STAGES OF REGIONAL DEVELOPMENT AND SPATIAL CONCENTRATION

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Abstract *- We develop an economic geography model which examines the spatial concentration of different kinds of activities during four stages of regional development. First, the localization of a "standardized" industry can be based on the exploitation of external and pecuniary scale economies within a monopolistic competitive environment (this is similar to the industry Krugman (1991a, b) refers to in his model). Secondly, an autonomous technological progress will influence the location of a technological industry, operating in a competitive environment; this technological progress will spread to other regions due to technological externalities. During the next stage of regional development, the industrial activity will lead to the development of an intermediate sector for services to production that might be a "metropolization" force.*

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1. INTRODUCTION

Regional development analysis cannot be isolated from an analysis of the relationships between localization, concentration and specialization. Historically speaking, the new economic geography approach suggests that various sources of agglomeration and dispersion exist –their importance depends on the economic development of related territories (Duranton, 1997). In this respect, Paul Krugman's core/periphery model (1991a, 1991b, 1995) provides a stylized approach to the so-called "industrial belt" in the second half of the XIXth century and at the beginning of the XXth century –scale economies and transportation costs were considered and so was their impact on the localization of industrial activities. This paper aims at widening this model to a broader frame; we will analyze regions with a heterogeneous development and productive specialization and analyze the resulting concentration and dispersion forces.

We identify four major stages of regional development and openness. Productivity and competitiveness effects (on which regional development is based) will change, from stage to stage –i.e. their forms and intensities are not constant. Hence, different kinds of activities can be distinguished; the initial agriculture-industry diptych can be extended. First, the localization of a "standardized" industry can be based on the exploitation of external and pecuniary scale economies within a monopolistic competitive environment (this is similar to the industry Krugman refers to in his model). Secondly, autonomous technological progress will influence the localization of a technological industry, operating in a competitive environment; this technological progress will spread to other regions due to technological externalities. During the next stage of regional development, the industrial activity will lead to the development of an intermediate sector for services to production that might be a "metropolization" force.

From a theoretical point of view, the present analysis is at the crossroads of two families of models from which the economic geography approach stems[1]: urban economic models used in the context of theories endogenizing the emergence of towns (Rivera-Batiz, 1988; Abdel-Rahman and Fujita, 1990) and new economic geography models that consider both imperfect competition environments and pecuniary externalities.

In a broad sense, four major stages in the opening and economic development of regions can be identified (Catin, 1993):

i. Preindustrial regions;

[1] For an overview on the three streams of economic geography, see Fujita and Thisse (1997).

ii. Regions with standardized industries;
iii. Regions with technological industries;
iv. Metropolitan regions (with superior services).

Such a taxonomy can be set up with a conjunction of two indicators for export performance: the export rate and the growth rate of industrial export for a given region.

During each stage, the export pattern changes, due to the evolution of regional specializations. During the first stage as well as during the transition to the second one, regional specialization is based on factor proportions and their relative prices. In the second stage, the regional industry becomes specialized in the production and export of standardized but low technological content goods – this specialization stems from the exploitation of scale economies and low-paid jobs. Economic development and geographic concentration have combined effects, which go through: i) supply and demand multiplier effects –this leads to a development of complementary and induced activities; ii) capacity investments and scale economies –which foster exports. In the third stage, the regional industry is oriented towards high-tech activities, based both on the exploitation of autonomous productivity gains and on a significantly skilled labor force. With a significant export basis, the usual internal multipliers will lag far behind foreign trade multipliers and non-price competitiveness effects. Technological interactions will boost innovating activities and investments through networks, whether organized or not. Cross-sectoral spillovers will give way to "backward and forward linkages", due to trade. In the fourth stage, the high-tech and rich region will experience worse performances for its exports of industrial commodities, as compared to regions in the second and third stage –mainly because its services exports increase. The technological potential and the metropolitan dimension of the region, together with the concentration of research and development, decision and commercial activities, lead to the production of superior services.

Briefly sketched, this analysis reveals that industrial specialization (during the first two periods) is rooted in scale economies and low-paid jobs, while specialization (in the third and fourth stages) rests on the exploitation of autonomous productivity gains as well as the existence of a skilled labor force. Therefore, with respect to the concentration of productive activities, Krugman's model can be related to stages 1 and 2 of regional development.

The present paper will provide an economic-geography-based model that could be applied to each development stage. As such, we will consider new productive activities (e.g. high-tech industries, superior services), new agglomeration and dispersion forces (e.g. autonomous productivity gains, pecuniary and technological agglomeration economies) and a dual approach to worker qualifications (skilled and non-skilled workers).

Agglomeration economies can be broken down into localization economies (scale economies external to the firm but internal to the sector), urbanization economies, economies of scale both external to firms and to sectors. The present model will consider that scale economies benefiting to industrial firms when regions reach a certain level of development are related to the presence of a specific and skilled labor force (localization economies) and to the presence of a sector providing superior services to production (urbanization economies). In addition to this, services for firms exhibit localization economies within the metropolitan region: due to the expansion of complementary activities, productivity gains will result in scale economies featured as external to firms but internal to service activities.

Section 2 will analyze the first stage of development (during which two regions have poor industrialization levels) as well as the second one, for which we will study the various processes that lead to the concentration of industries in one of these two regions –then giving way to a core/periphery scheme. Section 3 will shed light on the evolution of regional specializations, the development of a technological industry and on relocation processes. Finally, section 4 will examine factors leading to the development of a sector providing superior services to production and in turn, to a metropolization phenomenon within the central region.

According to Krugman, any increase in production results in an increase in the number of available variety; inter-sectoral spillovers within a given industry (i.e. supply multiplier effects) entail scale economies –these are external to firms but internal to the standardized industry. In addition to this, some urbanization economies are considered, at least implicitly. These external pecuniary economies are related to the size of the domestic market (an induction effect related to the size of the local market in Krugman's analysis); they can also be related to regional infrastructures whenever their influence on transport costs is examined (this point will be analyzed during subsequent sections).

In this perspective, we have the following regional industrial growth pattern: a region with a superior productivity will experience an increase in the number of industrial business set-ups (i.e. in the number of differentiated goods, given our monopolistic competition assumption) and, then, in the production volume. This increase in production and its resulting increase in regional incomes both promote new business set-ups because agents express a preference for product diversity. The creation of new plants, because of external pecuniary economies, impacts on productivity. The economic literature is abundant in labels for this growth process –Myrdal labeled it "the circular and cumulative causation", Hirschman labeled it "the backward and forward linkages", Arthur used the term of "positive feedback" and Matsuyama referred to "complementarities"…

In addition to this, the productivity effect (both taking over and expanding the multiplier effect, while depending upon it) impacts on competitiveness. A region with a high productivity will benefit from price-competitiveness, increase its volume of exports and production and, thus, raise business set-ups and its regional income.

Catin (1995a, 1995b) provided a comprehensive approach to productivity/multiplier/competitiveness linkages; the productivity linkage affects regional multipliers and increases the regional income, while the number of available varieties and price-competitiveness goes up (due to a decrease in the average production cost); multiplier and competitiveness effects give rise to feedback effects on the regional productivity.

2. INITIAL STAGES OF REGIONAL DEVELOPMENT – INDUSTRIALIZATION AND CONCENTRATION

Krugman's formal model (1991a, b) is presented in annex 1. We start from this framework to develop our analysis of the spatial concentration of activities through the stages of regional development in the subsequent sections.

2.1. Pre-industrial regions – stage 1 of development

According to Krugman, the following three parameters have an influence on the localization of the standardized industry (see annex 1):

(i) μ is the share of the standardized industry in the economy;
(ii) τ is the inverse index for transport costs for manufactured goods;
(iii) σ is the elasticity of substitution between manufactured goods and is used to estimate scale economies.

Depending on the value given to these parameters, we can have either a convergence (with respect to the interregional industry distributions) or a regional divergence (i.e. an industrial concentration).

When the zero-profit equilibrium situation is reached, $v=\sigma/(\sigma-1)$ gives the ratio of the marginal product of labor to its average product –i.e. a degree of scale economies. During the first stage of development (regions are in the pre-industrial period), the share granted to industry in the economy of each region is weak while the agricultural sector has a significant one. Then, $\mu<(1-\mu)$ and $0<\mu<.5$ will hold.

Furthermore, transport costs for manufactured goods decrease with region development (when regions are developing, so are infrastructures, especially those concerning transportation). Both pre-industrial regions experience infrastructure weaknesses and, consequently, transport costs for manufactured goods can be high. As a result, $0<\tau<.5$ (τ is the inverse index for transportation costs) will hold; the lower τ, the higher the transportation costs.

The standardized industry benefits from scale economies; these scale economies increase with the share of non-skilled workers allocated to the industry $-\frac{\sigma}{\sigma-1}=f\left(\frac{L_i}{L_i+(1-\mu)/2}\right), f'>0$.

Such conditions for parameters (i.e. $0<\mu<.5$, $0<\tau<.5$ together with $1.25<v<1.5$ and $3<\sigma<5$) lead to a particular interregional distribution of manufacturing industries; firms are not interested in concentrating in one of these 2 regions due to high transport costs and low scale economies; in fact, they will just provide their domestic market. The figure attached to annex (2a) illustrates the relative wage decline when f increases. In other words, workers will leave the region with the larger share of non-skilled labor and the geographic proportions of non-skilled workers will be balanced among regions. During stage 1, regions are equally endowed with non-skilled workers (i.e. $f = 1/2$) –a distribution which is a stable equilibrium.

2.2. Industrial concentration – stage 2 of development

During stage 2, the interregional distribution of workers allocated to the "standardized" industry is no longer a stable equilibrium. This can be explained with the following arguments. First, regions have developed and the standardized industry has a prevalent share in the economy ($.5<\mu<1$).Secondly, regions experience an economic development which induces the expansion of infrastructures; transportation costs will decline as a result ($.5<\tau<1$) and inter-regional trade for standardized goods will increase. Thirdly, induced-productivity gains are amplified due to a rural exodus and to workers moving from the agricultural to the manufacturing sector.

As mentioned above, w_1/w_2 variations (with respect to f) will determine whether the standardized industry will concentrate (in one region) or spread to the other. An increase both in f and w_1/w_2 induces workers to migrate from region 2 to region 1 (where the number of workers is more important); the standardized industry will, consequently, experience a spatial concentration.

Thus, the geographic concentration process of the standardized industry will result in a development differential between regions and the peripheral region will only produce agricultural goods. Finally, low transportation costs and the relative importance of scale economies (depending on the share granted to the industry in the economy) will lead to the emergence of a core/periphery scheme.

The figure listed in annex (2b) illustrates how a relative wage, increasing with *f*, will affect worker migrations; workers will leave the region having the lower proportion of non-skilled labor and go to the higher proportion of non-skilled labor region; a concentration of the standardized industry will result.

Now, the stability of such an equilibrium, with non-skilled workers concentrated in one region, is at stake. In other words, we have to determine the necessary conditions enabling a concentration in the standardized industry sector.

Suppose that all non-skilled workers are concentrated in one region, say region 1. We know that a fraction of the total income, μ, is allocated to purchasing manufactured goods, which are produced by the standardized industry. We also know that the total income is spent in region 1. Then, we have the following equations

$$Y_2 = \frac{1-\mu}{2} \tag{1}$$

$$Y_1 = \mu + \frac{1-\mu}{2} = \frac{1+\mu}{2} \tag{1'}$$

Rearrangement of eq. (17) and (17') leads to

$$\frac{Y_2}{Y_1} = \frac{1-\mu}{1+\mu} \tag{2}$$

The maximum amount sold by each firm and leading to a zero-profit can, now, be determined (in accordance with monopolistic competition assumptions). Let n be the number of firms operating in the standardized industry. Then, we obtain

$$v_1 = \left(\frac{\mu}{n}\right)\left(Y_1 + Y_2\right) \tag{3}$$

Given the complete concentration of the standardized industry in region 1, will a firm be interested in moving to region 2? Concentration in region 1 will be a stable equilibrium if a location in region 2 is unprofitable.

A firm can operate in region 2 if it attracts (in this region) the quantity of non-skilled workers required for its production; it will, consequently, provide workers with a competitive real wage; this wage is just a compensation for the increase in the cost of living, because any standardized goods are to be imported from region 1 and bear a transportation cost. So,

$$\frac{w_2}{w_1} = \left(\frac{1}{\tau}\right)^{\mu} \tag{4}$$

Thus, the profit-maximizing firm has to set a higher price for its goods compared to its competitors, given the higher wage deriving from eq. (20). The quantity sold in region 2 is, subsequently, equal to the representative firm sales multiplied by $\left(w_2\tau/w_1\right)^{-(\sigma-1)}$; the region-2"relocated"firm sales worth, in region 1, is equal to the representative firm sales worth weighted by $\left(w_2/w_1\tau\right)^{-(\sigma-1)}$. Thus, the relocated firm sales are worth

$$v_2 = \left(\frac{\mu}{n}\right)\left[\left(\frac{w_2}{w_1}\right)^{-(\sigma-1)} Y_1 + \left(\frac{w_2\tau}{w_1}\right)^{-(\sigma-1)} Y_2\right] \tag{5}$$

Combining equations (1), (1'), (3), (4) and (5) lead to the ratio of "relocated" standardized firm sales value to that of region-1 firms

$$\frac{v_2}{v_1} = 1/2\,\tau^{\mu(\sigma-1)}\left[(1+\mu)\tau^{\sigma-1} + (1-\mu)\tau^{-(\sigma-1)}\right] \tag{6}$$

Fixed costs in region 2 are higher because wages are higher (see eq. (20)). Henceforth, the production is profitable in region 2 if $V = v_2/v_1 > w_2/w_1 = \tau^{-\mu}$ holds. Once $\tau^{-\mu}$ is inserted in equation (6), V = v_2/v_1 is obtained

$$V = 1/2\,\tau^{\mu\sigma}\left[(1+\mu)\tau^{\sigma-1} + (1-\mu)\tau^{-(\sigma-1)}\right] \tag{7}$$

A relocation in region 2 is unprofitable if the industrial production is concentrated in region 1 and V>1; hence a concentration in region 1 is a stable equilibrium.

Now, the (positive or negative) impact on V of each parameter variation can be determined

$\frac{\partial V}{\partial \mu} < 0$: the value of the relocated firm sales is a decreasing function of μ, the fraction of income spent for the standardized industry goods;

$\dfrac{\partial V}{\partial \tau} < 0$: the value of the relocated firm sales decreases when transport costs diminish (i.e. when $\tau \to 1$), which strengthens the concentration process in region 1;

$\dfrac{\partial V}{\partial \sigma} > 0$: a rise in σ (i.e. a decrease in the value of scale economies) increases the value of the relocated firm sales.

Thus, regional specializations will be changed during the transition from stage 1 to stage 2 and, consequently, a regional development divergence will occur. The core region will become the concentration-based region (we arbitrarily assumed this was region 1) and will develop during stage 2, while the peripheral region will lag behind and be stuck at the preindustrial level of development. Due to the growth of manufactured goods exports to the peripheral region, the core region (the only region exporting manufactured goods) will undergo a developing process, both leading to and through stage 3. In the core region, an industrialized and urbanized one, the industry will be redeployed into more technology-intensive activities, i.e. into activities not only based on the exploitation of scale economies and low-paid jobs.

Proposition 1: *During the second stage of development, a decrease in trade costs leads to a concentration process in the core region*.

3. REGIONAL SPECIALIZATION DEVELOPMENT AND EVOLUTION – STAGE 3

3.1. Concentration of technology-intensive industries

The core-region industry will, step by step, turn to technological activities and reach stage 3. Before we turn to the analysis of such an evolution, an assumption must be changed. We previously stated that each input was sector-specific. We assume, now, that inputs are only sector specific during a particular stage, but can move to other sectors during the transition to another development stage. In other words, a share of the labor force working for the standardized industry can, in the long run, move to the technological industry. Intra-period specificity and inter-period evolution are realistic assumptions when the training and learning process is supposed to be time-consuming. We also assume that: (i) there is a sufficient share of workers upgrading their qualification level to meet the technological industry needs (i.e. a situation free from structural unemployment); (ii) labor force movements between sectors result in zero adjustment costs; (iii) the incentive to implement those sectoral changes is due to a wage differential benefiting skilled workers employed in the technological industry.

Finally, firms belonging to the technological industry sector will operate in a competitive environment, on the opposite of the standardized industry, and face constant returns to scale and produce homogeneous goods (in the long run, technology-related knowledge and diffusion are complete). However, an autonomous technological progress differential between regions can lead to localization differentiations. Regions can trade technological goods; however, strategic interactions are not considered.

Since stage 3, individuals include the consumption of technological goods into their utility function; and we have

$$U = C_B^{\mu} C_T^{\lambda} C_A^{(1-\mu-\lambda)} \tag{8}$$

C_T is the consumption of the homogeneous technological product. In each region, the agricultural supply is equal to $(1-\mu-\lambda)/2$. Let L_{T1} be the number of skilled workers located in region 1; and suppose $L_{T1} = \lambda$. The production of technological goods, called T, is

$$x_T = \left(e^{mt}\right) L_T^{\theta} K_T^{\zeta} \tag{9}$$

θ and ζ are technology-dependent and $\theta + \zeta = 1$ (i.e. this production function exhibits constant returns to scale).On the other hand, this production function allows the exploitation of an autonomous technological progress rate; e is the natural logarithm basis and mt stands for the rate of autonomous technological progress.

The rate of autonomous technological progress, *mt*, impacts on skilled workers and is supposed to respect the Harrod neutrality condition[2]. We further suppose that *mt* increases with the share of skilled workers in the total regional population

$$m_{1T} = v\left[L_{T1}/\left(L_1 + L_{T1}\right)\right], \qquad v' > 0$$

K_T, the capital required for the production of technological goods, is exogenous and just sufficient to reach x_T, the output level. Transport costs for technological goods, as well as for standardized goods, are assumed to take Samuelson's "iceberg" form. ψ is the inverse index for transport costs of technological goods.

[2] According to Harrod, a neutral technological progress implies Y = *f*(K,A(T)L) (i.e. the technological progress is labor-augmenting and, hence, increases production if the quantity of labor is raised).

We also assume, in this model, that the technological progress differential between regions is related to the distribution of skilled workers located in each region[3]. Returns on human capital are a source of agglomeration economies and raise the labor productivity.

In region 1, the technological industry representative firm will get the following profit

$$\Pi_{T1} = P_{T1}(e^{m1t})(L_{T1})^{\theta}(K_{T1})^{\varsigma} - W_{T1}(L_{T1}/Q) - g_1 K_{T1} \tag{10}$$

Skilled workers, employed in the technological industry located in region 1, are paid W_{T1}; the price of technological goods in region 1 is P_{T1}. This price is exogenous (according to perfect competition assumptions, firms are price-takers). g_1 is the operation cost for K_{T1}, the amount of capital used in region 1.

First-order conditions for a profit-maximizing behavior imply

$$W_{T1} = P_{T1}\left(\theta \frac{x_{T1}}{L_{T1}}\right) \tag{11}$$

Equation (11) reveals that price and marginal cost of technological goods are equalized –a result relevant to our perfect competition assumption. Here, the first-order condition for capital is not considered because g_1 results from the equalization of the aggregate demand for capital, K_T, to the supply of available capital in region 1, $\hat{K}$.

Wages paid to skilled workers, working in the technological sector located in region 1, derive from the substitution of x_T, resulting from equation (9), into equation (11)

$$W_{T1} = P_{T1}\theta\ (e^{m1t})(L_{T1})^{\theta-1}(K_{T1})^{\varsigma} \tag{12}$$

Thus, wages paid to skilled workers employed in the technological sector located in region 1 depend on P_{T1} (the price of technological goods produced in region 1), m_1t (the autonomous technological rate) and on θ and ζ (parameters respectively associated to labor and capital productivity).

The technological industry is assumed to be concentrated in the core region

3 This paper does not explicitly consider the various theoretical insights for which the technological progress is an endogenous process; this model could be fruitfully extended to product variety enlargement models (see Spence, 1976; Ethier, 1982; Romer, 1987 and 1990; Grossman and Helpman, 1991, chap. 3) or to quality improvement models (see, especially, Aghion and Howitt, 1992; Grossman and Helpman, 1991, chap. 4).

(due to its development level); we will, now, determine whether or not this concentration is a stable equilibrium, and whether or not a technological firm could profitably operate in the peripheral region, despite the region development lag.

Provided that λ is the share of total income spent for buying technological goods and that this whole income is spent in region 1, we obtain:

$$Y_2 = \frac{1-\mu-\lambda}{2} \tag{13}$$

$$Y_1 = \frac{1-\mu-\lambda}{2} + \mu + \lambda = \frac{1+\mu+\lambda}{2} \tag{14}$$

and, $$\frac{Y_2}{Y_1} = \frac{1-\mu-\lambda}{1+\mu+\lambda} \tag{15}$$

Provided that Q is the number of technological-industry-based firms, the individual production is worth

$$v_1^* = \left(\frac{\lambda}{Q}\right)(Y_1 + Y_2) \tag{16}$$

Any technological firm can be relocated in the peripheral region if it attracts skilled workers. Thus compensation must be paid because all standardized and virtually all technological goods are imported from the core region. Then, it follows

$$\frac{W_{T2}}{W_{T1}} = \left(\frac{1}{\tau}\right)^{\mu}\left(\frac{1}{\psi}\right)^{\lambda} \tag{17}$$

Proposition 2*: When the model is extended to a 2-goods one, interactions over localization decisions are considered with respect to transport costs associated to each product. In other words, every firm that makes a decision about its localization, takes 2 elements into account: (1) agents consume both industrial goods; (2) the transportation of goods from a region to another one is not costless.*

Due to higher wages, the output of the representative firm located in region 2 is worth the region-1 representative firm production, weighted by ($W_{T2}\tau\psi / W_{T1}$). (Conversely, in region 1, the relocated technological firm output is worth the representative firm output multiplied by $W_{T2} / W_{T1}\tau\psi$). Thus, the total output of the relocated firm is worth

$$v_1^* = \left(\frac{\lambda}{Q}\right)\left[\left(\frac{W_{T2}}{W_{T1}\tau\psi}\right)Y_1 + \left(\frac{W_{T2}\tau\psi}{W_{T1}}\right)Y_2\right] \tag{18}$$

With equations (16) to (18) and given (13) and (14), the ratio of relocated technological firm sales value to that of region-1 firms is

$$\frac{v_2^*}{v_1^*} = 1/2\left[(1+\mu+\lambda)\Phi + (1-\mu-\lambda)\Omega\right] \tag{19}$$

where, $\Phi = \psi^{\lambda-1}\tau^{\mu-1}$ and $\Omega = \psi^{-(\lambda-1)}\tau^{-(\mu-1)}$.

Proposition 3: *The production costs of technological goods are higher in the peripheral region for two related reasons:*

(i) there is an autonomous technological progress differential between regions; this differential benefits the core region since it has a larger proportion of skilled workers;

(ii) workers are paid a higher wage in region 2 due to a wage compensation (see eq. (17)) and labor productivity is lower.

Furthermore, provided a perfect homogeneity for technological goods, homogenous localization decisions made by technological firms do not depend on the elasticity of substitution between goods, while standardized firms do. Production in region 2 is profitable when

$$V^* = v_2^*/v_1^* > \left(W_{T2}/W_{T1}\right)\left(e^{m_2t}/e^{m_1t}\right) = \tau^{(-\mu)}\psi^{(-\lambda)}\left(e^{m_2t}/e^{m_1t}\right)$$

Let $e^{mt} = \left(e^{m_2t}/e^{m_1t}\right)$ and insert $\tau^{(-\mu)}\psi^{(-\lambda)}e^{mt}$ in eq. (19); the following result is obtained

$$V^* = 1/2\left(e^{mt}\right)\tau^{(-\mu)}\psi^{(-\lambda)}\left[(1+\mu+\lambda)\Phi + (1-\mu-\lambda)\Omega\right] \tag{20}$$

where, $\Phi = \psi^{\lambda-1}\tau^{\mu-1}$ and $\Omega = \psi^{-(\lambda-1)}\tau^{-(\mu-1)}$.

The value of the relocated technological firm output depends on ψ (the technological progress differential), on τ (the transport cost for the standardized goods) and is negatively affected by μ and λ (the respective shares of each industry in the economy). The technological industry concentration in the core region is a stable equilibrium if $V^* < 1$ holds.

If, during stage 3, the share of the technological industry in the economy is still inferior to the share of the standardized one, then $0<\lambda<.25$ and $.25<\mu<.5$ will hold; the share of the agricultural sector declines since the technological goods consumption positively enters in the utility function; and $0<(1-\mu-\lambda)<.25$ will result. Since transport costs for standardized and technological goods are low, due to the infrastructure development, we get $.75\tau<\tau<1$ and $.75<\psi<1$. On the other hand, we can, now, consider interactions related to localization decisions of both types of firms with respect to the transport cost differential between goods ($\psi\neq\tau$).

The numeral simulations given in annex (3) highlight some results. Case 3.1: whenever the transport cost differential between goods is zero, the weight of each industry in the economy has a marginal role to play regarding technological firm localization decisions; the incentive to relocate in the peripheral region is quasi-identical whatever the share of the technological industry in the economy. Here, the autonomous technological progress differential between regions plays a key role. A short technological progress differential, say $e^{mt} = 0.95$, can stabilize the equilibrium or lead to a concentration in the core region if transport costs for both industrial goods are low and equal ($\tau = \psi = 3/4$). Case 3.2.: if a transport cost differential between the two kinds of goods exists and if technological goods enter in the utility function with a higher share (i.e. if $\lambda>\mu$), the wage compensation required for firm relocation (derived from eq. (17)) will decline with a decrease in transport costs associated to these goods ($\psi > \tau$).

Proposition 4: *Technological firms will have an incentive to relocate, as high as*

(i) there is a transport cost differential benefiting the technological goods ($\psi > \tau$) and a high share for those goods in the economy ($\lambda > \mu$);

(ii) there is a transport cost differential benefiting the standardized industry ($\psi > \tau$) and a high share for those goods in the economy ($\mu > \lambda$).

The more favorable the transport cost differential is to the high share industry in the economy, the lower the wage compensation that has to be paid by a technological firm must paid to attract skilled workers in the periphery.

When the transportation is free of charge ($\psi = \tau = 1$), the technological industry is equally-divided between regions if the autonomous technological progress differential is set to zero ($e^{mt} = 1$); otherwise, the technological industry concentrates either in the core region or in the peripheral region when $e^{mt} < 1$ and $e^{mt} > 1$ hold, respectively.

Regarding the standardized industry, firms are equally-divided between regions whatever the value of the other parameters when transportation is costless for any industrial goods.

3.2. Decentralization of standardized industries

During the third stage of development, the core region experiences a growth leading to changes in its structures which, in turn, affect localization decisions of the standardized industry. Two factors can initiate a relocation movement of standardized firms from the core to the peripheral region:

(i) on the one hand, the central –urban and industrial– region is the concentration region for both industries: a congestion phenomenon may appear and expand in this region; production costs will increase with the number of firms (of both types) operating in the region;

(ii) on the other hand, the localization of standardized firms will, in turn, depend on transport costs for technological goods and, to some extent, on the conveyance-cost differential between the two kinds of industrial goods.

Given the transportation cost for technological goods, the wage compensation constraint (eq. 4) can be rearranged in the following way

$$\frac{W_2}{W_1} = \left(\frac{1}{\tau}\right)^{\mu}\left(\frac{1}{\psi}\right)^{\lambda} \tag{4'}$$

Equations (13) and (14), defining regional incomes, can be rewritten as

$$V = 1/2\,\tau^{\mu\sigma}\psi^{\lambda}\left[(1+\mu+\lambda)\Psi + (1-\mu-\lambda)\Gamma\right] \tag{7'}$$

where, $\Psi = \psi^{\lambda-1}\tau^{\sigma-1}$ and $\Gamma = \psi^{-(\lambda-1)}\tau^{-(\sigma-1)}$.

Following the Brakman et al. approach (1996), we will examine the impact of congestion costs on fixed costs and/or on variables under the control of the standardized industry.

Let $\theta_1 = (n_1 + Q_1)$, where n is the number of standardized firms located in region 1**,** and Q_1 is the number of technological firms located region 1; eq. (4.a) of the annex 1 can be rewritten as

$$L_1 = \alpha(\Theta_1) + \beta(\Theta_1)x_i \tag{4.a'}$$

The output of a representative firm in the standardized industry located in region 1 and 2, respectively, becomes

$$x_{i1} = \frac{\alpha(\Theta_1)(\sigma-1)}{\beta(\Theta_1)};\ \text{and}\ x_{i2} = \frac{\alpha(\Theta_2)(\sigma-1)}{\beta(\Theta_2)} \tag{8.a'}$$

Henceforth, the representative firm output depends on the number of firms located in the region. Brakman et al. demonstrate that firms will only produce fewer standardized goods as the number of firms increases if, and only if, the elasticity of the variable cost with congestion exceeds the elasticity of the fixed cost with congestion.

Assume, for instance, that congestion only affects fixed costs; the ratio of region-2 firm sales to that of region-1 standardized firms could be written as

$$V = 1/2\,\tau^{(\mu^2)}\psi^{-\lambda}\left(\frac{\alpha_1}{\alpha_2}\right)^{(\alpha-1)(\lambda-1)}\left[(1+\mu+\lambda)\Psi+(1-\mu-\lambda)\Gamma\right] \tag{7''}$$

where, ψ and Γ are identical to the definition given in eq. (7'), and α_1 and α_2 are fixed production costs for region 1 and 2, respectively.

Congestion costs associated to the central region play a key role and can explain why standardized firms would be willing to relocate to the peripheral region; however, the conveyance-cost differential (whether nil or not) between the two kinds of goods will affect such a relocation decision.

Invert eq. (4.a'), and you will observe that congestion (previously defined as an increase in production cost related to the number of firms located in a region) is similar to an increase in the quantity of labor used to produce a given amount of goods; therefore, congestion is similar to an increase in the wage per unit of output produced in the core region. This will result in the traditional explanatory scheme for industrial activity relocations (from core to peripheral spaces); these are based on wage differentials for a given skilled-labor level.

Annex 4 provides some simulations regarding the standardized industry during stage 3.

Proposition 5*: A concentration of the standardized industry in the core region reaches a stable equilibrium if the conveyance-cost differential is nil (highest curve on figure 4.1) or benefits technological goods (lowest curve on figure 4.1), the least-consumed goods in the economy ($\mu > \lambda$) – this result holds true even with poor scale economies ($\alpha > 10$). Conversely, concentration of the standardized industry in the central region is no longer in a stable equilibrium if scale economies are depleting ($\alpha > 6$ for the highest curve on fig. 4.2) when the conveyance-cost differential benefits technological goods, the most consumed goods in the economy.*

Annex 5 illustrates how congestion impacts on location decisions made by standardized firms. When scale economies are high ($\alpha = 2$) and the transport cost differential is nil (case 5.1), congestion costs in the central region must be high to prevent concentration in the standardized industry ($\alpha_1/\alpha_2 > 1$).

Strictly-positive transport cost differentials can, however, raise the incentive towards a decentralization into the peripheral region (case 5.2).

***Proposition 6**: The analysis of interactions between congestion and transport costs unto location decisions of standardized firms reveals that low transport costs increase the least-congested region's attractiveness. With low transport costs, a weak wage compensation is required for a relocation to the peripheral region; location decisions mainly depend on congestion costs. With high transport costs, firms will only provide domestic markets, and location decisions will be based on local market attractiveness and congestion. In this case, results are more ambiguous; on the one hand, firms are induced to remain concentrated in the core region to grasp the benefits of the local market size effect; yet, on the other hand, they are induced to decentralize their activities to the peripheral region since they experience congestion effects.*

The analysis of the interactions between congestion costs and σ (the elasticity of substitution between standardized goods) points out that the output per firm is low and the number of available variety is high when σ is small. Congestion is an increasing function with the number of varieties the standardized industry supplies (since the number of firms corresponds to the number of available varieties in a monopolistic competition setting). Hence, the peripheral region might become more attractive since the congestion effect dominates the local market size-effect.

Symmetrically, congestion costs will influence technological firm choices. Indeed, profits for a representative firm in the technological industry located in region 1 can be rewritten as follows

$$\Pi_{T1} = P_{T1}(e^{m1t})(L_{T1})^{\theta}(K_{T1})^{\varsigma} - W_{T1}(L_{T1}/Q) - g_1 K_{T1} - c_1(\Theta_1) \qquad (10')$$

where, $\Theta_1 = (n_1 + Q_1)$, c_1 is region-1 congestion cost, n_1 the number of region-1-located standardized firms and Q_1 the number of technological firms located in region 1; $\partial c_1 / \partial n_1 > 0$ and $\partial c_1 / \partial Q_1 < 0$.

Now, production costs are lower in region 2 due to a quasi-lack of congestion (in this region).

Let $\Xi = \tau\psi\left[c_1(\Theta_1)/c_2(\Theta_2)\right]^{-(1+\mu+\lambda)}$ and suppose that standardized firms are concentrated into the central region, then

$$V^* = 1/2\left(e^{mt}\right)\Xi\left[(1+\mu+\lambda)\Omega + (1-\mu-\lambda)\Upsilon\right] \qquad (20')$$

where, $\Omega = \tau^{(1-\mu)}\psi^{(1-\lambda)}$, $\Upsilon = \tau^{-(1+\mu)}\psi^{-(1+\lambda)}$ and $\Xi = \tau\psi\left[\dfrac{c_1(\Theta_1)}{c_2(\Theta_2)}\right]^{-(1+\mu+\lambda)}$.

A relocation to the peripheral region will be profitable if $V^* > \tau\psi\left[c_2(\Theta_2)/c_1(\Theta_1)\right]$.

During the fourth stage of development, the influence of congestion on technological firm location-related decisions is simulated; the interaction between congestion and metropolization effects is analyzed. During stage 4, technological firms can be induced to decentralize their activities to the peripheral region**,** since the core one experiences a congestion phenomenon. However, standardized firm relocations appear more common since these firms are much less dependent on agglomeration economies (the central region experiences such economies). Once the decentralization process for standardized firms is under way, congestion in the central region can deplete; the technological-goods specialization of the region is deepened.

5. STAGE 4 AND "METROPOLIZATION"

The fourth stage of development can be depicted by the following elements: (i) an increasing specialization in technological goods leads to the emergence of a sector providing firms with services; (ii) the service sector output is an intermediate input for the technological industry and is not traded (neither imported nor exported); (iii) the service sector is supposed to employ skilled-workers who worked for the technological industry during the previous stage. A specificity of this labor force to the service sector is another assumption we make.

Formally, the situation is

$$L_{S1} + L_{S2} = \lambda$$

where L_{S1} is the region-1 supply of skilled-workers to the service sector and L_{T1} is the region-1 supply of skilled-workers to the technological sector.

Now, the production of T, the technological goods, in region 1 is defined by

$$x_{T1} = \left(e^{m_1 t}\right) L_{T1}^{\theta} V_{ST1}^{\rho} K_{T1}^{\zeta} + c_1(\Theta_1) \tag{21}$$

with $\theta + \rho + \zeta = 1$.

$$V_{ST1} = \left[\sum_{z=1}^{r} S_{zT}^{\varepsilon} \right]^{1/\varepsilon} \quad \text{with } 0 < \varepsilon < 1 \tag{22}$$

S_{zT} is the quantity of services demanded by the technological industry**,** and r is the number of services this industry uses. V_{ST1} is the differentiated service aggregate for region 1.

Following the approaches of Abdel-Rahman and Fujita (1990) and Rivera-Batiz (1988), this production function for a competitive firm (belonging to the technological sector) exhibits a constant return to L_T (a homogenous skilled-labor input), K_T (the capital used in the technological industry) and S_{zT} (differentiated intermediate services). However, this function displays increasing returns to r (the number of intermediate and specialized services the industry uses); ρ stands for the need for a larger variety of intermediate goods in order to produce technological goods. Suppose, for instance, the equilibrium value for the number of firms providing the industry with services is reduced; then, services will be less specialized**,** and the industrial output will be weakened (even if the amount the industry allocates to input purchases remains constant).

Stated differently, this production function (i.e. eq. (21)) emphasizes the influence of agglomeration economies on location decisions made by the technological industry. The first right-hand term portrays localization economies (i.e. presence of a skilled labor force specific to the technological industry); the third right-hand term depicts urbanization economies (i.e. presence of a sector providing the economy with superior and specialized services for production). The productivity of technological activities is markedly connected to the importance and variety of services provided to firms operating in the metropolitan setting.

Due to a specialization in production, every firm produces one differentiated service, S_{zT}, and uses an identical technology function in which labor is the unique input. Label L_{SzT} the total amount of skilled labor required for producing S_{zT}; L_{SzT} is defined by

$$L_{SzT} = h + a(S_{zT}) \tag{23}$$

where h is the required fixed quantity of labor (i.e. a fixed cost) and a is the required marginal quantity of labor (i.e. a variable cost). They have identical cost and supply functions since services enter, symmetrically, in the V_{ST} function; and every technological firm uses the same quantity of every z services (with z = 1,…,r).

Hence the T-industry uses the following aggregate quantity of services for production

$$S_T = \sum_{z=1}^{r} S_{zT} = rS_{zT} \tag{24}$$

Rearrangement of eq.(22) leads to

$$V_{ST1} = (S_{zT})r^{(1-\varepsilon)/\varepsilon} \tag{25}$$

Insertion of eq. (25) in eq. (21) implies

$$xT1 = (e^{m1t})L_{T1}{}^{\theta}K_{T1}{}^{\varsigma}[(S_{zT})r^{(1-\varepsilon)/\varepsilon}]^{\rho} + c_1(\Theta) \tag{26}$$

then,

$$x_{T1} = r^{\rho(1-\varepsilon)/\varepsilon}\left(e^{m_1 t}\right)L_{T1}^{\theta}S_{zT}^{\rho}K_{T1}^{\zeta} + c_1\left(\Theta_1\right) \tag{26'}$$

eq. (26') describes a standard Cobb-Douglas production function with constant returns to scale (θ + ρ + ζ = 1). $r^{\rho(1-\varepsilon)/\varepsilon}$ accounts for agglomeration economies deriving from a specialization of the service sector (r is the number of services used in the technological industry). ε is positive and therefore, V_{ST1} is a concave function and specialization economies result in an increase in service variety ($\partial x_{T1}/\partial r > 0$). When r tends towards 1, there is a decrease in r (the number of services given by eq. (26)) and the impact of r on x_{T1} is depleted. As Rivera-Batiz (1988) explained it, when ε tends towards 1, V_{ST1} is just the sum of total quantities of services utilized by the technological industry –services become perfect substitutes for each other. If services are homogenous, their number has no influence on the industrial production; however**,** S_{zT}, the total quantity demanded, has.

The analyzed services exclusively meet the technological sector production; the agglomeration of the technological industry will be strengthened when services are intermediate goods and exhibit specificity. The size and variety of located services influence the productivity of the technological industry; on the other hand, an increase in the technological industry output raises the demand for services and thus, the productivity of the service sector due to scale economies, external to the firms of this sector[4]. The interconnection of productivity effects between service and technological sectors triggers a cumulative growth process and reinforces the basic element of a metropolization dynamics.

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[4] In the same vein, Abdel-Rahman and Fujita (1990) underlined the role of the size of the manufacturing sector in order to determine the size of this service sector.

Given the amount of labor required for producing S_{zT} (i.e. a given quantity of services), every firm faces identical total costs, equal to $W_{S1}L_{S1}$ (with W_{S1} and L_{S1} the wage offered to and the quantity of skilled-workers located in region 1 and employed in the service sector, respectively).There is a monopolistic competition setting and a free-entry in the service sector; in the service sector, a maximizing-profit behavior for a representative firm located in region 1 leads to

$$P_{S1} = \left(\frac{\varepsilon}{\varepsilon - 1}\right) a W_{S1} \tag{27}$$

Prices for representative services can be compared as follows

$$\frac{P_{S1}}{P_{S2}} = \frac{W_{S1}}{W_{S2}} \tag{28}$$

Profits tend towards zero because entry –in the sector– is free, which implies

$$P_{S1} - aW_{S1} = hW_{S1} \tag{29}$$

and

$$x_{S1} = x_{S2} = \frac{h(\varepsilon - 1)}{a} \tag{30}$$

Each region produces a quantity of services which is proportional to the quantity of skilled labor available in the service sector, namely

$$\frac{r_1}{r_2} = \frac{L_{S1}}{L_{S2}} \tag{31}$$

In zero-profit equilibrium, $\dfrac{\varepsilon}{\varepsilon - 1}$ is the ratio of the marginal product of labor to its average product, that is, the degree of scales economies in the service sector.

Now, profits for a representative firm of the technological sector located in region 1 are

$$\Pi T = P_{T1}x_{T1} - W_{T1}(L_{T1} / Q) - g_1 K_{T1} - \sum_{z=1}^{r} P(S_{zT1})S_{zT1} - c_1(\Theta_1) \tag{32}$$

where, W_{T1} is the wage offered to skilled workers by the technological industry located in region 1; P_{SzT1} is the price of services offered by the z^{th} firm to the T industry in region 1; P_{T1} is the price of technological goods in region 1 (this price is assumed to be exogenous); and x_{T1} is the quantity of technological goods produced in region 1. First-order conditions for a maximizing-profit behavior imply

$$W_{T1} = P_{T1}\left(\theta \frac{x_{T1}}{L_{T1}}\right) \tag{33}$$

$$S_{SzT1} = \left[\frac{\rho P_{T1} x_{T1}}{V_{ST1}^{\varepsilon} P_{SzT1}}\right]^{1/(1-\varepsilon)} \tag{34}$$

and

$$\rho\left(P_{T1} x_{T1}\right) = \sum_{z=1}^{r} P_{SzT1} S_{SzT1} \tag{35}$$

Eq. (33) indicates an equality between the price and marginal cost of the technological commodity. Eq. (34) is the quantity demanded to every service, and equation (35) shows that the total amount the technological industry spends on services for production is a fraction, ρ, of its income.

The wage offered to skilled labor working for the technological sector in region 1 can be found by substituting x_T in eq. (33):

$$W_{T1} = P_{T1}\left[\left(e^{m_1 t}\right)\left(L_{T1}^{\theta-1}\right)\left(S_{zT1}^{\rho}\right) r^{\rho(1-\varepsilon)/\varepsilon} K_{T1}^{\zeta} + c_1\left(\Theta_1\right)\right] \tag{36}$$

Thus, wages offered to skilled workers employed in the technological sector located in region 1 depend on P_{T1} (the price of technological goods produced in region 1), m_1t (the autonomous technological progress), θ, ρ, ε and ζ (parameters associated to the marginal product of skilled labor, service and capital, respectively), $r^{\rho(1-\varepsilon)/\varepsilon}$ (the diversity index), S_{T1}^{ρ} (the quantity of services used by the industry) and on the level of congestion of each region.

Hence, wages paid to skilled workers employed in the technological sector depend on agglomeration economies, and these are related to the intermediate consumption of services in the technological sector; similarly, the autonomous technological progress and agglomeration diseconomies affect wages.

Regarding a metropolitan region, a gap between V and V* (for every industry) can exist if a certain distribution of standardized industries between regions occurred during stage 3. On the contrary, V and V* will be equal if the standardized industry remains concentrated in the core region. Regional income discrepancies will explain both situations.

Regional incomes derive from equations (13) and (14) when the standardized industry remains concentrated in the core region. However, regional income will change if an interregional diffusion of the standardized industry occurs during stage 3. These new regional incomes are defined as

$$Y_2 = \frac{1-\mu-\lambda}{2} + \frac{\mu}{2} = \frac{1-\lambda}{2} \tag{13'}$$

$$Y_1 = \frac{1-\mu-\lambda}{2} + \frac{\mu}{2} + \lambda = \frac{1+\lambda}{2} \tag{14'}$$

which implies, $\frac{Y_2}{Y_1} = \frac{1-\lambda}{1+\lambda}$ (15')

If the standardized industry remains concentrated in the core region, the ratio of relocated technological firms' sales value to that of region 1 firms is

$$V^* = 1/2\left(e^{mt}\right)r^{-[\rho(1-\varepsilon)/\varepsilon]}\Xi\left[(1+\mu+\lambda)\Omega + (1-\mu-\lambda)\Upsilon\right] \tag{20'}$$

where

$$\Omega = \tau^{(\mu-1)}\psi^{(\lambda-1)},\ \Upsilon = \tau^{-(\mu-1)}\psi^{-(\lambda-1)} \text{ and } \Xi = \tau\psi\left[\frac{c_1(\Theta_1)}{c_2(\Theta_2)}\right]^{-(1+\mu+\lambda)}.$$

If the standardized industry is distributed among regions, this ratio becomes

$$V^* = 1/2\left(e^{mt}\right)r^{-[\rho(1-\varepsilon)/\varepsilon]}\ \Xi\ \left[(1+\lambda)\Omega + (1-\lambda)\Upsilon\right] \tag{20''}$$

where, $\Omega = \tau^{\left(\frac{\mu}{2}-1\right)}\psi^{(\lambda-1)}$, $\Upsilon = \tau^{-\left(\frac{\mu}{2}-1\right)}\psi^{-(\lambda-1)}$ and $\Xi = \tau\psi\left[\frac{c_1(\Theta_1)}{c_2(\Theta_2)}\right]^{-\left(1+\frac{\mu}{2}+\lambda\right)}$.

Annex 6 provides computed results for V* with respect to ε. The autonomous technological progress differential has a non-significant influence on localization (case 6.1) if a high specialization degree occurs in the service sector (e < 0.3). The distance between the different curves increases when ε increases.

***Proposition** 7: A weaker specialization in the service sector will bestow upon this sector a lower agglomeration force and, as such, a lower effect on V*. The autonomous technological progress differential is the key variable for firms, and the volume of output of the service sector is no longer crucial. Computational results for figure 6.2. highlight this agglomeration role given to the specialization level of the service sector.*

Case 6.3. is a simulation allowing changes in V^* when both congestion costs and the number of consumed services vary. In this case, concentration in the core region is in a stable equilibrium (until congestion costs reach a high value that is, exceed 1.5) if both the service sector is highly specialized and firms consume a large number of services. Conversely, the autonomous technological progress differential will be too weak to maintain a concentration in the core region if the number of consumed services diminishes and concentration costs exceed a critical threshold (equal to 1.3).

A regional asymmetry appears when these "negative feedbacks" are considered, and a concentration of both kinds of production in one region will become unlikely. Congestion costs explain why small industrial regions can still be economically profitable –a result empirically observed.

Due to congestion effects, particular firms (and mobile workers) might find it profitable to move from the core to the periphery as industrial production grows. Once a certain development threshold is reached, the agglomeration is associated with increasing congestion costs responsible for a gradual relocation of industrial activities from the core to the periphery.

6. CONCLUSION

The present theoretical model is an extension of the new economic geography approach, introduced by Krugman. The current model was an attempt to extend these previous works to the different stages of regional development. Its primary objective was to explicitly lay down the microeconomic foundations of regional macroeconomic mechanisms, which were only studied with empirical models or statistical studies. This paper presents an all-encompassing framework facilitating the analysis of localization movements, regional concentration and specializations into key economic activities; such an analysis is required to specify both the role and nature of productivity gains and external agglomeration economies when regions experience development.

The various concentration and/or dispersion forces can clearly differ with respect to their form or intensity, given the development stage of the examined regions. This paper explains why localization decisions can become heavily dependent on agglomeration economies and/or diseconomies when regions develop. During the first two stages (i.e. periods Krugman referred to), standardized firm concentration depends heavily on external pecuniary localization economies of scale. From stage 3, the technological industry development emphasizes the impact of technological externalities on regional specializations. During stage 3, the core region experiences a transition to an industrial and urban level which can, in turn, bring out a congestion phenomenon and then, a relocation of the standardized industry from the core to the periphery. During the final stage of development, technological firms consume intermediate goods designed as superior services for production. This results in interconnections between industry and service productivities and in a metropolization dynamics into the core region (technological and service specializations in the core region, the concentration of skilled workers, as well as the regional infrastructure level play a predominant role).

This model considers that standardized firm relocation is a pre-requisite condition for the migration of workers; this assumption would, however, deserve greater attention. Labor migrations and firm location decisions are, sometimes, simultaneously analyzed in the context of a labor market (see Jayet, 1997) or in the context of the economic geography. The results largely depend on the market structure (i.e. monopoly, perfect competition or imperfect competition structures). The present model could be enhanced with the introduction of an immigrating labor force as an alternative strategy to firm relocations, international trade in a clearly opened-economy model, service exports and the various interregional links within an economy.

Finally, the current model is based on comparative statistics between the different stages but does not explicitly address questions related to path and transition between periods. Recent works offered a dynamic approach to economic geography models (see especially those of Englmann and Walz, 1995; Martin and Ottaviano, 1999; Baldwin, Martin and Ottaviano, 2001; Ottaviano, 1999, 2001; Baldwin, 2001). These works are based on assumptions related to endogenous growth theories or forward looking expectations. In the first context (endogenous growth), the authors include an R&D sector**,** and the dynamics stems from the innovation accumulation. The scope of this kind of analysis is to demonstrate how the less developed regions can make up for their delay via the catch-up and regional leapfrogging phenomena. These analyses are another potential method to expand the present work.

ANNEX 1

The seminal Krugmanian model (1991a,b)

Suppose the economy is divided into 2 low-developed regions. Each region is endowed with the 2 following productive sectors:

(i) an agricultural sector (name it sector A) producing homogeneous goods (we will use them as a numeraire);
(ii) an industrial sector with an industry producing manufactured goods (this"standardized"industry is named B).

The standardized industry produces manufactured goods, which are differentiated, and acts in a monopolistic competition environment. Each firm produces a single variety of the goods due to increasing returns to scale. This model is a variant of the seminal Dixit and Stiglitz (1977) monopolistic competition model. Individuals have a similar utility function. This function is Cobb-Douglas shaped (i.e. elasticity of substitution is constant) and can be modeled as

$$U = C_B^{\mu} C_A^{(1-\mu)} \tag{1.a}$$

C_A and C_B are consumptions of the agricultural and manufactured and standardized goods, respectively. C_B, the standardized manufactured commodity production aggregate, can be defined by

$$C_B = \left[\sum_{i=1}^{n} c_i^{(\sigma-1)/\sigma} \right]^{\sigma/(\sigma-1)} \tag{2.a}$$

In eq. (2), n stands for the number of potential producers (n is supposed to be large) and σ is the elasticity of substitution between the different varieties produced by the industry ($\sigma > 1$).

This economy comprises 2 regions with 2 inputs each –agricultural labor force and industrial but low-skilled labor force. Following Krugman's intent, each factor is sector-specific. Peasants produce agricultural goods; 1 unit of labor is required to produce these goods. Farmers are supposed to be immobile between regions and the supply of farmers in each region is set to $(1-\mu)/2$. Call L_1 and L_2 the supply of non-skilled workers in each region, respectively –μ is the total amount of non-skilled workers. Then, we have

$$L_1 + L_2 = \mu \tag{3 .a}$$

There are fixed and –constant– marginal costs associated to the production of the i^{th} variety of the manufactured and standardized commodity; these costs give rise to internal scale economies, consistent for each firm to produce an i^{th} variety

$$L_i = \alpha + \beta x_i \tag{4.a}$$

L_i is the quantity of labor required to produce an x_i amount of the i^{th} variety.

We make two assumptions for transport costs. First, the transportation of the agricultural commodity is costless. Then, the price for agricultural goods and in turn, peasant incomes, are the same in both regions. Thus, the price/wage ratio can be used as a numeraire. We also assume that transportation costs for manufactured goods take a Samuelson "iceberg" form –i.e. transportation costs are, to some extent, incurred in the price of conveyed goods. There is just a fraction, τ (with $\tau < 1$), of shipped goods that reaches its destination. This results in a higher marginal cost for the foreign market, compared to the domestic market. Then, σ is the demand elasticity for every firm (Krugman, 1991), given the definition for the industrial aggregate (see eq. (2.a)) and the assumption of iceberg-shaped transportation costs. Firms producing standardized manufactured goods in region 1 are profit-maximizers and their behavior leads to

$$P_1 = \left(\frac{\sigma}{\sigma - 1}\right)\beta W_1 \tag{5.a}$$

P_1 and W_1 are the price and the wage for non-skilled workers in region 1, respectively. A similar equation automatically follows for region 2. Compare prices for representative commodities:

$$\frac{P_1}{P_2} = \frac{W_1}{W_2} \tag{6.a}$$

Profits will diminish to zero if entry in the sector is free. Then, we can write:

$$P_1 - \beta W_1 = \alpha W_1 \tag{7.a}$$

Which implies:

$$x_1 = x_2 = \frac{\alpha(\sigma - 1)}{\beta} \tag{8.a}$$

Therefore, the production per firm is constant whatever its localization, nominal wage and relative demand (this is a standard result with this kind of model). The number of standardized goods for each region is proportional to the number of workers

$$\frac{n_1}{n_2} = \frac{L_1}{L_2} \tag{9.a}$$

Short and long term equilibria can be considered. The short-term equilibrium is based on a Marshallian definition, i.e. an equilibrium associated with a given allocation of workers between regions. In the long run, however, workers can move to high-wage regions. Let C_{11} and C_{12} be the consumption in region 1 of goods produced either in region 1 or in region 2. P_1 and P_2/τ (transport cost included) are prices for goods produced in region 1 and 2, respectively. The relative demand for representative goods immediately follows

$$\frac{C_{11}}{C_{12}} = \left[\frac{P_1\tau}{P_2}\right]^{-\sigma} = \left[\frac{W_1\tau}{W_2}\right]^{-\sigma} \tag{10.a}$$

Let R_{11} be the ratio of region 1 expenditures on local manufactured goods to that on region 2 manufactured goods (i.e. imports from region 2 to region 1); then, it follows

$$R_{11} = \frac{n_1}{n_2}\left[\frac{P_1\tau}{P_2}\right]^{-\sigma}\left[\frac{C_{11}}{C_{12}}\right] = \frac{L_1}{L_2}\left[\frac{W_1\tau}{W_2}\right]^{-(\sigma-1)} \tag{11.a}$$

The total income of region 1 workers depends on the goods the region produces (either for domestic and foreign markets). Y_1 and Y_2 are regional incomes allocated to region 1 and 2, respectively (worker and farmer incomes included). Region 1 worker incomes can easily be found

$$W_1L_1 = \mu\left[\left(\frac{R_{11}}{1+R_{11}}\right)Y_1 + \left(\frac{R_{12}}{1+R_{12}}\right)Y_2\right] \tag{12.a}$$

Following a similar line, we obtain for region 2

$$W_2L_2 = \mu\left[\left(\frac{1}{1+R_{11}}\right)Y_1 + \left(\frac{1}{1+R_{12}}\right)Y_2\right] \tag{13.a}$$

Worker distributions and payoffs will affect regional incomes. With peasant incomes as a numeraire (an assumption we made before) we can derive equations (14.a) and (14.a')

$$Y_1 = \frac{1-\mu}{2} + W_1 L_1 \qquad (14.a)$$

$$Y_2 = \frac{1-\mu}{2} + W_2 L_2 \qquad (14.a')$$

With equations (11.a) to (14.a'), we can derive W_1 and W_2 for given proportions of workers between regions.

Now, when the focus is on the long-term equilibrium, worker proportions are no longer affected by nominal-wage disparities but related real-wages. Thus, workers who reside in the most densely populated region will pay lower prices for manufactured goods. Call f the fraction of non-skilled workers residing in region 1, so that $f = L_1/\mu$. Given the non-skilled worker distribution among regions, the price index for manufactured goods is

$$P_1 = \left[f W_1^{-(\sigma-1)} + (1-f)\left(\frac{W_2}{\tau}\right)^{-(\sigma-1)} \right]^{-1/(\sigma-1)} \qquad (15.a)$$

$$P_2 = \left[f\left(\frac{W_1}{\tau}\right)^{-(\sigma-1)} + (1-f) W_2^{-(\sigma-1)} \right]^{-1/(\sigma-1)} \qquad (15.a')$$

For the workers of both regions, equations (15.a) and (15.a') lead to the following (real) wages:

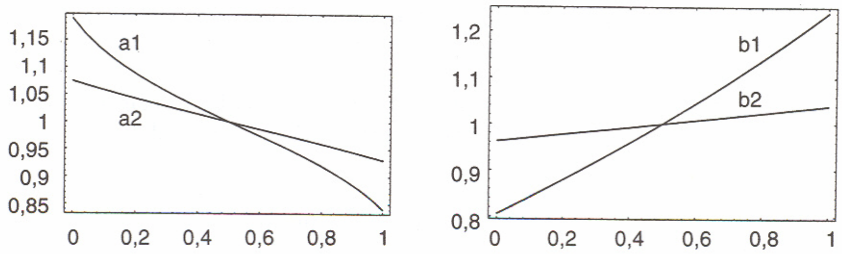
$$w_1 = W_1 P_1^{-\mu} \qquad (16.a)$$

$$w_2 = W_2 P_2^{-\mu} \qquad (16.a')$$

ANNEX 2

EVOLUTION OF THE REGIONAL (REAL) WAGE RATIO (ω1/ω2) AS A FUNCTION OF THE INDUSTRIAL LABOR FORCE DISTRIBUTION (f = L1/μ)

(2a) ***(2b)***



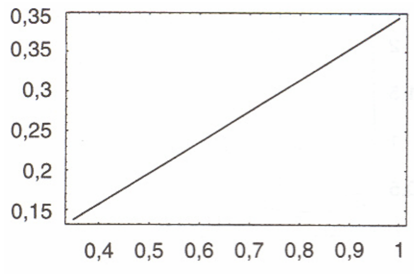
$a1 : \mu = 1/4, \sigma = 4, \tau = 1/2$
$a2 : \mu = 1/2, \sigma = 4, \tau = 1/2$

$b1 : \mu = 3/4, \sigma = 2, \tau = 3/4$
$b2 : \mu = 3/4, \sigma = 2, \tau = 0{,}95$

ANNEX 3

EVOLUTION OF V* AS A FUNCTION OF THE AUTONOMOUS TECHNOLOGICAL PROGRESS DIFFERENTIAL (m)

(3.1)



(3.2)

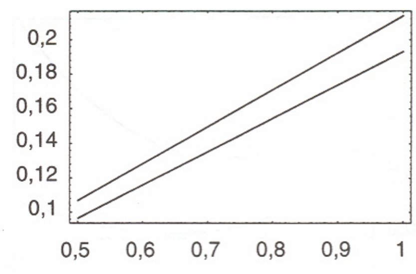


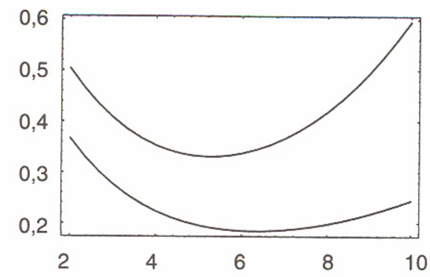
Figure (3.1): V* variations are considered when the autonomous technological progress differential evolves, transportation-cost differential excluded ($\psi = \tau = 3/4$);. $\mu = 1/2$ and $\lambda = 1/4$. We obtain similar results when $\mu = 1/2$ and $\lambda = 1/2$ (i.e. whatever the size of each industry in the economy).

Figure (3.2): a transportation-cost differential is introduced and $\psi > \tau$. In this case we reach the highest curve when $\lambda > \mu$; the opposite result follows when $\psi < \tau$ and $\lambda < \mu$ hold; there is a higher incentive to relocate for technological firms when industrial goods are the most-consumed goods in the economy and incur the lowest transportation cost.

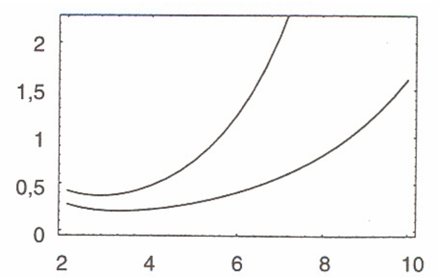
ANNEX 4

EVOLUTION OF V AS A FUNCTION OF THE ELASTICITY OF SUBSTITUTION BETWEEN STANDARDIZED GOODS (σ)

(4.1)



(4.2)



Cases (4.1) and (4.2) illustrate how scale economies affect V.

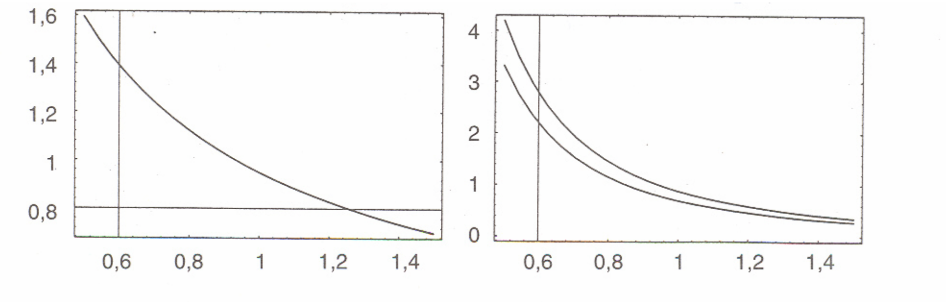
In ***case (4.1)***, the transportation-cost differential is zero (lowest curve on fig. (4.1)) and standardized goods have an important share in utility functions; the concentration of standardized firms achieves a stable equilibrium even with weak scale economies.

Case (4.2) indicates that if agents mainly consume technological goods, concentration can become unstable when $\sigma \geq 6$ and a strictly-positive transportation cost differential ($\psi > \tau$) exists (highest curve); if the transportation-cost differential is zero, instability occurs when σ is close to 10 (lowest curve).

ANNEX 5

EVOLUTION OF V AS A FUNCTION OF CONGESTION COSTS ($\alpha 2/\alpha 1$)

(5.1) ***(5.2)***

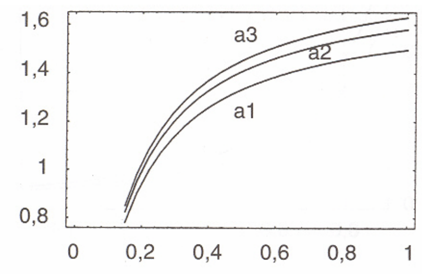


When scales economies are high ($\sigma = 2$) and the transportation-cost differential is zero (case 5.1 with $\mu = 1/2$ and $\lambda = 1/4$), the core region must exhibit high congestion costs to avoid a concentration in the standardized industry ($\alpha_2/\alpha_1 < 1$). When a transportation-cost differential exists (case (5.2) with $\tau > \psi$ and $\mu > \lambda$), there is a higher incentive to relocate when congestion costs for the core region are high. As congestion costs decline, the impact of the transportation-cost differential diminishes (the gap between the two curves is reduced).

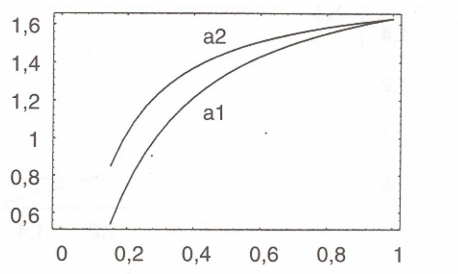
ANNEX 6

EVOLUTION OF V* AS A FUNCTION OF BOTH THE DEGREE OF SPECIALIZATION IN THE SERVICE SECTOR (ε) AND CONGESTION COSTS (α2/α1)

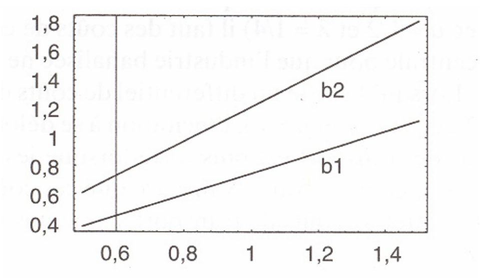
(6.1)



(6.2)



(6.3)



Cases (6.1) and (6.2) are related to ε, the parameter for specialization in the service sector. (6.1) and (6.2) offer simulations for which the transportation cost differential is zero (τ = ψ). Case (6.1) is for r = 10, ρ = .05, μ = 1/2 and λ = 1/4; three values are considered for the autonomous technological progress (a1: m = .9; a2: m = .95; a3: m = .98). In case (6.2), m = .98 for both considered situations (that is, the autonomous technological progress is identical). There is no transportation-cost differential but in one case r = 10 (situation a2), while r = 50 in the other (situation a1). There is just a change in the number of consumed services. The lowest curve is for r = 50. If there is a high specialization in the service sector (weak ε), the distance between both curves can vary due to high increasing returns to the number of intermediate services consumed by technological firms. These returns deplete as ε rises. In the polar case, ε = 1, services are perfect substitutes for each other and can be analyzed as homogenous; the number of consumed services no longer impacts on technological firm location decisions; both curves are merged. In case (6.3), we consider the evolution of V* as a function of congestion costs (b1 and b2 curves). For a given autonomous technological progress differential (m = .98) and a given degree of specialization in the service sector (ε = .2) (the transportation-cost differential is excluded) the lower curve (situation b1) is for r = 50, while the higher one (situation b2) is for r = 10. The distance between curves rises as congestion increases; technological firms using the bigger quantity of specialized services will relocate last.

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ÉTAPES DU DÉVELOPPEMENT RÉGIONAL

ET CONCENTRATION SPATIALE

Résumé *- Nous proposons un modèle d'économie géographique qui analyse les dynamiques de concentration-diffusion régionales de différentes activités productives durant quatre étapes de développement. Dans la phase de décollage et la deuxième étape, la localisation d'une industrie standardisée est basée sur l'exploitation d'économies d'échelle externes pécuniaires. Durant la troisième étape du développement, l'apparition et la croissance d'une industrie technologique mettent en évidence le rôle spécifique du progrès technique autonome et de sa diffusion dans la dynamique de concentration régionale. Durant la quatrième étape, la congestion pousse les industries banalisées à se délocaliser vers la périphérie alors que la spécialisation des industries technologiques au centre conduit au développement de services supérieurs à la production qui sous-tend un processus de métropolisation dans cette région.*

ETAPAS DEL DESARROLLO REGIONAL Y CONCENTRACIÓN ESPACIAL

Resumen *- Proponemos un modelo de economía geográfica que analiza las dinámicas de concentración – difusión de distintas actividades productivas a lo largo de cuatro etapas de desarrollo. En la fase de despliegue, la localización de una industria standard está basada en la explotación de economías de escala externas pecuniarias. A lo largo de la tercera etapa del desarrollo, la aparición y el crecimiento de una industria tecnológica ponen de relieve el papel específico del progreso técnico autónomo y de su difusión en la dinámica de concentración. A lo largo de la cuarta etapa, la congestión lleva las industrías comunes a deslocalizarse hacia la periferia mientras que la especialización de las industrias tecnológicas al centro lleva al desarrollo de servicios superiores a la producción que subtiende un proceso de metropolización en esta región.*