

Ricci, Luca Antonio

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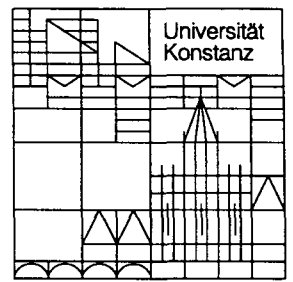
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Luca Antonio Ricci

**Geography and Comparative Advantage**

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# **Geography and Comparative Advantage**

**Luca Antonio Ricci**

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## **Luca Antonio Ricci**

Konstanz University  
SFB 178, Postfach 5560 D134  
D-78434 Konstanz, Germany  
email: ricci@hei.unige.ch

and

The Graduate Institute of International Studies

### **Geography and Comparative Advantage<sup>1</sup>**

This paper investigates the relation between agglomeration of economic activity and the pattern of specialization of countries. We develop a model encompassing a Ricardian comparative advantage, increasing returns to scale, product differentiation, monopolistic competition, trade costs, and factor mobility. Several interesting results arise. An endogenous relative increase in the size of one country makes this country less specialized in the homogeneous constant returns commodity and more specialized in the differentiated increasing returns IRS sectors; within the IRS industry, this country will become less specialized in the differentiated good in which it has a comparative advantage. Agglomeration occurs not only in large markets, but also in locations with a high average efficiency in the increasing return industry. *Ceteris paribus*, comparative advantage drives specialization, while absolute advantage drives agglomeration.

**Keywords:** Agglomeration; Specialization; Ricardian comparative advantage; Monopolistic competition; Scale economies; Location.

**JEL Classification:** F11; F12; F15; L13; R12.

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## 1. Introduction

This paper analyzes how endogenous agglomeration of economic activity alters the pattern of specialization of countries. It focuses both on sectoral specialization within the increasing returns to scale industry and on the whole increasing returns activity versus the constant return one.

In recent years the new location theory has investigated how agglomeration equilibria depend on a variety of centripetal and centrifugal forces. In general, tendency to agglomerate arises from forward (demanders want to be close to suppliers<sup>2</sup>) and backward linkages (the opposite), while tendency to disperse is driven either by pull in the peripheral market (such as location-specific demand<sup>3</sup>) or by some forms of congestion in the core region<sup>4</sup>.

But how does specialization of regions changes when agglomeration occurs? Most models of economic geography have one increasing returns-differentiated good (IRSD), which is subject to agglomeration effects, and one constant returns-homogenous commodity (CRSH), not subject to such effects. Obviously, when agglomeration occurs, the core region specializes in the IRSD good and the periphery in the CRSH commodity.

However, this answer is not completely satisfactory to a trade theorist. In particular, how does specialization within the increasing return industry changes, when agglomeration occurs? In fact, such industry is composed of many sectors, and regions may have a comparative advantage in some sectors: for a given comparative advantage, how does endogenous agglomeration in one region affect the degree of specialization of that regions within the IRS industry? One of the worrisome implication of new location theory is that the Single Market is likely to induce agglomeration of industrial activity in the core of the EU. Should such phenomenon occur, it would be very interesting to know, for example whether

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<sup>2</sup> The forward linkage may arise from demand of mobile consumers (such as manufacturing workers, as in Krugman 1991), or from demand of mobile firms using firms output as intermediate inputs (Krugman and Venables 1993, or 1995)

<sup>3</sup> For example, demand from immobile agricultural workers (Krugman, 1991) or from immobile consumers (Krugman and Venables, 1993, or 1995)

<sup>4</sup> Land rent (Elizondo and Krugman, 1992) or from location specific stock (such as housing entering the utility function, as in Helpman 1996), local public expenditure (Trionfetti, 1996). For variable congestion costs, see Alonso Villar (1996)

Germany would attract more the automobile or the chemical sector; or which activity would Portugal and Greece loose more.

The only paper we found that provide a particular framework dealing with agglomeration and specialization within the IRSD is Krugman and Venables (1993). They assume two locations with given and identical labor endowments, and two IRSD sectors each of which employs its own sectoral output as intermediate input (in addition to labor). This gives raise to sector specific concentration forces, even in the absence of interregional labor mobility, as forward and backward linkages occur among firms of the same sector. The centrifugal force is given by identical demand in the two location because of immobile consumers. When the centripetal forces dominate, both regions identically accommodate the two sectors and there is no specialization. When the centripetal forces dominate, there will be concentration of one sector in one location and full specialization.

Their paper has the merit of showing that specialization can derive from sector specific concentration forces. However, it cannot answer the question of what happen to specialization within the IRSD activity when there is agglomeration of such activity (i.e. both IRSD sectors being attracted by one location); in fact, there is no agglomeration of the whole IRSD activity, but sectoral linkages can only lead to concentration of one sector in one location.

When thinking about the question on agglomeration and specialization, it is natural to try to obtain a benchmark, a reference situation, by appealing to traditional trade theory and proxying agglomeration with country size: what happen to specialization of countries when there is a change in relative country size in a constant returns to scale perfectly competitive world, i.e in the absence of agglomeration effects? However, even this answer is unclear. In a Ricardian model, country size is irrelevant to the pattern of specialization (unless it affect extensively world prices through demand effects). In an Heckscher-Ohlin framework, it is impossible to alter country size (hence endowment) without altering the extent of the comparative advantage, and the answer would depend on how we conduct the experiment, i.e. in which proportion we alter the relative factor endowments of the two countries.

In order to address the question above, we develop a model which integrates

traditional trade theory and economic geography<sup>5</sup>. Specialization within the IRSD industry is driven by a comparative advantage while agglomeration of the whole IRSD activity is due to the backward and forward linkages.

Ricci (1996) introduced a Ricardian comparative advantage in a two-country two-IRSD-good trade model. The absence of factor mobility prevented agglomeration phenomena and parameters were chosen so as to ensure simple symmetric solution.

This paper builds on Ricci (1996) by extending it to generic expenditure shares, productivity levels, by allowing for labor mobility (hence agglomeration), and by introducing a tradable commodity.

Countries are assumed to trade in three goods: one constant return to scale homogeneous commodity, and two increasing returns to scale goods each being differentiated in varieties. This allows us to focus both on the degree of specialization in the constant return to scale homogeneous production versus the increasing returns to scale differentiated industry, and, more importantly, in the degree of specialization in one sector within the IRSD industry. As in Brülhart and Torstensson (1996), the expenditure on the freely traded CRSH good is chosen to exceed one half so as to prevent full specialization in the IRSD activity (for positive country sizes) and maintain nominal wage equalization. Labor is mobile across sectors.

In section 2 we lay out the model. In section 3, we assume labor immobility, and solve the model for given country sizes. This would allow us to infer how location choices and specialization are affected by the parameters of the model. In section 4 we allow for labor mobility, which would unfasten a forward linkage driven by consumers' demand (as in Krugman, 1991). We can then analyze the dynamics of the agglomeration and of specialization. Section 5 draws conclusion and discusses the effect of modifying our assumptions.

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<sup>5</sup> Building on Helpman and Krugman (1985), Martin and Rogers (1995) introduce a comparative advantage of the Heckscher-Ohlin type in an economic geography model. However, as for most geography models, the existence of only one CRS sector and one IRSD sector does not allow for the analysis of the specialization within the IRSD activity.

## 2. The model

Consider a world constituted by two locations: **1** and **2**. Each location **k** is inhabited by  $L_k$  individuals. There is only one factor of production (labor,  $L_k$ ) which is mobile across sectors. In the determination of the short run equilibrium (section 3) we will take factor endowments of countries as given; in section 4, we will then analyze migration decision of workers as function of the relative real wage and congestion.

### *Preferences and endowments*

All individuals share the same utility function. A representative consumer<sup>6</sup> of region **k** ( $k=1,2$ ) chooses consumption of an homogeneous good  $D$  ( $D_k$ ) and of varieties of two differentiated goods  $A$  and  $B$  ( $c_{iAk}$  and  $c_{jBk}$  respectively) so as to maximize the following preferences:

$$U_k = D_k^{1-\delta} C_{Ak}^{\delta\gamma} C_{Bk}^{\delta(1-\gamma)} \quad 0 < \gamma < 1 \quad 0 \leq 2\delta < 1$$

with

$$C_{Ak} = \left( \sum_{i=1}^{n_A} c_{iAk}^{(\sigma-1)/\sigma} \right)^{\sigma/(\sigma-1)}, \quad C_{Bk} = \left( \sum_{j=1}^{n_B} c_{jBk}^{(\sigma-1)/\sigma} \right)^{\sigma/(\sigma-1)}, \quad \sigma > 1$$

where  $\sigma$  is the elasticity of substitution among varieties of the same good,  $\delta$  is the share of expenditure on the two differentiated goods, of which  $\gamma$  is allocated to good  $A$  and  $1-\gamma$  to good  $B$ .  $n_A$  and  $n_B$  are the number of varieties of goods  $A$  and  $B$  effectively produced. Every individual supplies inelastically one unit of labor to domestic firms at the current domestic wage ( $w_k$ ), and receives profits ( $\pi_k=0$  in equilibrium) from these firms. There are no assets. The consumer's budget constraint is:

$$p_D D_k + \sum_{i=1}^{n_A} p_{iA}^k c_{iAk} + \sum_{j=1}^{n_B} p_{jB}^k c_{jBk} = w_k + \pi_k$$

where  $p_{iA}^k$  and  $p_{jB}^k$  are the location  $k$  prices of variety  $i$  of good  $A$  and of variety  $j$  of good  $B$ . Such prices, when related to varieties produced in the other region, include the trade costs.

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<sup>6</sup> As agents of different locations may face different prices, we need to distinguish them.



Symmetric trade costs ( $\tau > 1$ ) are of the Samuelson's iceberg type.  $p_D$  is the price of the commodity D, which freely traded and subject to no trade costs; its price is therefore identical in the two locations.

### *Technology and comparative advantage*<sup>7</sup>

Good D is produced under identical constant returns to scale to labor in both locations:

$$D_k^s = L_{Dk}^s$$

Each of the two differentiated goods (A or B) can be produced in a large number of varieties; the number of varieties actually produced is determined endogenously. Each variety is manufactured by a different firm. Increasing returns to scale arise from the presence of fixed costs and constant marginal costs, both in terms of labor. The fixed costs are identical for all sectors and for all locations ( $\alpha$ ). The marginal labor requirements vary across sectors and across locations ( $\beta_{fk} > 0$ ,  $f=A,B$ ;  $k=1,2$ ). Formally:

$$l_{A1i} = \alpha + \beta_{A1} x_{A1i} \quad ; \quad l_{B1j} = \alpha + \beta_{B1} x_{B1j}$$

$$l_{A2i} = \alpha + \beta_{A2} x_{A2i} \quad ; \quad l_{B2j} = \alpha + \beta_{B2} x_{B2j} \quad \text{with} \quad \beta_{A1}/\beta_{B1} < \beta_{A2}/\beta_{B2}$$

where  $l_{A1i}$  is the labor required to produce  $x_{A1i}$  units of variety  $i$  of good A in location 1; similarly for the other labels. The inequality  $\beta_{A1}/\beta_{B1} < \beta_{A2}/\beta_{B2}$  implies that, if the wage is identical across locations, region 1 has a comparative advantage in good A.

### *Firms' behavior*

Firms producing the commodity D face perfect competition and therefore set the price equal to marginal cost. The share of expenditure on D is chosen to be large enough as to ensure that both locations produce D in equilibrium<sup>8</sup>. Identical productivities in the two

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<sup>7</sup> Relative differences in productivities in the Ricardian framework are commonly attributed to technological differences. One could also conceive, however, that sectoral cost of production within each location are differently affected by domestic institutions, industrial policies, infrastructure, taxation, and so on.

<sup>8</sup> One half in normally enough, for positive country sizes, once we rule out the special case in which the small location is so efficient that despite its market size it becomes attractive to too many firms and fully specializes in the IRSD.

locations and the absence of trade costs imply that firms producing D charge the same price and pay the same nominal wage in both locations. Labor mobility across sectors ensures that the same nominal wage prevails also in the other sectors<sup>9</sup>. We normalize the nominal wage to 1:

$$p_D = w_k = 1 \quad \forall k=1,2$$

The market structure in the two differentiated sectors is the usual large group monopolistic competition (Dixit Stiglitz, 1977). All firms 'fk' producing varieties of good f (f=A,B) in location k (k=1,2) face always the same situation and we do not need to distinguish among them. Firms' profit maximization implies the usual markup pricing:

$$p_{fk} = \beta_{fk} \frac{\sigma}{\sigma-1} \quad \forall f=A,B \quad k=1,2$$

where  $p_{fk}$  is the producer price of one variety of good f manufactured in location k.

The zero profit condition due to monopolistic competition delivers the following optimal outputs  $x_{fk}$  for a firm producing one variety of f in k:

$$x_{fk} = \frac{\alpha}{\beta_{fk}} (\sigma-1) \quad \forall f=A,B \quad k=1,2$$

Therefore, within a sector (A or B), each firm located in the region which is less advantageous for that sector finds it optimal to charge a higher price and to produce a smaller output than a competitor located in the other region. However, all firms share the same optimal employment ( $l_{fk}$ ) and sales ( $p_{fk} x_{fk}$ ), as one can easily derive from the previous conditions:

$$p_{fk} x_{fk} = l_{fk} = \alpha \sigma \quad \forall f=A,B \quad k=1,2$$

Finally, the number of varieties in each sector and location are proportional to the respective employment:

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<sup>9</sup> Real wage will in general be higher in the location which is largest and more efficient in the average of the IRSD sectors. This would lead to migration as analyzed in section 4.

$$n_{fk} = \frac{L_{fk}}{\alpha \sigma} \quad \forall f=A,B \quad k=1,2$$

where  $n_{fk}$  is the number of varieties of good  $f$  produced in location  $k$ , and  $L_{fk}$  is the labor devoted to the production of  $f$  in  $k$ .

### Consumers' behavior

The solution to the consumer's maximization problem implies that every individual will allocate a given share of expenditure on each good. As all consumers of one location face the same prices and have homothetic utility functions, we can derive the aggregate demands of region  $k$  for the commodity  $D$  ( $D_k^d$ ), and for each variety of good  $A$  produced in region  $k'$  ( $A_k^{k'}$ ; superscripts  $k$  indicate the location of the consumers, while subscripts  $k'$  denote the location where the variety is produced):

$$D_k^d = (1-\delta) L_k$$

$$A_1^1 = \frac{p_{A1}^{-\sigma}}{n_{A1}p_{A1}^{1-\sigma} + n_{A2}(p_{A2}\tau)^{1-\sigma}} \delta \gamma L_1 \quad ; \quad A_2^1 = \frac{(p_{A2}\tau)^{-\sigma}}{n_{A1}p_{A1}^{1-\sigma} + n_{A2}(p_{A2}\tau)^{1-\sigma}} \delta \gamma L_1$$

$$A_1^2 = \frac{(p_{A1}\tau)^{-\sigma}}{n_{A1}(p_{A1}\tau)^{1-\sigma} + n_{A2}p_{A2}^{1-\sigma}} \delta \gamma L_2 \quad ; \quad A_2^2 = \frac{p_{A2}^{-\sigma}}{n_{A1}(p_{A1}\tau)^{1-\sigma} + n_{A2}p_{A2}^{1-\sigma}} \delta \gamma L_2$$

where, under the common assumption that  $n_A$  is large,  $\sigma$  approximates the perceived elasticity of demand. The expressions for good  $B$  ( $B_k^{k'}$ ) can be derived analogously.

### 3. The short run equilibrium (the trade and location model) .

In the determination of the short run equilibrium we take for given the endowments of the two countries ( $L_k$ ) and we derive the equilibrium location structure. Hence this equilibrium can be also viewed as a trade and location model for given country sizes. Firms are attracted by large markets and by the locations which present the higher productivity in their sector. However, normally some firms will still find it profitable to locate in the less productive and/or smallest region.

#### 3.1 Solution

The previous equations describe the equilibrium price of good D and the equilibrium prices, output, sales, and employment of each firm producing one variety of good A or B. We need to determine the employments in the three sectors (A, B, D) for each of the two locations (1, 2). As shown above, the number of varieties of good  $f$  produced in location  $k$  is simply proportional to the respective employment level of  $f$  in  $k$ .

Given nominal wage equalization across sectors and locations, world employment levels in each sector are simply proportional to the expenditure share on the good produced in that sector ( $L$  equals world population):

$$\begin{aligned} L_{A1} + L_{A2} &= (n_{A1} + n_{A2})\alpha\sigma = \delta\gamma L \\ L_{B1} + L_{B2} &= (n_{B1} + n_{B2})\alpha\sigma = \delta(1-\gamma)L \\ L_{D1} + L_{D2} &= (1-\delta)L \end{aligned}$$

Full employment requires that:

$$L_{Ak} + L_{Bk} + L_{Dk} = L_k \quad , \quad \forall f=A,B \quad k=1,2$$

Finally, two other independent relations can be obtained from the goods market equilibrium for varieties of A and B produced in one location; choosing location 1 we have:

$$p_{A1} x_{A1} = \alpha\sigma \quad , \quad p_{B1} x_{B1} = \alpha\sigma$$

We first solve the last two equations for the share of varieties (labor) of each differentiated good produced (employed) in location 1,  $\eta_{f1}$  with  $f=A,B$ :

$$\eta_{f1} \equiv \frac{n_{f1}}{n_f} \equiv \frac{L_{f1}}{L_f} = \frac{\beta_f^{\sigma-1} - \tau^{\sigma-1} + \beta_f^{\sigma-1} (\tau^{2(\sigma-1)} - 1) \lambda_1}{(\beta_f^{\sigma-1} - \tau^{\sigma-1}) (1 - \beta_f^{\sigma-1} \tau^{\sigma-1})}$$

$$\text{with } \beta_f = \frac{\beta_{f2}}{\beta_{f1}}, \quad \lambda_1 = \frac{L_1}{L}, \quad 0 \leq \lambda_1 \leq 1, \quad f=A,B$$

where  $\beta_f$  represents the absolute productivity advantage of location 1 in sector  $f$ .

These formulas inform us on the degree of sectoral concentration in country 1. Given overall expenditure on each good, we can derive for each differentiated sector the share of firms producing in 2. Employment in  $D$  in both regions can be residually derived from full employment. We can therefore obtain closed form solutions for all variables.

The concentration of sector  $f$  in country 1 ( $\eta_{f1}$ ) increases with the share of world population living in 1 ( $\lambda_1$ ), with the relative productivity advantage of country 1 in sector  $f$  ( $\beta_f$ ), and with the degree of returns to scale (which is inversely related to the elasticity of substitution between varieties,  $\sigma$ ); it decreases with the level of trade costs ( $\tau$ ).

The rationale is simple. Because of internal economies of scale, each firm chooses to locate in only one region. Concentration of one sector in one region is promoted by the market size of that region and by the incentive to exploit the productivity advantage of that region. Dispersion of the same sector across locations is pushed by the competition of firms for segmented markets, as trade costs create a price wedge between prices of different locations and the substitution effect translates this wedge into higher demand for local goods.

Firms tend to locate in large markets. This phenomenon is due to the usual 'home market effect': in the presence of trade costs, and *ceteris paribus* (i.e. for identical prices and per-capita income across locations), sales of a firm to a local consumer are always higher than sales to a foreign consumer, as long as the elasticity of substitution among competing goods is larger than 1. This effect is one of the two linkages generating agglomeration economies: an enlarging market attracts firms (backward linkage); if workers were mobile (see section 4), this location would become more attractive to workers because of lower cost-index of consumption (forward linkage). The two effects would induce a circular chain of concentration.

Firms of a given sector tend to locate in the region with the highest productivity.

Ceteris paribus (country size), varieties produced in the most productive location are sold at a lower price and receive a larger demand than varieties produced in the other location: as all firms have the same sales in equilibrium, the most productive location must (ceteris paribus) accommodate a larger number of firms.

The previous concentration incentives are reduced by trade costs. In fact, dispersion of the same sector across locations is pushed by the competition of firms for segmented markets, as trade costs create a price wedge between prices of different locations and the substitution effect translates this wedge into higher demand for local goods.

Note that the location choices of firms of each sector is independent of variables which are specific to the other sector, notably the number of varieties and the productivity levels of the other sector in the two locations. This result is quite striking and is of course sensitive to the modification of some assumption (wage equalization, no intermediate inputs from the other sector) as we will discuss later. It is however particularly interesting that in this simple benchmark case there is independence of location choices across sectors. It could be also surprising to note (as we will show later) that notwithstanding this independence countries still tend to specialize more in the differentiated good in which they have a comparative advantage (whose definition must take into account productivities of both sectors in both locations).

Given our choices of expenditure parameters, both countries will always produce the homogenous good D, which ensures wage equalization. However, if one country is large and very productive, it could accommodate all production of one or both differentiated goods. As the purpose of the model is to analyze the degree of specialization, we will focus mainly on the set of parameters such that both countries produce both differentiated goods. In section 4, we will discuss more in details possible equilibria with full agglomeration of one or both sectors in one location.

### **3.2 Conditions for non-full specialization within the differentiated industry**

We can derive conditions on parameter values and on the country 1's share of world population such that each country produces both differentiated goods:

$$0 < \eta_{fl} < 1 \quad \text{if} \\ \tau > \text{Max} \left[ \beta_f, \frac{1}{\beta_f} \right] \quad \wedge \quad \frac{\tau^{\sigma-1} - \beta_f^{\sigma-1}}{\beta_f^{\sigma-1}(\tau^{2(\sigma-1)} - 1)} < \lambda_1 < \frac{\tau^s(\tau^{\sigma-1} - \beta_f^{\sigma-1})}{\tau^{2(\sigma-1)} - 1}, \quad f=A,B$$

If these conditions are not satisfied there will be full specialization.

### 3.3 Comparative statics

In this section we analyze the effects of a change in the share of world population living in country 1 ( $\lambda_1$ ), in the relative productivity across locations for the same sector ( $\beta_f$ ), and in trade costs ( $\tau$ ). It can be shown that<sup>10</sup>:

$$\frac{d\eta_{fl}}{d\lambda_1} = \frac{\beta_f^{\sigma-1}(\tau^{2(\sigma-1)} - 1)}{(\tau^{\sigma-1} - \beta_f^{\sigma-1})(\tau^{\sigma-1}\beta_f^{\sigma-1} - 1)} > 1$$

$$\frac{d\eta_{fl}}{d\beta_f} > 0, \quad \frac{d\eta_{fl}}{d\tau} \geq 0 \quad \text{if} \quad \lambda_1 \leq \frac{(\tau^s - \beta_f^s)^2}{(\tau^s - \beta_f^s)^2 + (\tau^s \beta_f^s - 1)^2}$$

#### 3.3.1 Market size.

When country 1 becomes relatively larger ( $\lambda_1$  increases), it attracts firms of both sectors. A derivative of  $\eta_{A1}$  with respect to  $\lambda_1$  is larger than 1 implies that a given increase in country 1 share of world labor (income) generates a larger increase in the share of firms of each sector located in 1 ("agglomeration multiplier").

Note also that the share of firms of each sector located in 1 is linear in the share of population living in 1 (equivalently, the derivative is independent of the relative country size), implying that the agglomeration multiplier is independent of the actual agglomeration level or of country size: in other words, for a given 1% increase in the country 1 share of world population there will be always the same increase (larger than 1%) in the share of firms located in 1, no matter whether country 1 is initially small or large. Finally, note that the agglomeration multiplier is different across sectors and independent of regional productivity

<sup>10</sup> The first inequality requires the condition  $\tau > \text{Max}[\beta, 1/\beta]$ , which, as described before, is one of the conditions ensuring non-full specialization.

levels prevailing in the other differentiated sector<sup>11</sup>.

### 3.3.2 Regional productivity differentials within sectors.

Location choices are affected not only by the market size, but also by the productivity differential for competing varieties across locations. An increase in the productivity differential between sector  $f_1$  and  $f_2$  raises the share of firms producing  $f$  in 1.

### 3.3.3 Trade costs.

An increase in trade costs tend to reduce the incentive to agglomerate in the large and more productive location. In fact, the derivative with respect to  $\tau$  shows that, when trade costs increase, the share of firms producing  $f$  in 1 would raise when country 1 is small (and, ceteris paribus, has few firms) and would decrease when country 1 is "large". The critical level of country size is inversely related to the productivity advantage: the more productive a location is, the smaller it has to be in order for it to attract firms when trade costs raise.

### 3.3.4 Altering the assumptions

The size of the agglomeration multiplier and its sector specificity depend on our assumptions of wage equalization and no intermediate inputs. We now briefly discuss what could happen if we modified such assumptions. It seems that those results may be altered in different directions depending on which modification is pursued. Hence, we may still consider those results an interesting benchmark.

If firms producing differentiated goods would use output of their sector as intermediate inputs, the agglomeration multiplier would be reinforced but still sector specific. If instead firms would use as intermediate inputs the output of the whole IRSD industry, not only the agglomeration multiplier would be reinforced, but there would also be agglomeration externalities across sectors: an increase in productivity of location  $k$  in sector  $f$  would also raise the incentive of firms in the other sector to locate in  $k$ .

In the case of full specialization and no wage equalization (for example if there is no CRSH good) the agglomeration multiplier could no more be larger than one (as there would be no sector from which to extract labor); an increase in productivity of location  $k$  in sector

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<sup>11</sup> We will discuss further on how changing assumptions may affects these results.



f would no more be neutral on the other sector: competition for labor and the consequent increase in relative wage would reduce the incentive for the other sector to locate in k.

### 3.4 Specialization

We now want to analyze the degree of specialization of each country within the increasing returns to scale industry and investigate how it varies when agglomeration occurs. Given the generality of the model, it is enough to construct an index for one country. We measure the degree specialization of country 1 in good A relative to good B ( $SE_1$ ) by the relative employment level in the two sectors in country 1 (equivalent to the relative number of varieties produced):

$$SE_1 \equiv \frac{L_{A1}}{L_{B1}} \equiv \frac{n_{A1}}{n_{B1}} = \frac{\eta_{A1}}{\eta_{B1}} \frac{n_A}{n_B}$$

By differentiation, we can find that 1) an increase in the productivity advantage in one sector makes the country more specialized in that sector (implying that an increase of the comparative advantage raises the degree of specialization, as expected from traditional trade theory); 2) more interestingly, an increase in the world population share of country 1 reduces the specialization in A of country 1 if this country has a comparative advantage in good A:

$$\frac{dSE_1}{d\beta_A} > 0 \quad , \quad \frac{dSE_1}{d\beta_B} < 0 \quad , \quad \frac{dSE_1}{d\lambda_1} < 0 \quad \text{if} \quad \beta_A > \beta_B$$

This implies that a change in relative country size makes both countries less specialized in the differentiated good in which the growing country has a comparative advantage.

From section 3.3.1 we also know that when the share of world income of country 1 becomes larger, there will be a more than proportional increase of the share of firms located in 1. This implies an increase of country 1 specialization in the IRS industry as relative to the CRS sector.

We can therefore conclude that a relative increase in size of one country makes this country less specialized in the homogeneous CRS commodity and more specialized in the differentiated IRS sectors. Within the IRS industry, this country will become less specialized

in the differentiated good in which it has a comparative advantage. The opposite would hold for the other country.

Measuring specialization by output levels (instead of employment) does not alter qualitatively the results.

#### 4. The long run equilibrium (the geography model) .

In this section we allow workers to move to their preferred location in order to investigate the dynamics sequence of the temporary equilibrium and to infer the long run equilibrium. Most of the intuition being already acquired with the comparative statics of the previous section, this one is mostly for completeness.

Models of economic geography are based on the tensions of centripetal and centrifugal forces. The centripetal force that characterize such models the circular chain of forward and backward linkages. Centrifugal forces vary from assuming that part of the demand is location specific (Krugman, 1991), to congestion forces of various kinds (land rent, as in Elizondo and Krugman, 1992; location specific stock -housing- entering the utility function, as in Helpman 1996).

In our model, the backward linkage has been described in section 3: an enlargement of a market attract firms. We now allow for the forward linkage (agglomeration of firms in one market raises the incentive of consumers to locate there) through the usual assumption that workers move progressively to the location that offers the highest real wage. Real wage is in general higher in the location which has the largest number of firms and the highest average efficiency in the IRSD sectors. We will also introduce a centrifugal force by assuming that workers dislike too crowded areas. This last congestion component is not essential to the understanding of insights of this paper: it just allows for non-full agglomeration in the long run. The law of motion for country 1 labor share is:

$$d\lambda_1 = \rho (\omega[\lambda_1]-1) G[\lambda_1]$$

where  $\rho$  is the speed of the adjustment,  $\omega$  is the relative real wage of country 1 versus 2 (recall that nominal wage is equalized across locations), and  $G$  is the congestion factor<sup>12</sup>:

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<sup>12</sup>The specific function for  $G$  ensures that the congestion component is 1 when countries have equal size and approaches  $-\infty$  when one country tend to disappear.

$$\omega = \frac{P_2}{P_1} = \left[ \left( \frac{\lambda_1 (\beta_A^{\sigma-1} \tau^{\sigma-1} - 1)}{(\tau^{\sigma-1} - \beta_A^{\sigma-1})(1 - \lambda_1)} \right)^\gamma \left( \frac{\lambda_1 (\beta_B^{\sigma-1} \tau^{\sigma-1} - 1)}{(\tau^{\sigma-1} - \beta_B^{\sigma-1})(1 - \lambda_1)} \right)^{1-\gamma} \right]^{\frac{\delta}{\sigma-1}} \quad \frac{d\omega}{d\lambda_1} > 0$$

$$G[\lambda_1] = 1 + h [ -\log(.25) + \log(\lambda_1(1-\lambda_1)) ] \quad \frac{dG}{d\lambda_1} > 0 \quad \text{if} \quad \lambda_1 < .5$$

where  $P_k$  is the price index of location  $k$ , and  $h$  ( $h \geq 0$ ) measures the extent of congestion. The formula for the relative real wage hold as long as the conditions for non-full specialization in the IRSD activity are satisfied. If full agglomeration of firms in one location occurs, the relative real wage becomes constant (independent of relative country size), and higher than 1 for the core location. Note that the congestion factor has the advantage that it does not alter firms choices as it does not modify the determination of the temporary equilibrium.

A long run equilibrium occurs when workers have no incentive to move, because the higher real wage of the largest and, on average, more efficient location is compensated by large congestion costs.

In analyzing the equilibria, it is important to notice that the relative real wage of country 1 increases with its share of world income, while the congestion factor decreases with the inequality of country size.

Let's assume for the moment that there is no congestion component ( $h=0$ ). If the conditions for non-full specialization are satisfied, there usually exist one distribution of income ( $\lambda_1$ ) such that the relative real wage is 1 and workers have no incentive to move. Such equilibrium is however unstable, as an increase in size of one location raises its real wage. Any slight change in the relative country size would induce firms and workers to move to the enlarging location, and that would continue until all firms are there. At that point the relative real wage would not increase anymore, but would still be higher than 1. Hence workers would continue moving in that location until the other location would disappear.

The existence of congestion would instead prevent workers from moving all in one location. There will be two stable equilibria with asymmetric (but positive) country sizes, and one unstable equilibrium at an intermediate level of relative country size. Depending on

parameters configurations, the stable equilibria may be characterized by full agglomeration of one or both sectors, or of none.

In order to describe this point better, let us start from a temporary equilibrium (as described in section 3) in which both countries produce the three goods, but relative real wage of country 1 versus 2 is higher than 1. Workers will start moving to location 1. Firms of both sectors would then move to 1 (more than proportionally with respect to workers). This will increase the relative real wage of 1 even more, attracting more workers. However, congestion would neutralize these forward and backward linkages before all workers go to location 1. When workers stop moving, each differentiated sector could still be produced in both locations, or only in one.

The stable equilibrium with a larger share of population in location  $k$  is more likely to be characterized by agglomeration of sector  $f$  in  $k$  if: congestion effects are low ( $h$  close to 0); the productivity advantage of  $k$  in  $f$  ( $\beta_{fk}/\beta_{f-k}$ ) is high; and trade costs ( $\tau$ ) are low.

## 5. Remarks and Conclusions.

This paper investigates how the agglomeration of economic activity due to forward and backward linkages affects the pattern of specialization of countries, with particular emphasis on the specialization in different sectors of the increasing returns to scale activity.

We develop a model in which two regions trade in one constant returns to scale homogeneous (CRSH) commodity and in two increasing returns differentiated (IRSD) goods of the Helpman Krugman type. In the IRSD industry, marginal productivities differ across locations and across sectors, giving rise to a Ricardian comparative advantage. Labor mobility allows for agglomeration of firms.

We find that an endogenous relative increase in the size of one country makes this country less specialized in the homogeneous CRS commodity and more specialized in the differentiated IRS sectors. Within the IRSD industry, this country will become less specialized in the differentiated good in which it has a comparative advantage. The opposite would hold for the other country.

One usual result of economic geography models is that when forward and backward linkages are stronger than the centrifugal forces, agglomeration will occur in the region which is initially larger<sup>13</sup>. When locations differ in productivity levels, this may not be true. If the country which is initially small has a sufficiently high average efficiency in the IRSD industry (i.e. productivities in the two IRSD sectors sufficiently higher than in the other location) agglomeration will occur in that country. This is particularly interesting once we remember that productivity levels in this model are just a proxy for low cost of production, and costs of production are generally affected by infrastructure, taxation, industrial policies, and so on.

It is then interesting to notice that productivity levels have different implication for specialization and for agglomeration. Specialization and the pattern of intra-industry trade is affected by the relative productivity advantage (comparative advantage), while agglomeration by absolute productivity advantages.

The location choices of firms in the two sectors of the IRSD activity present some expected results and some more interesting ones. As intuitive, firms tend to locate in regions

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<sup>13</sup> Most (if not all) models of economic geography assume that "history matters", as witnessed by the law of motion of workers or firms. See Krugman (1991) for an analysis of history versus expectations.

which are large and which offer the highest productivity in their sector; these location incentives are reduced by trade costs and enhanced by the degree of return to scale.

More interestingly, a given increase in the share of world income of country  $k$  generates a *larger* increase in the share of firms of each sector located in  $k$  ("agglomeration multiplier"). Such agglomeration multiplier is independent of the actual agglomeration level and of market size, it is different across sectors, and for each sector it is independent of regional productivity levels prevailing in the other differentiated sector. These last results are sensitive to our specification, but they still represent an interesting benchmark, as discussed in section 3.3.4.

We hope our framework helped analyze the relation between agglomeration, specialization, productivity, and comparative advantage. It is left for future work to explore the interesting cases arising from the alterations of the adopted assumption.

## References

- Alonso Villar O., 1996, "Configuration of Cities: the Effects of Congestion Costs and Government", paper presented at the II<sup>nd</sup> meeting of the ESF-funded research group on "European Economic Performance", LSE-CEP, London, June 28-30.
- Brühlhart M. and Torstensson J., 1996, "Regional Integration, Scale Economies, and Industry Location", paper presented at the CEPR-ERWIT conference, Glasgow, September 4-8.
- Dixit A. and Stiglitz J. E. 1977, "Monopolistic Competition and Optimum Product Diversity" American Economic Review, vol. 67.
- Elizondo R.L. and Krugman P. 1992, "Trade policies and Third World Metropolis" MIT mimeo.
- Helpman E. 1996, "The Size of Regions", presented and the CEPR-CUSO conference on 'Trade, Location, and Technology', Champéry, February 16/21.
- Helpman E. and Krugman P., 1985, Market Structure and Foreign Trade , Cambridge, MIT Press.
- Krugman P. 1991, Geography and Trade, Cambridge, MIT Press.
- Krugman P. and Venables A. 1995, "Globalization and the Inequality of Nations", Quarterly Journal of Economics, vol.110, n 4, pp. 857-880.
- Krugman P. and Venables A. 1993, "Integration, Specialization, and Adjustment", CEPR working papers No 886.
- Martin and Rogers, 1995, "Industrial Location and Public Infrastructure", Journal of International Economics
- Ricci L. A., 1996, "A Ricardian Model of New Trade and Location Theory", International Economics working papers, June, University of Konstanz - SFB178
- Trionfetti F. 1996, "Public Expenditure and Economic Geography", presented at the CEPR-CUSO conference on 'Trade, Location, and Technology', Champéry, February 16-21.