UNIVERSITY
of
GLASGOW

Department *of* Economics

REGIONAL INTEGRATION AND MIGRATION: AN ECONOMIC GEOGRAPHY MODEL WITH HETEROGENEOUS LABOUR FORCE

Nicola D. Coniglio*

University of Glasgow

Glasgow, December 2002

Abstract

This paper aims to analyse the effect of deepening regional integration on the incentive for factors of production, in particular labour, to spatially relocate. We adopt a general equilibrium, economic-geography model built on Krugman (1991) allowing for skill heterogeneity in the manufacturing sector. At a given level of trade costs, due to the productivity premium associated with the concentration of high-skilled workers in one region, this type of worker will be more willing to migrate than low-skilled ones. The paper shows the existence of a range of trade costs for which only high-skilled workers have an incentive to migrate. Therefore, introducing labour heterogeneity in the basic core-periphery model enables us to explain one of the most striking features of interregional migration patterns: the positive self-selection of the migrants.

Keywords: core-periphery model, economic integration, economic geography, interregional migration.

JEL Classification: F12, F15, F22, J24, R12

---

* I am grateful to Kjetil Bjorvatn, Karen Helene Midelfart, Ian Wooton, Maurizio Zanardi, and participants at the CEPR workshop: "The Economic Geography of Europe: Measurement, Testing and Policy Simulations", Villars 2002, and seminar participants at the University of Glasgow and the Norwegian School of Economics and Business Administration in Bergen for useful comments and suggestions. The usual disclaimer applies.

1. INTRODUCTION

It is a matter of record that pronounced regional disparities are very persistent in many EU countries. The spatial distribution of economic activity is far from uniform and economic agglomeration can be observed at all geographical levels.

The main focus of a recent strand of research has been the origins of such spatial inequalities and to investigate the effects of increased regional integration on the degree of spatial agglomeration. In the basic model of Krugman (1991), the interaction between interregional labour migration, scale economies, transport costs and a spatially immobile source of demand generates forces of both agglomeration and dispersion. Since some factors of production are spatially mobile, when transport costs fall below a critical level, agglomerative forces become strong enough to give rise to a core-periphery structure. Therefore, even if regions are a priori identical, due to migration-induced demand linkages, they can endogenously differentiate into an industrial core and a deindustrialised periphery.[1]

It has been argued that while this approach is relevant for studying agglomeration within national boundaries, in the EU context low rates of migration seem to limit the role of labour mobility as a driving force for agglomeration. Empirical studies suggests that although such an adjustment process works through regional migration in the US (Blanchard and Katz 1992), in Europe very little migration across European countries is observed despite large intercountry wage differences (Decressin and Fatàs 1995). This difference in the adjustment mechanism between the US and the European labour markets is still remarkable even if we consider internal migration within European countries.

While the rates of internal and international migration have been very low, several studies have demonstrated that some groups of individuals are more geographically mobile

[1] For a survey of the New Economic Geography literature see Fujita et al (1999), Ottaviano and Puga (1998), or more recently Neary (2000).

and more reactive to regional wage differentials. In migration literature it is a standard proposition the fact that economic migrants[2] tend to be, on average, more skilled, young, educated and entrepreneurial than similar individuals who choose to remain in their place of origin (*positive self-selection of the migrants*).[3] A better understanding of the pattern of migration is important for assessing the economic and sociological consequences for the origin and destination regions. The more migrants are favourably selected and the more beneficial will be their impact on the destination economy. On the contrary, the more positively selected are the migrants the greater, in general, will be the adverse effect on the region of origin.[4]

Modern economies have made an epochal transition from a world where the basic source of value, productivity and economic growth has been physical labour and manual skill, to a world of knowledge-intensive capitalism where a fundamental role is played by intelligence and intellectual labour (human capital). Scientists, engineers and high skilled workers on the factory floor and in advanced services companies are the sources of innovations and ideas. The *wealth of regions* and nations in the 21st century economies is largely based on this human infrastructure (Florida, 1995). Consequently, a region with a more skilled labour force is likely to grow faster than a region with a less skilled labour force. Migration of high skilled workers may potentially have consequences on the regional

[2] We refer to economic migrants as individuals who move from one place of work and residence to another, both within or across countries, on the basis of a decision taken comparing their own economic opportunities in origin and destination locations. In this way we want to distinguish those migrants from refugees and those migrating for other reasons.

[3] For a review of theoretical and empirical contributions on this topic see Chiswick (2000). Borjas, Bronars and Trejo (1992) find evidence of self-selection studying internal migration in the U.S. In fact migrants with higher educational levels appear to be attracted toward regions with higher returns to education.

[4] According to some authors (see Mountford 1997, or Stark et al 1997), when migration is not a certainty, the brain drain may be associated with a brain gain for the source region. The possibility to migrate gives an incentive to invest in human capital formation. Therefore, higher levels of human capital in the economy could outweigh the negative effects of the brain drain. While this outcome may, in principle, be realistic when assessing the effects of North-South migration, it seems to be less appropriate when applied to migration flow between and within developed countries.

economic performance, since it affects the way the regions maintain and sustain human resources.

The regional level of skills can be interpreted as the stock of human capital in the economy. According to Lucas (1988) the accumulation of human capital is a source of positive spillovers. It is reasonable to argue that workers' skills are augmented through learning and exchange of ideas, and that workers therefore increase their productivity by interacting with those around them. As a result, migration of a worker from a region where the average level of human capital is low to one where the average level is high will raise his productivity. Geographic proximity is crucial since it allows ideas to travel more rapidly, the impact of such localised externalities weakens with distance. As proposed by Kremer (1993), many production processes consist of multiple tasks, all of which must be successfully completed for the product to have a full value. The matching of skilled workers in the production process increases the probability of successfully performing those tasks. In equilibrium, skilled workers are matched together in the core region. This assumption is consistent with a series of stylised facts. First of all, the substantial wage and productivity differences between rich and poor regions.

This paper aims to analyse the effect of a deepening of a regional integration process on the incentive for labour to spatially relocate. We adopt a general equilibrium, economic-geography model similar to Krugman (1991). We allow for skill heterogeneity in the manufacturing sector. Two types of manufacturing workers exist in our simplified economy: low and high-skilled, where skills are associated with the efficiency unit of labour offered in the labour market. We assume that the former is able to supply one unit of labour. High-skilled workers are potentially more productive than the unskilled ones. Interaction between high-skilled manufacturing workers in a region (we assume that proximity is needed here)

increases the productivity of each worker by means of a knowledge diffusion process. In the model the skill premium is endogenous and increasing in the regional quota of high-skilled workers.[5]

We analyse the migration behaviour of low and high-skilled workers in a process of regional economic integration. At a given level of trade costs, due to the productivity premium associated with the high-skilled matching in one region, this type of workers will be more willing to migrate than low-skilled ones. The results of the paper show the existence of a range of trade costs for which only high-skilled workers have an incentive to migrate. Therefore introducing labour heterogeneity in the basic core-periphery model enables us to explain one of the most striking features of interregional migration patterns: the positive self-selection of the migrants. Another important implication of the model is the existence of a persistent wage and productivity differential between the core and peripheral regions, a result which is supported by a recent strand of empirical literature.

The paper is organized as follows. In section 2, we present recent empirical evidence on agglomeration and human capital externalities. Section 3 develops the model. In Section 4 we examine the possible spatial equilibria and their features. Section 5 concludes.

[5] According to Glaeser (1998), firms choose to locate in cities and pay the higher wages and suffer congestion costs because workers in cities are more productive: "...if workers weren't more productive firms would leave cities altogether and hire elsewhere. Since the urban wage premium appears to be a centuries-old phenomenon, we must assume that over the long run, firms are quite willing to pay these higher wages".

2. Agglomeration and Human Capital Externalities: empirical evidence

In our model, the interaction between high-skilled workers in a region increases the productivity of each worker by means of a knowledge diffusion process. Regions with a higher average level of human capital are therefore more attractive for high-skilled workers. The skill premium is endogenous and increasing in the regional quota of high-skilled workers. One of the implications of the model is the existence of a wage and productivity differential between the core and peripheral regions.

Economic theory gives several explanations on why nominal wages may be different across regions in the short run, one of the main reasons being the existence of asymmetrical regional shocks and, overtime, divergences of regional business cycles. In the long run, after the necessary adjustments in local labour markets have taken place, regional nominal wages should, in principle, converge.

One possible explanation for the observed lack of convergence in the long run is linked to the existence of differences in the regional "endowment" of amenities. Local amenities, such as good climate, favorable physical morphology of the area, air and water quality, may affect regional wages through two main channels. First, through a positive (or negative) effect on consumer utility. For example if consumer values the warm and sunny weather of Southern Italy, they will require a wage premium to live and work in rainy and cloudy climate of Northern Italy. As a result, *ceteris paribus*, we expect workers of similar characteristics willing to accept lower salaries in region with pleasant weather conditions. Secondly, local non-exclusive amenities may also have a direct influence on labour productivity. If the effect is positive we will expect higher wages. The attractiveness of the area, due to a positive regional wage differential, will induce migration, and therefore these productivity differences will be capitalised into differentials in land rents.

The impact of exogenous regional characteristics on the spatial variation in factor prices is generally evaluated using hedonic price estimation technique (Roback 1982). As Hanson (2001) points out, although empirical evidence supports the hypothesis that local amenities contribute to explaining regional differences of factor prices, some evidence shows that considerable differences remain even within regions with a similar endowment of exogenous amenities.

Some theories, based on the existence of localized human capital externalities, argue that differentials in factor remuneration may be persistent over time if regions present a different level of human capital (see Eaton and Eckstein 1997). The main idea is that the level of skills, education and experiences of the local labour force positively affect workers' productivity. Interaction between skilled individual enables flows of ideas, diffusion of best practice and, in general, the possibility to benefit from a local knowledge stock. As a consequence, also high-skilled workers from other areas will be attracted toward regions with higher returns to skills. Therefore, a positive self-selection of migrants (see Borjas et al. 1992) may generate a self-sustaining mechanism of growth. According to the theory the level of local human-capital has an important role in explaining spatial differences in wages and housing prices. Recent empirical studies have supported this prediction using micro data**.** Rauch (1993) employs US Census data on wages and human capital of individuals in 237 cities in 1980 to estimate externalities in cities using individual wage-regressions. The notion of human capital defined by Rauch contains both education and work experience components. His results suggest that the external effect of a one-year increase in average schooling in cities has a positive and statistically significant effect on wages of workers in the same city of around 4%. These results hold even when he controls for the effects of other factors such as R&D investment policies that favour cities, as well as university concentration

in urban areas. More recently, Ciccone and Peri (2000) find that a one-year increase in average schooling in US cities raises aggregate productivity by 8 to 11%.[6]

How then, are externalities transmitted across regions? Is there any evidence that their effects are weaker over longer distances? Ciccone and Hall (1996) use data at the county level to see if variations in population density can explain the large discrepancies in productivity levels across the US.[7] In their analysis, they control for the endogeneity of employment density to ensure that the correlation between density and productivity that they find is not merely the result of productive regions growing faster than less productive ones. They find that doubling employment density increases labour productivity by 6%. Their results hold even when other factors are taken into account (such as the level of public capital, the level of education and the influence of market size). According to their analysis, closer interaction between workers in a geographical unit does have a positive effect on productivity.

Other indirect evidence supports the argument that the relevance of spatial influence decay as distance increases. In fact, the geographical distribution of income and unemployment, both in absolute values and variations over time is strongly correlated across neighbouring regions (see Overman and Puga, 1999, and Quah, 1996).

3. THE MODEL

We consider a world economy consisting of two regions (1,2). There are two sectors: agriculture and manufacturing. Agriculture is perfectly competitive and produces a homogeneous good according to a constant-return-to-scale technology. This sector employs

[6] For a survey on empirical work relating schooling to aggregate labour productivity see de la Fuente and Domenech (2000). They also estimate the effect of a one-year increase in average schooling on the average labour productivity for OECD countries, finding evidence of a positive impact by around 4%.

interregionally immobile farm labourers (sector-specific factor). We assume that the unit labour requirement is one.

Manufacturing is a monopolistically competitive sector producing a variety of differentiated products with increasing-return-to-scale technology and employs interregionally mobile workers. We assume the existence of two types of workers in the manufacturing sector, which differ only in terms of the level of efficiency unit of labour supplied.

3.1 Consumers'-workers' behaviour

All individuals share the same Cobb-Douglas utility function:

$$U = M^{\mu} A^{1-\mu} \tag{1}$$

where M is a quantity index of consumption of manufactured goods and A is consumption of the agricultural good. Therefore μ is the expenditure share of manufactured goods. The manufacturing aggregate M, is a sub-utility function of a discrete number of varieties defined by a constant elasticity of substitution function:

$$M = \left[\sum_{1}^{n} m_i^{\rho} \right]^{1/\rho} = \left[\sum_{1}^{n} m_i^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} \tag{2}$$

[7] According to the authors, in the U.S. a worker in the most productive state is two-thirds more productive than a worker in the least productive state.

where n is the number of varieties produced, m_i consumption of each variety and ρ a parameter representing the intensity of the "love for variety" in the manufacturing sector. The constant elasticity of substitution between any two varieties is $\sigma \equiv 1/(1-\rho)$, $(\sigma>1)$.

The consumers maximize (1) subject to the following budget constraint:

$$P_A A + \sum_1^n m_i p_i = Y$$

where Y is income and P_A, p_i respectively the prices of the homogeneous product and prices for each variety of the manufacturing aggregate.

A two stage budgeting procedure can be applied. The first step in the consumer's problem is to choose each m_i in order to minimise the cost of attaining a given M:

$$\min \sum_1^n p_i m_i \quad \text{s.t. } M = \left[\sum_1^n m_i^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}$$

the first-order conditions. imply $\dfrac{m_i^{-1/\sigma}}{m_j^{-1/\sigma}} = \dfrac{p_i}{p_j}$ therefore

$$m_i = \left(\frac{p_i}{p_j} \right)^{-\sigma} m_j$$

and by substitution of this last equation in the budget constraint we obtain:

$$M = \left[\sum_1^n \left(\frac{p_i}{p_j} \right)^{1-\sigma} m_j^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}$$ which implies:

$$m_j = \frac{p_j^{-\sigma}}{\left[\sum_1^n p_i^{1-\sigma}\right]^{\frac{\sigma}{\sigma-1}}} M \tag{3}$$

Equation (3) is the compensated demand function for the *j*th variety.

The minimum cost of attaining a fixed amount of *M*, can be expressed by using equation (3) and summing over all the varieties as:

$$\sum_1^n p_j m_j = M\left[\sum_1^n p_i^{1-\sigma}\right]^{\frac{1}{1-\sigma}} \tag{4}$$

where the second part of the expression on the right-hand side can be easily interpreted as the *manufactured goods price index:*

$$P = \left[\sum_1^n p_i^{1-\sigma}\right]^{\frac{1}{1-\sigma}} \tag{5}$$

P measures the minimum cost of purchasing a unit of the composite index *M*, and can be thought of as an expenditure function.

Demand for each variety *j* can be written as:

$$m_j = \left[\frac{p_j}{P}\right]^{-\sigma} M \tag{6}$$

The second step of the consumer's problem is to choose the optimal allocation of income between *A* and *M* so that the utility is maximised

Maximising $U = M^{\mu} A^{1-\mu}$ subject to. $PM + P_A A = Y$, gives us the uncompensated demand for *A* and for each variety, m_j:

$$A = (1-\mu)Y / P_A \tag{7}$$

$$m_j = \frac{p_j^{-\sigma}}{P^{-(\sigma-1)}} Y\mu \tag{8}$$

From the consumer's utility maximisation problem we can also express the indirect utility function, substituting (7) and (8) in (1) yields:

$$U = \frac{\mu^{\mu}(1-\mu)^{1-\mu} Y}{P^{\mu} P_A^{(1-\mu)}} \tag{9}$$

the term $P^{\mu} P_A^{(1-\mu)}$ can be interpreted as the regional cost-of-living index in the economy. What is the welfare effect of an increase in the number of variety? Assuming that all varieties are available at the same price $p_i = p_j, \forall j \in [1,...,n]$, we can rewrite the manufacturing goods price index as:

$$P = \left[\sum_{1}^{n} p_i^{1-\sigma} \right]^{\frac{1}{1-\sigma}} = p_i n^{\frac{1}{1-\sigma}}$$

Therefore, an increase in the number of available varieties reduces the manufacturing price index. Consequently, given that the indirect utility function (9), is decreasing in the manufacturing price index, the regional welfare increases.

The elasticity of substitution between varieties, σ, determines the responsiveness of the price index to a change in the available number of varieties.

3.2 Labour supply and human capital externalities

The world farmer's population employed in the agriculture sector is 1 - μ. Since farmers cannot regionally relocate, the supply in each region is (1 - μ)/2.

The manufacturing sector employs two types of workers (i) *low-skilled workers*, and (ii) *high-skilled workers*. [8] Both types of workers are endowed with one unit of labour, and may move between regions. We assume that the global population of workers of each type is normalised to 1. The total population of manufacturing workers therefore sums to 2.

The existence of localised human capital externalities implies that the interaction between high-skilled workers in a region increases the productivity of each skilled worker by a knowledge diffusion process. The productivity of high-skilled workers, i.e. the efficiency unit of labour supplied, depends upon the number of workers with similar characteristics in the regional labour force. In the model the skill premium s_i is endogenous, and may differ between regions according to the size of the regional highly skilled population $s_i = f(S_i)$, where S_i represents the population of high-skilled workers in region *i*. We formalise the positive interaction between high-skilled workers in a region as:

$$s_i = (S_i)^{\lambda} \tag{10}$$

[8] In this model, labour provided by low and high skilled is qualitatively homogeneous. Manufacturing workers of the two types are perfect substitutes.

where the parameter λ measures the strength of human capital externalities. Such externalities are increasing in the quota of high-skilled workers but at a decreasing rate. Given $\partial' s_i / \partial S_i = \lambda (S_i)^{\lambda-1} > 0$, and $\partial'' s_i / \partial S_i = \lambda(\lambda-1)(S_i)^{\lambda-2} < 0$, it follows that $0 < \lambda < 1$. The fact that high skilled are more efficient in providing unit of labour according to a skill premium s_i, is reflected in the following relation between low/high skilled competitive wages in each location:

$$w_i^s = w_i \left(1 + s_i\right) \tag{11}$$

where w_i^s and w_i, represent respectively the worker nominal wages of high-skilled and low-skilled in region *i*. In this formulation of the model we have no explicit reference to a quality (vertical) differentiation of the manufacturing sector products. In a similar work Mori and Turrini (2000) assume that skilled workers add "quality" to each unit of products. They consider therefore product differentiation to have both a horizontal dimension (variety), and a vertical one (quality).

It is useful to distinguish between the world population of manufacturing workers and the world total supply of effective units of labour. The two measures are not identical since the geographical distribution of skilled workers (the human capital level in each region) is going to affect the total number of units of labour supplied. Total units of effective labour in one region are given by:

$$L_i = U_i + (S_i)^{1+\lambda} \tag{12}$$

where U_i and S_i represent respectively the share of total low and high-skilled workers population, which live in region *i*.

It is important to note that the number of skilled workers, as a fraction of the total manufacturing labour force, is exogenously determined.[9]

3.3 Production technology

Agriculture is a constant return to scale, perfectly competitive sector. We normalise the unitary labour input requirement to 1. Agricultural products are freely traded and therefore agricultural prices and wages are equalised across regions and shall be our numeraire. Consequently, $P_A = w_A = 1$ in both regions.

The production of any variety of the manufactured good involves a fixed and a constant marginal cost:

$$l_i = \alpha + \beta x_i \tag{13}$$

where x_i is the quantity produced and l_i the labour requirement for its production. Because of economies of scale at firm level and consumers' preferences for variety, firms produce a single product facing an elasticity of demand equal to σ.

Imported manufacturing varieties incur Samuelson iceberg trade costs. If a variety is shipped from one region to the other, part of each unit melts away during the transport, therefore only a fraction $1/\tau$ arrives at destination.[10] The introduction of this kind of trade costs implies that, if a variety is produced in region 1, consumers in the two different regions have to pay

[9] In subsequent research, we consider the worker's human capital investment decision and the role of public policy.

different prices. A manufacturing good produced in region 1 costs the F.O.B. price p_i for a home consumer, while the consumers in region 2 pay the C.I.F. price (τp_i).[11]

As a consequence, according to the number of variety produced in each region, the manufacturing price index *P* may assume different values between regions:

$$P_1 = \left[n_1 p_1^{1-\sigma} + n_2 (p_2 \tau)^{1-\sigma} \right]^{\frac{1}{1-\sigma}}$$
$$P_2 = \left[n_1 (p_1 \tau)^{1-\sigma} + n_2 p_2^{1-\sigma} \right]^{\frac{1}{1-\sigma}} \quad (14)$$

3.4 Size of the regional manufacturing industry

Production technology is the same for each variety in both locations. Manufacturing labour is the only input. We continue to assume perfect substitubility in the production function between low-skilled and high-skilled workers. A firm producing a specific variety at region *i*, faces a wage rate w_i for each unit of labour, which consequently represent the low-skilled nominal wage. [12]

Given the following profit equation:

$$\pi_i = p_i x_i - (\alpha + \beta x_i) w_i \quad (15)$$

the profit-maximising behaviour of a firm located in region *i* is a constant mark-up over the regional wage rate:

---

[10] $\tau \geq 1$ represents the amount of the goods dispatched per unit received at destination.

[11] F.O.B. and C.I.F. are commercial clauses frequently used in international transaction meaning respectively *Free On Board* and *Cost Insurance and Freight*.

[12] In this way we are able to preserve the features of Dixit-Stiglitz framework (in particular, the number of varieties being proportional to the regional labour force, and the scale of each firm invariant to the skilled vs. unskilled labour ratio).

$$p_i = \left(\frac{\sigma}{\sigma - 1} \right) \beta w_i \tag{16}$$

Relative prices must then be:

$$\frac{p_1}{p_2} = \frac{w_1}{w_2} \tag{17}$$

Free entry drives profit to zero, and the optimal output level is the same for each firm in any region:

$$x_i^* = \frac{\alpha(\sigma - 1)}{\beta} \tag{18}$$

the associated equilibrium labour input is also constant and given by:

$$l_i^* = \alpha + \beta x_i = \alpha + \alpha(\sigma - 1) = \alpha\sigma \tag{19}$$

Full employment of the labour force allow us to determine the number of manufacturing varieties in equilibrium[13]:

$$n_i = \frac{L_i}{l_i^*} = \frac{L_i}{\alpha\sigma} \tag{20}$$

[13] Since each variety is produced in one location by a single firm, n_i represents both the number of varieties and the number of firms in region *i*.

An increase in the regional size works through changes in the variety of goods (firms) available, leaving inalterated both mark-up over marginal cost and the scale of individual production. The equilibrium number of firms is therefore proportional to the region's effective population of workers:

$$\frac{n_1}{n_2} = \frac{L_1}{L_2} \tag{21}$$

3.5 Equilibrium conditions in goods and labour markets

In equilibrium the optimal output for any firm should be equal to the demand for its product in both regions:

$$\begin{aligned} x_1^* &= \mu\left[\left(\frac{p_1^{-\sigma}}{P_1^{-(\sigma-1)}}Y_1\right)+\left(\frac{(p_1\tau)^{-\sigma}}{P_2^{-(\sigma-1)}}Y_2\right)\right] \\ x_2^* &= \mu\left[\left(\frac{(p_2\tau)^{-\sigma}}{P_1^{-(\sigma-1)}}Y_1\right)+\left(\frac{p_2^{-\sigma}}{P_2^{-(\sigma-1)}}Y_2\right)\right] \end{aligned} \tag{22}$$

After some manipulation, using the pricing rule equation, we obtain the following expression for the nominal wages at which each firm breaks even:

$$\begin{aligned} w_1 &= \left(\frac{\sigma-1}{\alpha\sigma}\right)\left[\frac{\mu}{x^*}\left(Y_1P_1^{\sigma-1}+Y_2P_2^{\sigma-1}\tau^{1-\sigma}\right)\right]^{\frac{1}{\sigma}} \\ w_2 &= \left(\frac{\sigma-1}{\alpha\sigma}\right)\left[\frac{\mu}{x^*}\left(Y_1P_1^{\sigma-1}\tau^{1-\sigma}+Y_2P_2^{\sigma-1}\right)\right]^{\frac{1}{\sigma}} \end{aligned} \tag{23}$$

We choose the following normalisation[14] in order to simplify the wage equation and the manufacturing price index:

$$\beta = \frac{\sigma - 1}{\sigma}$$
$$\alpha = \frac{1}{\sigma} \tag{24}$$

From the pricing rule equation we get: $p_i = w_i$ and $n_i = L_i$. It is possible to rewrite the price index as:

$$P_1 = \left[L_1 w_1^{1-\sigma} + L_2 w_1^{1-\sigma} \phi \right]^{\frac{1}{1-\sigma}}$$
$$P_2 = \left[L_1 w_2^{1-\sigma} \phi + L_2 w_2^{1-\sigma} \right]^{\frac{1}{1-\sigma}} \tag{25}$$

and the wage equation as

$$w_1 = (\sigma - 1)\mu^{\frac{1}{\sigma}} \left[Y_1 P_1^{\sigma-1} + Y_2 P_2^{\sigma-1} \phi \right]^{\frac{1}{\sigma}}$$
$$w_2 = (\sigma - 1)\mu^{\frac{1}{\sigma}} \left[Y_1 P_1^{\sigma-1} \phi + Y_2 P_2^{\sigma-1} \right]^{\frac{1}{\sigma}} \tag{26}$$

where $\phi = \tau^{1-\sigma} = 1/\tau^{\sigma-1}$ (remember $\sigma > 1$). The parameter ϕ which is a function of the trade costs can be interpreted as a parameter reflecting freeness of trade, ranging in between zero for very high trade costs when $\tau \to \infty$ (autarky), and one in the case of no trade costs, i.e. $\tau = 1$.

[14] The scope of these normalisations, widely used in this literature, is to shift the analysis to the number of manufacturing workers and their wages in each region in order to study the equilibria in the model and their stability.

The price index equations (25) as noted before have an important property. The regional manufacturing price index will tend to be lower, the higher is the share of effective manufacturing labour in the region, since more varieties are produced locally without incurring therefore in transport costs (*price-index effect*).

The total regional income Y_i is given by the sum of all farmers and workers wages

$$\begin{aligned} Y_1 &= w_1 L_1 + (1-\mu)/2 \\ Y_2 &= w_2 L_2 + (1-\mu)/2 \end{aligned} \tag{27}$$

where *1-*μ is the world population of immobile farmers.

Real wages are obtained by deflating nominal wages by the regional cost-of-living index $P_i^{\mu}\left(P_A\right)^{1-\mu}$. As the agriculture product is the numeraire, the index can be simplified to P_i^{μ}. We assume that workers are paid linearly according to their level of skill s_I; consequently the real wages, (ω_i^u, ω_i^s respectively for low- and high-skilled workers) are:

$$\begin{aligned} \omega_1^u &= \frac{w_1}{P_1^{\mu}} \\ \omega_2^u &= \frac{w_2}{P_2^{\mu}} \end{aligned} \tag{28}$$

$$\begin{aligned} \omega_1^s &= \frac{w_1[1+(S_1)^{\lambda}]}{P_1^{\mu}} \\ \omega_2^s &= \frac{w_2[1+(S_2)^{\lambda}]}{P_2^{\mu}} \end{aligned} \tag{29}$$

The economy is assumed to reach instantaneously a short-run equilibrium for any given allocation of workers between regions. The solution of the set of equations (25)-(27) determines w_1 and w_2 for which (i) consumers maximise utility (ii) profits are both maximised and driven to zero by free entry (iii) all markets clear.

4. SPATIAL EQUILIBRIA

In the long-run, in the absence of migration costs, real wage differentials are the only determinant in the decision of low and high-skilled workers to move from one region to the other. The regional share of both types of workers adjust according to the real wage difference:

$$\begin{aligned} &\dot{U}_i = \chi(\omega_1^u - \omega_2^u) = \chi(\omega^u) \\ &\dot{S}_i = \chi(\omega_1^s - \omega_2^s) = \chi(\omega^s) \\ &\chi' > 0 \end{aligned} \tag{30}$$

where χ is a function increasing in ω^u and ω^s, which represent the regional real wage differentials for low- and high-skilled workers. Regional migration flows to region 1 are positive if workers enjoy a higher level of utility (i.e. higher real wages) by moving in this region.

We would like to determine when the long-run equilibrium will exhibit regional convergence (symmetric equilibrium), and when it will lead to a core-periphery structure with all workers and manufacturing sector concentrated in one region. In addition, we are interested in determining whether, in the long-run, the migration pattern will exhibit the feature of favourable self-selection of the migrants. To answer these questions we have to consider the local stability of these equilibria. Let consider the case where the world economy

is at the symmetric equilibrium. It is easy to see that if labour allocation between regions is identical, that is $S_1 = S_2 = U_1 = U_2 = 1/2$, the nominal wages are the same in the two regions, $w_1 = w_2$. Assume now that as a consequence of a shock to the symmetric equilibrium $L_1 > L_2$, that is some workers are allocated from region *2* to region *1*. If this change in stocks positively affects real wage in region *1* relative to region *2*, it will encourage migration as initial symmetric equilibrium is unstable. The opposite is true if the real wage differential becomes negative.

The initial movement of a single worker has four effects. [15]

The first is the *price-index effect*, working in favour of divergence. As mentioned above, the cost of living will be lower in the country with the larger manufacturing sector, because a smaller proportion of trade costs will be paid for by the same bundle of manufactured goods.

A second agglomerative force, *the home-market effect*, reinforces this effect. From (26), nominal wages in a region will tend to be higher if income in the region is high. The reason is that firms can afford to pay higher wages if they have good access to a larger market As a consequence, the large market retains a more than proportional share of manufacturing sector. The idea is not a new one but finds its root in the literature on market potential (see Harris, 1954).

Third is the *competition effect*. The presence of more firms in the local market will increase competition to serve the regional immobile consumers thus tending to reduce local profits and so encouraging the stability of the symmetric outcome.

Finally, the migration of a skilled worker has a positive effect on the productivity of skilled workers in the host region, and therefore a positive effect on their nominal wages. We call this last effect which is peculiar to high-skilled workers migration, *skill premium effect*.

The stability of the symmetric equilibrium is given by the relative strength of these agglomerative and dispersive forces at work. For sufficiently high trade costs, imported manufactured varieties are so expensive that it is profitable to have a symmetric equilibrium. Conversely, at low trade costs the symmetric equilibrium is always unstable. Regional economic integration has no impact on the location of industry until a critical level of freeness of trade is reached. When this threshold of freeness of trade, the ϕ-break, is reached the symmetric outcome becomes unstable since workers have an incentive to migrate. The *skill premium effect* is peculiar to high-skilled workers, therefore the incentive to migrate and the relative ϕ-break will be higher for this type of workers.

Formally a stable equilibrium is any point where:

(i) the regional wage differentials are zero and $\{\partial\omega^u/\partial U_i, \partial\omega^u/\partial S_i, \partial\omega^s/\partial S_i, \partial\omega^s/\partial U_i\}$ are all strictly negative. This is the case of a stable symmetric equilibrium where $S_i = U_i = 1/2; \forall i \in \{1,2\}$. A positive increase in the quota of low or high-skilled workers in the region, negatively affects the real wage differential. Agglomerative forces are dominated by dispersive forces, therefore as a consequence counter-migration of manufacturing workers will re-equilibrate the size of the regional manufacturing labour force;

(ii) $\omega^u > 0, \omega^s > 0$ and S = U = 1 (or vice versa $\omega^u < 0, \omega^s < 0$ and S = U = 0), in the case of a core-periphery equilibrium. The entire population of low and high-skilled workers will be concentrated in the core. In this case we have the condition that in the core region $\{\partial\omega^u/\partial U_i, \partial\omega^u/\partial S_i, \partial\omega^s/\partial S_i, \partial\omega^s/\partial U_i\}$ are all strictly positive.

(iii) $\omega^u = 0, \omega^s > 0$ with $S_i = 1$ and $U_i = 0$ when a positive self-selection equilibrium is a stable outcome. In this case high-skilled workers will be concentrated in the core region,

[15] This adjustment mechanism assumes that entry and exit of firms occurs infinitely faster than migration. Firms are therefore always in equilibrium.

while a symmetric equilibrium is still stable for the unskilled workers ($\{\partial\omega^u / \partial U_i, \partial\omega^u / \partial S_i\}$ should be strictly negative).

In Figures 1 and 2[16] we plot respectively the low and high-skilled workers real wages in region 1[17] at different levels of trade costs. This allows us to analyse how the integration process, measured by the level of trade costs, will affect the equilibrium size of the manufacturing sector and the average level of human capital in the regions. We report the real wage differential for low and high-skilled workers as a function of the share of only one type of manufacturing labour keeping the other at the symmetric equilibrium. In this way we assess, for each type of worker, how the real wage differential reacts as a consequence of variations of both types of manufacturing workers population. Specifically, diagrams (a) [(b)] of both figures report the real wage differentials as a function of the share of low-skilled [high-skilled] workers in region *1*, given that high-skilled [low-skilled] workers are equally distributed between the two regions, $S = 1/2$ [$U = 1/2$].

For high trade costs (ϕ = 0.05, or τ = 2.714) the symmetric equilibrium is stable since the cost of supplying a market by exporting is too large. Both low and high-skilled have no incentive to migrate in region *2*. When a worker migrates (either high or low-skilled), the host region becomes less attractive than the destination one. In the long-run the economy converges to a symmetric equilibrium in which manufacturing is equally divided.

As the economy becomes slightly more integrated (ϕ = 0.05, or τ = 2.487), the symmetric equilibrium is no longer stable for both type of workers. Consider the low-skilled first. From Fig. 1 it is evident that an increase in the share of both low and high-skilled

[16] The model cannot be solved analytically. In the paper, all the figures presented are derived by numerical simulations. The values of the parameters are similar to those used in related papers. We let μ = 0.3, while σ = 4; mark-up estimates are normally between 20-30%, which correspond an elasticity of substitution σ between 6 and 4. Agglomerative externalities are chosen on the basis of the empirical evidence mentioned in the conclusions, δ = 0.1. Analytical expressions for ϕ^u , ϕ^s *break* and ϕ *self-selection*, have been derived using a procedure first introduced by Puga (1999) to which we refer. Maple files containing the simulation procedure and the stability analysis are available from the author on request.

workers has a negative effect on the real wage differential (the schedule is downward-sloping for both *U* and *S*). The competition effect is in this case stronger than the effect of the other two agglomerative forces. For the high-skilled worker the situation is different (Fig. 2) If the skilled manufacturing labour force concentrates in one region, these workers become more productive and the competition effect is more than compensated by the skill premium effect. However, migration of the low-skilled has a negative impact on the high-skilled real wage.

Finally, at low trade costs ($\phi = 0.60$, or τ = 1.1856), the symmetric equilibrium becomes unstable and a core-periphery structure arises.

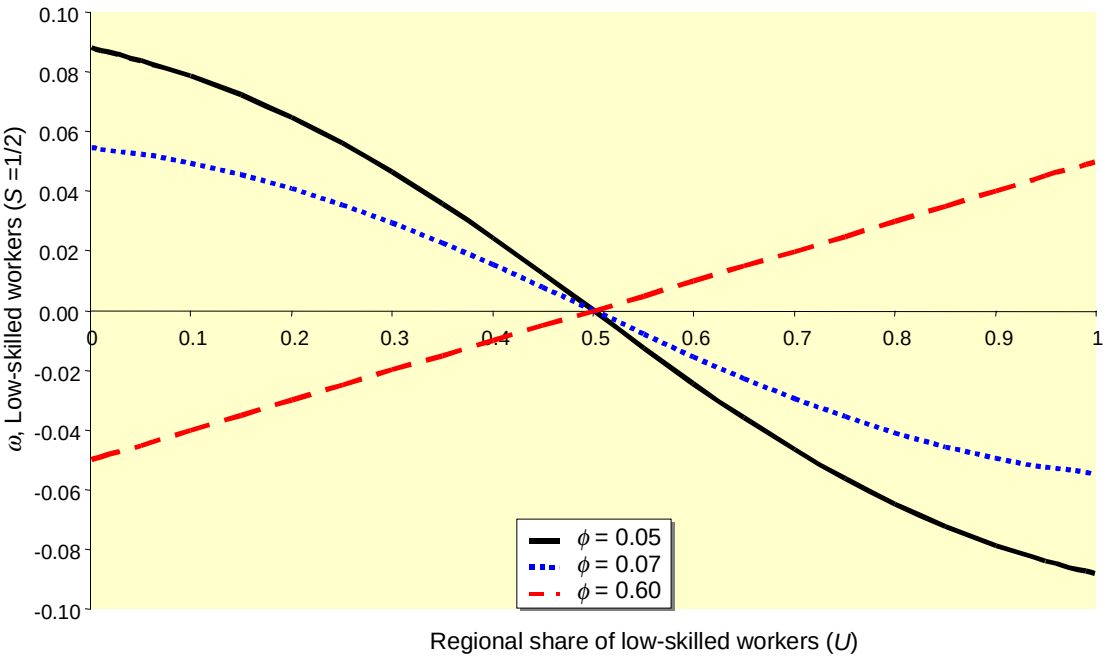
Fig. 3 shows how the types of equilibria are related with trade costs. The shares of manufacturing labour force in region *1*, *U* and *S*, are measured on the vertical axis. Solid and dotted lines represent respectively stable and unstable equilibria. At high trade costs, there is a unique stable equilibrium in which skilled and unskilled workers are equally divided between the two regions.

[17] Since the two regions are perfectly symmetric we restrict the following analysis to region 1.

Fig. 1

Low-skilled workers real wage differential: effects of low and high-skilled migrants at different level of trade costs

(a) *S* = 1/2



(b) *U* = 1/2

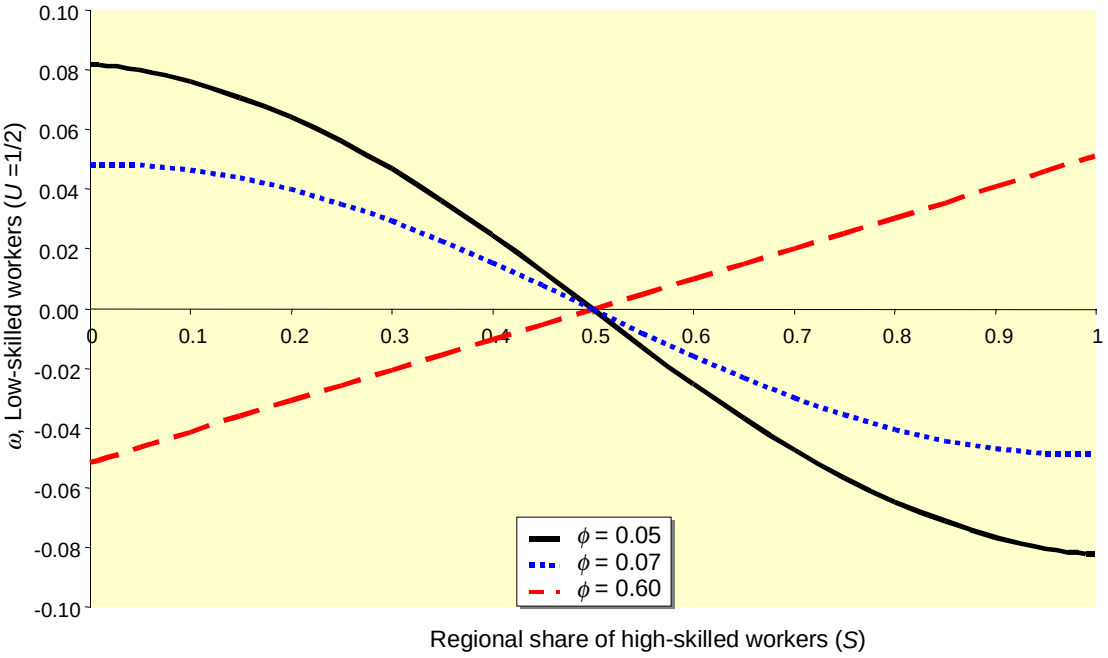
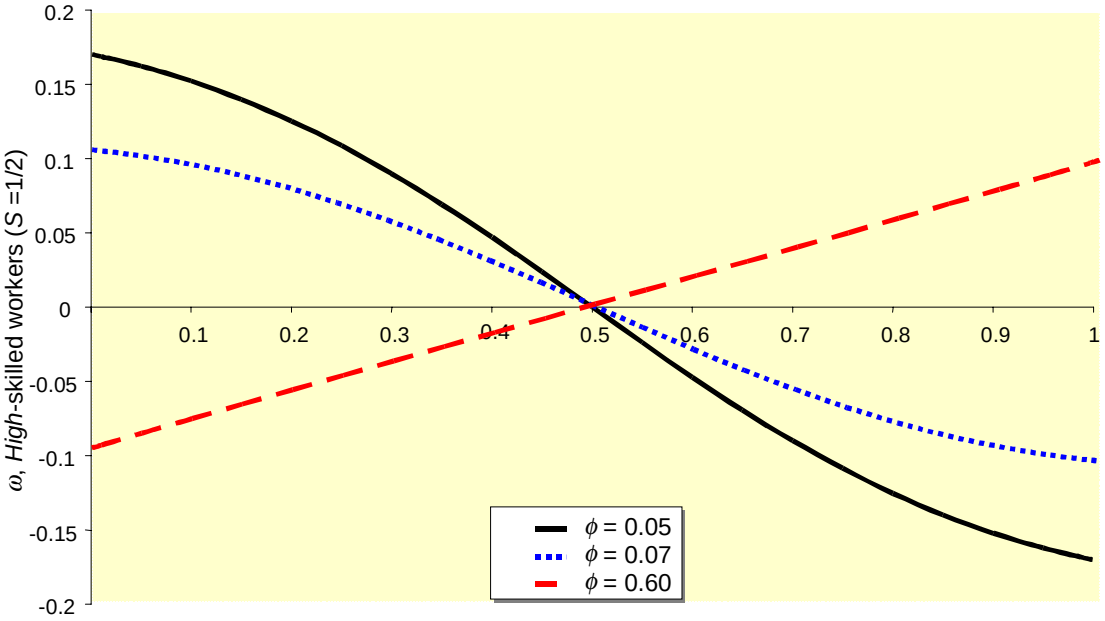


Fig. 2

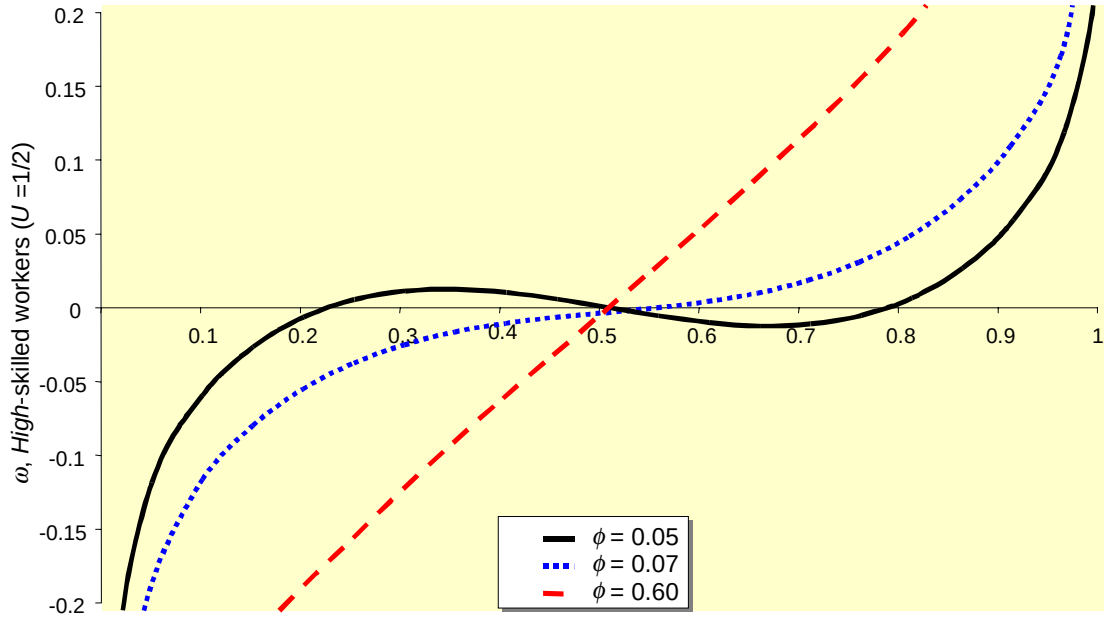
High-skilled workers real wage differential: effects of low and high-skilled migrants at different level of trade costs

(a) *S* = 1/2



Regional share of low-skilled workers (*U*)

(b) *U* = 1/2



Regional share of high-skilled workers (S)

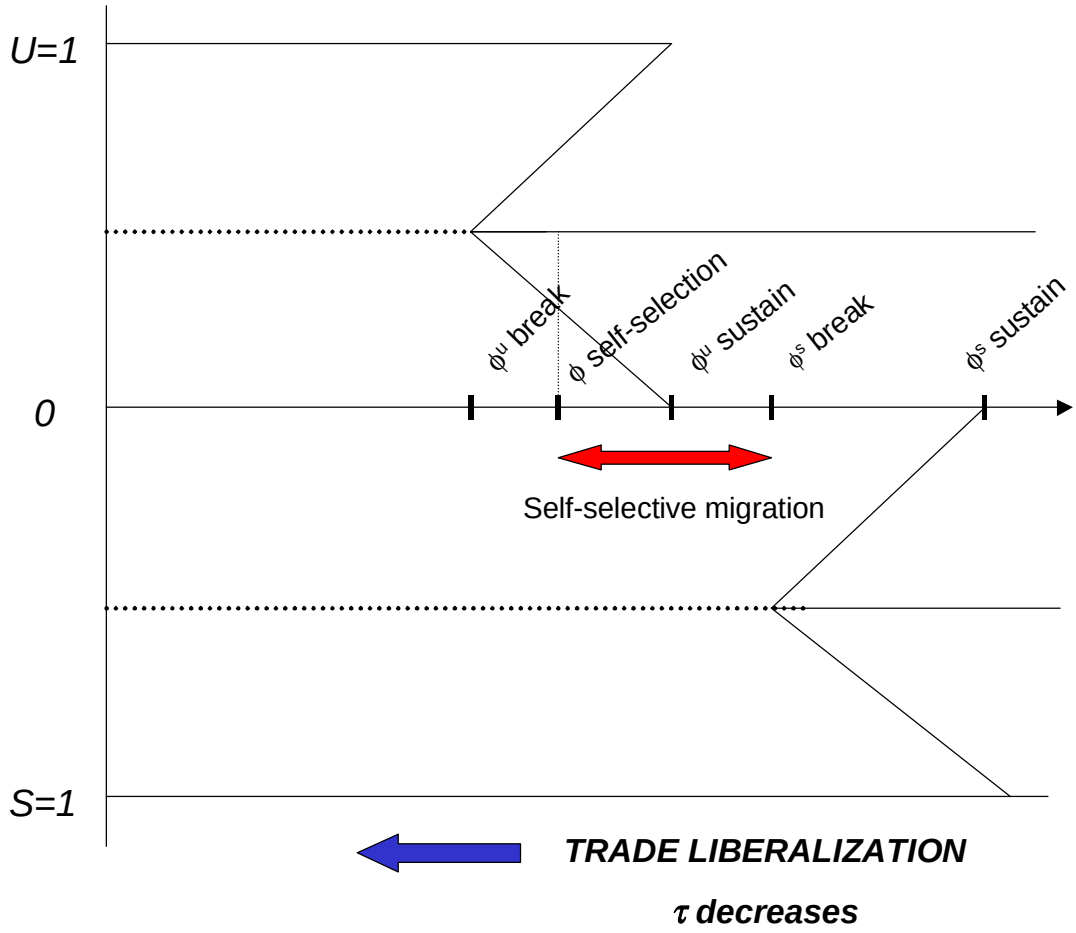
When trade barriers fall below a critical level *(ϕ^s sustain)* a core-periphery equilibrium for the high-skilled becomes possible. However, the symmetric equilibrium is still stable for values above another critical value *(ϕ^s break*).[18] As the regional economies become more integrated high-skilled workers will migrate first in response to real wage differentials.

We next consider whether there is a range of transport costs for which only the high-skilled migrate to the core region. We compute a critical level of trade costs for which $U = ½$ and $S = 1$ (or zero) is a stable equilibrium, *ϕ-self selection*. For trade costs below these level a core-periphery equilibrium as in Krugman (1991) is the only stable outcome. The stability of the symmetric equilibrium for the low-skilled is affect by high-skilled workers' migration. The concentration of high-skilled workers in the core region will strengthen the agglomerative forces since more varieties are produced (price-index effect) and more income will be generated in this region (home-market effect). For sufficiently high trade costs, the symmetric equilibrium for the low-skilled may still be stable. But as regional integration proceeds, the stability may be reversed. A two-stage process of industry location may arise. First, the core region (which is still relatively small) is attractive only to workers in the skill intensive industry. Concentration of skilled workers increases productivity and firms are willing to pay higher nominal wages. Second, as a threshold of trade costs is reached, *ϕ-self selection*, high-skilled workers' concentration in the core region, also induces low-skilled workers to migrate leaving the periphery deindustrialised (the home-market and price-index effects become stronger than the competition effect).

[18] For values of trade costs within the range (ϕ^s break < ϕ^s < ϕ^s sustain), both concentration of the high skilled in one of the two regions and symmetry are possible equilibria. The model does not predict which equilibria will arise; policy and history have clearly a potential role in determining the outcome.

Fig. 3

Trade costs and stability of the spatial equilibria



From fig. 3 the following relations are evident:

ϕ^u *break* < ϕ *self-selection* < ϕ^u *sustain* < ϕ^s *break* < ϕ^s *sustain*

there exist therefore a range of trade costs for which a self-selecting equilibrium is possible (ϕ *self-selection* < ϕ < ϕ^s *sustain*) and another smaller range for which is the only stable equilibrium (ϕ^u *sustain* < ϕ < ϕ^s *break*).

The critical values considered depend on the parameters of the model. All the threshold values are increasing in μ. If the share of manufactures in the economy is large, the

agglomerative forces will be stronger for two reasons. First, the manufactured products will have a bigger share in the bundle of consumption of a representative individual so the *price-index effect* becomes more important. Second, he share of manufactures in world income will be larger and therefore strengthens the *backward linkage effect.*

Critical values are decreasing in σ, the elasticity of substitution in demand. The range of trade costs in which the core-periphery equilibrium occurs is greater the smaller is the elasticity of substitution between varieties. Lower σ implies that consumers view different varieties as being more distinctive, increasing their love of variety. The result is an equilibrium with more varieties and a lower output of each. By decreasing σ, the magnitude of scale economies, one of the agglomerative forces in the model is reduced. Finally an increase in the strength of the positive externalities between high-skilled worker, λ, makes agglomeration possible at higher level of trade costs.

5. CONCLUSION

This paper uses a version of the core-periphery model of trade and location by Krugman (1991) to analyse the migration behaviour of workers with different skills in a process of regional economic integration. Introducing labour heterogeneity in the basic core-periphery model enables us to explain one of the most striking features of interregional migration patterns, the positive self-selection of migrants.

In our model, the interaction between high-skilled workers in a region increases the productivity of each worker by means of a knowledge diffusion process. Regions with a higher average level of human capital are therefore more attractive for high-skilled workers. The skill premium is endogenous and increasing in the regional quota of high-skilled workers.

We find that there exists therefore a range of trade costs for which a self-selecting equilibrium is possible and another smaller range for which is the only stable equilibrium. One of the results of the model is the existence of a wage and productivity differential between the core and peripheral regions. Recent empirical works have supported this prediction using micro data.

The paper presented is highly stylised. In particular, the existence of congestion costs in the core region as in Helpman (1995), or an imperfectly mobile labour force across regions as modelled by Ludema and Wooton[19] (1997), can prevent the model from having an unrealistic catastrophic agglomeration at low transport costs (especially in the EU context). It is not intention of this paper discount these factors. The aim is to emphasise that the mechanisms highlighted in the paper may play an important role in the debate concerning the adequacy of regional cohesion policies at both national and European levels.

[19] They assume that workers have preferences for living in a particular location. The labour supply is not perfectly elastic as assumed in our model but the labour supply schedule is upward-sloping. The authors obtain a U-shaped relationship between manufacturing location and trade liberalization.

References

Blanchard, O., Katz, O.J.L. (1992), Regional evolutions, *Brooking Papers on Economic Activity* 1, 1-75.

Borjas, G.J., S.G. Bronars, and S.J. Trejo. (1992), Self-Selection and Internal Migration in the United States, *Journal of Urban Economics* 32: 159-185.

Chiswick B. R. (2000), Are Immigrants Favourably Self-Selected? An Economic Analysis, IZA Discussion Paper N. 131.

Ciccone A., Peri G. (2000), Human Capital and Externalities in Cities, CEPR Discussion Paper No. 2599, London.

Ciccone, A. and R. Hall (1996), Productivity and the Density of Economic Activity, *American Economic Review* 86: 54-70.

De la Fuente A., Donenech R. (2000), Human Capital in Growth Regressions: How Much Difference does Data Quality Make?, *OECD Working Paper* No. 262.

Decressin, J. and Fatas A. (1995), Regional Labour Market dynamics in Europe, *European Economic Review* 39, 1627-1655.

Eaton J., Eckstein Z. (1997), Cities and Growth: theory and evidence from France and Japan, *Regional Science and Urban Economics*, vol. 27.

Fujita M., Krugman P. and Venables A. J. (1999) *The Spatial Economy: Cities, Regions and International Trad*e. The MIT Press, Cambridge.

Florida R. (1995), Toward the Learning Region, *Futures*, Vol. 27 No.5, 527-536.

Glaeser, E.L. (1998), Are cities dying?, *Journal of Economic Perspectives* 12 (2), 139-160.

Glaeser, E.L., H. Kallal, J. Sheinkman, and A. Shleifer (1992), Growth in Cities, *Journal of Political Economy* 100: 1126-1152.

Hanson G. (2001), Scale Economies and the Geographic Concentration of Industry, *Journal of Economic Geography*, Vol.1 (3).

Harris, C.D. (1954), The Market as a Factor in the Localization of Industry in the United States, *Annals of the Association of American Geographers* 44: 315-348.

Helpman E.(1997), The Size of Regions, in *Topics in Public Economics. Theoretical and Applied Analysis*, D. Pines, E. Sadka and I. Zilcha (eds.), , Cambridge University Press, Cambridge.

Kremer M. (1993), The O-Ring theory of Economic Development, *Quarterly Journal of Economics* 108 (3), 551-575.

Krugman P. (1991) Increasing returns and economic geography, *Journal of Political Economy* **9**9, 484-499.

Lucas, R. E. (1988), On the mechanics of economic development, *Journal of Monetary Economic*s, 22, 3-42.

Ludema R. and Wooton I. (1999), Regional Integration, Trade, and Migration: Are Demand Linkages Relevant in Europe?, in *Migration the Controversies and the Evidence*, Faini R., de Melo J. and K. Zimmermann (eds.), CEPR London.

Mori T. and Turrini A. (2000), Skills, Agglomeration, and Segmentation, Development Studies Working Paper N. 141, Centro Studi Luca D'Agliano.

Mountford A. (1997), Can a brain drain be good for growth in the source economy?, *Journal of Development Economics*, Vol. 53, 287-303.

Neary, J. P. (2000), Of Hype and Hyperbolas: Introducing the New Economic Geography, fothcoming in *Journal of Economic Literature.*

Ottaviano G. and Puga D. (1998) Agglomeration in the global economy: a survey of the new economic geography, *The World Economy* 21, 707-731.

Overman H., Puga D. (1999), Unemployment Clusters across European Region and Countries, CEPR Discussion Paper No. 2225, London.

Puga D. (1999), The Rise and fall of Regional Inequailities, *European Economic Review* 43, 303-334.

Quah D. (1996), Regional Convergence clusters across Europe, *European Economic Review*, Vol. 40.

Rauch, J.E. (1993), Productivity Gains from Geographic Concentration of Human Capital: Evidence from the Cities, *Journal of Urban Economics* 34: 380-400.

Roback J. (1982), Wages, rents, and the quality of life, *Journal of Political Economy*, Vol. 90, 1257-1278.

Stark O., Helmenstein C., Prskawetz A. (1997), A Brain Drain with a Brain Gain, *Economic Letters* Vol. 55, 227-234.

Sveikauskas, L. (1975), The Productivity of Cities, *Quarterly Journal of Economics* 89:393-413.