Review of International Economics, 11(3), 512–526, 2003

Economic Integration and Regional Income Inequalities: Competing Dynamics of Regional Wages and Innovative Capabilities

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Abstract

A factor-price difference scenario has recently been used by Krugman and Venables and by Puga to explain why, in the absence of labor migrations, economic integration should first produce and then dissolve regional income inequalities. The authors question this scenario in a dynamic analysis framework that extends the Baldwin, Martin, and Ottaviano ones to allow for regional wage differences. In this context, wage flexibility is no more a sufficient condition to induce long-run convergence. Indeed, when regions are equally sized, the innovative capability advantage of the "core" outweighs the wage cost advantage of the "periphery" even for very low transport costs, and regional wage gaps are likely to persist in the long run.

1. Introduction

In the New Economic Geography (NEG) literature, the lack of interregional labor mobility has been recently emphasized as allowing the relationship between integration and industrial agglomeration to be nonmonotonic (Krugman and Venables, 1995; KV hereafter). Acknowledging the low level of migrations in Europe, it has been argued that European integration, through declining trade costs, should induce this kind of dynamics, first producing, then dissolving interregional income inequalities.[1]

Theoretically, two very different rationales can nonetheless underlie such a U-shaped convergence scenario. The first one, completed by Puga (1999), relies on the KV factor-price differences argument. Using a static comparative analysis framework, the author shows that, starting from high levels of trade costs, the reduction of these initially encourages agglomeration. However, if workers do not move, this process can end up with opening wage differences and then, for low enough trade costs, firms can be incited to move again, bringing about convergence in terms both of industrial employment and of income. In the second rationale, as developed by Baldwin et al. (2001; BMO hereafter), factor-price differences are intentionally ruled out[2] in order to emphasize the role of interregional knowledge spillovers. In this dynamic framework, a U-shaped convergence scenario emerges as soon as integration processes bring, after the fall of industrial transport costs, an even further fall of knowledge communication costs.

This paper aims at confronting both these rationales in a unified model where two innovative regions with fixed labor forces interact through trade and knowledge flows but without labor migrations. Contrary to BMO (2001), parameter values, specifically the share of global spending devoted to industrial products, can take all their range values so that equal as well as unequal wage trajectories are allowed to emerge. This leads us to explicitly discuss the relationship between the underlying structural para-

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meter values and the likelihood of wages divergence on the long-run steady-state paths. We also let the regions differ in terms of their labor force size, as such differences lead to interesting insights on welfare issues. Within this framework, it is noteworthy that our model comes very close to the Grossman and Helpman (1991; GH hereafter) one where two differently sized countries interact in a context of perfectly localized knowledge externalities and costless trade.[3] In this respect, our model departs from theirs mainly because of the presence of transport costs. In particular, this allows equilibria with active R&D in both regions to be stable despite the localized nature of technological externalities, an outcome that cannot arise when transport costs are nil.

Two main results of the analysis can be presented as follows. First, the occurrence of a regional wage gap in the first phase of integration is not a sufficient condition for inducing the redeployment of industrial activities in a later phase of the integration process. Indeed, when knowledge is imperfectly localized and regions are equally sized, a wage advantage cannot compete with an innovative capabilities advantage. Regional wage gaps induced by the integration process can then be a source of large welfare losses for the peripheral regions (as in the Puga story) but, here, without providing them with any long-run advantage. Second, regional wage gaps make more likely the re-spread of innovative activities if interregional technological spillovers exogenously intensify (as in the BMO story). Finally, a normative implication of the paper is to challenge Puga's view according to which favoring labor market flexibility should be considered as the primary requirement to induce income convergence among European regions.

2. The Basic Framework of Analysis

The Regional Economies

Two regions, A and B, of labor force L^A and L^B, respectively, implement three kinds of economic activities: innovative, industrial, and traditional ones. In each region, the innovative activity employs a fraction of the labor force in order to invent new designs for industrial goods. In the course of innovation, knowledge capital is accumulated as a byproduct and benefits to all the local researchers in improving their marginal productivity. This R&D activity is active as long as firms in the industrial sector are incited to produce an always larger set of differentiated industrial products (M goods). The industrial sector is then supposed to behave under monopolistic competition: each variety of industrial good is produced in a single firm which entails variable labor costs beyond the fixed cost paid to researchers for acceding to monopoly rights. Finally, the traditional activity employs the residual labor force in order to produce a homogenous final good (T good) which enters as an imperfect substitute for the differentiated industrial goods in the utility function of the representative consumer. Individual preferences are supposed to be identical in both locations.

Trade and Factors Mobility

In the absence of labor migrations, regions A and B can still interact through two channels: trade in goods and knowledge capital flows.[4] Here come assumptions that deserve specific comments. First, for final goods trade, we adopt the standard simplifying assumption according to which trade in T goods is costless but trade in M goods is impeded by frictional (that is iceberg) transport costs.[5] As advocated in the NEG literature, the main advantage of this transport technology is its tractability in monopolistic competition frameworks. However, it also has the undesirable implication that transport costs increase proportionally with traded volumes.[6] In the perspective of our analysis, this introduces a bias in favor of dispersion since fixed transport and communication costs will not act here as specific barriers to the catching-up of peripheral regions.[7] Second, we assume that R&D products (new designs) cannot be traded between regions. M goods are designed and manufactured in the same location. This extreme assumption is made here for two reasons. First, from an heuristic point of view, this allows us to keep our results comparable to those of GH (1991) and BMO (2001).[8] Second, this assumption is more realistic than the dual one according to which designs should be perfectly mobile.[9] The main implication for our analysis is that it introduces a bias in favor of agglomeration since convergence mechanisms cannot act here through the re-spread of M-good production units.[10] Finally, we assume that, despite nontraded designs, some part of the knowledge accumulated in one region flows to the other one as a costless byproduct of engaging into trade. In other words, researchers of region A (respectively B) benefit not only from the knowledge accumulated locally but also from some part of the knowledge accumulated in region B (respectively A). This defines our concept of imperfectly localized knowledge externalities.

The Integrated Economy

Under the above assumptions, the integrated economy can be described for exogenous given values of transport cost and of intensity of interregional knowledge flows. Starting with consumers' behavior, each household in regions A and B maximize the following utility function:

$$U = \int_0^\infty e^{-\rho t} \ln Q_t dt,$$

where ρ is the time preference parameter and Q is the consumption composite of the T goods and a CES aggregate of the differentiated M goods:[11]

$$Q = C_T^{1-\alpha} C_m^{\alpha} \quad \text{with } C_M = \left[\int_0^{N^i} x_i^i(u)^\beta di + \int_0^{N^j} x_j^i(v)^\beta dv\right]^{1/\beta} \quad \text{and } 0 < \alpha < 1, 0 < \beta < 1,$$

where $x_i^i(u)$ is the consumption of the variety u from the continuum $[0, N^i]$ of differentiated industrial products manufactured domestically, and $x_j^i(v)$ is the consumption of the variety $v \neq u$ from the continuum $[0, N^j]$ which are imported from the foreign region. N^A and N^B, respectively, approximate the number of industrial varieties available in regions A and B.[12] Two parameters that will appear central to the analysis are β, the intensity of preference for variety in manufactured goods, and α, the share of M goods in the consumption of a typical agent.

Endowed with these preferences, households optimize their consumption by sharing their nominal expenditure, E, between the T goods and the M goods so that, for $i = A$, B:

$$(1-\alpha)E^i = p_T C_T,$$

$$\alpha E^i = p_M C_M.$$

Let us note that $E^w = E^A + E^B$, the nominal world spending. The equilibrium in the world market for the T goods requires then

$$p_T(T^A + T^B) = (1-\alpha)E^w. \tag{1}$$

With constant returns to scale (CRS) in the traditional sector, T goods will be produced only in the region with the lowest unit production cost and will be priced at the level of the minimum cost. With a technology that requires, by adequate choices of units, one unit of labor per unit of goods, it follows that

$$p_T = \min(w^A, w^B),$$

$$s_T^i = 0 \text{ when } w^i > w^j \quad \text{for } i, j = A, B \text{ and } j \neq i,$$

where $s_T^i = T_i/(T^A + T^B)$ is the share of region i in the world output for the traditional good, and w^i is the wage rate there. From (1), note that s_T^i also represents the share of world spending devoted to traditional goods produced in region i.[13]

Furthermore, considering the Dixit–Stiglitz preferences on M goods, we know that all the varieties coming from a common location and sold in a common location will be demanded in the same quantity at the equilibrium. Then, the consumption composite can be rewritten more simply as

$$C_M = \left[N^i x_i^{i\beta} + N^j x_j^{i\beta}\right]^{1/\beta}.$$

It follows that, in the steady state, all the varieties of M goods which share the same origin and the same sale location will be identically priced. The share of world spending on industrial products devoted to the goods originating from region i can then be calculated as

$$s_M^i = \frac{N^i\left(p_i^i x_i^i + p_i^j x_i^j\right)}{\alpha E^w} \quad \text{for } i, j = A, B \text{ and } j \neq i,$$

where p_i^i is the price of a variety of region i sold on the local market, and p_i^j is the price of a variety originated from region i and sold on the foreign market.

The demand functions of the M goods are such that, whatever the value of the manufacturing composite C_M, the cost of attaining it is minimized. This means that $x_i^i(u)$ and $x_j^i(v)$ are solutions of the following minimization problem:

$$\min E^i = \int_0^{N^i} p_i^i(u)x_i^i(u)du + \int_0^{N^j} p_j^i(v)x_j^i(v)du$$

$$\text{s.t.}\left[\int_0^{N^i} x_i^i(u)^\beta du + \int_0^{N^j} x_j^i(v)^\beta du\right]^{1/\beta} = C_M.$$

Consequently, we have for $i, j = A, B$ and $j \neq i$:

$$x_i^i(u) = x_i^i = \frac{\alpha E^i \left(p_i^i\right)^{-\sigma}}{N^i\left(p_i^i\right)^{1-\sigma} + N^j\left(p_j^i\right)^{1-\sigma}}, \tag{2}$$

$$x_j^i(v) = x_j^i = \frac{\alpha E^i \left(p_j^i\right)^{-\sigma}}{N^i\left(p_i^i\right)^{1-\sigma} + N^j\left(p_j^i\right)^{1-\sigma}}, \tag{3}$$

where $\sigma = 1/(1 - \beta)$ represents the common price elasticity of the demand functions for each variety of M goods.

Those goods are priced at a mark-up over unit production costs. Moreover, the retained transport costs specification implies that the same good is priced τ times the f.o.b. price when it is sold abroad, with τ greater than 1. Suppose that the production of one unit of industrial products requires a variable cost of a_M units of labor and a fixed cost corresponding to the rental rate of the license for the variety design. Moreover, let units[14] be measured such that $a_M = \beta$. Under such a technology, the demand functions for the industrial varieties can be used to compute the share s_M^i. Moreover, these prices and demands allow us to calculate the profits that accrue to manufacturers of M goods in either region. All of this gives for $i, j = A, B$ and $i \neq j$:

$$p_i^i = w^j \text{ and } p_i^j = \tau w^i, \tag{4}$$

$$s_M^i = \frac{N^i}{\alpha E^w}\left[\frac{\alpha E^i (p_i^i)^{1-\sigma}}{N^i (p_i^i)^{1-\sigma} + N^j (p_j^i)^{1-\sigma}} + \frac{\alpha E^j (p_i^j)^{1-\sigma}}{N^j (p_j^j)^{1-\sigma} + N^i (p_i^j)^{1-\sigma}}\right], \tag{5}$$

$$\pi^i = p_i^i x_i^i + p_i^j x_i^j - w^i a_M x_i^i - w^i a_M \tau x_i^j,$$

$$\pi^i = \frac{\alpha E^w}{\sigma N^w}\frac{s_M^i}{\theta_N^i},$$

where w^i is the wage rate in region i, and θ_N^i is the share of region i in the world varieties of industrial products, so that $\theta_N^i = N^i/N^w$ with $N^w = N^A + N^B$. Let θ_E^i denote the share of region i in world spending; then, using the pricing equations, (5) can be rewritten as

$$s_M^i = \theta_N^i\left[\frac{\theta_E^i (w^i)^{1-\sigma}}{\theta_N^i (w^i)^{1-\sigma} + (1-\theta_N^i)\phi (w^j)^{1-\sigma}} + \frac{\theta_E^j \phi (w^i)^{1-\sigma}}{(1-\theta_N^i)(w^j)^{1-\sigma} + \theta_N^i \phi (w^i)^{1-\sigma}}\right],$$

where $\phi = \tau^{1-\sigma}$ is a tractable indirect variable for apprehending the level of transport costs: for a given value of σ, and τ varying between infinity and 1, ϕ rises from 0 (prohibitive trade costs) to 1 (costless trade).

In each region, free entry into innovation ensures that the value of the representative industrial firm cannot be higher than the cost of research. As in BMO (2001), this cost is a labor cost that decreases proportionally with the knowledge already accumulated in the local as well as in the foreign research activities. Specifically, the R&D activity is conceptualized as the sum of individual projects, each unit of labor invested in research during a lapse of time dt producing $1/a^i(t)dt$ new designs, with $1/a^i(t) = N^i(t) + \lambda N^j(t)$, $i = A, B$, $0 \leq \lambda \leq 1$.

Technological externalities are imperfectly localized insofar as $\lambda < 1$. Moreover, the higher is λ, the stronger is the intensity of interregional knowledge flows.[15]

In such a setting, the cost of designing a new variety is $w^i/(N^i + \lambda N^j)$. Thus, noting $A^i = \theta_N^i + \lambda(1 - \theta_N^i)$, we have the following free-entry condition:

$$v^i \leq \frac{w^i}{N^w A^i} \text{ with strict equality for } \dot{N}^i > 0, \quad i = A, B. \tag{6}$$

Moreover, the familiar no-arbitrage condition requires that

$$\pi^i + \dot{v}^i = r v^i, \quad i = A, B. \tag{7}$$

Finally, the equilibrium conditions for the labor markets are

$$L_N^i + L_M^i + L_T^i = L^i, \quad i = A, B, \tag{8}$$

with L_N^i, L_M^i, and L_T^i being the quantities of labor allocated respectively to the innovative activity, the industrial one, and the traditional one.

L_T^i is easily computed considering that, in the competitive sector of traditional goods, the value of labor exactly matches the value of production:

$$w^i L_T^i = (1-\alpha)E^w s_T^i, \quad i = A, B.$$

L_N^i is calculated by aggregating all the R&D individual projects carried out in the region i. Hence, at this aggregate level, the accumulation function of the new designs is

$$\dot{N}^i = (1/a^i)L_N^i, \quad i = A, B. \tag{9}$$

This gives

$$L_N^i = \frac{g^i \theta_N^i}{A^i}, \quad i = A, B,$$

with g^i the innovation rate in region i. Note that L_N^i will be constant in the steady state only if the local innovation rate is constant and if the share of local research in the global R&D activity is stable. This means that, in such a framework, a situation where both regions innovate at different rates is not sustainable in the long run.

L_M^i is computed from the demand functions (2) and (3) and from the labor requirements in the industrial sector which are equal to $a_M x_i^i + \tau a_M x_i^j$ for each produced variety. Then we have

$$L_M^i = \frac{\beta\alpha E^w s_M^i}{w^i}, \quad i = A, B.$$

Finally, the labor market-clearing equations can be written as

$$\frac{g^i \theta_N^i}{A^i} + \frac{\beta\alpha E^w s_M^i}{w^i} + \frac{(1-\alpha)E^w s_T^i}{w^i} = L^i, \quad i = A, B.$$

In the steady state, the intersectoral resources allocation in each region remains fixed. From the preceding equation, this requires constant wage and constant market shares (s_M^i, s_T^i, and θ_N^i) in each region. Several different long-run outcomes are however possible, especially depending on preference and technology parameters. Moreover, the local stability of each of these outcomes will further depend on the level of transport costs and on the intensity of interregional knowledge flows.

3. Equal Wage and Unequal Wage Long-Run Equilibria

Insofar as equilibrium conditions require constant market shares in our framework, possible long-run outcomes can be only of two types: whether both regions innovate at the same constant rate or whether only one of them innovates. However, in each case, equal- as well as unequal-wage steady states may prevail depending on two parameters: the share of global spending devoted to industrial goods and the relative size of the regions. In this section, we follow GH (1991) to explicitly derive the conditions on parameters α, L_A, and L_B that allows us to discriminate between the different possible long-run outcomes according to the wage dynamics they entail.

Equal-Wage Steady States

Broadly speaking, equal-wage steady states will prevail as far as regional economies under integration end up sharing the global T goods production. Indeed, this is the competitive pricing of traditional goods on the global market that requires equal unit costs and then equal wage rates between regions.

The first kind of such long-run outcomes are steady states in which R&D and industrial activities are concentrated in a single region while firms in both locations engage in the production of T goods. Let region i be the region that concentrates all the R&D and industrial activities, so the equilibrium conditions require $g^i > g^j = 0$. Moreover, relative wages being constant in the long run, (1) requires that the market shares of the innovative region approach 1; i.e., $s_M^i = 1$ and $\theta_N^i = 1$. The steady state is then characterized by a no-arbitrage equation derived from (7) and two market-to-market clearing conditions derived from (8):

$$\frac{\alpha E^w}{\sigma w} = r + g^i, \quad i = A, B, \tag{10}$$

$$g^i + \frac{\beta \alpha E^w}{w} + \frac{s_T^i (1-\alpha) E^w}{w} = L^i, \quad i = A, B, \tag{11}$$

$$\frac{s_T^j (1-\alpha) E^w}{w} = L^j, \quad j = A, B \text{ and } j \neq i. \tag{12}$$

These three equilibrium equations, together with $s_T^i + s_T^j = 1$, determine the long-run wage, the long-run innovation rate, and the long-run market shares in the traditional sector. Solving this system, we find that $s_T^j \leq 1$ requires that

$$\frac{L^j}{L^i + r} \leq \frac{1-\alpha}{\alpha}. \tag{13}$$

Then, in a steady state in which one region performs all the world R&D, that same region can also produce T goods only if it is large in comparison to its trade partner or if the share of world spending devoted to T goods is great. It is noteworthy that this condition neither depends on the level of M-good transport costs nor on knowledge transfer costs.[16]

The second kind of long-run outcomes entailing equal wage rates are steady states in which both the regions remain unspecialized under integration; i.e., each of them still performs R&D, industrial, and traditional activities. Such steady states involve $g^i = g^j = g$ in the long run. The condition $w^i = w^j = w$ is once more required by competition in the T-good sector, and the steady-state no-arbitrage conditions are:[17]

$$\frac{s_M^k \alpha E^w}{\sigma w} = r + g^k, \quad k = i, j. \tag{14}$$

The labor market-clearing conditions can be written as

$$g^k \frac{\theta_N^k}{A^k} + \frac{s_M^k \beta \alpha E^w}{w} + \frac{s_T^k (1-\alpha) E^w}{w} = L^k, \quad k = i, j. \tag{15}$$

Note that the no-arbitrage conditions imply that $s_M^i = s_M^j = 1/2$; i.e., the regions share evenly the world market for industrial products. Moreover, $s_T^j \le 1$ now implies

$$\frac{L^j - L^i}{L^i + r} \le \frac{2(1-\alpha)}{\alpha}. \tag{16}$$

In words, in the R&D dispersed case, both regions can produce T goods only when the difference in their size is relatively small. Once more, this condition reproduces the one derived by GH (1991) under the extreme assumptions of costless trade and perfectly localized knowledge externalities. Note, however, that while in the GH costless world those outcomes are always unstable (i.e., they can emerge in the long run only if the initial market shares in the industrial sector happen to coincide with the steady-state shares), in our costly trade framework these outcomes may be stable for high enough transport costs. Even more specifically, those steady states computed in the case where $L^A = L^B = L$ will correspond to the familiar symmetric outcomes emphasized by the NEG literature.

Unequal-Wage Steady States

The common feature of those steady states is that T goods end up being produced by only one of the regions. Two sub-cases have, however, to be carefully distinguished depending on whether only one region innovates (the R&D concentrated case) or both regions innovate (the R&D dispersed case).

Starting with the R&D concentrated case, the region, say region i, that performs the industrial and innovative activities does not perform at all the traditional activity. Then, long-run wage rates are such that $w^i > w^j = 1$. Moreover, with $g^i > g^j = 0$, the arbitrage equations and the labor market-clearing ones are

$$\frac{\alpha E^w}{\sigma w^i} = r + g^i, \quad i = A, B, \tag{17}$$

$$g^i + \frac{\beta\alpha E^w}{w^i} = L^i, \quad i = A, B, \tag{18}$$

$$(1-\alpha)E^w = L^j, \quad j = A, B \text{ and } j \neq i. \tag{19}$$

Such unequal wage trajectories will prevail when the share of the M goods in global spending is high or when the size of the region specializing in R&D is small compared to the other one; i.e., when condition (13) is reversed.

In the R&D dispersed case, region i performs only R&D and industrial activities while region j performs all the three activities. In this case, long-run wage rates are again such that $w^i > w^j = 1$ but now we have $g^i = g^j = g$. The arbitrage equations and the labor market-clearing ones are then

$$\frac{\alpha E^w}{\sigma w} \frac{s_M^k A^k}{\theta_N^k} = r + g, \quad k = i, j, \tag{20}$$

$$g\frac{\theta_N^i}{A^i} + \frac{s_M^i \beta\alpha E^w}{w^i} = L^i, \quad i = A, B, \tag{21}$$

$$g\frac{\theta_N^j}{A^j} + s_M^j \beta\alpha E^w + s_T^j(1-\alpha)E^w = L^i, \quad j = A, B \text{ and } j \neq i. \tag{22}$$

In this case, only large differences in the relative size of the regions can lead to unequal wage trajectories; i.e., condition (16) must be reversed. Those outcomes are then impossible when regions are equally sized.

In the case of equally sized regions, it is also straightforward that condition (13) resumes to $\alpha \leq (L + r)/(2L + r)$ which, considering the magnitude of L relative to r, can appropriately be rewritten as $\alpha < 1/2$. This condition means that, when $L^A = L^B = L$, regional wages can differ in the long run only if R&D ends up being concentrated *and* if the share of world spending devoted to M goods is relatively high (more than a half).

As far as we know, no direct attempt to estimate parameter α has yet been completed within the NEG literature.[18] What must be emphasized, however, is that high values of α are exactly what helps a U-shaped convergence scenario to emerge in the static NEG models, while low values of α are exactly what is required in the BMO dynamic model to rule out such a factor-price difference scenario.

4. The U-Shaped Convergence Scenario Revisited

When regions are equally sized,[19] fully characterizing the long-run equilibria leads to distinguish the familiar symmetric outcomes of the NEG literature from two main types of core–periphery (CP) outcomes, namely equal-wage CP outcomes and unequal-wage CP outcomes. Let us now compute the growth rates of the main variables in each of these three different long-run steady states.

Within the prevailing framework, the symmetric outcomes present characteristics that are identical to the ones computed by BMO (2001). In our own setting, the long-run innovation rates are easily derived in resolving (14) for E^w and in substituting in (15). We get

$$g_S^i = \frac{\alpha(1+\lambda)L - \rho(\sigma - \alpha)}{\sigma}, \quad i = A, B. \tag{23}$$

As expected, these innovation rates are positively influenced by the size of the labor force (L is large), the degree of monopolistic power (weak σ), the relative share of industrial goods in the final consumption (high α), and the intensity of interregional technological spillovers (large λ).

Real-income growth rates are deduced knowing, first, that the nominal income Y remains constant in the steady state and, second, that the price index of consumption in each location, $P = P_T^{1-\alpha}P_M^{\alpha}$, decreases at the rate $g_S^i/(\sigma - 1)$. P_T is chosen as the natural *numéraire*, and P_M^i is defined as

$$P_M^i = \left[\int_0^{N^i} (p_i^i)^{1-\sigma} di + \int_0^{N^j} (p_j^i)^{1-\sigma} dj\right]^{1/(1-\sigma)}, \quad i = A, B, j \neq i. \tag{24}$$

Equation (24) with $w_i = w_j = 1$ ensures that, in the steady state, P grows at the specified rate. Then, regional real incomes increase also at a common rate $g_{YS}^i = \alpha g_S^i/(\sigma - 1)$, while real wage levels are identical between both the regions and equal to $1/P$.

Such symmetric steady states are, however, stable only for a given range of relatively high transport costs.[20] For low enough transport costs, the alternative core–periphery outcomes will prevail in the long run. These steady states are such that the innovation rate in the periphery, say region j, is zero ($g_{CP}^j = 0$), while the innovation rate in the core is constant and positive. However, the specific value this innovation rate will take depends further on the type of steady states realized. When the core–periphery equilibrium entails regional equal wages, the long-run innovation rate in the core region is given, on resolving (17) for E^w and substituting in (18) and (19), by[21]

$$g^i_{CPe} = \frac{\alpha 2L - \rho(\sigma - \alpha)}{\sigma} \quad \text{with } \alpha < 1/2. \tag{25}$$

Alternatively, when the core–periphery equilibrium entails regional unequal wages, the long-run innovation rate in the core is given, on resolving the no-arbitrage condition (20) for E^w and substituting in the labor market-clearing conditions (21) and (22), by

$$g^i_{CPu} = \frac{L - \rho(\sigma - 1)}{\sigma} \quad \text{with } \alpha > 1/2. \tag{26}$$

A one might expect, none of these innovation rates is influenced by the intensity of interregional technological externalities, as innovation occurs only in the core. Moreover, in both cases, and despite their unequal performances in terms of innovation, region *i and* region *j* experience real-income steady growth, since both of them benefit from the regular decrease of industrial goods prices. We have

$$g^i_{YCPe} = g^{ji}_{YCPe} = \alpha g^i_{YCPe}/(\sigma - 1) \quad \text{with } \alpha < 1/2, \tag{27}$$

$$g^i_{YCPu} = g^{ji}_{YCPu} = \alpha g^i_{YCPu}/(\sigma - 1) \quad \text{with } \alpha > 1/2. \tag{28}$$

Finally, real wage levels differ between regions at least for one reason—because the price index is higher in the periphery than in the core region owing to transport costs. This real wage difference is widened when regional nominal wages also diverge. Respectively denoting by ω^i and ω^j the real wage rates prevailing in regions *i* and *j*, we have

$$\omega^i = 1/P^i = (N^w)^{\frac{\alpha}{\sigma-1}} > 1/P^j = (\phi N^w)^{\frac{\alpha}{\sigma-1}} = \omega^j \quad \text{with } \alpha < 1/2, \tag{29}$$

$$\omega^i = w^i/P^j = (\phi N^w)^{\frac{\alpha}{\sigma-1}} w_i^{-\alpha} >> 1/P^j = (\phi N^w)^{\frac{\alpha}{\sigma-1}} w_i^{-\alpha} = \omega^j \quad \text{with } \alpha > 1/2. \tag{30}$$

Comparative Steady-State Analysis

A first striking feature is that g_{CPu} (prevailing when α is high) is always greater than g_{CPe} (prevailing when α is low). This feature can be explained as follows. When T goods end up being produced only in the periphery, the core reaches the maximal innovation rate a region can sustain under the prevailing technology. In others words, the fact that a share $(1 - \alpha)$ of global expenditure is spent on T goods no more bears on labor allocation decisions in this core, and then g_{CPu} no more depends on parameter α.

Turning now to the comparison between both these CP outcomes and the symmetric one, here an apparently paradoxical result is obtained. While the innovation rate prevailing under equal-wage CP outcomes is obviously higher than the symmetric one (at least, as far as λ is not strictly equal to one), this is no longer the case when the CP outcomes entail unequal regional wages. Specifically, comparing terms in (23) and (26), g_{CPu} is higher than g_S only if

$$\lambda < \frac{1 - \alpha}{\alpha}. \tag{31}$$

Condition (31) has to be interpreted as a condition of existence of unequal-wage CP outcomes. Although we cannot analytically characterize the transitional dynamics of this system,[22] we can present the intuition as follows. Suppose the integrated economy is on a symmetric equilibrium where $w^i = w^j = 1$ and $\theta_N^i = \theta_N^j = \frac{1}{2}$. For low enough values of transport costs, this equilibrium becomes unstable, and any positive shock on θ_N^i brings about a cumulative advantage to region i in the sense that this initial perturbation reinforces innovation profitability in region i compared to region j.[23] However, while R&D and industrial sectors expand in region i and shrink in region j, there comes a time when T goods are no longer produced in region i, and the nominal wage begins to rise there. When agglomeration is completed with $\theta_N^i = 1$ and $\theta_N^j = 0$,[24] the marginal cost of innovation is w^i/N^i in region i, where w^i is the CP equilibrium value of nominal wage in region i, and $w^i > w^j = 1$. The upshot is that if condition (31) holds, this cost is permanently lower than $1/\lambda N^i$; i.e., the marginal cost that should be paid to restart innovative activities in region j. In consequence, the unequal-wage CP configuration is sustainable in the long run: whatever the further decrease in transport costs, R&D will remain unprofitable in the periphery despite its wage-cost advantage.

This analysis gives two meaningful insights. First, unequal-wage CP outcomes can emerge in the long run under very plausible conditions; i.e., if the share of global spending on M goods is not excessively high, or if knowledge externalities are localized enough. Note that, in the limit case where α is higher but close to a half, condition (31) reverts to the general condition $\lambda < 1$. In others words, unequal-wage CP outcomes are likely even when knowledge partly diffuses between regions.

Second, emphasizing the fact that CP outcomes are always stable when they exist, it immediately follows that the relationship between integration (the fall of transport costs) and agglomeration is monotonic in our setting. In other words, the wage gap that characterizes our CP outcomes cannot induce a redispersion of R&D and industrial activities even for very low transport costs. The reason is that the wage dynamics which opened catching-up opportunities in the static comparative analysis framework of Puga (1999) are pinned down here by the competing dynamics of innovation costs.

Welfare Issues

In the dynamical setting we work in, welfare issues are of specific interest because of the tension that exists between the static and the dynamic welfare effects of agglomeration. On the one hand, the static effects are unambiguously negative for the periphery which has to support transport costs for all its M-good consumption. On the other hand, residents of this region still benefit from innovations that are made in the core since they also import the novel goods that emerge from the foreign R&D activity. These gains are exactly the reason why the welfare implication of the static models of economic geography can change dramatically once account is taken of the dynamic effects of integration processes. BMO (2001) prove the point in presenting, under equal-wage CP outcomes, plausible scenarios where the periphery actually experiences welfare gains.[25]

Can similar welfare patterns arise also under unequal-wage CP outcomes? To answer this question, let us proceed in two steps. First, note that, in the prevailing framework, ϕ near 1 (costless trade) and λ near zero (perfectly localized knowledge externalities) are the most favorable conditions for allowing the periphery to experience positive welfare gains. Indeed, other things being equal, a low level of transport costs means weak (negative) static effects for the periphery[26] and unchanged (positive) dynamic effects; in contrast, a low value of λ means large (positive) dynamic effects for the periphery[27] and unchanged (negative) static effects. Second, recall that those extreme values of $\phi = 1$ and $\lambda = 0$ exactly match the work assumptions of GH (1991) who demonstrated the occurrence of net welfare losses for the periphery when T goods are produced only in this region.[28] From both these observations, it immediately follows that integration processes leading to unequal-wage CP outcomes are always welfare-depressing for the periphery.

In this comparative welfare analysis, a final insight can be obtained by discussing further the general case of unequally sized regions. Specifically, when regions differ in terms of their labor force sizes, a direct implication is that the indeterminacy on which of the regions will specialize in R&D no longer holds. Other things being equal, the large region has a comparative advantage in technological efficiency, and then, when transport costs fall enough, this region will be the natural candidate to become the core.[29] Nonetheless, as this region is large, it is likely that, even for a low budget share of T goods, demands will be placed on its labor force to manufacture also T goods. The equal-wage core–periphery steady state is then more likely to prevail than the unequal-wage one, and the (small) periphery may strongly benefit from the acceleration of innovation occurring in the core.

Intensification of Knowledge Flows

The last issue that remains to be investigated is what happens if the intensity of inter-regional knowledge flows increases in the course of the integration process. BMO (2001) document a U-shaped convergence scenario proceeding through two distinct phases. In the first phase, the fall of transport costs (decreasing τ) upsets the symmetric equilibrium and an (equal-wage) CP outcome emerges. In a second phase, a further fall in the cost of ideas transfer (rising λ) leads to redistribution of innovative and industrial activities towards the periphery. The present paper adds that, allowing unequal-wage CP outcomes to prevail, such a reconvergence scenario becomes even more likely. Indeed, acknowledging the wage advantage of the periphery, the redistribution of innovative and industrial activity will occur sooner if the technological advantage of the core actually erodes. However, the important point remains that, without this exogenous shock on λ, long-run convergence cannot be expected in the dynamic setting we have analyzed. This strongly contrasts with the endogenous U-shaped dynamics occurring under comparable structural conditions in the static frameworks of KV (1995) and Puga (1999).

5. Conclusions

Insufficient wage flexibility in a context where workers are geographically immobile is often presented as a core explanation for the lack of regional real-income convergence observed among European regions. The argument is that the institutional rigidities that prevent regional wage differences to prevail also destroy the long-run competitiveness of peripheral European regions and preclude then the possibility of reconvergence for these regions. Such a scenario has been completed in a static framework of analysis by Puga (1999). In this paper, we have investigated the effects of integration in a dynamic framework of analysis where regional growth is induced by endogenous innovation processes. In this context, frictionless labor markets are no longer a sufficient condition to induce long-run convergence as peripheral regions may not be able to benefit from a wage-cost advantage even on this long-run horizon. The technological lag they experienced during the first (polarization) phase of the integration process is such that a wage advantage cannot compensate for it, at least when the regions are equally sized. Consequently, the relative decrease in wage these regions experience translates only into welfare losses. However, if the integration process progressively intensifies the interregional diffusion of knowledge, as in BMO (2001), long-run real convergence can actually be expected.

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Notes

1. KV (1995) first developed their argument on globalization and the dynamics of North–South income inequalities.
2. By adequate restriction on the range of parameter values.
3. See ch. 8 entitled *Hysteresis*.
4. Actually, there is an additional asset in the model bearing a risk-free interest rate *r*. Following GH (1991) and BMO (2001), we however assume that capital assets are also immobile between regions.
5. This assumption is common to KV (1995), Puga (1999), and BMO (2001).
6. For a general comment on the implications and limits of the iceberg cost specification, see Neary (2001).
7. On this line, models which explicitly take into account transport and communication infrastructures could be more meaningful.
8. Actually, BMO (2001) interpret the R&D sector as a (knowledge) capital-producing sector instead of a new-designs producing activity. This allows them to rely on a "factor immobility" argument instead of a "trade impossibility" argument as we do.

9. Martin and Ottaviano (1999) show how technological spillovers from producers towards researchers maintain a strong geographical link between the location of industrial and innovative activities even when designs can be traded.
10. Recent work investigates specifically the role of multilocation firms. For instance, Gao (1999) develops a model where vertical multinational firms emerge when, at some point of the integration process, factor-cost disadvantages outweigh the importance of agglomeration economies. Ekholm and Forslid (2001) introduce horizontal and vertical multiregion firms into the core–periphery model of Krugman (1991). Both of these extensions tend to make production units more spread out even if headquarters or R&D laboratories still cluster altogether. In this sense, agglomeration tendencies are weakened.
11. From now, we will omit temporal indices when this entails no confusion.
12. Each of these variables is increasing in t so far as the R&D activity is active in the corresponding region. Moreover, for simplicity, we assume that no redundancy exists between the sets of industrial products manufactured in each region.
13. Indeed, equation (1) can be rewritten as $p_T T^i = (1 - \alpha)E^w s_T^i$.
14. Following FKV (1999) and BMO (2001), we choose this standard normalization to reduce the dimensionality of the parameter space and help to derive more simple analytical expressions. However, as pointed out by Neary (2001), such normalization, while harmless in local analysis, can become undesirable in nonlocal comparisons because the effects of a greater substitutability in demand (a rise in σ) cannot be distinguished from the effects of a higher ratio of variable to fixed costs. In the modeled economy, changes in one are exactly offset by changes in the other.
15. With such a specification, note that two implicit assumptions are made. First there is no overlapping between the regional knowledge stocks. Indeed, if this were the case, λ would also represent, in some part, such redundancy. Second, each innovation has an infinite economic life so that there is no depreciation in the process of knowledge accumulation. See Baldwin and Forslid (2000) for further comments on this issue.
16. Specifically, this implies that condition (13) reproduces exactly the one computed by GH (1991) under the extreme assumptions of costless trade and perfectly localized knowledge externalities.
17. We use subscript k when the same equation characterizes *two* equilibrium conditions; i.e., the one prevailing in region $i = A, B$ *and* the one prevailing in region $j = A, B, j \neq i$.
18. However, a recent paper of Antweiler and Trefler (2000) proposes estimations of returns to scale on a database covering all internationally traded good-producing industries for 71 countries over the period 1972–92. Their results reveal that over 33 industries (27 in manufacturing and 7 outside of manufacturing), only a third has to be considered as CRS industries. Relative income shares of those industries are not considered in the paper.
19. Later in the paper we come back to the more general case of unequally sized regions in order to discuss further welfare issues.
20. Stability issues are beyond the scope of the paper as our main argument is on comparative steady-state analysis. We refer readers to BMO (2001) where those issues are carefully exposed (see, in particular, their methodology to derive the critical value of transport costs under which the symmetric steady state loses its stability).
21. Subscript "e" indicates equal-wage steady states, while subscript "u" indicates unequal-wage ones.
22. See BMO (2001) for similar methodological concerns.
23. Specifically, CP outcomes are reached only asymptotically in the prevailing framework (the number of M goods produced in region j remains fixed, but the value of these drops forever toward zero owing to the ceaseless introduction of new varieties of M goods in region i).
24. These CP equilibrium values are reached only asymptotically.
25. For instance, such a result emerges when the model is calibrated with the following parameter values: $\alpha = 0.3$; $\rho = 0.1$; $\sigma = 3$; $\lambda = 0.7$.
26. The static welfare losses are entirely due to the existence of transport costs.

27. The growth gains for the whole integrated economy that have to be expected from the concentration of R&D activities in only one region are larger the more localized are knowledge externalities.
28. See GH (1991, p. 232).
29. This conjectured scenario is not unrelated to the "scale effects" characterizing both the new international trade theory and the new growth one. Here, scale matters because, all else equal, the large region tends to enjoy a comparative advantage in performing the activities that are subject to increasing returns to scale. Note, however, that the implication according to which large regions should innovate faster than small ones is not validated by international comparisons.