasing, the industrial share of country C_1 continuously increases to a limit value that represents more than half of the $M-$sector.

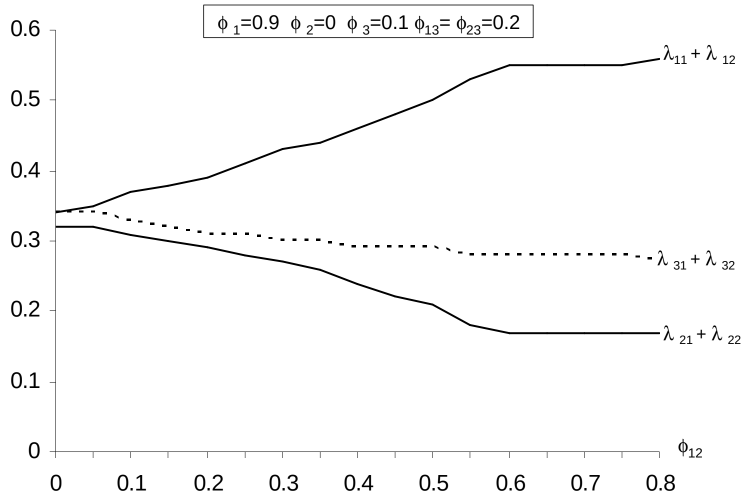

Figure 2: Industrial share in each of the 3 countries.

Now, let us assume that the domestic trade costs of our three countries are such that $\phi_1 > \phi_2 > \phi_3$, which means that the hinterland region of country C_3 faces higher trade costs than that of the two RIA members. Figure 3 focuses on some specific parameter values. We have performed the same simulation exercise for many other values corresponding to this ranking of domestic trade costs and the outcome is the same.

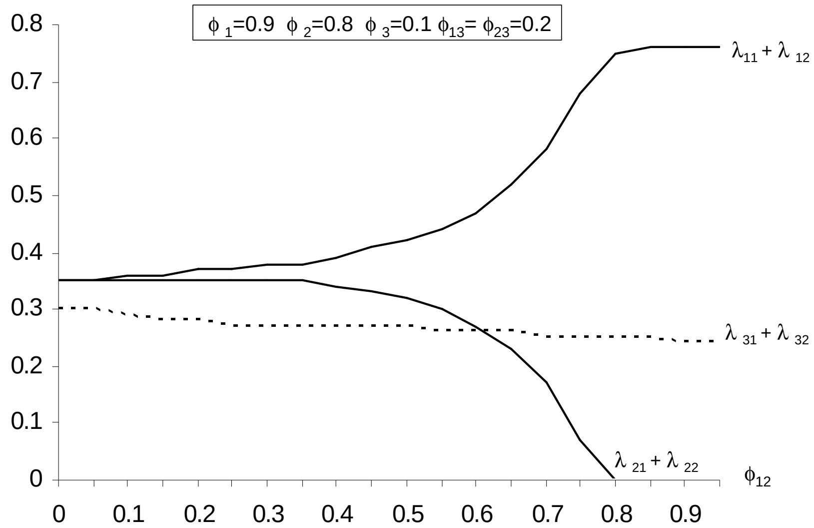

Figure 3: Industrial share in each of the 3 countries.

In this configuration, country C_3 left out of the RIA is disadvantaged even when intra-RIA trade costs are very high. An interesting result here is that the two RIA members initially (i.e. when the intra-RIA trade is still very high) attract the same industrial share. As intra-RIA trade costs are lowered, this stability is broken and a divergence process is triggered between them, obviously to the advantage of country C_1, which possesses the best domestic infrastructure. We performed this simulation exercise for many other values of ϕ_1, ϕ_2 and ϕ_3 verifying $\phi_1 > \phi_2 > \phi_3$ and we noticed that as ϕ_2 came closer to ϕ_1, the divergence process within the RIA was triggered for higher values of the intra-RIA trade costs ϕ_{12}. This result indicates that a common effort of the RIA members to strengthen their domestic infrastructure are more likely to induce a stable RIA. Figure 4 focuses on the case where the domestic infrastructures within the RIA are harmonized to the level of the well-endowed partner.[11] In this configuration, the two RIA members attract a slightly increasing industrial share to the disadvantage of country C_3 left out the RIA.

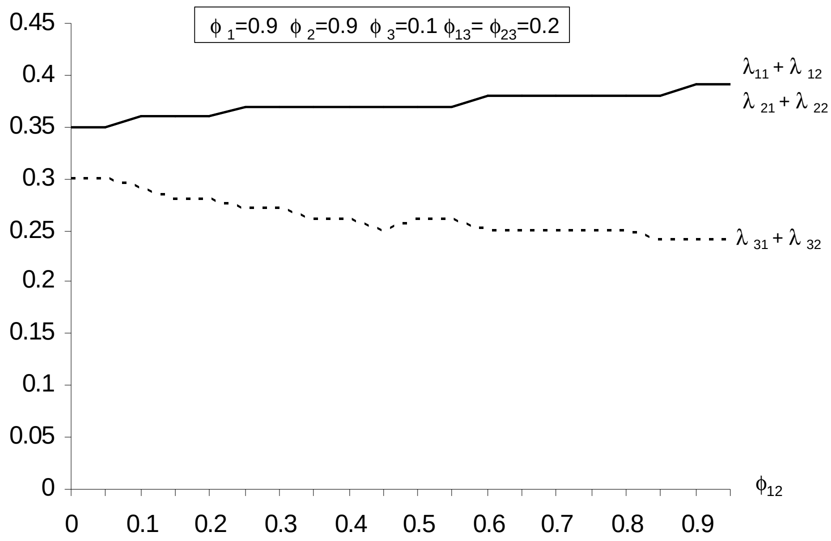

Figure 4: Industrial share in each of the 3 countries.

These three graphs point to three key results. First, country C_1, which possesses the best domestic infrastructure, attracts a higher industrial share to the disadvantage of the two other countries. This result is a confirmation of the findings in Martin and Rogers (1995). Second, an improvement of the domestic infrastructure of country C_2 to the level of the well-endowed RIA

[11] In Figure 4, the curve representing $\lambda_{31} + \lambda_{32}$ depicts a slight non-monotonicity, but this is rather due to computation approximations under GAMS.

member gives a global advantage to the RIA to the disadvantage of the ROW, but a reinforcement of the integration can trigger a divergence process if the domestic infrastructure of the RIA members is not exactly set to the same level. This result extends the findings of Martin and Rogers (1995). Third, these graphs give an insight on why some RIAs collapse. Indeed, as can be seen in Figure 7, for very low intra-RIA trade costs ($\phi_{12} > 0.8$), country C_2 looses all its industrial share and thus totally specializes in agriculture. To avoid this situation, country C_2 has a strong incentive to withdraw from the RIA so as to protect its industrial share like country C_3.

A side result is that a country remaining outside the RIA will see its industrial sector threatened sooner or later by at least the well-endowed RIA member, if not both members. Since the richness of the geography of our model helps us to address the evolution of the principal and the hinterland regions as intra-RIA trade costs are lowered, we dedicate the following subsection to the analysis of the six regions described in Figure 1.

3.2 Evolution of the internal geography of the trading partners

Let us mention that by geography, we mean the industrial share captured by each of the six regions as the intra-RIA trade costs continuously decrease. In our framework, each country has a principal region that is the entry and exit point, and an hinterland region facing domestic trade costs. As in the previous subsection, we focus on three key cases: when $\phi_1 > \phi_3 > \phi_2$, when $\phi_1 > \phi_2 > \phi_3$

and when $\phi_1 = \phi_2 > \phi_3$. Figure 5 illustrates the specific case where $\phi_2 = 0$.

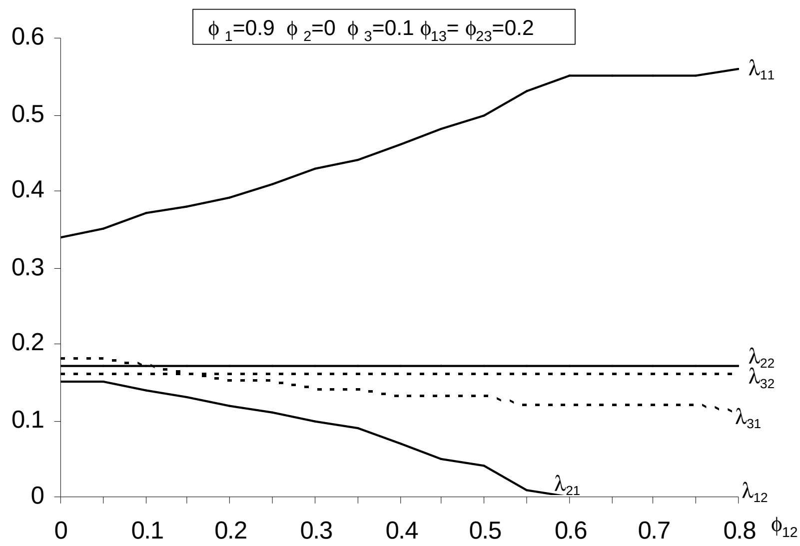

Figure 5: Industrial share in each of the 6 regions.

For this trade costs configuration, the hinterland region of country C_1 totally specializes in the agricultural good since no M-firms are located in this region. In return, region R_1 attracts an increasing industrial share as trade becomes freer within the RIA. In the second RIA country, the M-firms' location is different: the hinterland region captures a constant industrial share while the principal region looses M-firms until total specialization in the A-sector. This result is due to the extreme assumption setting $\phi_2 = 0$. In such a situation, the hinterland region is in autarky and since consumers like variety, some M-firms will locate to this region to supply some industrial good. The country left outside the RIA is a bit protected by the high trade costs with the RIA members ($\phi_{13} = \phi_{23} = 0.2$), but both the principal and the hinterland regions loose some industrial firms to the advantage of country C_1's principal region R_1 as the intra-RIA trade costs are decreased. In country C_3 too, the hinterland region attracts a higher industrial share because of high domestic trade costs. The results are quite different when $\phi_1 > \phi_2 > \phi_3$. Figure 6 illustrates the specific case where ϕ_1=0.9, ϕ_2=0.8 and ϕ_3=0.1.

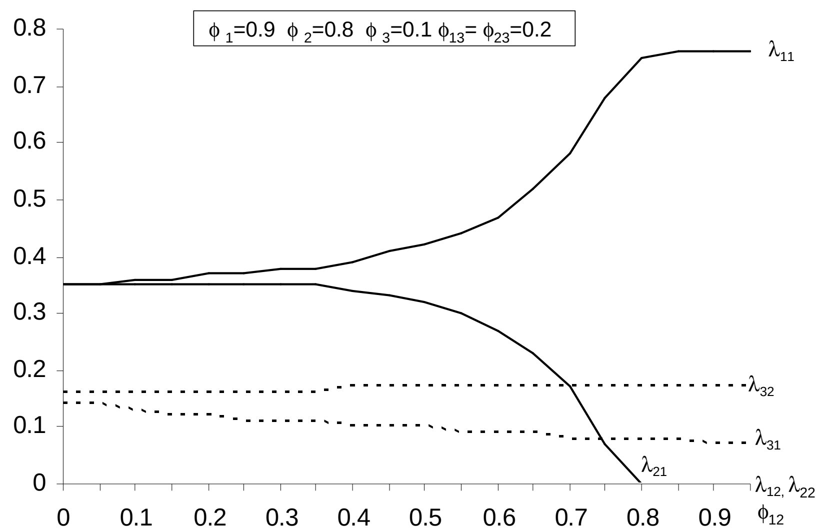

Figure 6: Industrial share in each of the 6 regions.

For this second configuration, the hinterland regions of the two RIA members totally specialize in the A-sector for any level of intra-RIA trade costs. Since domestic infrastructures are good within the RIA, capital owners are better off investing their capital in a "big market" and take advantage of the good intra-RIA accessibility. For very low intra-RIA trade costs, country C_2 looses all its industrial sector to the advantage of the principal region of country C_1. Country C_3 is affected to a lower extent as intra-RIA trade costs are lowered, but its principal region continuously looses some M-firms to the advantage of region R_1 of country C_1 while its hinterland region keeps its industrial share. Here again, high domestic trade costs react as "natural protection" for this hinterland region.

Finally, Figure 7 focuses on the case where $\phi_1 = \phi_2 > \phi_3$.

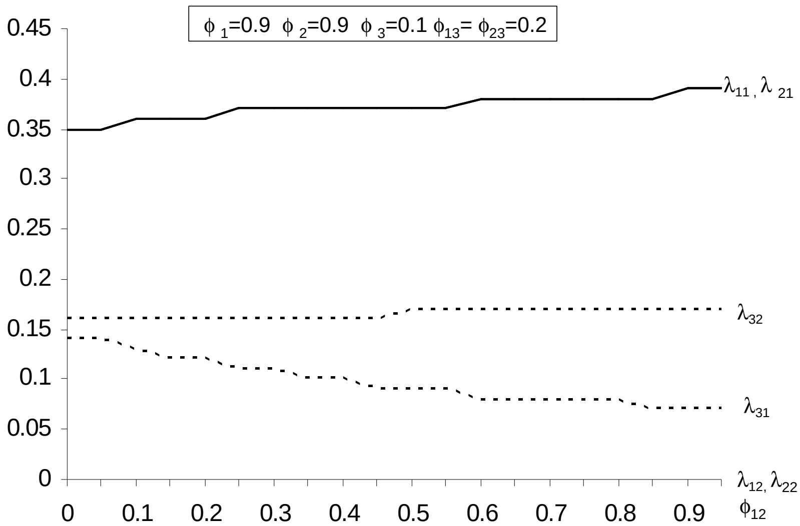

Figure 7: Industrial share in each of the 6 regions.

In this case, hinterland regions within the RIA totally specialize in agriculture, while in return, the principal regions increasingly attract M-firms from the principal region of the country left outside the RIA: at the country level, we have a convergence of the RIA members industrial shares, while at the regional level, we have a divergence between principal and hinterland regions of the RIA members.

These simulations show that a reduction in intra-RIA trade costs favors convergence of the countries forming the RIA only when this is coupled with an improvement of the domestic infrastructures of country C_2 to the level of country C_1. Otherwise, the well-endowed country of the RIA attracts M-firms from its partner and increases its industrial share as intra-RIA trade costs are lowered. Hence, the uneven spread of economic activities observed within some developing RIAs is not a fatality. Paving inter-states roads help to increase intra-RIA trade flows (Coulibaly and Fontagné, 2004), but less developed trading partners also need a common investment policy to improve their domestic infrastructures to the level of the well-endowed members of the RIA.

4 Conclusion

This study is in line with the argument made by Henderson et al. (2001) suggesting that “rigorous theoretical and empirical analysis is needed to increase understanding of the role of geography in development and to better design development policy”. We propose an explanation of the persistent uneven development observed within some developing regional integration areas by focusing on a geography that is characteristic of developing countries: we assume “port-like economies” in which each country comprises a principal region endowed with international infrastructures and an hinterland region. In addition to the two developing countries forming the RIA, the model includes a third (developing) country left out of the integration process so as to evaluate the gains and losses of being a RIA member.

The main result of the paper states that with initial differences in transport infrastructures between the two countries forming the RIA, the integration process will lead to a divergence between the countries. On the contrary, when discrepancies in infrastructure equipment are reduced prior to the reduction in intra-RIA trade costs, the divergence takes place inside each country, between the access and the hinterland region. These results extend the findings by Martin an Rogers (1995) since they examine regional divergence or convergence within a country as the integration process is reinforced. This divergence process at both region and country levels lead to a persistent uneven spread of economic activities that can exacerbate tensions within regions and RIA members, hence collapsing RIAs.

In this paper, we did not focus on the cost-benefit and welfare implications of infrastructure investment. However, the comparative statics of firms relocation as domestic and international trade costs decrease give some insights on the desirability of a harmonization of domestic infrastructures within RIA members, e.g. to ensure them a higher industrial share to the disadvantage of countries left out the RIA, but also for a regional compensation mechanism within each member to help hinterland regions who may lose some of their industrial share as integration proceeds. We however would need a complete policy cost-benefit analysis to evaluate this issue fully.

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