Economic Integration Geography and Growth: A theoritical Analysis

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Abstract
Economic integration plays an important role in trade, in knowledge diffusion and in economic growth. However, this role depends on the geographical distance between countries. The purpose of this paper is to study the geographical distance effects on the advantages of economic integration. To do so we extend the Romer and Rivera Batiz (1991) model by adding the distance between countries. Our main findings are: in the presence of the geographical distance effects (i) the growth rate does not double compared to autarky as in the Romer and Rivera Batiz model, ii) the share of human capital allocated to research sectors increases and (iii) the growth rate in centralized equilibrium is lower than that in decentralized equilibrium.
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1. Introduction

Several economists have shown that geographical proximity influences innovation and research in an open economy. (Grossman and Helpmann (1991), Keller (1997, 2000, 2001, 2002), Eaton and Kortum (2000), Breshi and Malerba (1996), Ben David and Rahman (1996), Maurice et alii (2002, 2004), etc...). The reasons are that the geographical proximity facilitates knowledge transmission across borders. Each country can benefit from the positive externalities if its neighbors are well endowed with R&D. Proximity increases the extent of knowledge transmission through formal and informal means. This is explained by the fact that trade requires transport costs which depend on the geographical distance. Proximity internalizes the technological spillovers and generates an interesting interdependences between the firms operating in the same fields . This role is very important, especially for the transmission of knowledges that require face-to-face interactions. Proximity is an important factor because of the non-rival nature of knowledges that are easily transmitted and with less costs between adjacent units. Indeed, despite the improvement and diversification of ICTs in the world level, face- to- face contacts remain the most important and easiest. However, these contacts are more expensive if geographical distance increases. In these conditions, more tacit knowledges are important more technology diffusion will be geographically concentrated.In terms of upstream and downstream relationship, the technological activities of neighbors reduce trade with very distant partners because the diversity of technological activities in a given geographical region increases the products differentiation and strengthens the relationships between customers and suppliers. It allows the development of new products that compete with those of other geographical areas. In addition, the variety of industries has a positive effect on the technological externalities: externalities are very important when industries are very diversified. Also, technological spillovers from FDI are dependent on the geographical proximity between the foreign and local companies. In this sense, FDI spillovers should first be received by their neighbors before other companies. When FDI workers move to domestic enterprises or when the joint-ventures unveil their products and technologies, the profits are first captured by the neighbors and spread gradually toward other companies more distant. This learning-by-watching effect represents a form of wild imitation which allows domestic firms to benefit from new products, new technologies, new techniques and methods of production, marketing, introduced on the domestic market by FDI (Teece (1977), Aitken and Harrison (1999)). Integration policies show the scope of geographical distance in trade flows and in international knowledge diffusion. Why for example Tunisia is not particularly more interested in an economic integration with Latin America or Asian countries and why the Tunisian policy is more oriented toward the European Union? Why Mexico is not very interested to cooperate with sub-Saharan countries than with USA and Canada ? Why Turkey accepts several concessions at the expense of its cultural and religious values to be a member of the European Union ? Does Turkey accept the same concessions to be a member of a more distant union? Answers to these questions are explained in part by the the geographical distance effetcts on trade between countries. Indeed, it is easier and less expensive for Tunisia to follow and to benefit from European R&D activities than from those of Latin American or Asian countries. Also, it is more interesting for Mexico to integrate with the Latin American countries than with the sub-Saharan ones and it is more profitable for businessmen, workers, exporters and importers in turky to take the European market as their first target. The reference model of economic integration and knowledge diffusion effects on economic growth is that of Romer and Rivera Batiz (**RRB**) (1991). Unfortunately, this model does not consider geographical distance effects. The objective of this paper is to extend the RRB model by adding geographical distance between countries. As in RRB model we assume that the two countries are symmetric everywhere, except for innovations which are different. The

Symmetry refers particularly to the identity of the absorption capacity, the human capital size and the externalities.

2. The Model

Our model is based on that of RRB (1991) . It is a model with two countries (d and f) and three sectors wich are the the final good sector, the intermediate goods sector and the research sector.

2-1) Final good and the intermediate goods sectors

The production function is the same in the the final good and intermediate goods sectors . The production factors are unskilled labor (L), human capital H and a set of intermediate goods produced locally and imported. In terms of production costs, we assume as in RRB model, that one unit of intermediate goods is equivalent to η units of a final good.The quantity produced of each intermediate good is equal to x : the quantity z is consumed locally and the rest (m) is exported to the other country $(x = z + m)$. The stock domestic capital is the sum of all available intermediate goods. In a symmetric equilibrium of two countries ($x_{id} = x_{jd} = x_d$), the expression of the capial stock, in term of the final good, in the country d is the following:

$$K_d = \eta \int_0^{A_d} x_d di = \eta A_d x_d \quad \text{and} \quad x_d = \frac{K_d}{\eta A_d} \tag{1}$$

The production functions in the two countries are the following:

$$Y_d = H_{Yd}^{\alpha} L_d^{\beta} \left[\int_0^{A_d} z(i)^{1-\alpha-\beta} di + \int_0^{e^{-qD_{df}} A_f} m_{df}(j) dj \right] \tag{2-a}$$

$$Y_f = H_{Yf}^{\alpha} L_f^{\beta} \left[\int_0^{A_f} z(j)^{1-\alpha-\beta} dj + \int_0^{e^{-qD_{df}} A_d} m_{fd}(i) di \right] \tag{2-b}$$

Where:

- Y_d and A_d represent respectively the final good production and the number of intermediate goods produced by the country d . A_d represents then the state of its home technology. A_f is the number of intermediate goods produced by the country f ,and Y_f is its production.
- $z(i)$ is the quantity of the intermediate good (i) produced and used by the country d .
- $m_{df}(j)$ is the quantity of the intermediate good (j) imported from the country f and $m_{fd}(i)$ is the quantity of the the intermediate good (i) exported to the country f .

In the following development we are interested only in the country d and the same approach remains valid for the other country.

In the production function q is the key variable $(q \geq 0)$. D_{df} is the distance between countries d and f . The choice of the exponential shape is justified because it permits putting $e^{-qD_{df}}$ between zero and one whatever the distance between the two countries. In an extreme case, if q is equal to zero, then $e^{-qD_{df}}$ is equal to one and both countries are completely opened and the geographical distance has no effect. Really, this is not possible because geographical distance between two countries is never equal to zero. Moreover, geographical distance between countries is measured by distance between Capitals and not by the distance between borders: for example the distance between Tunisia and Libya is equal to the distance between Tunis and Tripoli.

If, $q \succ 0$ then, $e^{-qD_{df}}$ decreases and the proportion of varieties imported by the country d from the country f decreases if the distance between both countries increases. This means that If $q \succ 0$ then, the innovation sector effects of the country f on the production of the country d decline if the distance increases.

In the final good sector, the quantity purchased of each intermediate good corresponds to the equality between its marginal productivity and its price.

$$\frac{\partial Y_d}{\partial z(i)} = (1-\alpha-\beta)H_{Yd}^{\alpha} L_d^{\beta} z(i)^{-\alpha-\beta} = p(z(i)) \qquad (3)$$

$$\frac{\partial Y_d}{\partial m_{df(j)}} = (1-\alpha-\beta)H_{Yd}^{\alpha} L_d^{\beta} m_{df}(j)^{-\alpha-\beta} = p(m_{df}(j)) \qquad (4)$$

In the intermediate goods sector, each producer must pay a variable cost to productive factors and a fixed cost (equals to the price of a patent) to the domestic or foreign research sectors ($p_A(i)$). The total cost of the production of the intermediate good i in country d is:

$$TC(x(i)) = \eta x(i) + P_A(i) = \eta(z(i) + m_{fd}(i)) + p_A(i) \qquad (5)$$

Intermediate goods have no deprecation and the price of each good is equals to the rent paid by the final good sector. In these conditions, the total revenues of the monopolist of intermediate good i on the domestic and foreign markets are:

$$RT(z(i)) = \int_0^{\infty} p(z(i))\, z(i) e^{-r_t^d} dt = \frac{p(z(i))\, z(i)}{r^d} \qquad (6)$$

$$RT(m_{fd}(i)) = \int_0^{\infty} p(m_{fd}(i)) m_{fd}(i) e^{-r_t^d} dt = \frac{p(m_{fd}(i)) m_{fd}(i)}{r^d} \qquad (7)$$

r^d is the interest rate in the country d . The total profit of the monopolist is:

$$\pi(x(i)) = \frac{p(z(i))z(i) + p(m_{fd}(i))m_{fd}(i)}{r^d} - \eta(z(i) + m_{fd}(i)) - p_A(i) \qquad (8)$$

The maximization of this profit implies

$$\frac{\partial \pi(x(i))}{\partial z(i)} = 0 \Leftrightarrow \frac{\partial p(z(i))z(i)}{\partial z(i)} + p(z(i)) = \eta r^d \qquad (9)$$

$$\frac{\partial \pi(x(i))}{\partial m_{fd}(i)} = 0 \Leftrightarrow \frac{\partial p(m_{fd}(i))m_{fd}(i)}{\partial m_{fd}(i)} + p(m_{fd}(i)) = \eta r^d \qquad (10)$$

From the previous analysis we determine the equilibrium quantities $z(i)$ and $m_{fd}(i)$ and their prices:

$$z(i) = \left[\frac{\eta r^d}{(1-\alpha-\beta)^2 H_{Yd}^{\alpha} L_d^{\beta}}\right]^{\frac{-1}{\alpha+\beta}} \quad \text{and} \quad p(z(i)) = \frac{\eta r^d}{1-\alpha-\beta} \qquad (11)$$

$$m_{fd}(i) = \left[\frac{\eta r^d}{(1-\alpha-\beta)^2 H_{Yd}^{\alpha} L_d^{\beta}}\right]^{\frac{-1}{\alpha+\beta}} \quad \text{and} \quad p(m_{fd}(i)) = \frac{\eta r^d}{1-\alpha-\beta} \qquad (12)$$

2-2. The balance of Trade equilibrium

Trade between the two countries depends only on the exchange of intermediate goods. The final good is non-exchangeable. Trade equalizes the equilibrium present prices of all intermediate goods in the two countries. The equality of these prices and that of the production elasticities of intermediate goods ($(1-\alpha-\beta)$) generate the equality of all demanded quantities.

For each country, trade equilibrium is equivalent to the equality between its imports and its exports. If the country d produces A_d varieties of intermediate goods and exports to the country f , then the total volume of its exports X_d when we consider the geographical diatance is:

$$X_d = \int_0^{e^{-qD_{df}} A_d} m_{fd}(i) di = e^{-qD_{df}} A_d m_{fd} \qquad (13)$$

In a symmetric equilibrium, $p_d(i) = p_d$ and $m_{fd}(i) = m_{fd}$. In these conditions, the nominal value of total exports X_d^N is:

$$X_d^N = p_d X_d = p_d e^{-qD_{df}} A_d m_{fd} \qquad (14)$$

The total volume of imports of the country d is

$$M_{df} = \int_0^{-e^{-qD_{df}} A_f} m_{df}(j)dj = e^{-qD_{df}} A_f m_{df} \qquad (15)$$

The total nominal value of imports M_{df}^N is

$$M_{df}^N = p_f M_{df} = p_f e^{-qD_{df}} A_f m_{df} \qquad (16)$$

The equality of exports and imports in country d implies the following condition of Trade balance equilibrium.

$$A_d p_d m_{fd} = p_f A_f m_{df} \qquad (17)$$

Since the final and intermediate goods sectors use the same production function, then they can be combined in a single sector. Thus, in the following analysis , we distinguish only between two sectors which are the research sector and another one of production.

2-3. The Knowledge accumulation

The research sector accumulates innovations using human capital and the stock of available knowledge (domestic and foreign). With the geographical distance variable, the knowledge accumulation function in the country d is the following

$$\dot{A}_d = \delta H_{dA}\left(A_d + e^{-qD_{df}} A_f\right) \qquad (18)$$

H_{dA} is the share of human capital allocated to the research sector in the country d

Researchers sell their innovations to intermediate goods producers at a price p_{dA} wich is a patent price and corresponds to a zero profit in the intermediate goods sector (arbitration condition). In these conditions, the profit equation is:

$$\pi(\bar{x}) = \frac{p(\bar{x}_d)(z + m_{fd})}{r^d} - \eta(z + m_{fd}) - p_{Ad} = \frac{p(\bar{x}_d)\bar{x}_d}{r^d} - \eta\bar{x}_d - p_{Ad} \qquad (19)$$

Replacing η by its expression from the equilibrium price $p(\bar{x}_d)$, the expression of p_{Ad} can be identified:

$$p_{Ad} = \frac{(\alpha + \beta)}{r^d} p(\bar{x}_d)\bar{x}_d \qquad (20)$$

2-4. Household Behaviors

As in the RRB model we assume that households in two countries have the same preferences and maximize the following inter-temporal utility function.

$$U = \int_0^{\infty} u(c)e^{-\rho t}dt \quad \text{and } u(c) = \frac{c^{\sigma-1} - 1}{1-\sigma} =, \ \sigma \in [0, +\infty] \qquad (21)$$

Where c is the consumption, ρ is the preference rate for present and σ the inverse of the inter-temporal elasticity substitution. Households choose between consumption and saving. The interest rate is assumed to be the same in the two countries because trade equalizes the return rates of capital in the two countries ($r^d = r^f = r$). Taking into account the prefrences of housholds, the growth rate g is given by the Ramsey-Keynes condition $g = \frac{1}{\sigma}(r - \rho)$.

In what following, we determine the growth rate given by the supply conditions. We distinguish between decentralized equilibrium and centralized equilibrium.

2-5. The Decentralized equilibrium and Allocation of the human capital:

Researchers decide to work in the sector where they are better paid. In equilibrium, the human capital mobility implies the equality of its marginal productivity in all sectors. The marginal productivity of human capital in the production sectors is:

$$MPH_{Yd} = \alpha H_{Yd}^{\alpha-1} L_d^{\beta} \left[\int_0^{A_d} z(i)^{1-\alpha-\beta} di + \int_0^{e^{-qD_{df}} A_f} m_{df}(j) dj \right] \tag{22}$$

The marginal productivity of human capital in the research sector is:

$$MPH_{dA} = P_A \delta \left(A_d + e^{-qD_{df}} A_f \right) \tag{23}$$

Since $z(i) = m(j)$ then, equality of the marginal productivity of human capital in all sectors implies

$$\alpha H_{Yd}^{\alpha-1} L_d^{\beta} z^{1-\alpha-\beta} = \delta p_A \tag{24}$$

As we replace the patent price by its expression, the previous equation becomes

$$\alpha H_{Yd}^{\alpha-1} L_d^{\beta} z^{1-\alpha-\beta} = \delta \frac{(\alpha+\beta)}{r^d} p(\bar{x}_d)\bar{x}_d \tag{25}$$

Using the Trade balance equilibrium and the symmetrical equilibrium of intermediate goods sectors in the two countries($z = m_{fd} = m_{df}$) , we can deduct the following relationship between x and z

$$x = \frac{A_d + e^{-qD_{df}} A_f}{A_d} z \tag{26}$$

This relationship implies that the intermediate goods production is more important in the openenness than in the autarky. The difference is more important when the size of foreign research activity is also important (A_f). In the autarky, the intermediate goods sector produces only to satisfy the local market ($x = z$). This result shows that trade has a level effect on the intermediate goods production. But even in the case of openness, the intermediate goods production decreases if the geographical distance impedes trade (qD_{df} increases). By using the relationship between x and z and the equation which equalizes the marginal productivities of human capital in all the sectors, we deduce:

$$\alpha H_{Yd}^{1-\alpha} L_d^{\beta} z^{1-\alpha-\beta} = \delta \frac{(\alpha+\beta)}{r^d} p(x) \frac{\left(A_d + e^{-qD_{df}} A_f\right)}{A_d} z \tag{27}$$

Since $p(x) = p(z)$, when we replace $p(z)$ and z by their equilibrium values ,we can determine the share of human capital allocated to the final good and inermediate goods sectors:

$$H_{Yd} = \frac{\alpha r^d A_d}{\delta(\alpha+\beta)(1-\alpha-\beta)\left(A_d + e^{-qD_{df}} A_f\right)} \tag{28}$$

This equation shows that the human capital allocation depends on the geographical distance between both countries. Indeed, the share of human capital allocated to the final good and intermediate good sectors becomes more important as the geographical distance increases. Since the human capital is constant, then this also means that the share of human capital allocated to the research sector is more low if the two countries are very distant.

The knowledge accumulation rate.

In each country, the knowledge accumulation depends on the domestic stock of knowledge and on the knowledge imported from the other country.

$$\frac{\overbrace{A_d + e^{-qD_{df}} A_f}^{\bullet}}{A_d + e^{-qD_{df}} A_f} = \frac{\dot{A}_d + e^{-qD_{df}} \dot{A}_f}{A_d + e^{-qD_{df}} A_f} \tag{29}$$

By using the knowledge accumulation function in each country, we can express the knowledge evolution according to the shares of the human capital allocated to the research sectors in the two countries, that is:

$$\frac{\overbrace{A_d + e^{-qD_{df}} A_f}^{\bullet}}{A_d + e^{-qD_{df}} A_f} = \delta\left(H_{Ad} + e^{-qD_{df}} H_{Af}\right) \tag{30}$$

This equation implies that if both countries are very distant then the knowledge evolution in the country d depends less on the human capital allocated to the research sector of the country f. Indeed, if the geographical distance between two countries is relatively high, then the term $e^{-qD_{df}} H_{Af}$ becomes weak.

The growth rates in both countries:

$$g_d = \delta\left(H_{Ad} + e^{-qD_{df}} H_{Af}\right) \quad \text{(31-a)}$$

$$g_f = \delta\left(H_{Af} + e^{-qD_{df}} H_{Ad}\right) \quad \text{(31-b)}$$

In each country, the growth rate depends on the geographical distance between the two countries. The main contribution of our model compared to that of RRB (1991) is when the effect of the geographical distance exists $(q \succ 0)$ then the growth rate is the same in the two countries but does not double compared to autarky. Indeed, when $q \succ 0$ then $e^{-qD_{df}} \prec 1$, Therefore:

$$g_d = \delta\left(H_{Ad} + e^{-qD_{df}} H_{Af}\right) < \delta\left(2H_{Ad}\right) \quad \text{(32-a)}$$

$$g_f = \delta\left(H_{Af} + e^{-qD_{df}} H_{Ad}\right) < \delta\left(2H_{Af}\right) \quad \text{(32-b)}$$

The growth rate does not double compared to the autarky because the geographical distance prevents each country to benefit fully from the human capital allocated by the other country to its research sector. If the distance effect is total ($e^{-qD_{df}} = 0$) then the integration between the two countries has no growth effect and each country regain its growth rate of autarky.

$$g_d = \delta\left(H_{Ad}\right) \quad \text{(33-a)}$$

$$g_f = \delta\left(H_{Af}\right) \quad \text{(33-b)}$$

However, if $q=0$, then growth rate in each country double compared to the autarky and our model will be equivalent to that of RRB (1991).

$$g_d = \delta\left(H_{Ad} + H_{Af}\right) = \delta\left(2H_{Ad}\right) \quad \text{(34-a)}$$

$$g_f = \delta\left(H_{Af} + H_{Ad}\right) = \delta\left(2H_{Af}\right) \quad \text{(34-b)}$$

Result 1*: Economic integration between two symmetrical countries does not double the growth rate in each country compared to autarky as long as the geographical distance plays a negative effect.*

2-6. Effects on growth:

Using equation 28, the fact that $g = \frac{1}{\sigma}(r - \rho)$ and the equality of interest rates in two countries, then the growth rate with the geographical distance parameter is:

$$g_d = \frac{\delta\left(H_d + e^{-qD_{df}} H_f\right) - \lambda\rho}{1 + \lambda\sigma} \quad \text{where} \quad \lambda = \frac{\alpha}{(1-\alpha-\beta)(\alpha+\beta)} \quad (35)$$

The growth rate depends negatively on the geographical distance because each country benefits less from the human capital of its partner when the geographical distance is high.

The final good production function in the country d can be expressed as following

$$Y_d = H_{Yd}^{\alpha} L_d^{\beta} \left[\frac{K_d}{\eta}\right]^{1-\alpha-\beta} \left[A_d + e^{-qD_{df}} A_f\right]^{\alpha+\beta} \quad (36)$$

This expression shows a level effect which depends on the number of imported intermediate goods. This level effect depends negatively on the geographical distance. Indeed, the final good production in country d declines if the geographical distance between the two countries increases.

The coefficient $\left[\frac{A_d + e^{-qD_{df}} A_f}{A_d}\right]^{\alpha+\beta}$ which represents the level effect is a decreasing function of the distance variable. In an extreme case, if the geographical distance prevents completely trade then the previous coefficient is equal to one and we find Romer (1990) model for an economy in autarky, that is:

$$Y_d = H_{Yd}^{\alpha} L_d^{\beta} \left[\frac{K_d}{\eta} \right]^{1-\alpha-\beta} A_d^{\alpha+\beta} \quad (37)$$

2-7. The Centralized equilibrium :

In a centralized equilibrium our model imply the following results:

The human capital allocation : the share of the human capital allocated by two independent central planners (without coordination) in both countries are (see appendix):

$$H_{Ad}^{op} = \frac{(\alpha+\beta)\delta H_d - \alpha\rho}{(\alpha\sigma+\beta)\delta} - \frac{\alpha\sigma e^{-qD_{df}} H_{Af}^{op}}{(\alpha\sigma+\beta)} \quad (38\text{-a})$$

$$H_{Af}^{op} = \frac{(\alpha+\beta)\delta H_f - \alpha\rho}{(\alpha\sigma+\beta)\delta} - \frac{\alpha\sigma e^{-qD_{df}} H_{Ad}^{op}}{(\alpha\sigma+\beta)} \quad (38\text{-b})$$

According to these equations, the share of the human capital oriented to the research sector in each country is an increasing function of the geographical distance. Indeed, H_{Ad}^{op} and H_{Af}^{op} increase when $e^{-qD_{df}}$ decreases that is when the geographical distance is important.

If we consider the two previous expressions as reaction functions of two central planners, we can say that each central planner must rely less on the share of the human capital allocated to the research sector in the other country. This means that, each central planners must reduce its opportunist behaviour to benefit from the allocation of the human capital in the other country. We distinguish two extreme cases:

If the geographical distance has no effect on bilateral trade between the two countries ($q=0$), the two reaction functions will be:

$$H_{Ad}^{op} = \frac{(\alpha+\beta)\delta H_d - \alpha\rho}{(\alpha\sigma+\beta)\delta} - \frac{\alpha\sigma H_{Af}^{op}}{(\alpha\sigma+\beta)} \quad (39\text{-a})$$

$$H_{Af}^{op} = \frac{(\alpha+\beta)\delta H_f - \alpha\rho}{(\alpha\sigma+\beta)\delta} - \frac{\alpha\sigma H_{Ad}^{op}}{(\alpha\sigma+\beta)} \quad (39\text{-b})$$

In this case, the opportunist behavior of the central planner is maximum and it can save the maximum of human capital that would have been allocated to the domestic research sector. Indeed, when $q=0$ then $e^{-qD_{df}} = 1$ and the share of human capital allocated to the domestic research sector is minimal.

In the other extreme case, if the geographical distance prevents completely the bilateral trade between the two countries ($e^{-qD_{df}}$ equals zero), then the two reaction functions show the higher share of the human capital allocated to the domestic research sector in each economy.

This is explained by the fact that each central planner cannot benefit from the human capital allocated to the research sector in the other country .In this case, the centralized equilibrium is equivalent to that of autarky and we find the same result as Romer (1990).

$$H_{Ad}^{op} = \frac{(\alpha+\beta)\delta H_d - \alpha\rho}{(\alpha\sigma+\beta)\delta} \quad (40\text{-a})$$

$$H_{Af}^{op} = \frac{(\alpha+\beta)\delta H_f - \alpha\rho}{(\alpha\sigma+\beta)\delta} \quad (40\text{-b})$$

When we compare the human capital allocation without and with geographic distance we find the following inequalities:

$$H_{Ad}^{op} = \frac{(\alpha+\beta)\delta H_d - \alpha\rho}{(\alpha\sigma+\beta)\delta} - \frac{\alpha\sigma e^{-qD_{df}} H_{Af}^{op}}{(\alpha\sigma+\beta)} > \frac{(\alpha+\beta)\delta H_d - \alpha\rho}{(\alpha\sigma+\beta)\delta} - \frac{\alpha\sigma H_{Af}^{op}}{(\alpha\sigma+\beta)} \quad (41\text{-a})$$

$$H_{Af}^{op} = \frac{(\alpha+\beta)\delta H_f - \alpha\rho}{(\alpha\sigma+\beta)\delta} - \frac{\alpha\sigma e^{-qD_{df}} H_{Ad}^{op}}{(\alpha\sigma+\beta)} > \frac{(\alpha+\beta)\delta H_f - \alpha\rho}{(\alpha\sigma+\beta)\delta} - \frac{\alpha\sigma H_{Ad}^{op}}{(\alpha\sigma+\beta)} \quad (41\text{-b})$$

Graphically, the non-co-operative equilibrium of two planners when we consider the geographical distance, implies that the two reaction functions intersect in a point which gives, in each country, the higher share of human capital allocated to research sector.

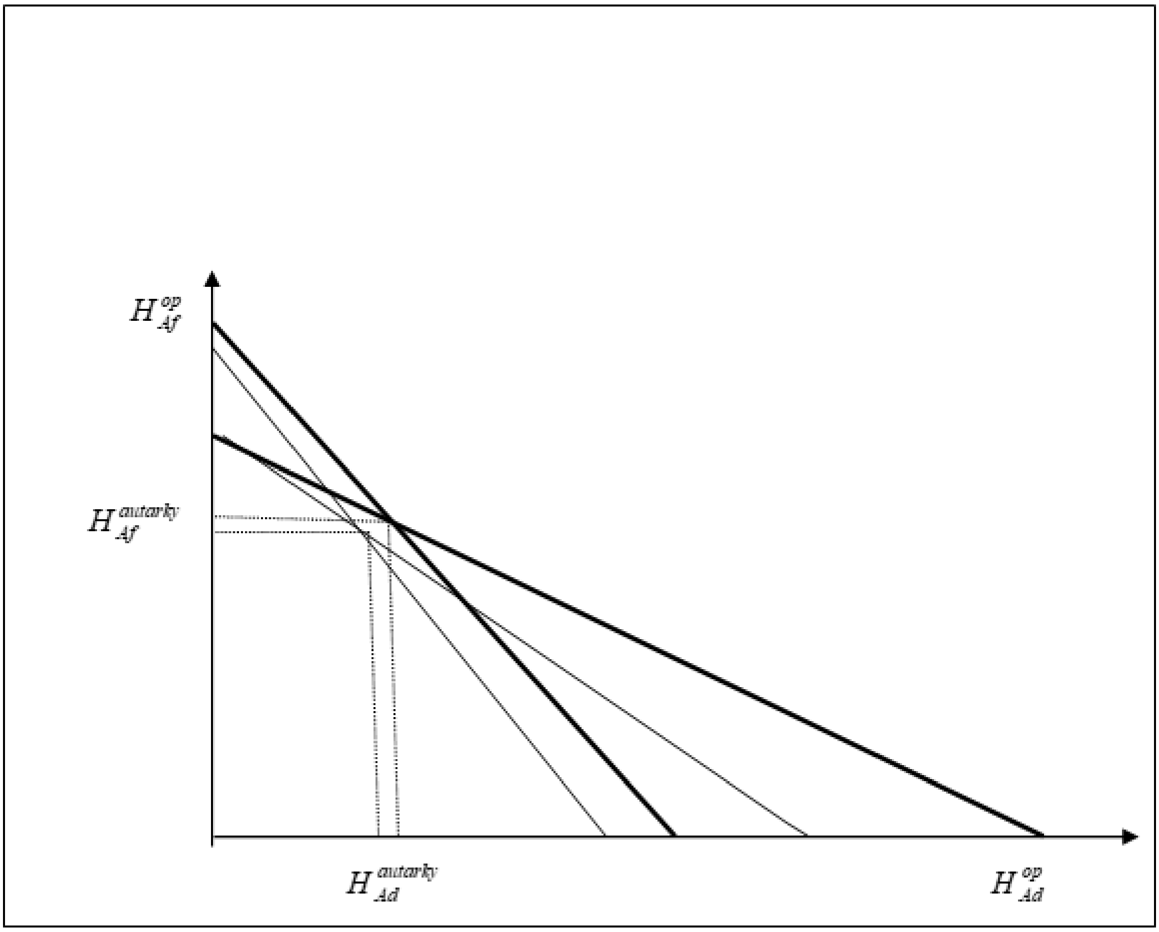

Chart 1: Geographical distance effects on the human capital allocation toward the research sectors.

With the geographical distance effetct, the intersection of the two curves in bold represents the solutions of the centralized equilibrium without coordination between the two planners.

In contrast, the intersection of two other curves give the solutions of the same equilibrium when geographic distance has no effect on bilateral trade. It is clear that the share of human capital allocated to the research sector by each central planner increases if the geographical distance reduces the trade between the two countries. In this case, each planner accounts less on the foreign allocation of the human capital and adopts a less opportunist behavior.

If the two countries have the same level and the same allocation of the human capital then, the shares of this factor allocated to the research sectors in the two countries in a centralized equilibrium with the geographical distance are the following:

$$H_{Ad}^{op} = \frac{(\alpha+\beta)\delta H_d - \alpha\rho}{\left[\alpha\sigma\left(1+e^{-qD_{df}}\right)+\beta\right]\delta} \qquad (42\text{-a})$$

$$H_{Af}^{op} = \frac{(\alpha+\beta)\delta H_f - \alpha\rho}{\left[\alpha\sigma\left(1+e^{-qD_{df}}\right)+\beta\right]\delta} \qquad (42\text{-b})$$

If the geographical distance does not interfere completely the bilateral trade between the two countries, then the level of human capital, allocated to the research sector in each country, remains lower than its level in a centralized equilibrium of autarky but it is superior to the solution of a centralized equilibrium that ignores the geographical distance effect. Indeed,

if $0 \le e^{-qD_{df}} \le 1$ then $1 \le 1+e^{-qD_{df}} \le 2$ and therefore :

$$\frac{(\alpha+\beta)\delta H_d - \alpha\rho}{(2\alpha\sigma+\beta)\delta} < \frac{(\alpha+\beta)\delta H_d - \alpha\rho}{\left[\alpha\sigma\left(1+e^{-qD_{df}}\right)+\beta\right]\delta} < \frac{(\alpha+\beta)H_d - \alpha\rho}{(\alpha\sigma+\beta)\delta} \qquad (43\text{-a})$$

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$$\frac{(\alpha+\beta)\delta H_f-\alpha\rho}{(2\alpha\sigma+\beta)\delta} < \frac{(\alpha+\beta)\delta H_f-\alpha\rho}{\left[\alpha\sigma\left(1+e^{-qD_{df}}\right)+\beta\right]\delta} < \frac{(\alpha+\beta)H_f-\alpha\rho}{(\alpha\sigma+\beta)\delta} \qquad \text{(43-b)}$$

These two inequalities compare human capital levels allocated to the research sector, in countries d and f, in the following cases:
- Centralized equilibrium in the open economy without the geographical distance (the term to the left of the each inequality).
- Centralized equilibrium in the open economy with the geographical distance (the term in the middle of the each inequality).
- Centralized equilibrium in autarky (the term on the right each inequality).

These inequalities show that if the effect of the geographical distance increases ($e^{-qD_{df}}$ converge to zero), then human capital allocation will converge to its level of autarky. This also means that as the geographical distance impedes the bilateral trade, each central planner cannot reduce the share of human capital allocated to the research sector.
We show that the geographical distance, in a no-cooperative centralized equilibrium, has a positive effect on the world human capital allocation to the research sector because it prevents the opportunist behavior of each central planner. Indeed, in our model, the global human capital allocation (the sum of the two countries allocation) to research sectors is:

- If the geographical distance impedes the bilateral trade between the two countries

$$H_{A(dis\tan ce)}^{World} = \frac{(\alpha+\beta)\delta\left(H_d+H_f\right)-2\alpha\rho}{\left[\alpha\sigma\left(1+e^{-qD_{df}}\right)+\beta\right]\delta} \qquad (44)$$

- If the geographical distance has no effect on bilateral trade between the two countries:

$$H_A^{World} = \frac{(\alpha+\beta)\delta\left(H_d+H_f\right)-2\alpha\rho}{(2\alpha\sigma+\beta)\delta} \qquad (45)$$

- If the two countries are in autarky:

$$H_{A(Autarky)}^{World} = \frac{(\alpha+\beta)\delta\left(H_d+H_f\right)-2\alpha\rho}{(\alpha\sigma+\beta)\delta} \qquad (46)$$

The comparison of these equations shows that the share of human capital allocated to the research sector in the world is higher if the geographical distance impedes Trade. This share reached its maximum in the absence of trade between countries.

$$\frac{(\alpha+\beta)\delta\left(H_d+H_f\right)-\alpha\rho}{(2\alpha\sigma+\beta)\delta} < \frac{(\alpha+\beta)\delta\left(H_d+H_f\right)-\alpha\rho}{\left[\alpha\sigma\left(1+e^{-qD_{df}}\right)+\beta\right]\delta} < \frac{(\alpha+\beta)\delta\left(H_d+H_f\right)-\alpha\rho}{(\alpha\sigma+\beta)\delta} \qquad (47)$$

This implies

$$H_A^{World} < H_{A(dis\tan ce)}^{World} < H_{A(Autarky)}^{World} \qquad (48)$$

Since the two countries are symmetric and have the same human capital allocation (as in RRB model (1991)), the growth rate of the centralized equilibrium in each country depends on the centralized allocation of human capital, that is:

$$g_d^{cemtralised} = \delta\left(H_{Ad}^{op}+e^{-qD_{df}}H_{Af}^{op}\right) < \delta\left(2H_{Ad}^{op}\right) < \delta\left(2H_{Ad}\right) \qquad \text{(49-a)}$$

$$g_f^{centralized} \quad g_f^{centralised} = \delta\left(H_{Af}^{op}+e^{-qD_{df}}H_{Ad}^{op}\right) < \delta\left(2H_{Af}^{op}\right) < \delta\left(2H_{Af}\right) \qquad \text{(49-b)}$$

These two expressions show, in each country, the three following results:
- first, if the geographical distance impedes the bilateral trade , then the growth rate of centralized equilibrium is lower than the growth rate of decentralized equilibrium.
- second, the growth rate in centralized equilibrium and in decentralized equilibrium does not double after the openness.
- finally, since geographical distance has the same effect on the two countries, so they have the same growth rate in the cases of the centralized equilibrium and in the decentralized equilibrium.

The equalisation between the growth rate which follows from the supply conditions and that given by the demand conditions ($g=\frac{1}{\sigma}(r-\rho)$) , imply in each country these following growth rates:

- If the geographical distance impedes the bilateral trade between the two countries, the growth rate is:

$$g_{distance} = \frac{(\alpha + \beta)\delta(H_d + H_f) - 2\alpha\rho}{\left[\alpha\sigma\left(1 + e^{-qD_{df}}\right) + \beta\right]} \quad (50)$$

- If the geographical distance has no effect then the growth rate is:

$$g = \frac{(\alpha + \beta)\delta(H_d + H_f) - 2\alpha\rho}{(2\alpha\sigma + \beta)} \quad (51)$$

Result *2:* If the geographical distance impedes the bilateral trade , then the growth rate of centralized equilibrium is lower than the growth rate of decentralized equilibrium.

Comparison between equations 50 and 51 shows that centralized growth increases if the geographical distance increases which seems rather curious and needs an explanation. In this model, growth depends on the share of human capital allocated to the research sector. However, we have shown that in a non-co-operative centralized equilibrium, and when the geographical distance effect is low, then planners will adopt an opportunist behaviors and allocate less of human capital to the domestic research sector. But , if distance impedes bilateral trade, then the opportunist behaviour becomes low and human capital allocation in favor of research sector becomes relatively more important. At the same state, growth increases as a function of distance because it implies a high share of human capital, allocated to the research sector.

3. Conclusion

In this paper we have extended the RRB (1991) model to study the geographical distance effects on the economic integration benefits . We have shown theoretically that geographical distance reduces economic integration effects on the economic growth, on the world allocation of human capital and on the research activities. In addition, the geographical distance effects create a sub-optimal centralized equilibrium.

References

Aitken B. J. and Harrison A. E. (1999) "Do Domestic Firms Benefit from Direct Foreign Investment? Evidence from Venezuela", *American Economic Review, 89(3) pp 605-618*

Andrea Ascani, Riccardo Crescenzi, Simona Iammarino (2012) " New Economic Geography and Economic Integration: A Review. " WP1/02 Search Working Paper.

Ben David D. and Rahman A. (1996) "Technological Convergence and International Trade", *CEPR, Discussion paper 1359.*

Breshi and Malerba (1996) "Sectoral Innovation Systems" *in C Edquist (eds) Systems of Innovation: Theory and Evidence, Oxford University Press*

Eaton J. and Kortum S. (2000) "Technology Geography and Trade" *Econometrica, 70(5)*

Grossman G. M. and Helpman E. (1991) "*Innovation and Growth in the Global Economy" MIT Press, Cambridge, Massachusetts.*

Keller W. (1997) "Technology Flows Between Industries: Identification and Productivity Effects", *Economic Systems Research, 9 pp 213-220.*

Keller W. (2001) «Knowledge Spillovers at World's Technology Frontier", *NBER Working paper N°8150.*

Keller W. (1998) "Are International R&D Spilloves Trade-Related? Analysing Spillovers Among Randomly Matched Trade Partners", *European Economic Review, 42 pp 1469-1481.*

Keller W. (2004) "International Technology Diffusion" , *Journal of Economics Literature, 42 pp 752-782*

Keller W. (1999) "How Trade Patterns and Technology Flows Affect Productivity Growth?, *NBER working paper series N° 6990.*

Keller W. (2002) "Trade and the Transmission of Technology", *Journal of Economic Growth, 7, 5-24.*

Keller W. (2000) "Do Trade Partners and Technology Flows Affect Productivity Growth? *World Bank Economic Review 14 pp 17-47.*

Keller W. (2002) "Geography Localization of International Technology Diffusion", *American Economic Review, 92 pp 120-142.*

Maurice S. Wang Y. and Olarrega M. (2002) "North-South and South-South Trade-Related Technology Diffusion: An Industry Level Analysis", *Policy Research Working Paper N 2861 World Bank.*

Maurice S. and Wang Y. (2004) "On the Quantity and Quality of Knowledge, the Impact of Openness and Foreign R&D on North-North and North-South Technology Spillovers", *World Bank Policy Research Working paper N°3190.*

Maurice S. and Wang Y. (2004) "Regional Integration and Technology Diffusion: The case of NAFTA", *World Bank.*

Maurice S. and Wang Y. (2004) "North South Technology Diffusion Regional Integration and the Dynamics of

Natural Trading Partners Hypothesis", *Discussion Paper N°1384.*

Maurice S., Wang Y. and Olarreaga M. (2002) "Trade- Related Technology Diffusion and the Dynamics of North- South and South-South Integration", *World Bank Policy Research Working paper N°2861.*

Romer P. (1990) "Endogenous Technical Change", *Journal of Political Economy, 98(5) pp 71- 102.*

Romer P. and Rivera-Batiz L. A. (1991a) "Economic Integration and Endogenous Growth" *Quarterly Journal of Economics, 106 pp 531-555.*

Romer P. and Rivera Batiz L. A. (1991b) "International Trade whit Endogenous Technical Change" European *Economic Review, 35 pp 971-1001.*

Teece, D. (1977) "Technology Transfer by Multinational Firms: The Resource cost Transferring Technological Know-how", *Economic Journal, 87 pp 242-261.*

Appendix: Human capilal allocation by the central planner in country d

The program maximisation of central planner in the country d is:

$$\max \int_0^\infty \frac{c^{1-\sigma}-1}{1-\sigma} e^{-\rho t} dt$$

S/C $\dot{K}_d = (H_d - H_{dA})^\alpha L_d^\beta \left[\frac{K_d}{\eta}\right]^{1-\alpha-\beta} \left[A_d + e^{-qD_{df}} A_f\right]^{\alpha+\beta} - c$ (a)

$$\dot{A}_d = \delta H_{dA}\left(A_d + e^{-qD_{df}} A_f\right) \quad \text{(b)}$$

$$H_d = H_{Yd} + H_{dA} \quad \text{(c)}$$

To resolve this program we use the Hamiltonian,:

$$H = e^{-\rho t}\frac{c^{1-\sigma}-1}{1-\sigma} + \lambda_1\left[(H_d - H_{dA})^\alpha L_d^\beta \left(\frac{K_d}{\eta}\right)^{1-\alpha-\beta}\left(A_d + e^{-qD_{df}} A_f\right)^{\alpha+\beta} - c\right] + \lambda_2 \delta H_{dA}\left(A_d + e^{-qD_{df}} A_f\right)$$

λ_1 et λ_2 are the present implicit prices of capital and knowledges.

$\lambda_1 = e^{-\rho t}u_1$ and $\lambda_2 = e^{-\rho t}u_2$

c and H_{dA} are the control variables. K_d and A_d are the state variables.

The first order conditions are:

$$\frac{dH}{dc} = e^{-\rho t}c^{-\sigma} - \lambda_1 = 0 \quad (1)$$

$$\frac{dH}{dH_{Ad}} = -\lambda_1\left[\alpha(H_d - H_{Ad})^{\alpha-1} L_d^\beta \left(\frac{K_d}{\eta}\right)^{1-\alpha-\beta}\left(A_d + e^{-qD_{df}} A_f\right)^{\alpha+\beta}\right] + \lambda_2\delta\left(A_d + e^{-qD_{df}} A_f\right) = 0 \quad (2)$$

$$\frac{-dH}{dK_d} = -\lambda_1\left[\frac{(1-\alpha-\beta)}{\eta}(H_d - H_{Ad})^\alpha L_d^\beta \left(\frac{K_d}{\eta}\right)^{-\alpha-\beta}\left(A_d + e^{-qD_{df}} A_f\right)^{\alpha+\beta}\right] = \dot{\lambda}_1 \quad (3)$$

$$\frac{-dH}{dA_d} = -\lambda_1\left[(\alpha+\beta)(H_d - H_{Ad})^\alpha L_d^\beta \left(\frac{K_d}{\eta}\right)^{1-\alpha-\beta}\left(A_d + e^{-qD_{df}} A_f\right)^{\alpha+\beta-1}\right] - \lambda_2\delta H_{Ad} = \dot{\lambda}_2 \quad (4)$$

Transversality conditions are:

When $t \longrightarrow +\infty$ then $\lambda_1 K_d e^{-\rho t} = 0$ and $\lambda_2 A_d e^{-\rho t} = 0$

Equation (2) implies:

$$u_1\left[\alpha(H_d - H_{Ad})^{\alpha-1} L_d^\beta \left(\frac{K_d}{\eta}\right)^{1-\alpha-\beta}\left(A_d + e^{-qD_{df}} A_f\right)^{\alpha+\beta}\right] = u_2\delta\left(A_d + e^{-qD_{df}} A_f\right) \quad (5)$$

For a given values of H and L:

$$\frac{\dot{u}_1}{u_1} + (1-\alpha-\beta)\frac{\dot{K}_d}{K_d} = \frac{\dot{u}_2}{u_2} + (1-\alpha-\beta)\frac{\dot{A}_d}{A_d} \quad (6)$$

the path of balanced growth implies that the stock of capital and that of knowledge increase in the same rate:

$$\frac{\dot{K}}{K} = \frac{\dot{A}}{A}$$

In these conditions, equation (6) implies:

$$\frac{\dot{u}_1}{u_1} = \frac{\dot{u}_2}{u_2}$$

Equations (1), (2), (3) and (4) imply respectively the following relations :

$$c^{-\sigma} = u_1 \quad \text{and} \quad \frac{\dot{u}_1}{u_1} = -\sigma \frac{\dot{c}}{c} = -\sigma g_c \tag{1'}$$

$$\frac{u_1}{u_2} = \frac{\delta\left(A_d + e^{-qD_{df}} A_f\right)}{\alpha\left(H_d - H_{Ad}\right)^{\alpha-1} L_d^{\beta} \eta^{\alpha+\beta-1} K_d^{1-\alpha-\beta}\left(A_d + e^{-qD_{df}} A_f\right)^{\alpha+\beta}} \tag{2'}$$

$$\frac{\dot{u}_1}{u_1} = \rho - (1-\alpha-\beta)\left(H_d - H_{dA}\right)^{\alpha} \eta^{\alpha+\beta-1}\left(A_d + e^{-qD_{df}} A_f\right)^{\alpha+\beta} L^{\beta} K_d^{\ -\alpha-\beta} \tag{3'}$$

$$\frac{\dot{u}_2}{u_2} = \rho - \frac{u_1}{u_2}(\alpha+\beta)\left(H_d - H_{dA}\right)^{\alpha} \eta^{\alpha+\beta-1}\left(A_d + e^{-qD_{df}} A_f\right)^{\alpha+\beta-1} L^{\beta} K_d^{\ 1-\alpha-\beta} - \delta H_{dA} \tag{4'}$$

Equations (2') and (4') imply :

$$\frac{\dot{u}_2}{u_2} = \rho - \frac{\delta}{\alpha}(\alpha+\beta)\left(H_d - H_{dA}\right) - \delta H_{dA} = \rho - \frac{\delta(\alpha+\beta)H_d}{\alpha} + \delta\frac{\beta}{\alpha} H_{dA} \tag{7}$$

As $\frac{\dot{u}_1}{u_1} = \frac{\dot{u}_2}{u_2}$ and $\frac{\dot{u}_1}{u_1} = -\sigma\frac{\dot{c}}{c} = g_c$, then :

$$\rho + \sigma g_c = \frac{\delta(\alpha+\beta)H_d}{\alpha} - \delta\frac{\beta}{\alpha} H_{dA} \tag{8}$$

The growth rate in the country d in the regular state state is given also by that of research sector

$$g = g_c = g_A = \frac{\dot{A}}{A} = \delta\left(H_{Ad} + e^{-qD_{df}} H_{Af}\right)$$

This expression of growth rate and equation (8) are used to determine the share of human capital allocated to the research sector by central planner.

$$H_{Ad}^{op} = \frac{(\alpha+\beta)\delta H_d - \alpha\rho}{(\alpha\sigma+\beta)\delta} - \frac{\alpha\sigma e^{-qD_{df}} H_{Af}^{op}}{(\alpha\sigma+\beta)} \tag{9}$$